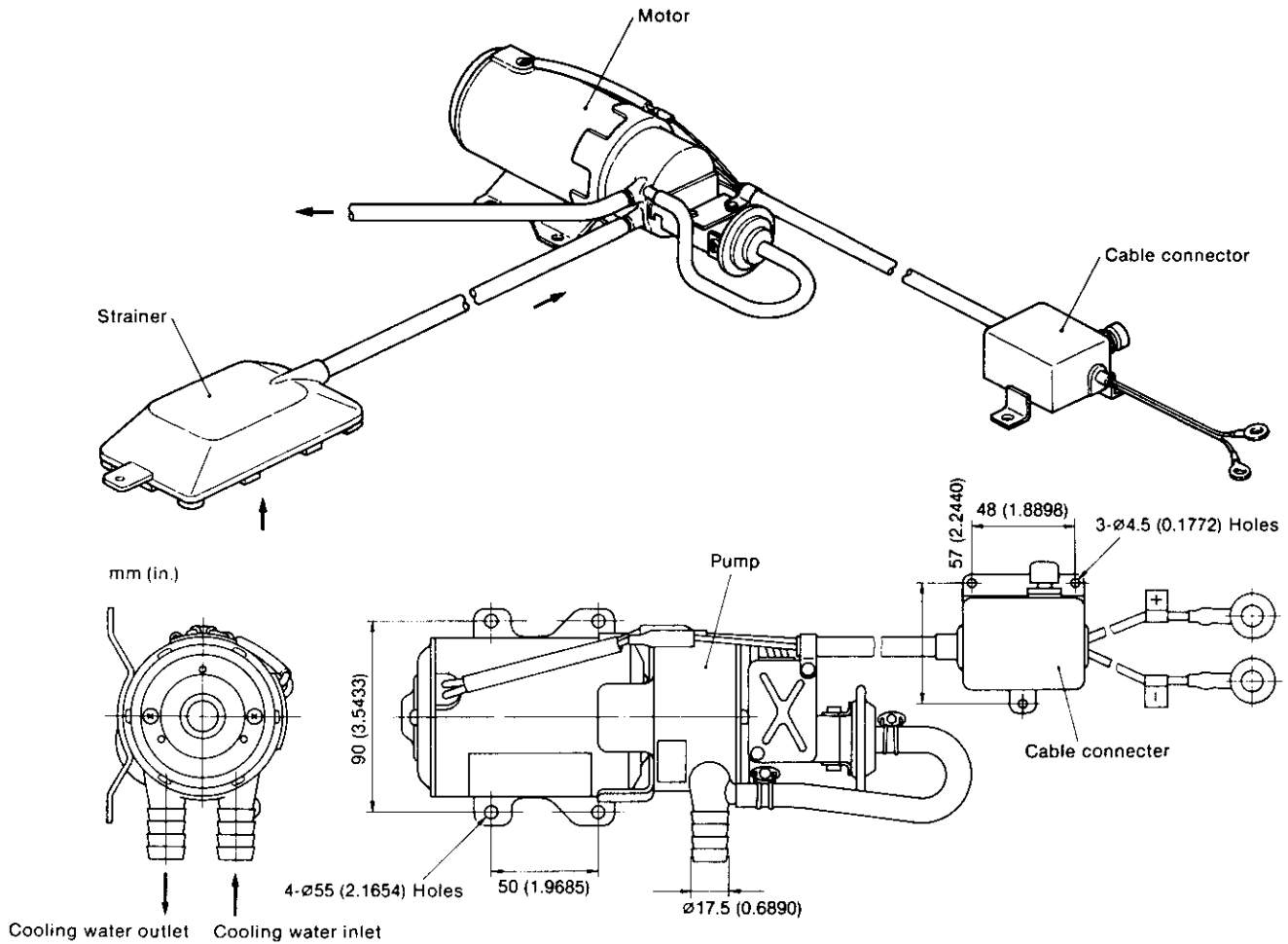


6. Bilge Pump and Bilge Strainer (Optional)



6-1 Bilge pump

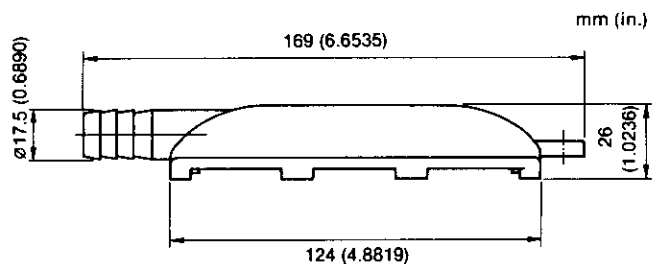
6-1.1 Specifications

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

6-1.2 Performance of pump (in pure water)

Self-suction performance	Voltage	11.5V
	Max. self-suction lift	1.2m (3.94 ft)
	Self-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

6-2 Bilge strainer



CHAPTER 8

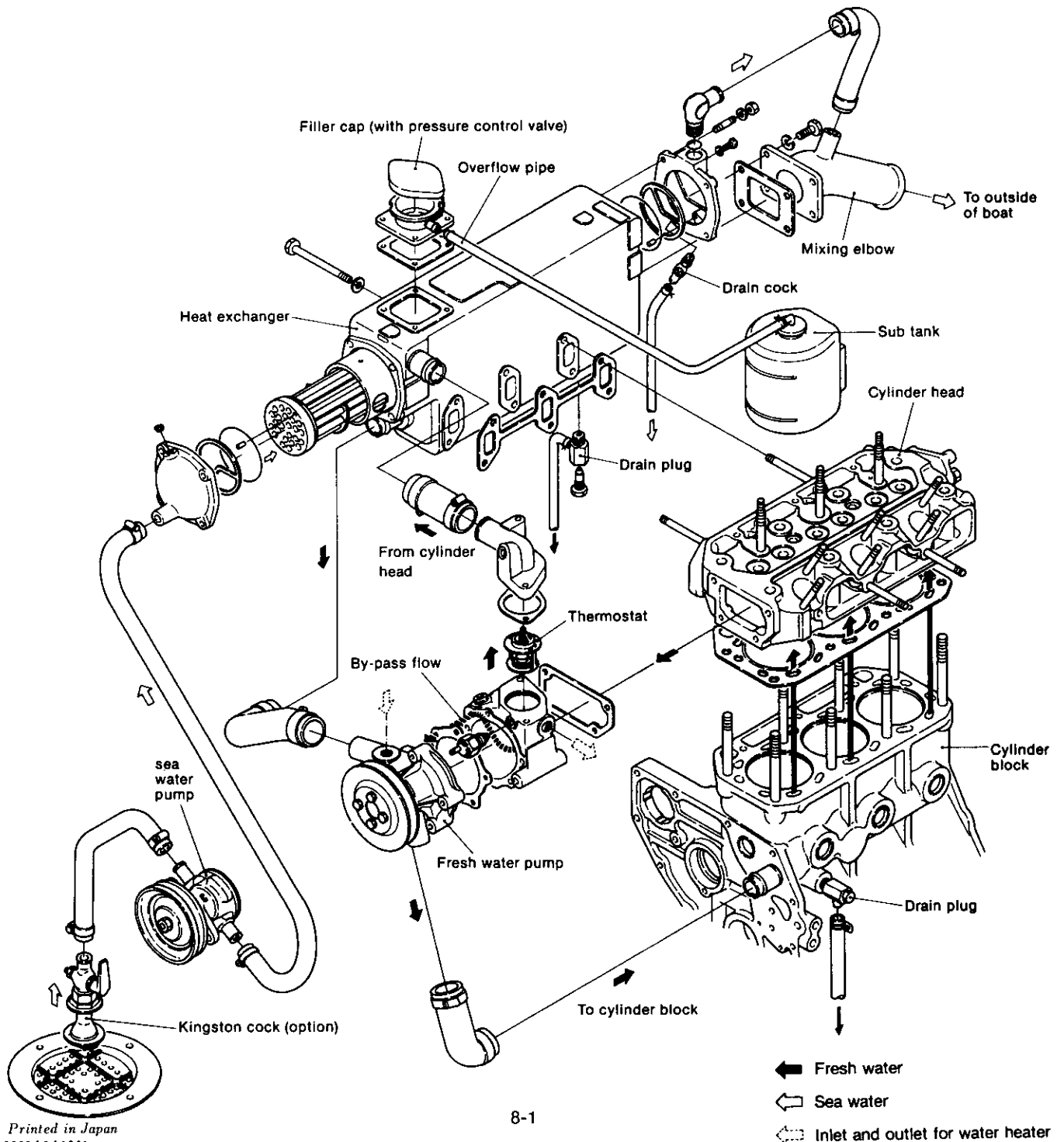
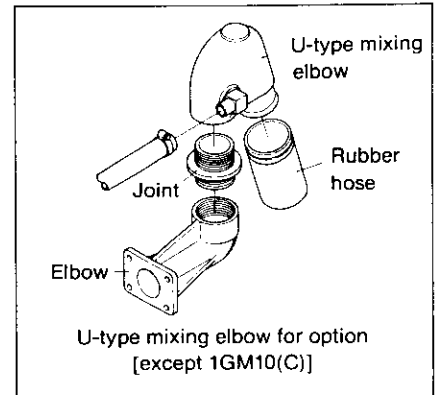
FRESH WATER COOLING SYSTEM

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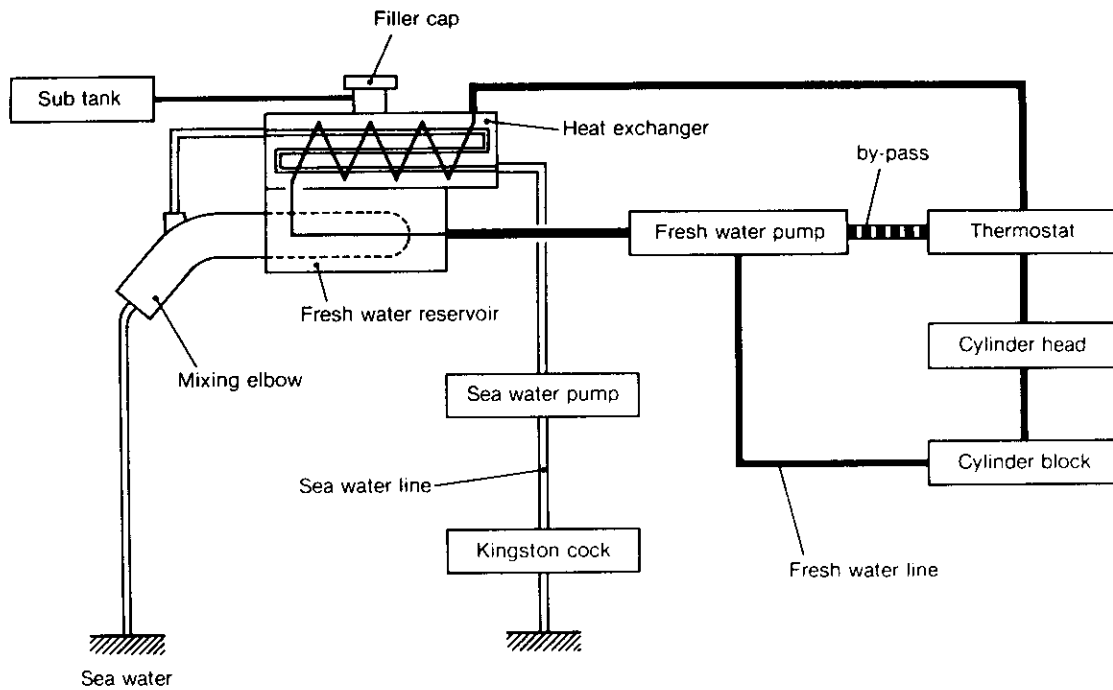
1. Cooling System

1-1. System Diagrams

Models 2GM20F, 3GM30F and 3HM35F are constructed from different parts but use the same water flow. The illustration below is of model 3HM35F.



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 engine starting or when the 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 the fresh water temperature is always kept at the proper level 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.

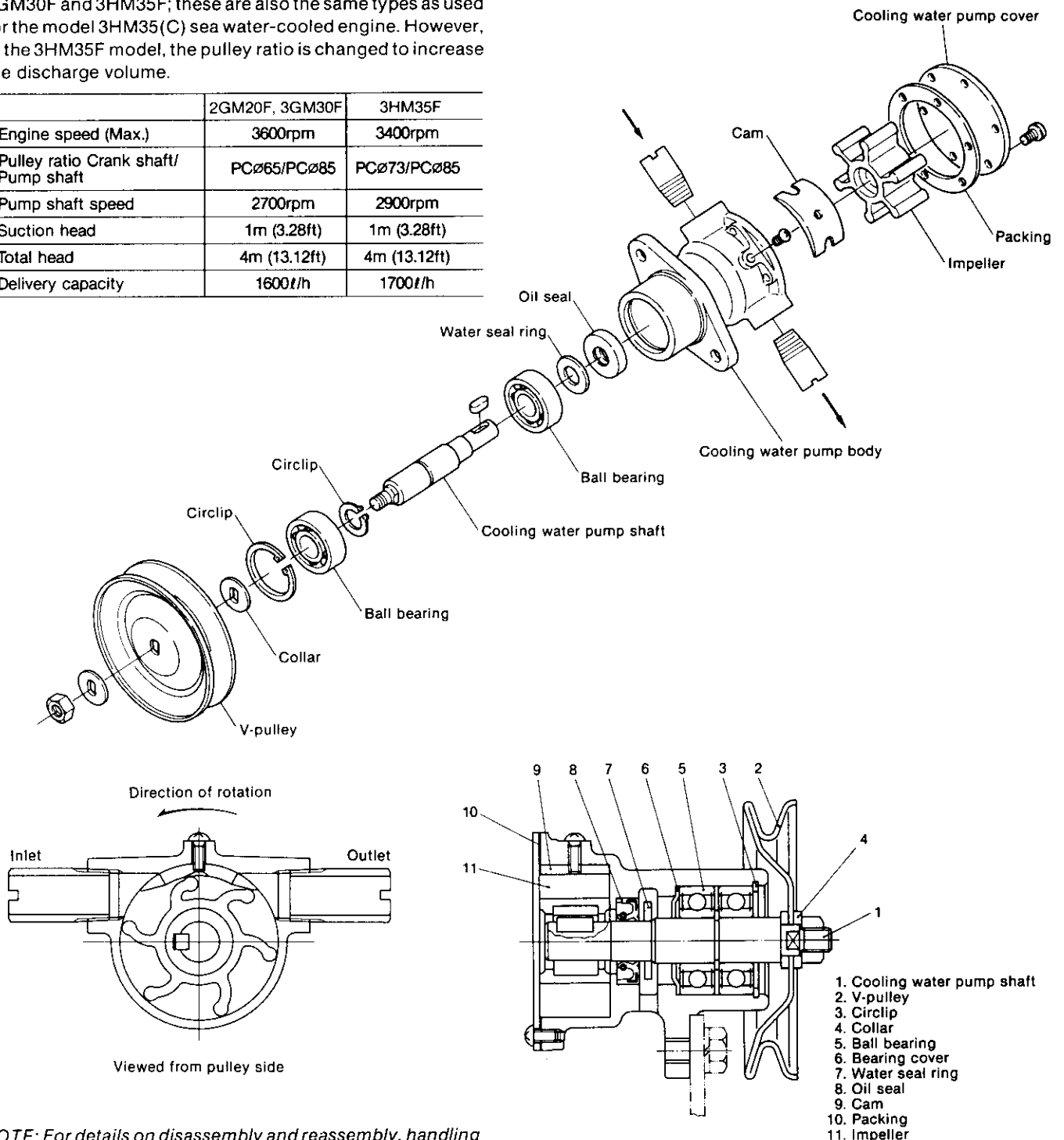
Sea water flows from the heat exchanger into the mixing elbow, and is discharged with the exhaust gas.

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 2GM20F, 3GM30F and 3HM35F; these are also the same types as used for the model 3HM35(C) sea water-cooled engine. However, in the 3HM35F model, the pulley ratio is changed to increase the discharge volume.

	2GM20F, 3GM30F	3HM35F
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	1600t/h	1700t/h



NOTE: For details on disassembly and reassembly, handling precautions and inspection, refer to "Chapter 7, Section 2. Water pump (P.7-5)".

3. Fresh Water Pump

3-1. Pump construction

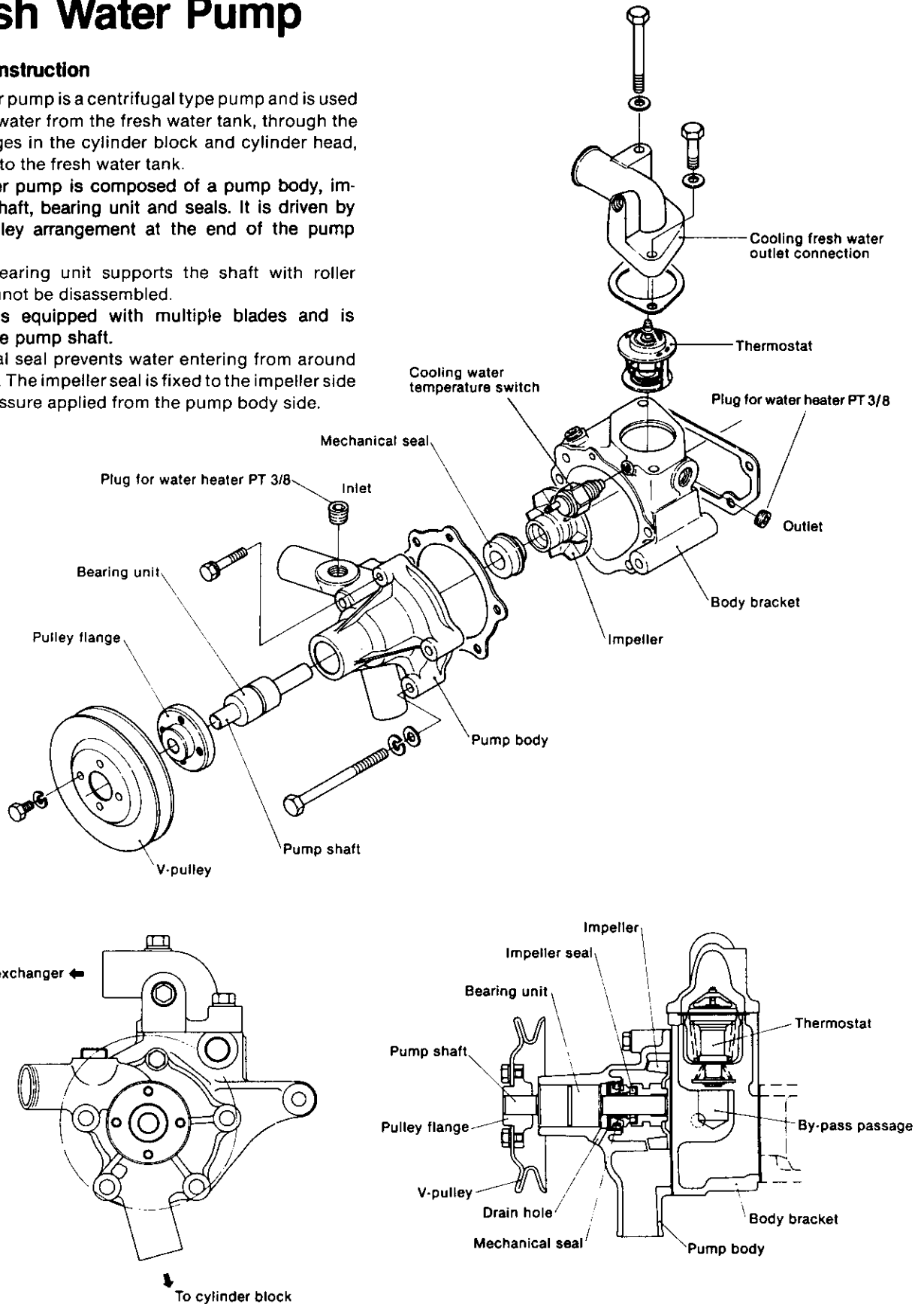
The fresh water pump is a centrifugal type pump and is used to move fresh water from the fresh water tank, through the cooling passages in the cylinder block and cylinder head, and then back to the fresh water tank.

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 with roller bearings. It cannot be disassembled.

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

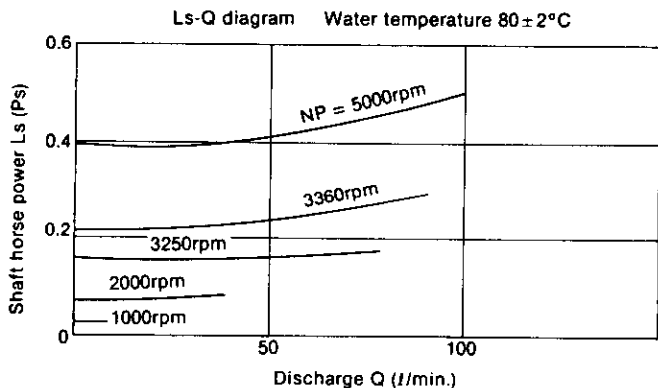
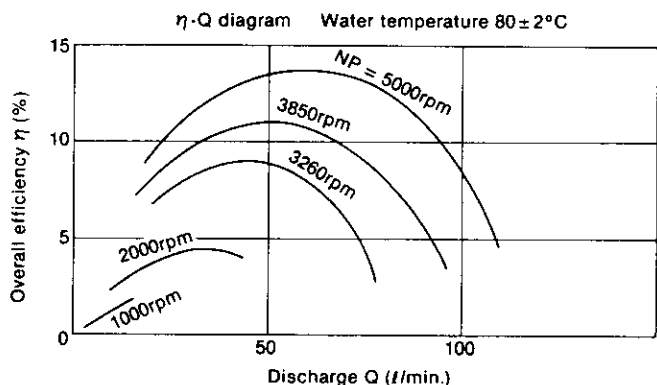
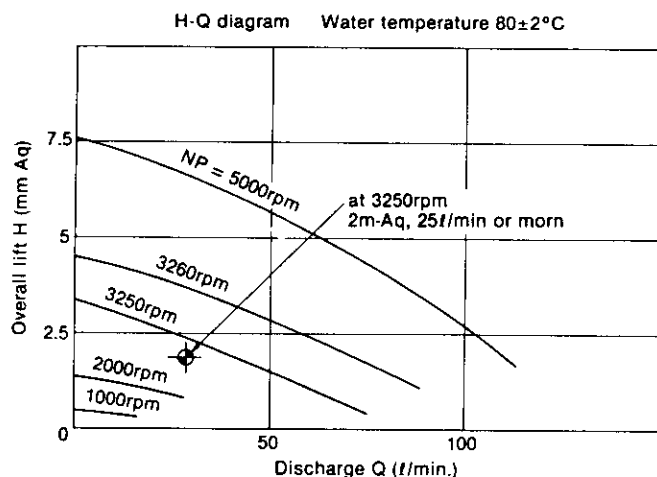
The mechanical seal prevents water entering from around the pump shaft. The impeller seal is fixed to the impeller side with spring pressure applied from the pump body side.



3-2. Pump capacity and characteristic

	2GM20F,3GM30F	3HM35F
Crank shaft speed	3600rpm	3400rpm
Pulley ratio Crankshaft/ 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)

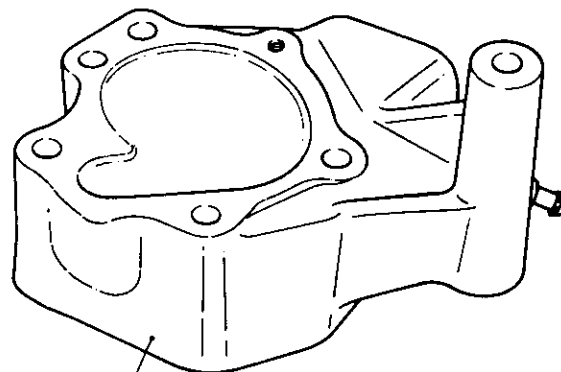
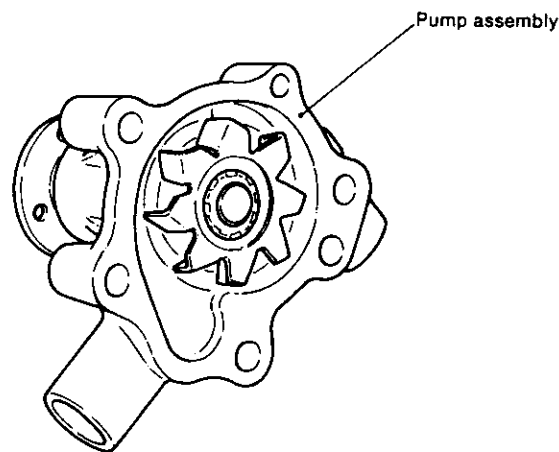
NOTE: The same type of fresh water pump is used for models 2GM20F, 3GM30F and 3HM35F.



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.

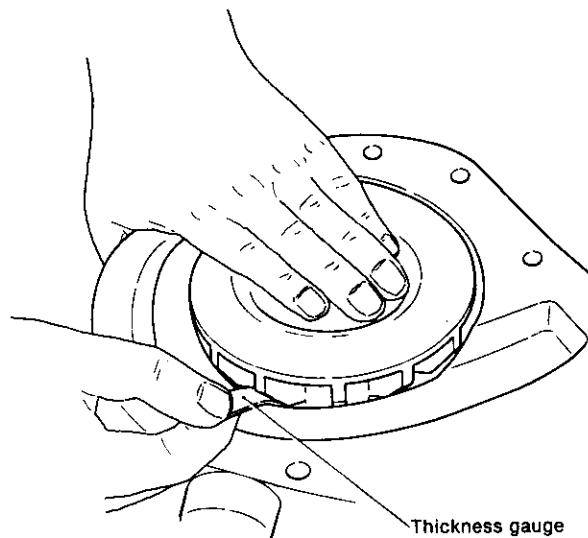
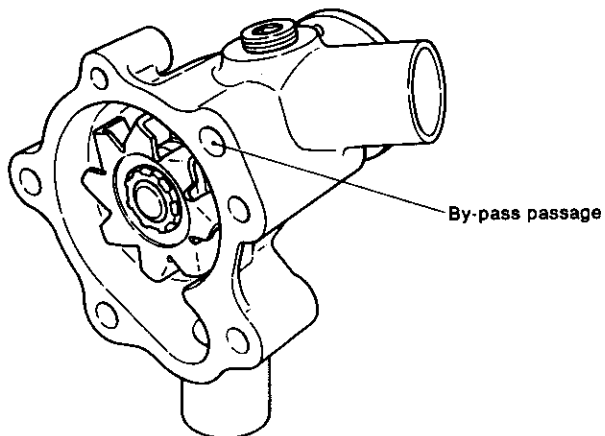
kgf-cm(ft-lb)	
Tightening torque for pump setting bolts	40—80 (2.89 ~ 5.79)



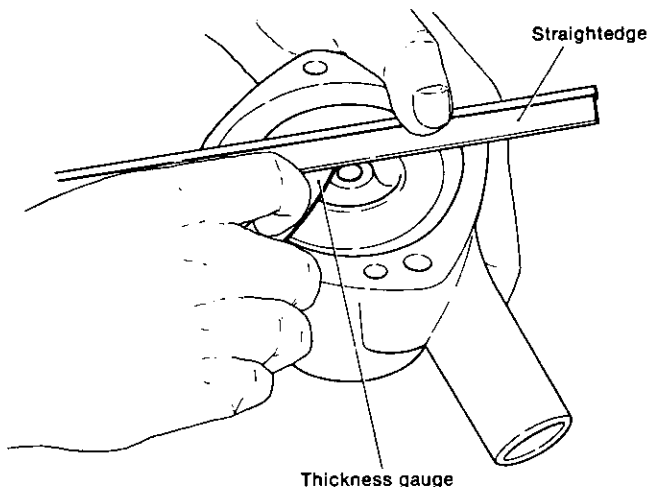
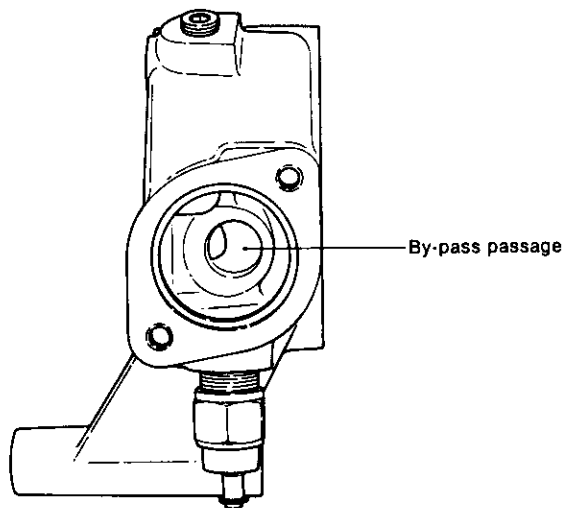
3-4. Inspection and measurement

- (1) 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.
- (2) Impeller inspection
Check impeller for damage, corrosion and water. Replace if required.
- (3) 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.

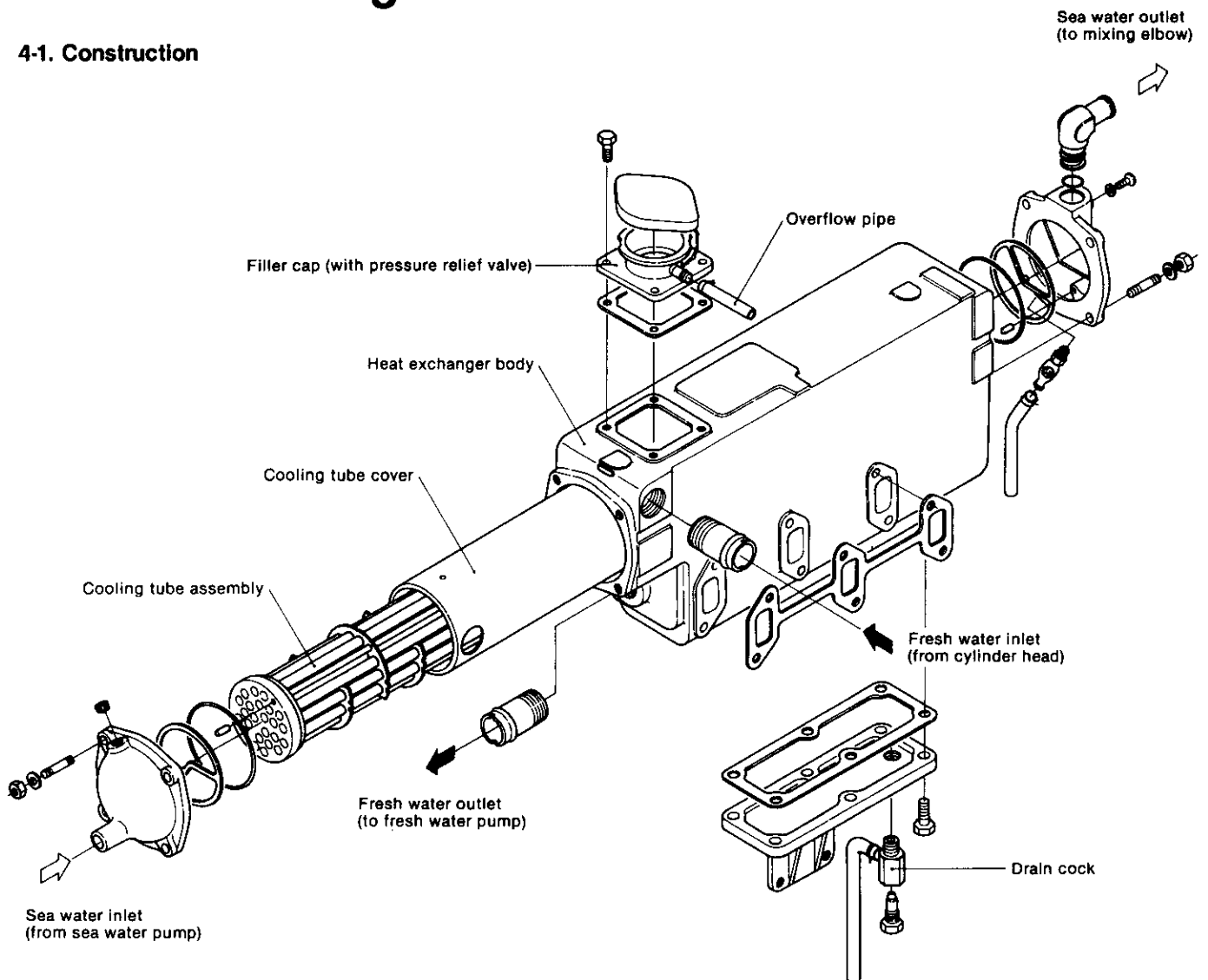
	mm (in)
	Maintenance standard
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)
Clearance between impeller and bracket	0.5 (0.0197)

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

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 uses sea water to cool the fresh water, which has reached a high temperature, while being circulated in the cylinder block. 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

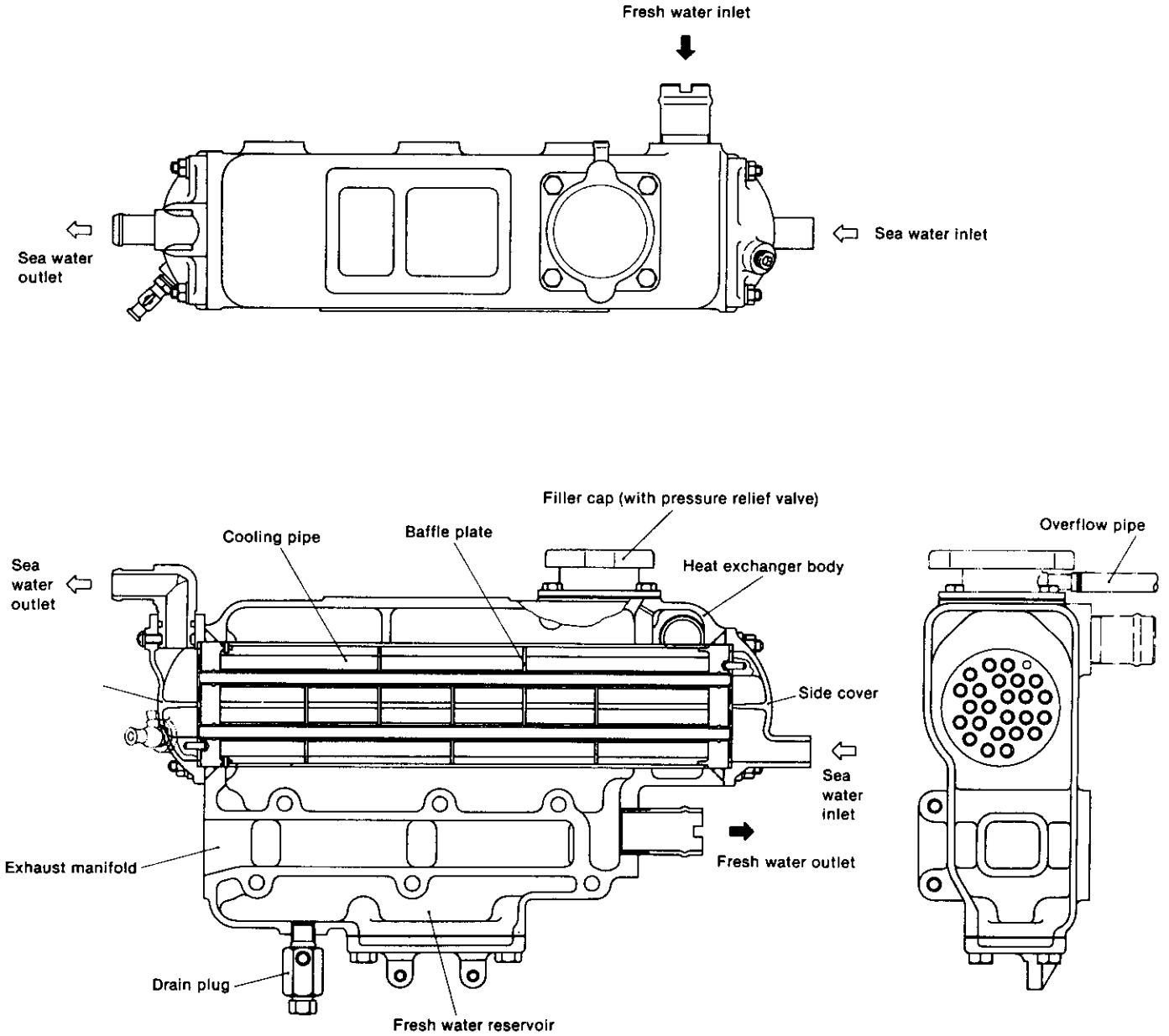
water passes through the flow path formed between the tubes and baffle plates inside the cooling tube cover. The lower part of the heat exchanger stores the fresh water, acting as a fresh water tank. An exhaust gas passage, leading out of the storage position, is integrated with the water-cooled exhaust manifold.

Chapter 8 Fresh Water Cooling System
4. Heat Exchanger

SM/GM(F)(C)-HM(F)(C)

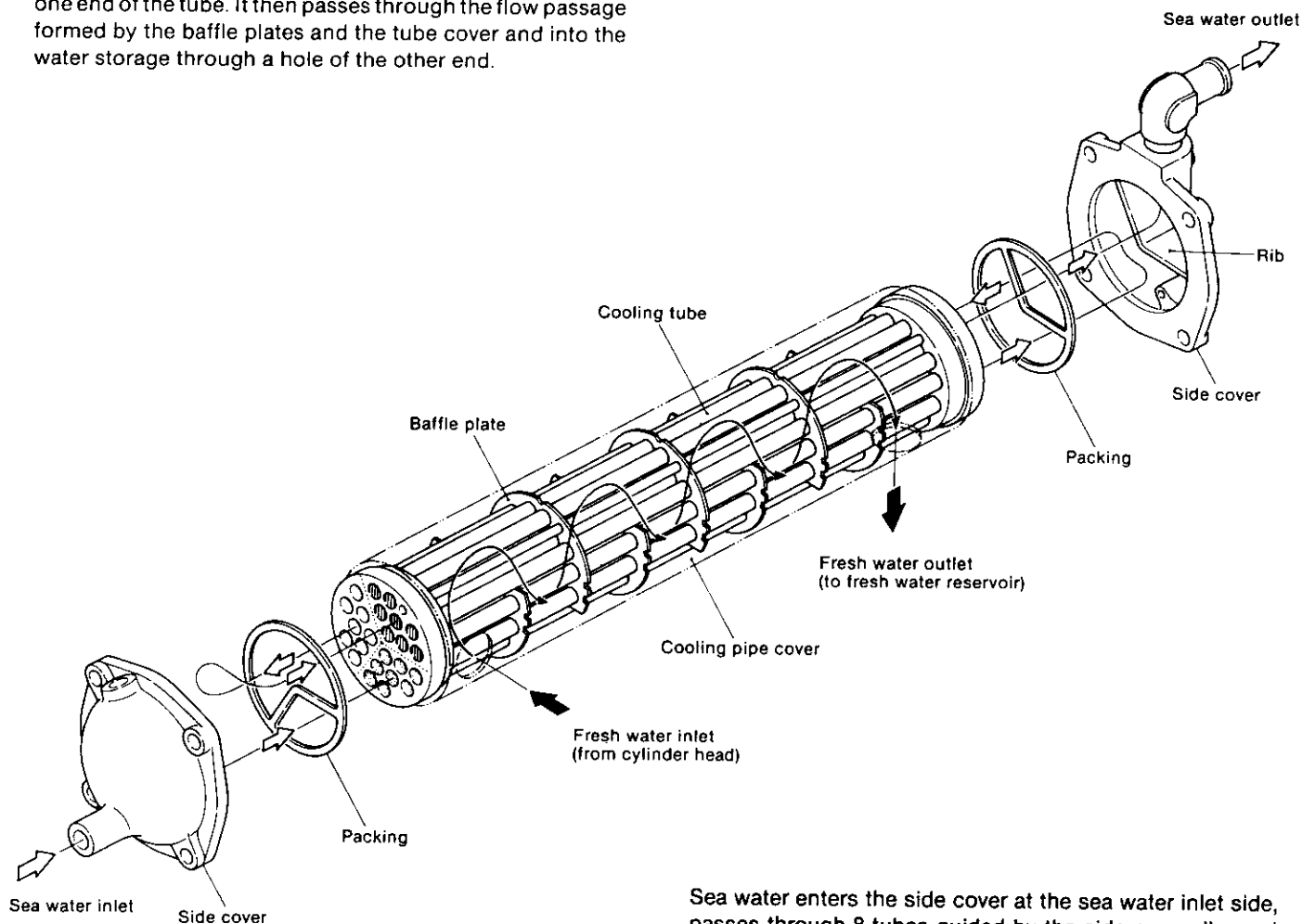
The filler cap on top of the heat exchanger is equipped with a pressure relief valve. When pressure exceeds the specified limit, this valve opens to release pressure through the overflow pipe.

On the other hand, when the cooling system pressure becomes negative in relation 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 tube. It then passes through the flow passage formed by the baffle plates and the tube cover and into the water storage through a hole of the other end.



Sea water enters the side cover at the sea water inlet side, passes through 8 tubes guided by the side cover ribs and then leaves the side cover at the sea water outlet side. Here it passes through another 8 tubes guided by the 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 from 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

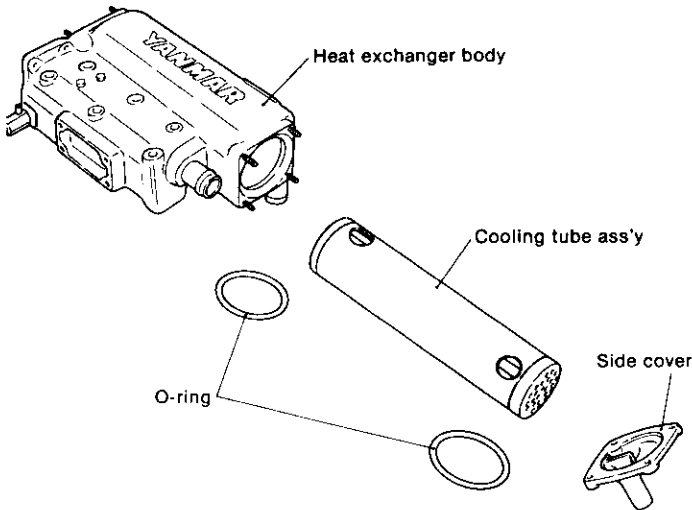
Model of engine		2GM20F	3GM30F	3HM35F
Output (DIN 6270 B rating)	kw/rpm	18.2/3600	27.3/3600	25.4/3400
Pipe dia. X pieces	mm	ø6/ø8 × 24	ø6/ø8 × 24	ø6/ø8 × 24
Radiation area	m ²	0.119	0.163	0.208
Radiation area/HP	m ² /HP	0.0066	0.0060	0.0061
Fresh water capacity	l (cu. in)	2.9 (177.0)	3.4 (207.5)	4.9 (299.0)

4-4. Disassembly

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

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

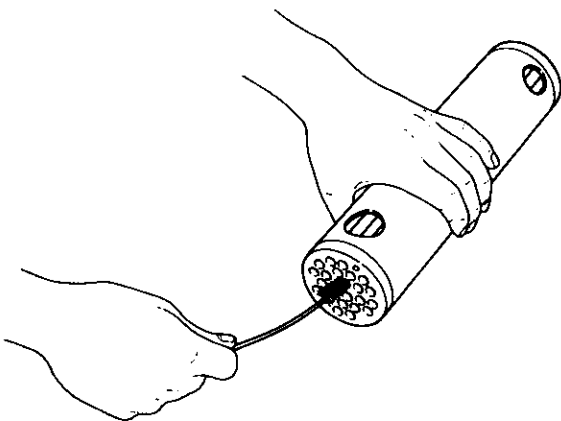
- (2) Remove filler cap and port.
- (3) Remove lower cover and packing.



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.

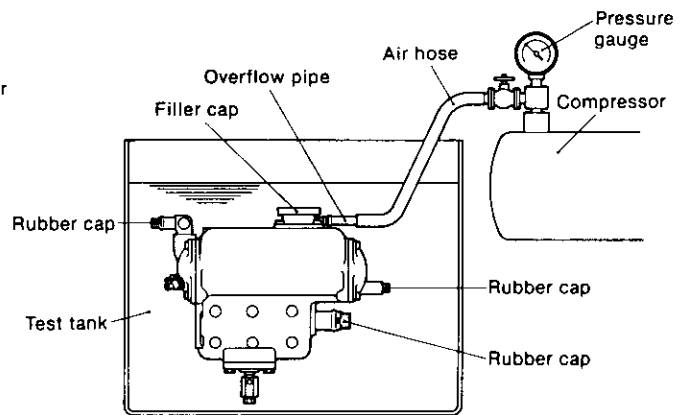
4-5.2 Heat exchanger body

- (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.

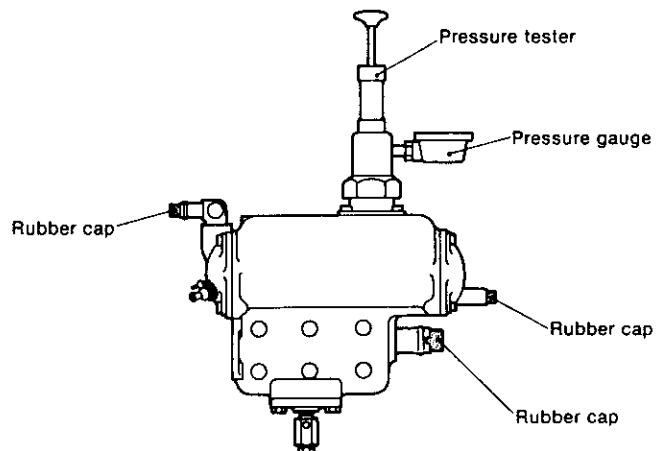
NOTE: Air pressure should be 0.5 ~ 2.0kgf/cm² (7.11 ~ 28.45 lb/in²).



Leakage test using compressed air and test tank

- (2) Test using pressure tester

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



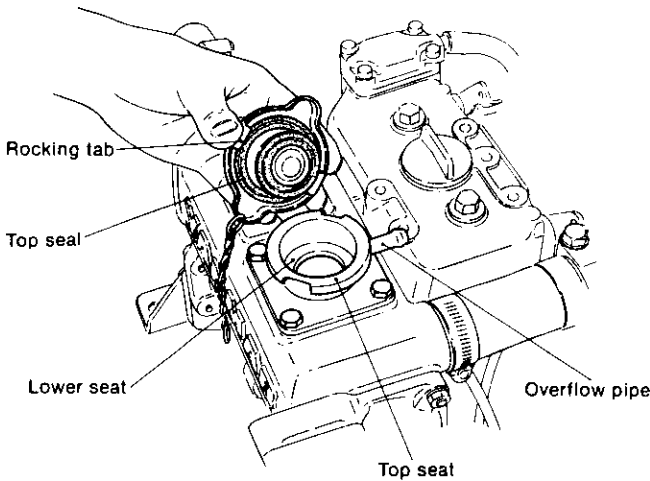
Leakage test using a pressure tester

5. Filler Cap and Subtank

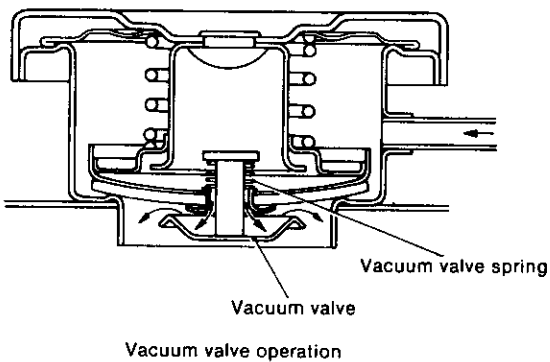
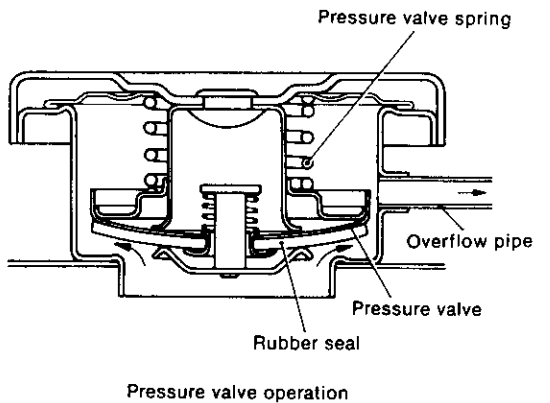
5-1. Filler cap construction

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 the cooling system pressure is within the specified range 0.9kgf/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 the water cools down and the pressure in the system is lower than atmospheric pressure, the vacuum valve opens and air enters the system through the overflow pipe.

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

Action of Pressure control Valve

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

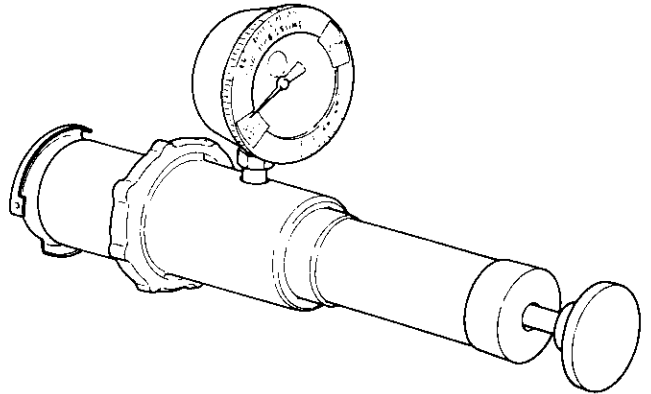
5-3. Filler cap inspection

(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.

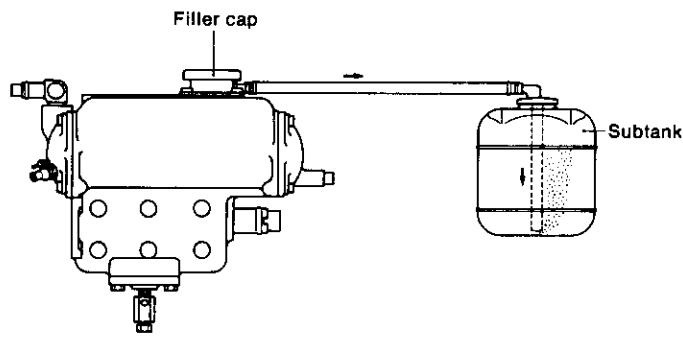
Increase pressure and if pressure remains constant for six seconds, the cap is normal. If pressure does not increase or does not remain constant for six seconds, check for defects. Repair or replace as required.



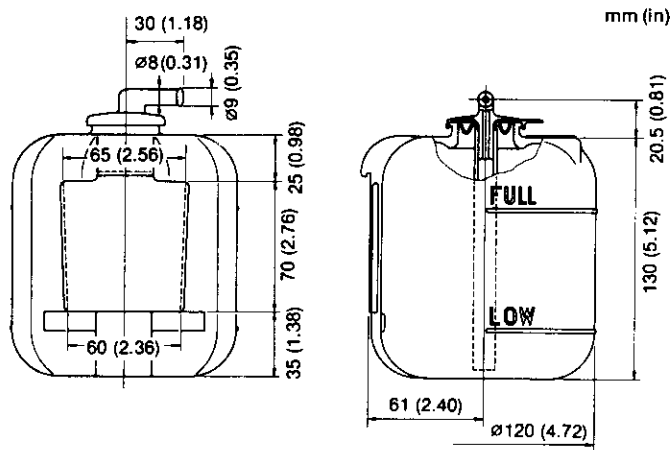
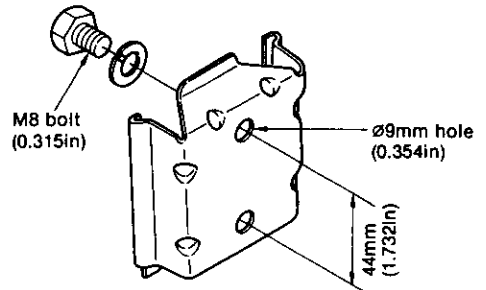
5-4. Subtank function

When the cooling system pressure rises above 0.9kgf/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, thereby removing one possible cause of accidents.



Subtank mounting plate (attached to subtank)



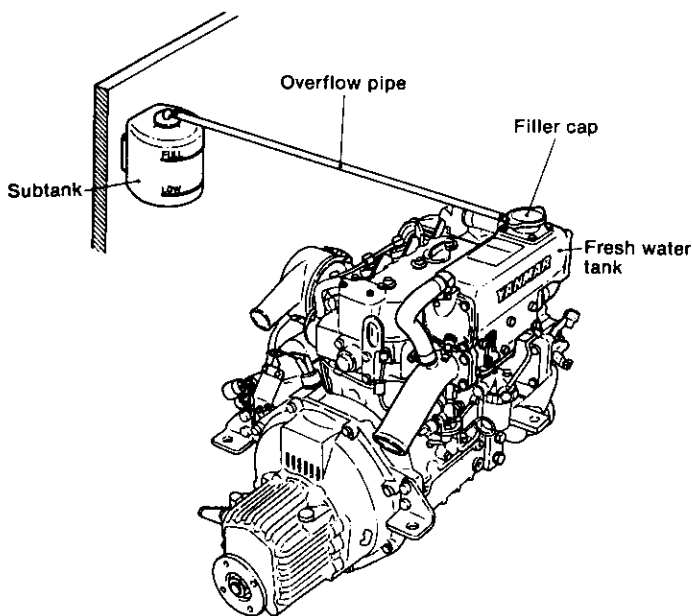
- (1) Mount the subtank at the same height as the fresh water tank.
 - (2) Ensure that the length of the overflow pipe is no more than 1m (39.37 in.), and that it does not break.
- NOTE: If a subtank is not used, be careful not to immerse the overflow pipe in the bilge, since this can cause bilge water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

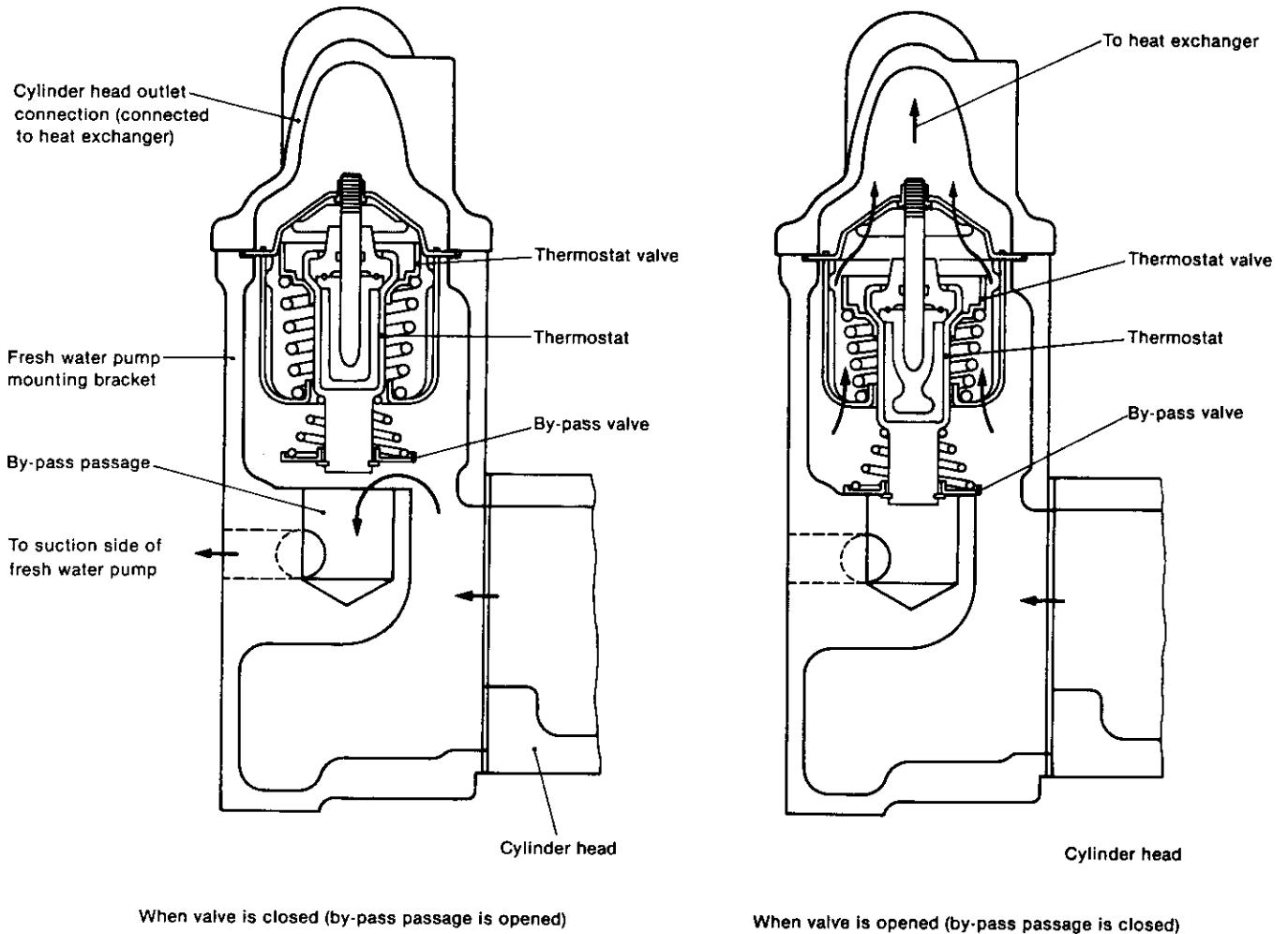
		l (cu. in)
Subtank capacity	Over all capacity	1.25 (76.28)
	Full scale position	about 0.8 (48.82)
	Low scale position	about 0.2 (12.20)
Part No.	120445-44530	

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 of 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 level.

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

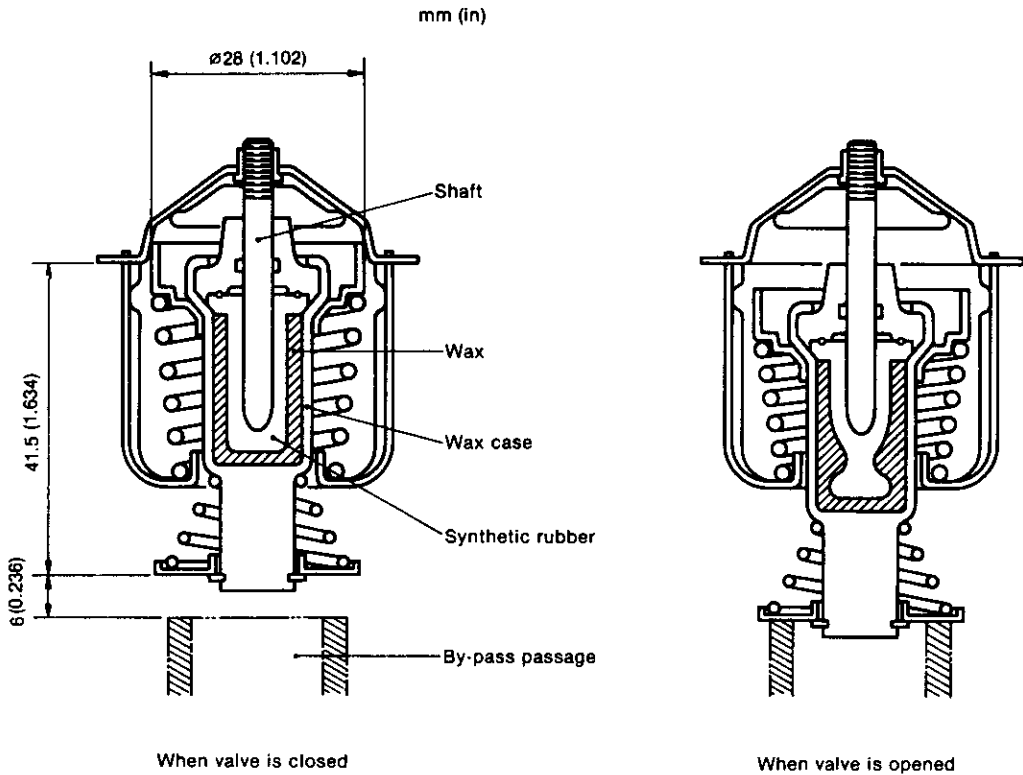
temperature is low, and fresh water is fed to the fresh water pump inlet through the drilled hole in the by-pass passage, to be circulated inside the engine.

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 it is cooled and then fed to the fresh water pump. With the thermostat valve open, the by-pass passage is throttled. The by-pass passage is completely closed as the temperature rises.

6-2. Construction

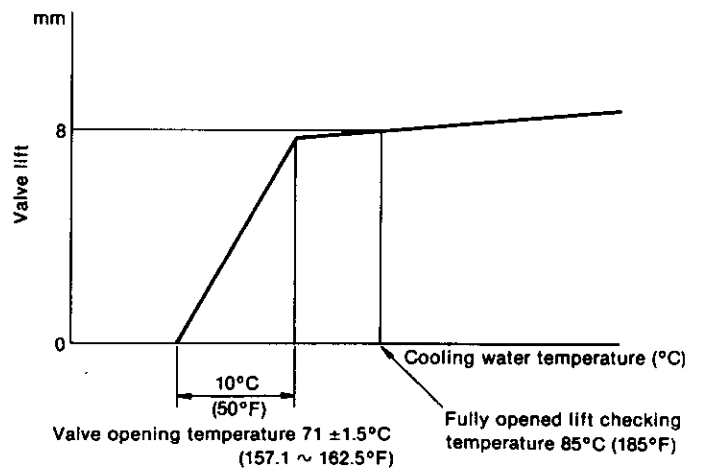
A wax-pellet type thermostat is used for this engine. The "wax-pellet" type is the description given to a quantity of wax in the shape of a small pellet. When the temperature of

the cooling water rises, the wax melts and its volume expands. The valve is opened or closed by these variations in volume.



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

Characteristic of Thermostat



6-3. Inspection

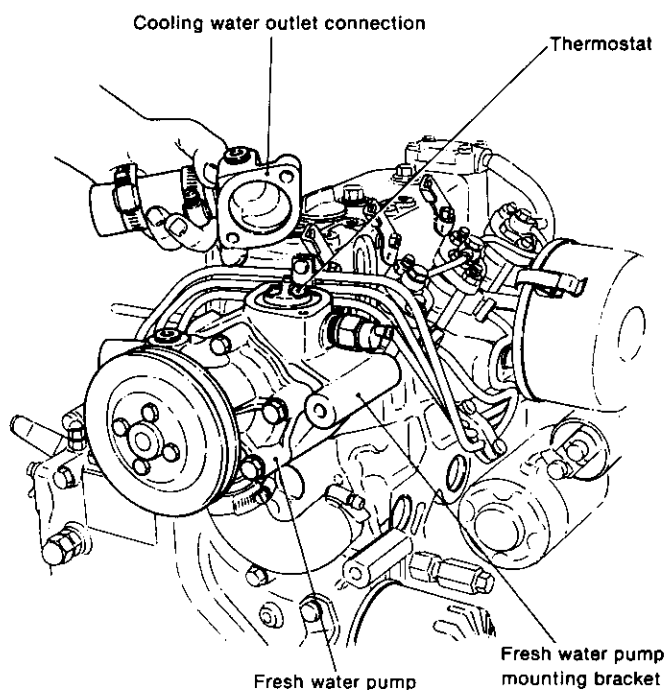
- (1) Remove the cooling water outlet connection at the top of the fresh water pump mounting bracket and take out the thermostat.

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.

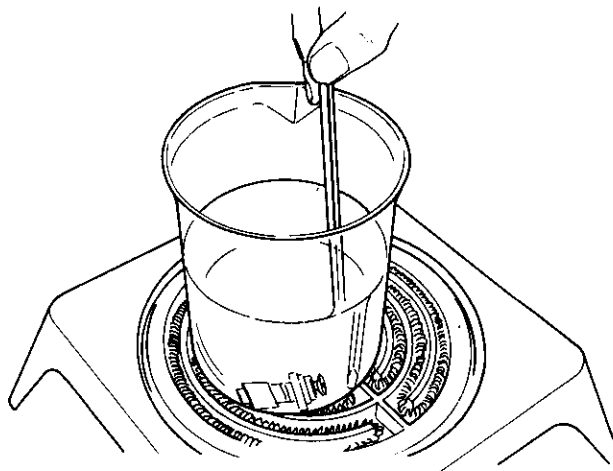
- (4) Replace the thermostat when it has been in use for a year, or after every 2000 hours of operation.

Part No. code of thermostat	121750-49800
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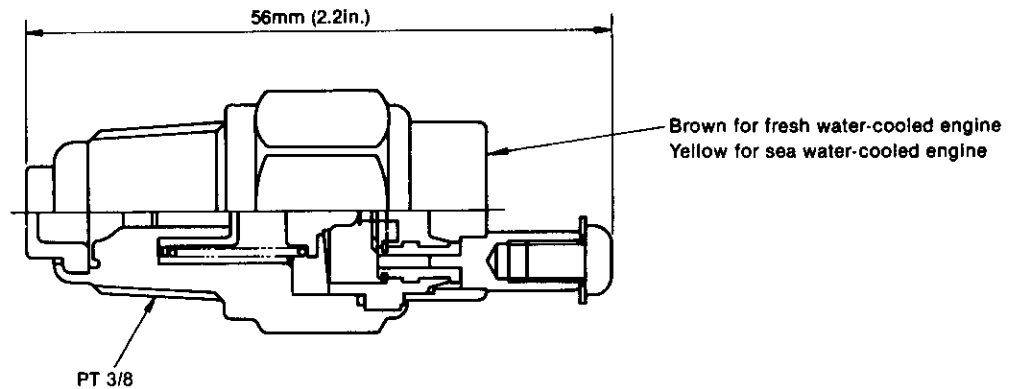
- (2) Testing the thermostat

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				
95° C (202~193° F)	88° C (187° F) or higher	DC 12V 1A	Within 60 sec.	Green	127610-91350

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 temperatures can rise to a point where they 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 affect, resulting in overheating.

(2) Fresh water tank capacity

Model	Capacity ℓ (cu. in)
2GM20F	2.9 (177.0)
3GM30F	3.4 (207.5)
3HM35F	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 not all the water will 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 the cooling system and check for leaks.

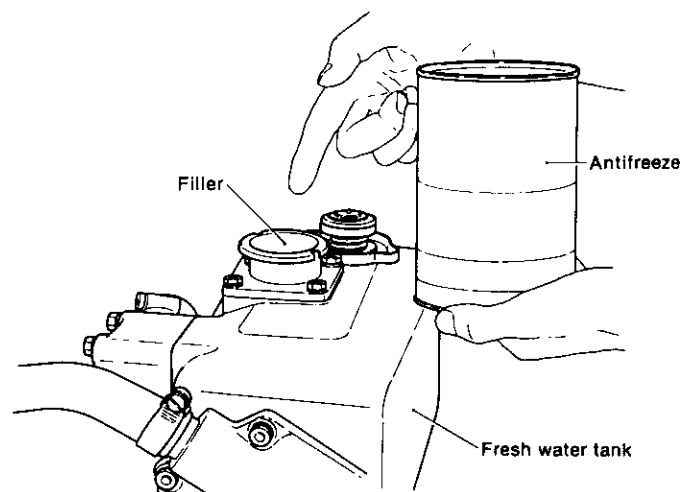
2) Select mixing ratio according to the following table.

Temperature	ℓ (cu. in)					
	-5°C	-10°C	-15°C	-20°C	-25°C	-30°C
Mixing ratio	12%	22%	29%	35%	40%	44%
2GM20F	0.35 21.40	0.64 39.10	0.84 51.30	1.02 62.20	1.16 70.80	1.28 78.10
3GM30F	0.41 25.00	0.75 45.80	0.99 60.40	1.19 72.60	1.36 83.00	1.50 91.50
3HM35F	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 the mixing ratio carefully, especially when using premixed coolant.

3) Tighten the drain cock and fill the cooling system. Then, run the 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.

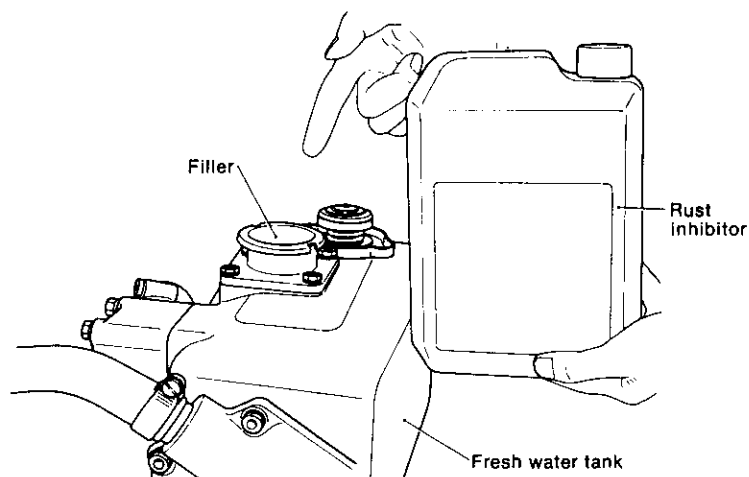
NOTE: When antifreeze protection is no longer necessary, drain water, flush cooling system and refill with fresh water.

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-up 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 affect.

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.

CHAPTER 9

MODIFYING THE COOLING SYSTEM

1. General	9-1
2. Disassembly of Sea Water-Cooled Engine	9-2
3. Assembling modified parts to the Fresh Water-Cooled Engine	9-7
4. Cautions When the Engine is Installed Inboard	9-12

1. General

1-1. Direct sea water-cooled engine and fresh water-cooled engine

Engine models 2GM20, 3GM30 and 3HM35 are sea water-cooled, and models 2GM20F, 3GM30F and 3HM35F are fresh water-cooled.

The main parts of both sea water-cooled and fresh water-cooled engines are the same; only the cooling systems are different. Sea water-cooled engines can therefore be modified into fresh water cooling by the special parts kit prepared by YANMAR for this modification.

1-2. Modification method

When modifying a seawater-cooled engine into a fresh water-cooled engine, follow the sequence described in Section 2.

1-3. Testing a modified engine

Any engine modified as a fresh water-cooled engine must be given an operating test (running) to check for leakage. This test shall be made before delivery.

1-4. Warranty

Engines modified as fresh water-cooled engines are not covered by the general warranty.

1-5. Kit for modification into a fresh water-cooled engine

The kits for modification into a fresh water-cooled engine differ according to the engine model.

When ordering the modification kit state the following code number.

Applicable Engine Model	2GM20 – 2GM20F	3GM30 – 3GM30F	3HM35 – 3HM35F
Fresh water cooling kit	728271-99510	728374-99510	728671-99510
Mixing elbow Ass'y	○	—	—
Fresh water pump Ass'y		○	
Sea water pump Ass'y		○	—
Heat exchanger Ass'y	*○	*○	*○
Subtank Ass'y		○	
Thermostat Ass'y		○	
Cooling water pipe Ass'y		○	*○
Fuel oil pipe Ass'y	*○	*○	*○
Speed control cable bracket Ass'y	○	—	—
V-belt and other parts Ass'y		○	*○

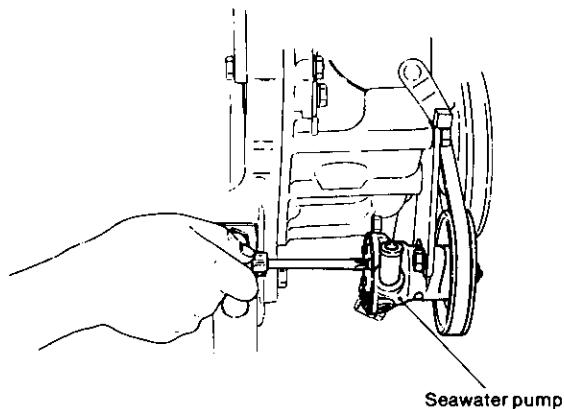
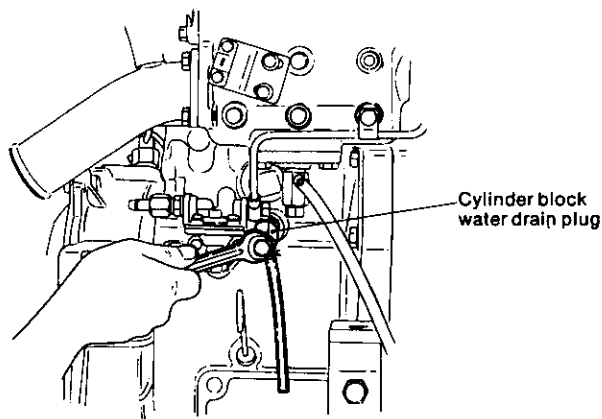
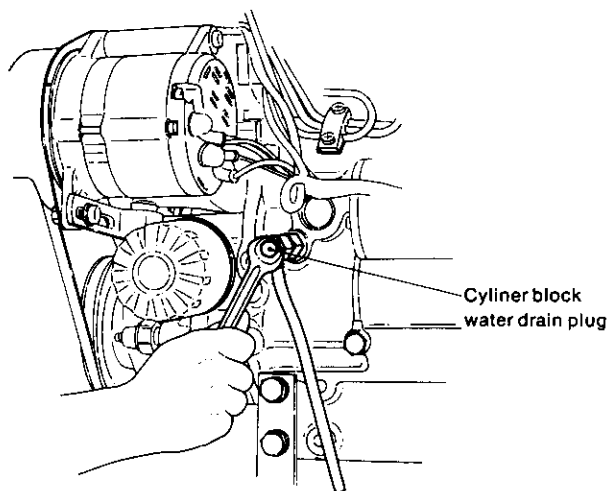
NOTES: ○ parts marked are those included in the modification kit (necessary for modification).
 — parts marked are those not included in the kit (unnecessary for modification).
 *○ parts marked are those which differ according to the engine model (not interchangeable).

2. Disassembly of sea water-cooled engine

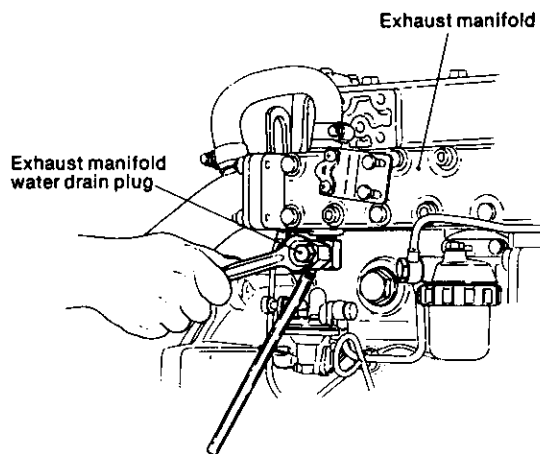
2-1. Drain the cooling sea water

Locations of Cooling Water Drain Plugs

	2GM20	3GM30	3HM35
Cylinder block	○ (Intake side)	○ (Exhaust side)	○ (Exhaust side)
Cooling water pump	○	○	○
Exhaust manifold	—	○	○

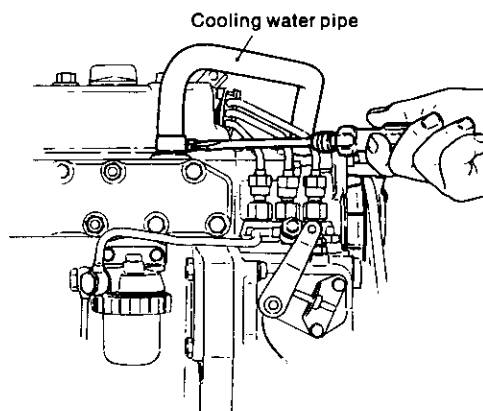


Note: CSW = Cooling Sea Water
 CFW = Cooling Fresh Water



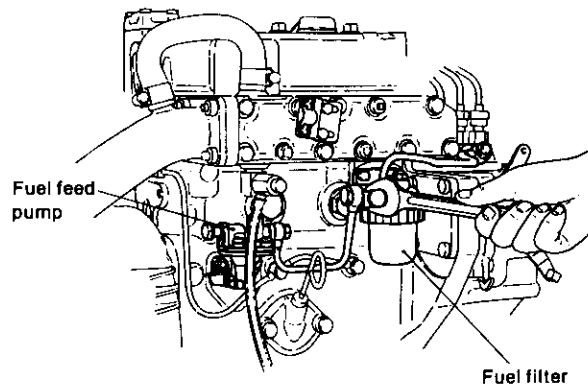
2-2. Remove the cooling water pipe

- (1) For model 2GM20, remove the CSW hose between the thermostat and mixing elbow.
- (2) For models 3GM30 and 3HM35, remove the CSW hose between the thermostat and exhaust manifold.



2-3. Remove the fuel oil pipe

- (1) Remove the fuel pipe between the oil filter and fuel pump.
- (2) Remove the fuel pipe between the fuel feed pump and fuel filter.



2-4. Remove the fuel filter (2GM20)

For models 3GM30 and 3HM35, the filter may be removed as assembled to the exhaust manifold.

2-5. Remove the remote control bracket (2GM20)

For models 3GM30 and 3HM35, the bracket may be removed as assembled on the exhaust manifold.

2-6. Remove the mixing elbow (2GM20)

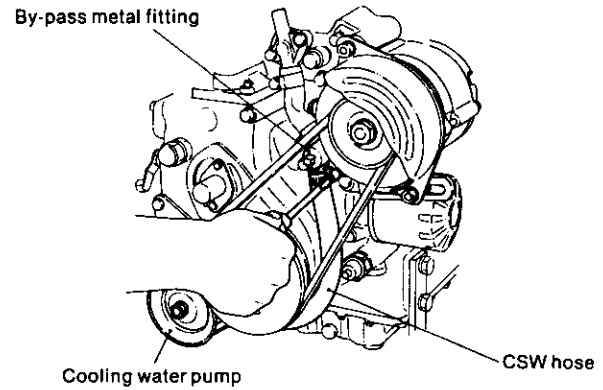
For models 3GM30 and 3HM35 the elbow may be removed as assembled on the exhaust manifold.

2.7 Remove the exhaust manifold (3GM30, 3HM35)

- (1) For models 3GM30 and 3HM35, the exhaust manifold may be removed with the fuel filter, remote control bracket and mixing elbow assembled on the exhaust manifold.
- (2) Remove the exhaust manifold fixing studs.

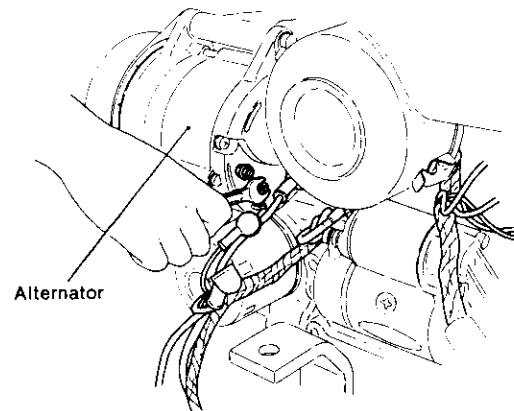
2-8. Remove the cooling water pipe

Remove the CSW hose between the CSW pump and by-pass metal fitting.



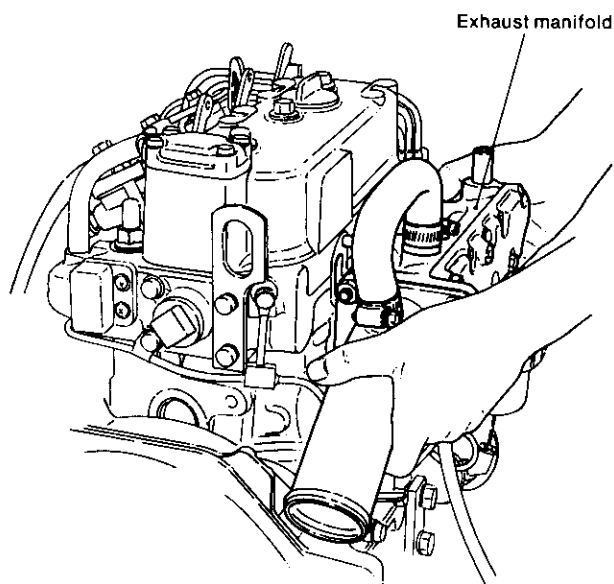
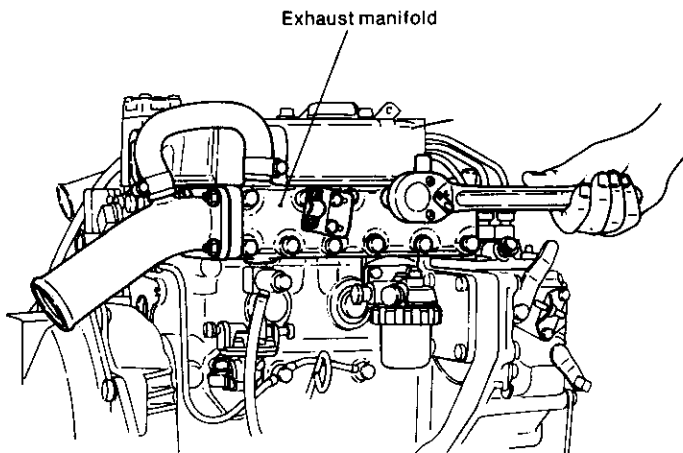
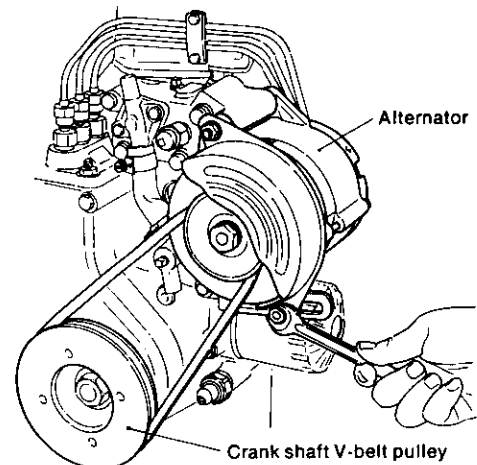
2-9. Remove the electrical wiring

Remove the wiring connected to the alternator and cooling water temperature sender.



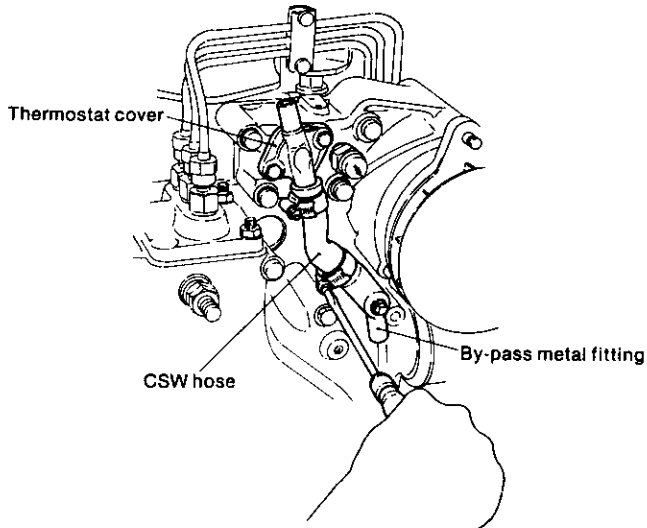
2-10. Remove the alternator

Remove the alternator cover and V belt after loosening the alternator adjusting bolt. The alternator can be more easily removed when removed as assembled on the thermostat bracket.

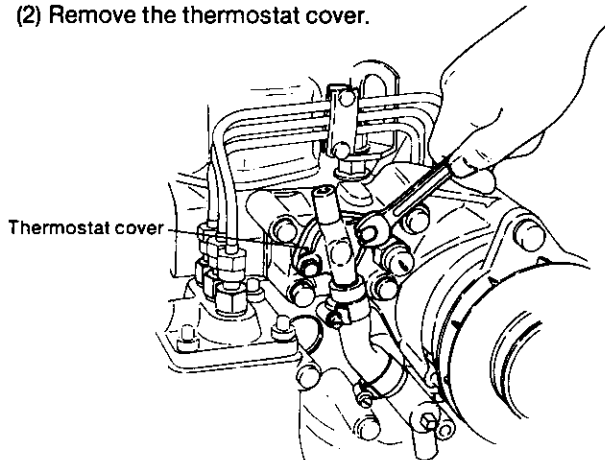


2-11. Remove the thermostat cover

(1) Loosen the clamp of the cooling water hose between the by-pass metal fitting and thermostat at the by-pass metal fitting side.



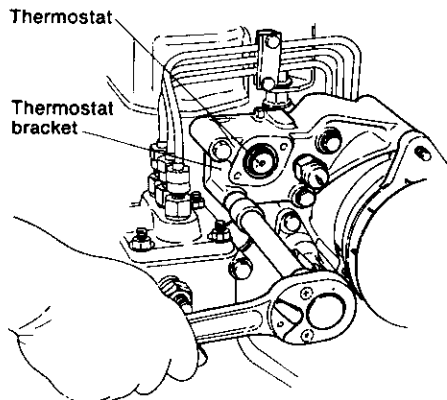
(2) Remove the thermostat cover.



2-12. Remove the high pressure pipe anti-swing metal fitting from the thermostat bracket.

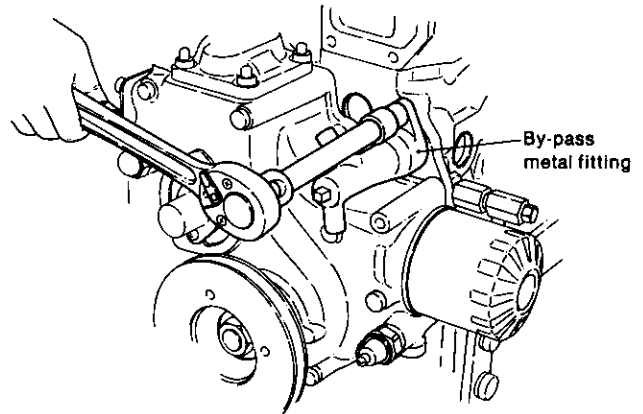
2-13. Remove the thermostat bracket

Remove the cooling water temperature sensor and alternator as assembled on the thermostat bracket.

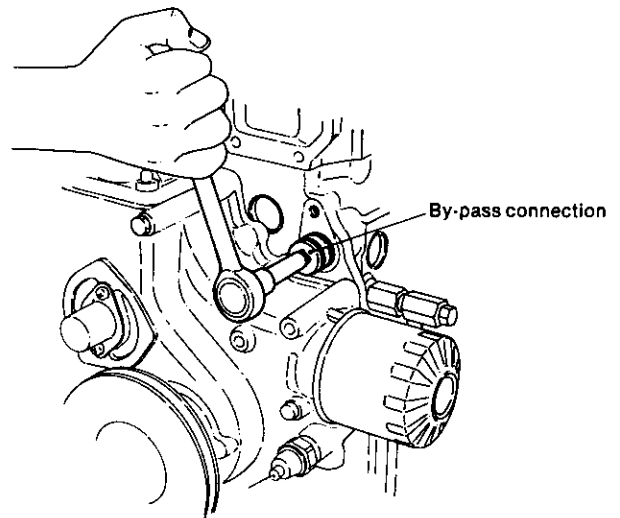


2-14. Remove the cooling water by-pass connection

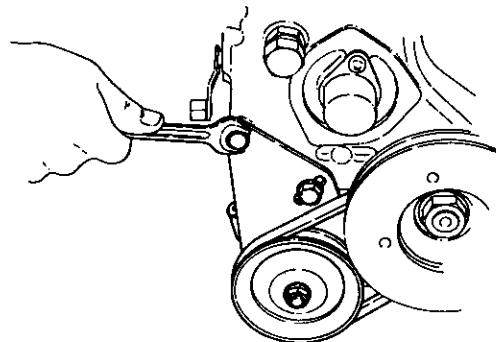
(1) Remove the cooling water by-pass metal fitting (L-type joint).



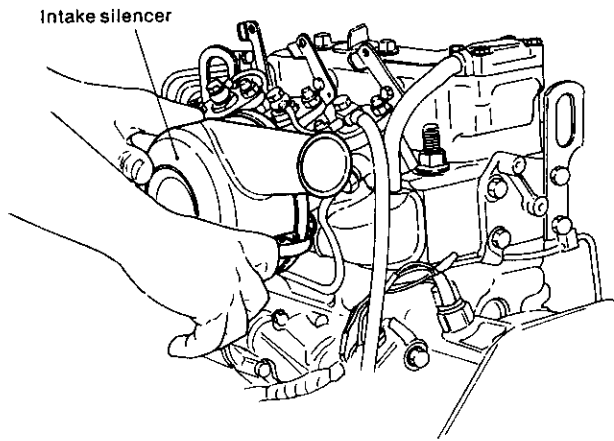
(2) Extract the by-pass connection screwed into the cylinder block.



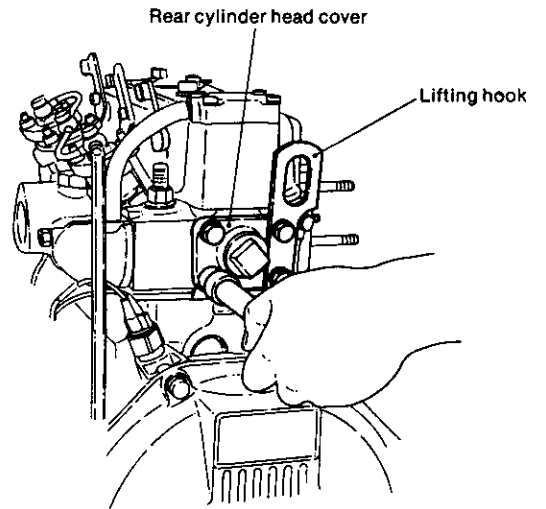
2-15. Remove the CSW pump



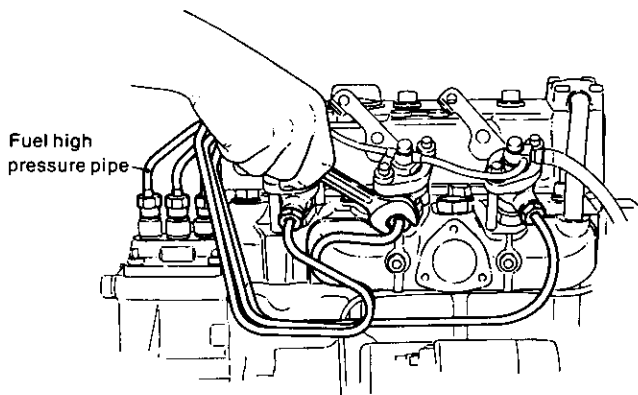
2-16. Remove the intake silencer



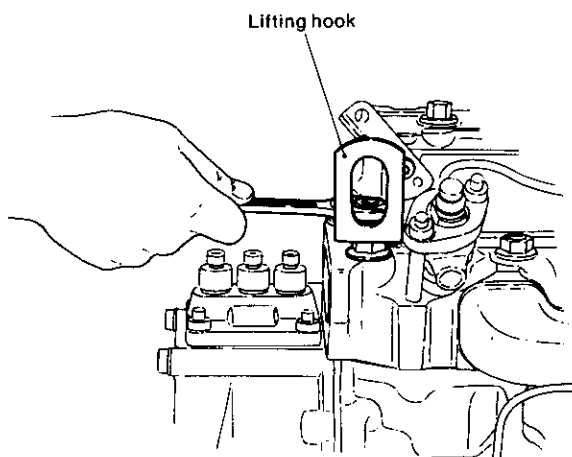
2-19. Remove the lifting hook at the rear or the engine together with the rear cylinder head cover



2-17. Remove the fuel high pressure pipe



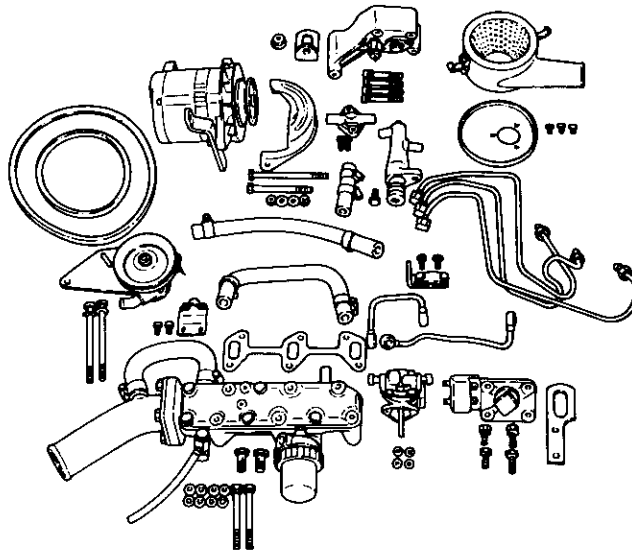
2-18. Remove the lifting hook at the front of the engine (3GM30, 3HM35)



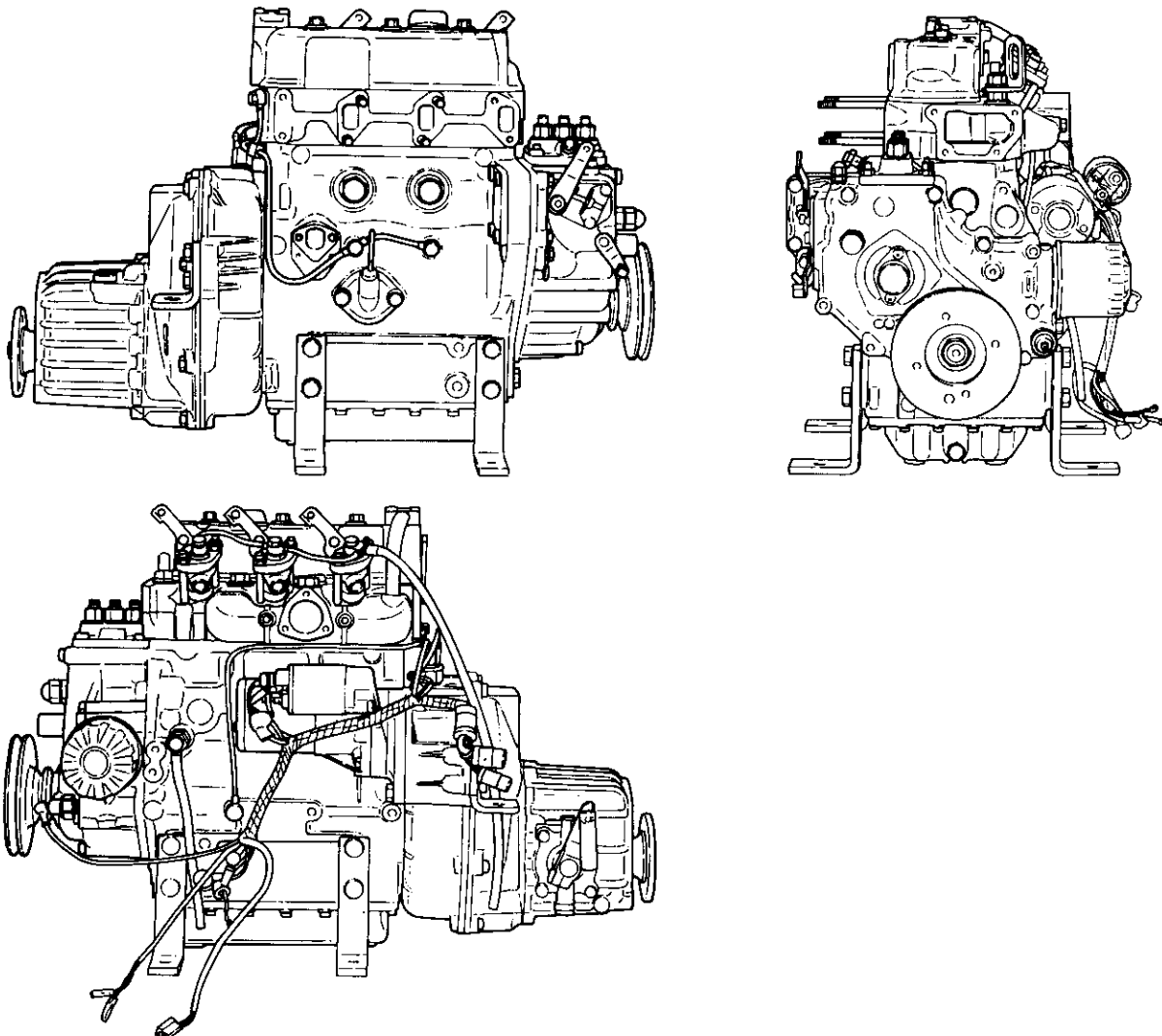
The disassembly necessary to modify a sea water-cooled engine into a fresh water-cooled engine is completed with

this step. The removed parts, and the appearance of the engine after disassembly are shown below:

Removed parts

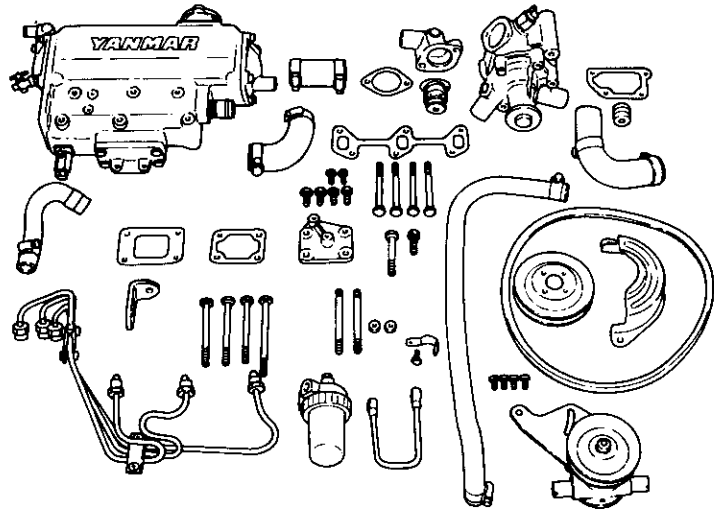


Appearance of engine after disassembly (Example Model, 3GM30)

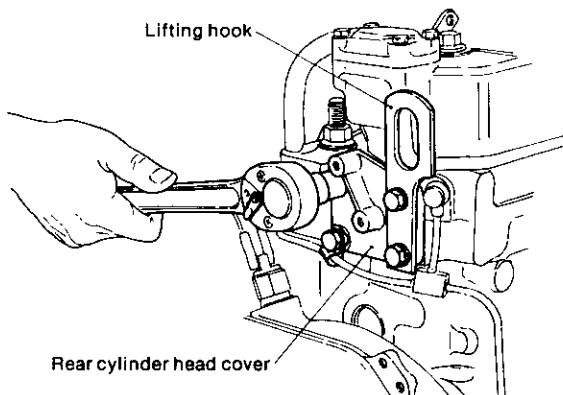


3. Assembling modified parts to the fresh water-cooled engine

The parts required to modify a sea water-cooled engine to a fresh water-cooled engine are as shown below.



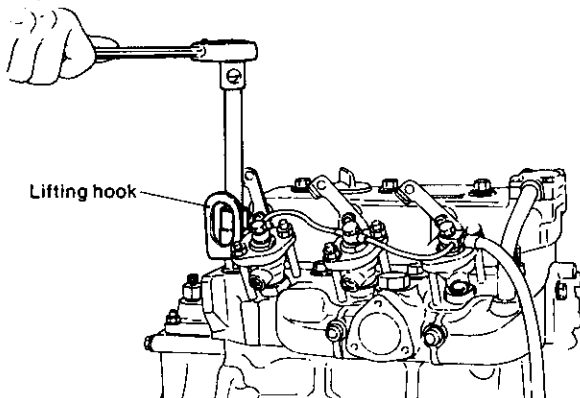
3-1. Assemble the rear cylinder head cover together with the rear lifting hook.



NOTE: New packing should be used.
Apply Threebond No.4 on both surfaces of packing.

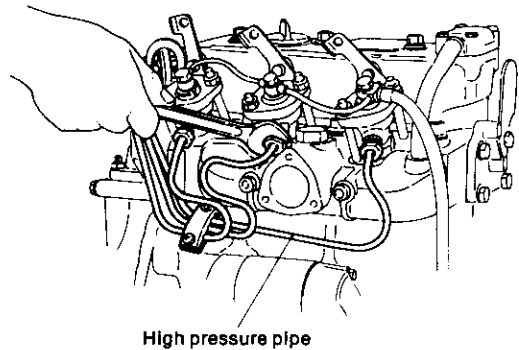
3-2. Assemble the front lifting hook (3GM30, 3HM35)

The hook on the model 2GM20 is in a position not affected by the modification.



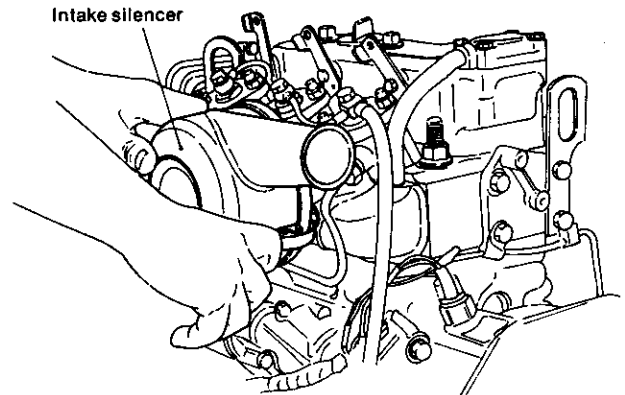
NOTE: Use the special lifting hook for the fresh water-cooled engine.

3-3. Assemble the fuel injection tube



NOTE: Use the special high pressure pipe for a fresh water-cooled engine. The shape and dimensions are different from those for a sea water-cooled engine.

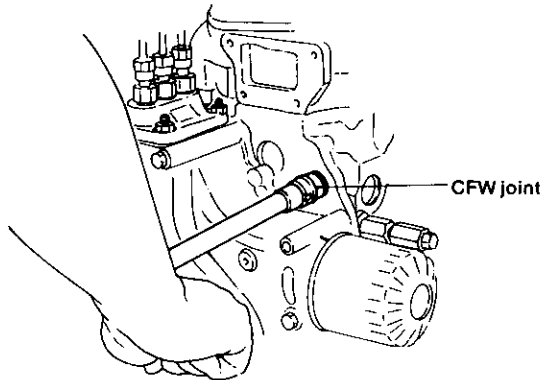
3-4. Assemble the intake silencer



NOTE: The intake silencer is the same for both the fresh water and sea water-cooled engines.

3-5. Assemble the CFW joint to the cylinder block

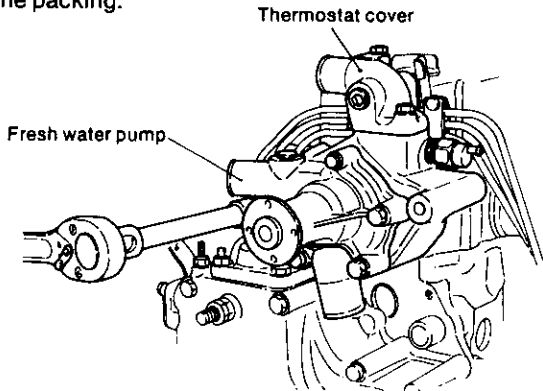
Apply Threebond No.20 to the threads and screw.



Tightening torque	2.5 ~ 3.5 kgf-m (18 ~ 25 ft-lb)
-------------------	---------------------------------

3-6. Assemble the CFW pump assembly

Assemble after applying Threebond No.4 to both surfaces of the packing.



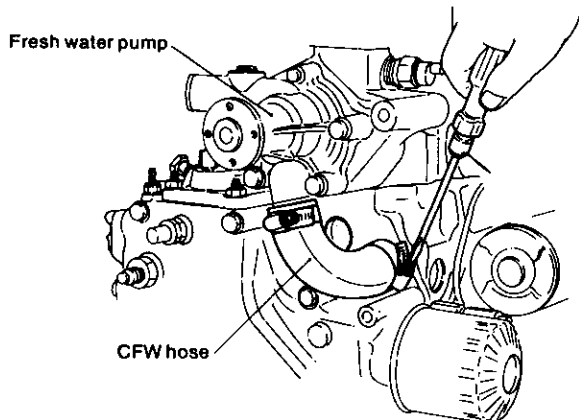
Tightening torque	2 ~ 2.5 kgf-m (14.5 ~ 18 ft-lb)
-------------------	---------------------------------

3-7. Assemble the thermostat and thermostat cover

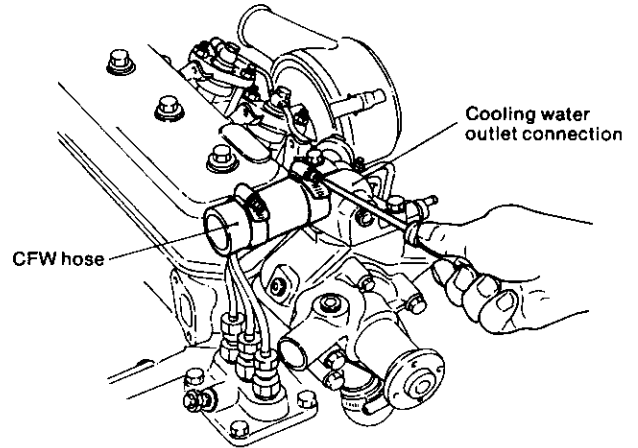
NOTE: Apply Threebond No.4 to both surfaces of the packing.

3-8. Assemble the CFW hose

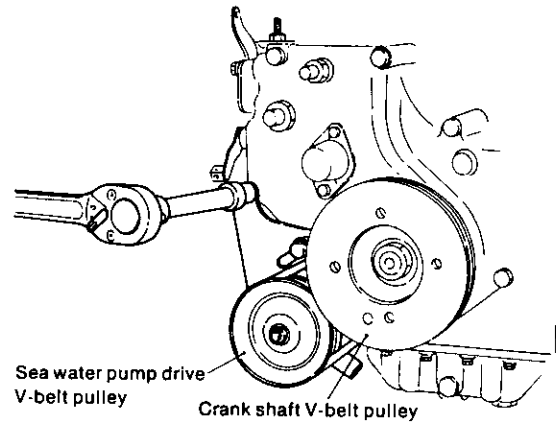
(1) Connect the CFW hose between the CFW pump and cylinder block and tighten the hose clamp.



(2) Connect the CFW hose between the CFW pump and heat exchanger by connecting it to the CFW pump; tighten the hose clamp slightly. The hose clamp will be securely tightened after the heat exchanger is assembled.



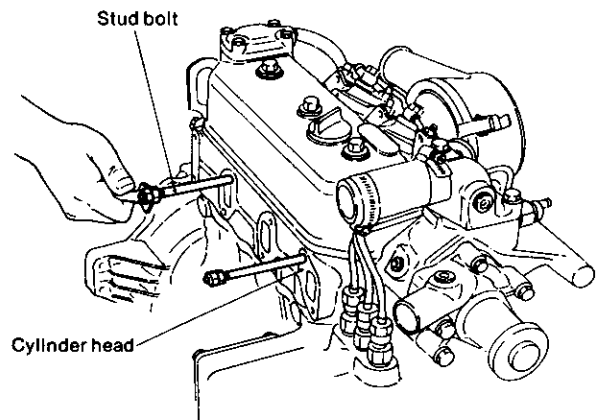
3-9. Assemble the CSW pump



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

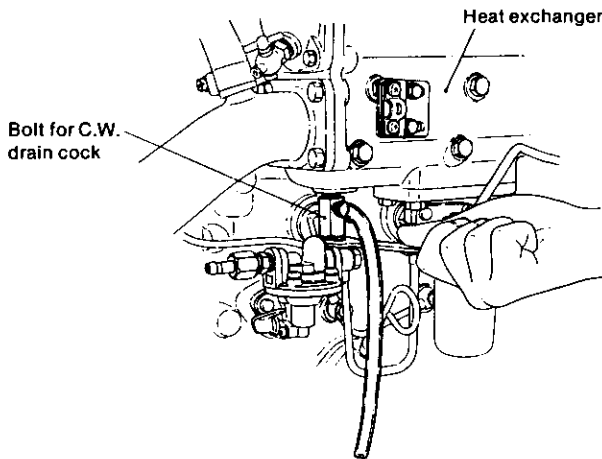
3-10. Insert the stud bolt for fitting the heat exchanger

Apply Three bond 203M to the threads.

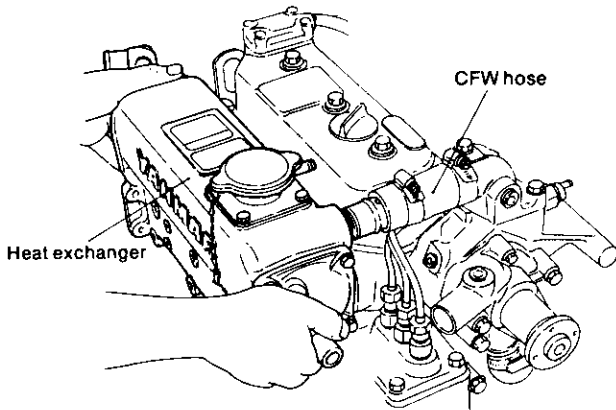


Tightening torque	1 ~ 1.5 kgf-m (7.3 ~ 10.9 ft-lb)
-------------------	----------------------------------

3-11. Assemble the heat exchanger



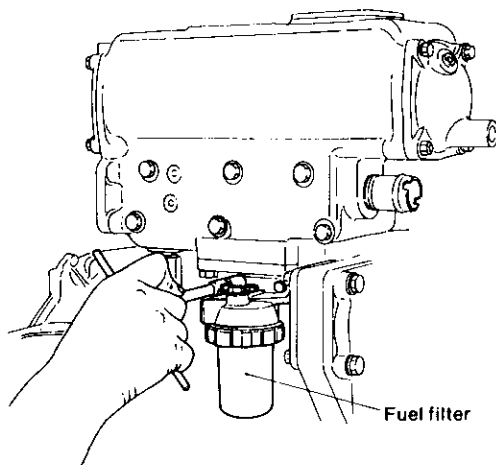
For model 3GMD, connect the pipes after removing the CW drain cock bolt at the bottom of the heat exchanger to prevent the pipe from jamming against the fuel feed pump.



NOTE: New gasket packing must be used.

Tightening torque	2 ~ 2.5 kgf-m (14.5 ~ 18 ft-lb)
-------------------	---------------------------------

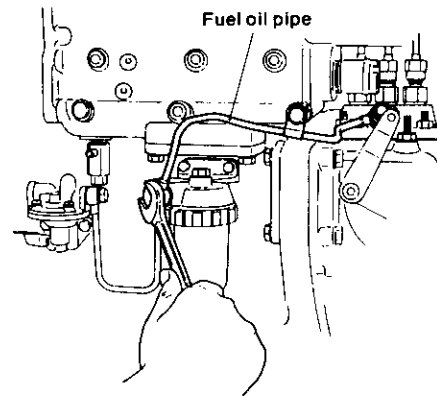
3-12. Assemble the fuel filter



NOTE: The same fuel filter is used as for a sea water-cooled engine.

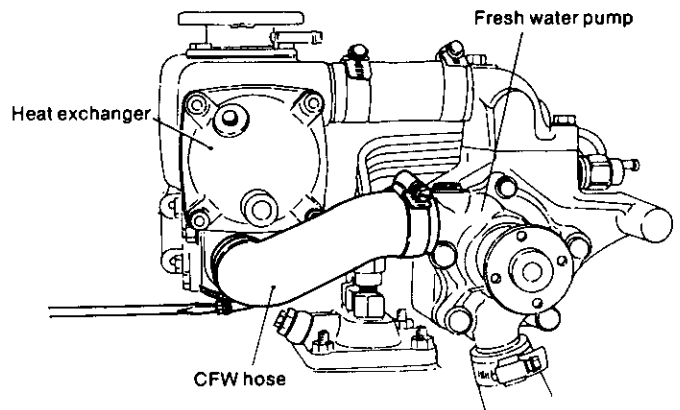
3-13. Assemble the fuel oil pipe

- (1) Connect the fuel oil pipe between the fuel feed pump and fuel injection pump.
- (2) Connect the fuel oil pipe between the fuel filter and fuel injection pump.



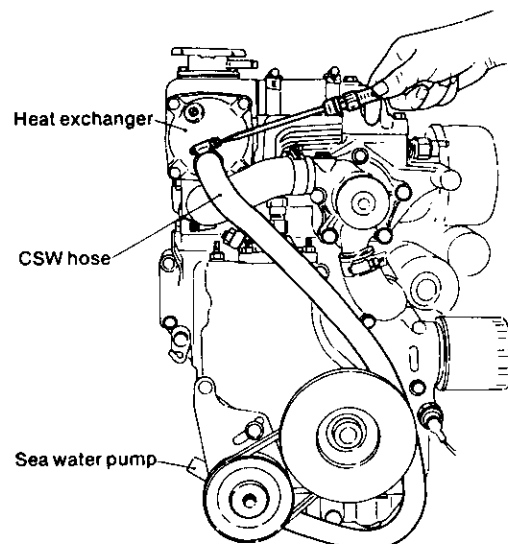
3-14. Assemble the CFW hose

Connect the CFW hose between the CFW pump and heat exchanger and tighten the hose clamp.

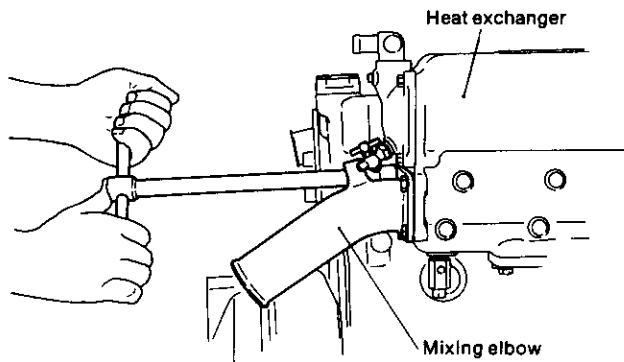


3-15. Assemble the CSW hose

Connect the CSW hose between the CSW pump and heat exchanger and tighten the hose clamp.

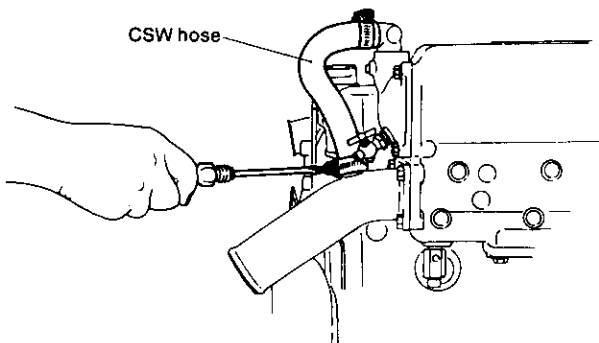


3-16. Assemble the mixing elbow

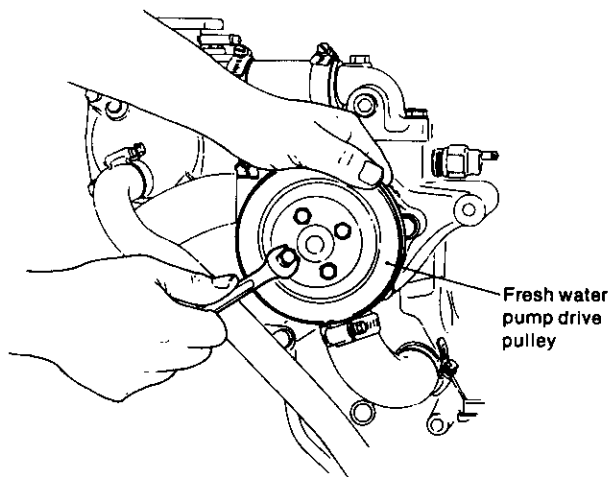


NOTE: New gasket packing must be used.

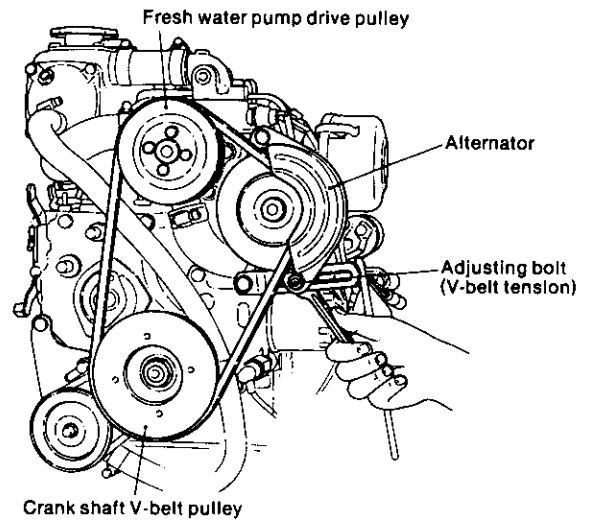
3-17 Connect the CSW hose between the head exchanger and mixing elbow and tighten the hose clamp.



3-18. Assemble the CFW pump V-belt pulley



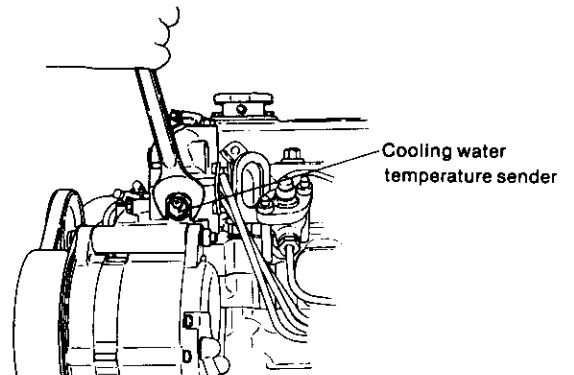
3-19. Assemble the alternator



V-belt tension Depressed with a force of 10kg (22 lb.)	Approx. 10mm (Approx. 0.3937 in.)
---	--------------------------------------

3-20. Assemble the cooling water temperature sensor

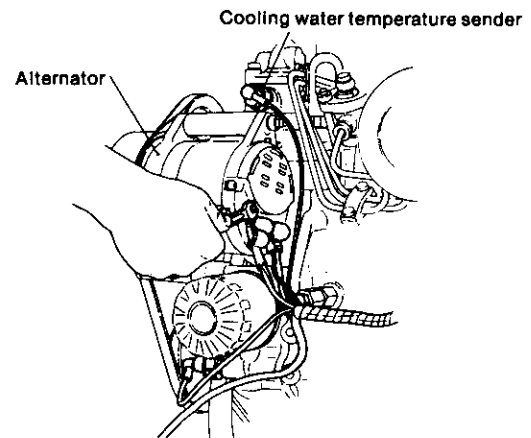
First fit the cooling water temperature sender to the CFW pump and then assemble both units together.



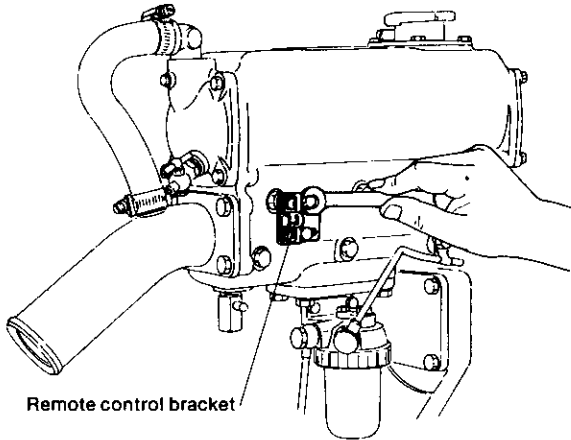
NOTE: Apply Threabond No.4 to the threads.

3-21. Connect electrical wiring

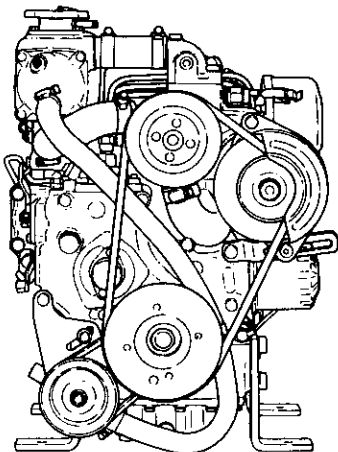
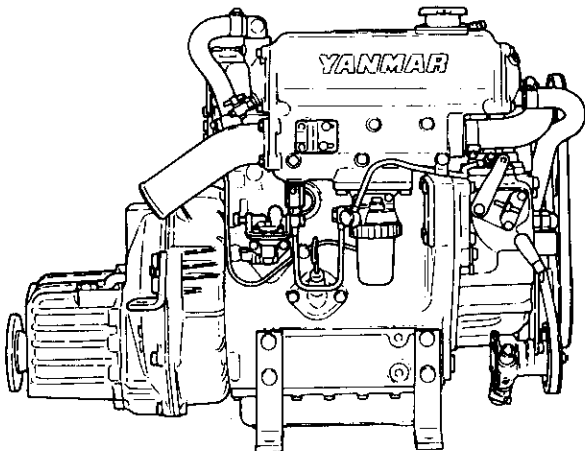
Connect the electrical wirings to the alternator and cooling water temperature sender.



3-22. Assemble the remote control bracket.

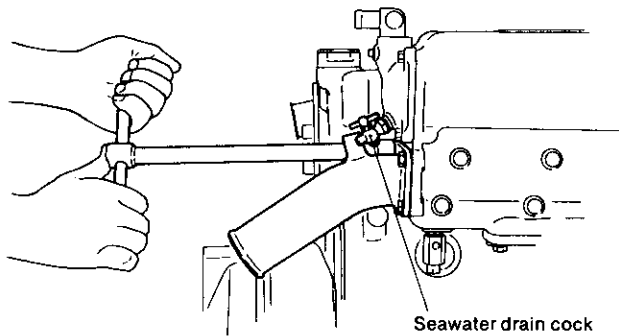


The sea water-cooled engine has now been modified as a fresh water-cooled engine.



4. Cautions when the engine is installed inboard

- (1) In the case of a fresh water-cooled engine, a fresh water subtank must be installed. For the installation method, refer to the "Installation of the subtank" section.
- (2) A seawater drain cock and the fresh water drain plug are provided in the heat exchanger; a drain hose should be fitted to each plug.



- (3) There is no problem when the engine is installed in a newly built ship, but when an engine in use is modified, care must be taken because the cooling water piping is different.

	2GM20 – 2GM20F	3GM30 – 3GM30F	3HM35 – 3HM35F
Hose at CSW pump inlet (Kingston cock—CSW pump) outer dia/inner dia	$\phi 20/13 - \phi 24/17$	$\phi 20/13 - \phi 24/17$	$\phi 24/17 = \phi 24/17$
Kingston cock to be used	10A – 15A	10A – 15A	15A

NOTE: Kingston cocks are optional.

10A	Part No.43662 – 010030	1GM10, 2GM20, 3GM30
15A	Part No.43662 – 015020	2GM20F, 3GM30F, 3HM35F

Pin diameter of mixing elbow is different

2GM20 – 2GM20F
 (44mm) (51mm)
 (1.7323in.) (2.0079in.)

CHAPTER 10

REDUCTION AND REVERSING GEAR

[A] For Engine Models 1GM10, 2GM20(F) and 3GM30(F)	
1. Construction	10-1
2. Shifting Device	10-7
3. Inspection and Servicing	10-14
4. Disassembly	10-19
5. Reassembly	10-24
[B] For Model 3GM35(F)	
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3. Operation and Maintenance	10-34
4. Inspection and Servicing	10-35
5. Disassembly	10-40
6. Reassembly	10-44
[C] Marine Gear Models KM2P, KM3P and KM3V for Engine Models 1GM10, 2GM20(F) and 3GM30(F)	
1. Construction	10-50
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5. Reassembly	10-73
[D] V-drive Gear, Model KM3V	
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[A] For engine models 1GM10, 2GM20(F) and 3GM30(F)

1. Construction

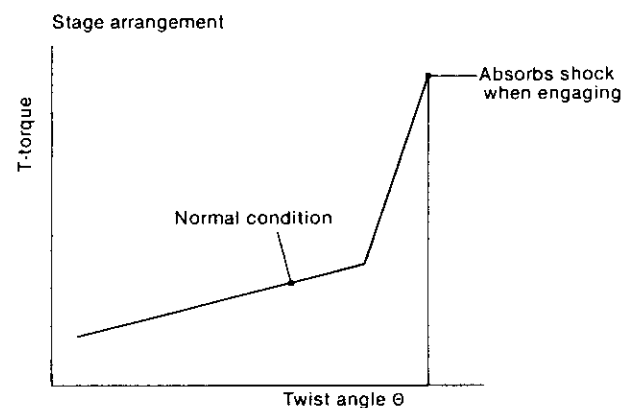
1-1 Construction

This clutch is a cone-type, mechanically operated clutch. When the drive cone (which is connected to the output shaft by the lead spline) is moved forward or backward, its taper contacts with the large gear and transfers power to the output shaft.

The construction is simple when compared with other types of clutch and it serves to reduce the number of components, making for a lighter, more compact unit which can be operated smoothly. Although it is small, the power transmission efficiency is high even under a heavy load. Its durability is high and it is reliable as high grade materials are used for the shaft and gear, and a taper roller bearing is incorporated. Power transmission is smooth as connection with the engine is made through the damper disc.

- The drive cone is made from special aluminum bronze which has both higher wear-resistance and durability. The drive cone is connected with the output shaft through the thread spline. The taper angle, diameter of the drive cone, twist angle, and diameter of the thread spline, are designed to give the greatest efficiency, thus ensuring that the drive cone can be readily engaged or disengaged.
- Helical gears are used for greater strength. The intermediate shaft is supported at 2 points to reduce deflection and gear noise.
- The clutch case, mounting flange and side cover are made from an aluminum alloy of special composition to reduce weight. It is also anticorrosive against seawater.
- As the damper disc is fitted to the output shaft, power can be transmitted smoothly. For the damper disc, springs of different strengths are used so that two stages of torque and twist angle are applied. That is, in the first stage, only the weak spring is used, and the strong spring comes into action for a torque higher than a predetermined value.

This prevents gear noise due to torsional vibration as well as absorbing shock when engaging.



- The oil level dipstick hole doubles as a breather in addition to being the oil supply port. There is a small clearance between the dipstick and the inside of the dipstick tube which functions as a breather.
- The engagement between the cone and the large gear can be maintained even when the load on the propeller is zero. This is done by the action of the notch and spring joint on the operation lever in the operation device. The operation device can still be used without adjusting the remote operation device when the cone is internally worn, because it is compensated for by the spring joint.
- In order to reduce friction on the operation lever shaft, a needle bearing is used to allow smooth operation.

1-2 Specifications

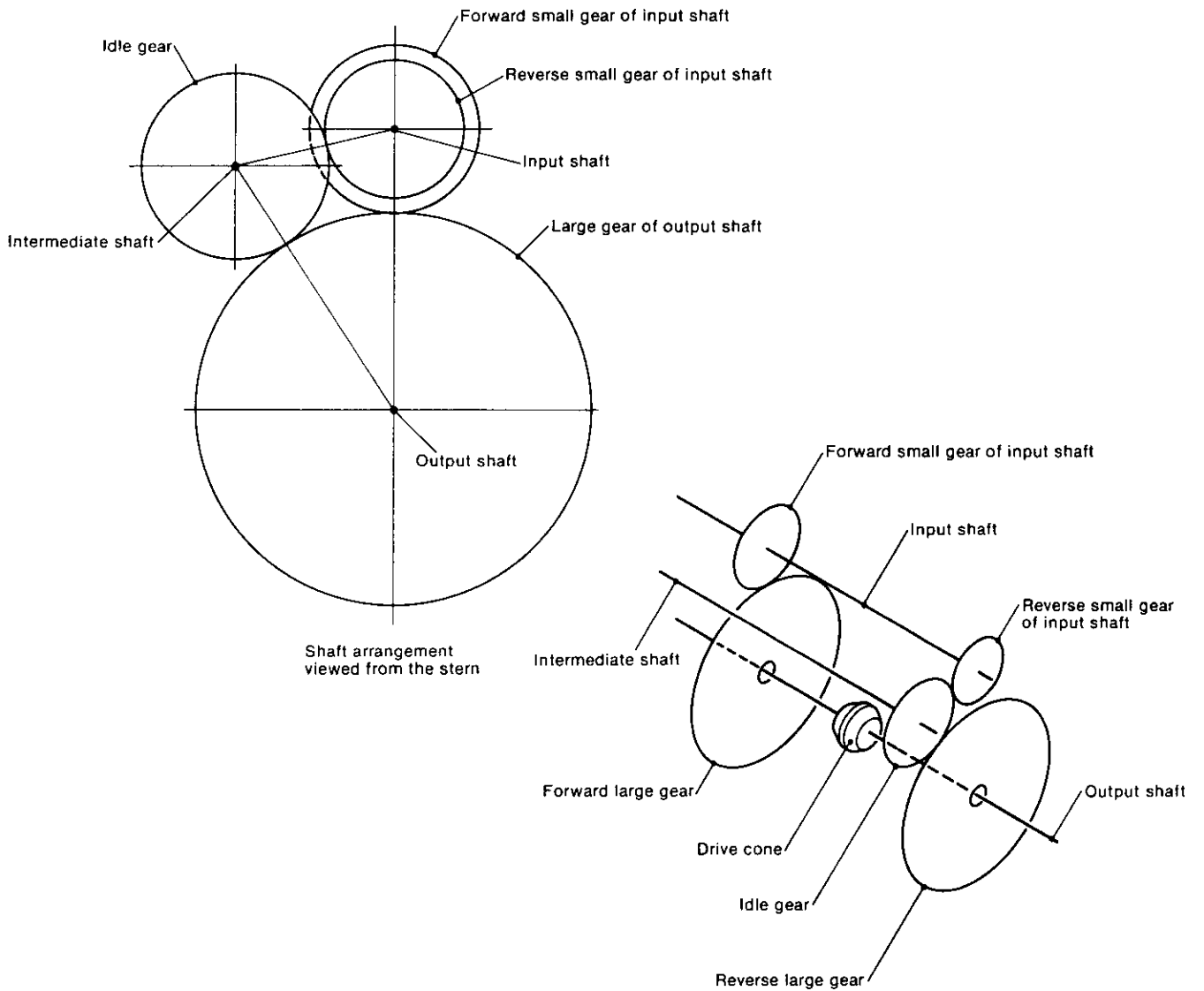
Model		KM2-C			KM3-A		
For engine models		1GM10, 2GM20(F)			3GM30(F)		
Clutch		Constant mesh gear with servo cone clutch (wet type)					
Reduction ratio	Forward	2.21	2.62	3.22	2.36	2.61	3.20
	Reverse	3.06	3.06	3.06	3.16	3.16	3.16
Propeller shaft rpm (Forward) rpm		1540	1298	1055	1441	1303	1063
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern				
	Output shaft	Forward	Clockwise, viewed from stern				
		Reverse	Counter-clockwise, viewed from stern				
Remote control	Control head		Single lever control				
	Cable		Morse, 33-C				
	Clamp		YANMAR made, standard accessory				
	Spring joint		YANMAR made, standard accessory				
Output shaft coupling	Outer diameter		ø100mm (3.93")				
	Pitch circle diameter		ø78mm (3.07")				
	Connecting bolt holes		4—ø10.5mm (4—ø0.41")				
Position of shift lever		Left side, viewed from stern					
Lubricating oil		SAE #10W-30, CC class					
Lubricating oil capacity		0.25ℓ			0.3ℓ		
Dry weight		9.5kg (20.9 lbs)			11.0kg (24.3 lbs)		

Models KM2C and KM3A reduction and reverse gear boxes, shafts and gears are the same except for the following items:

- No. of gear teeth (derives different gear ratios).
- Distance between bearings for input and output shafts.
- Clutch case, mounting flange.

1-3 Power transmission system

1-3.1 Arrangement of shafts and gears



1-3.2 Reduction ratio

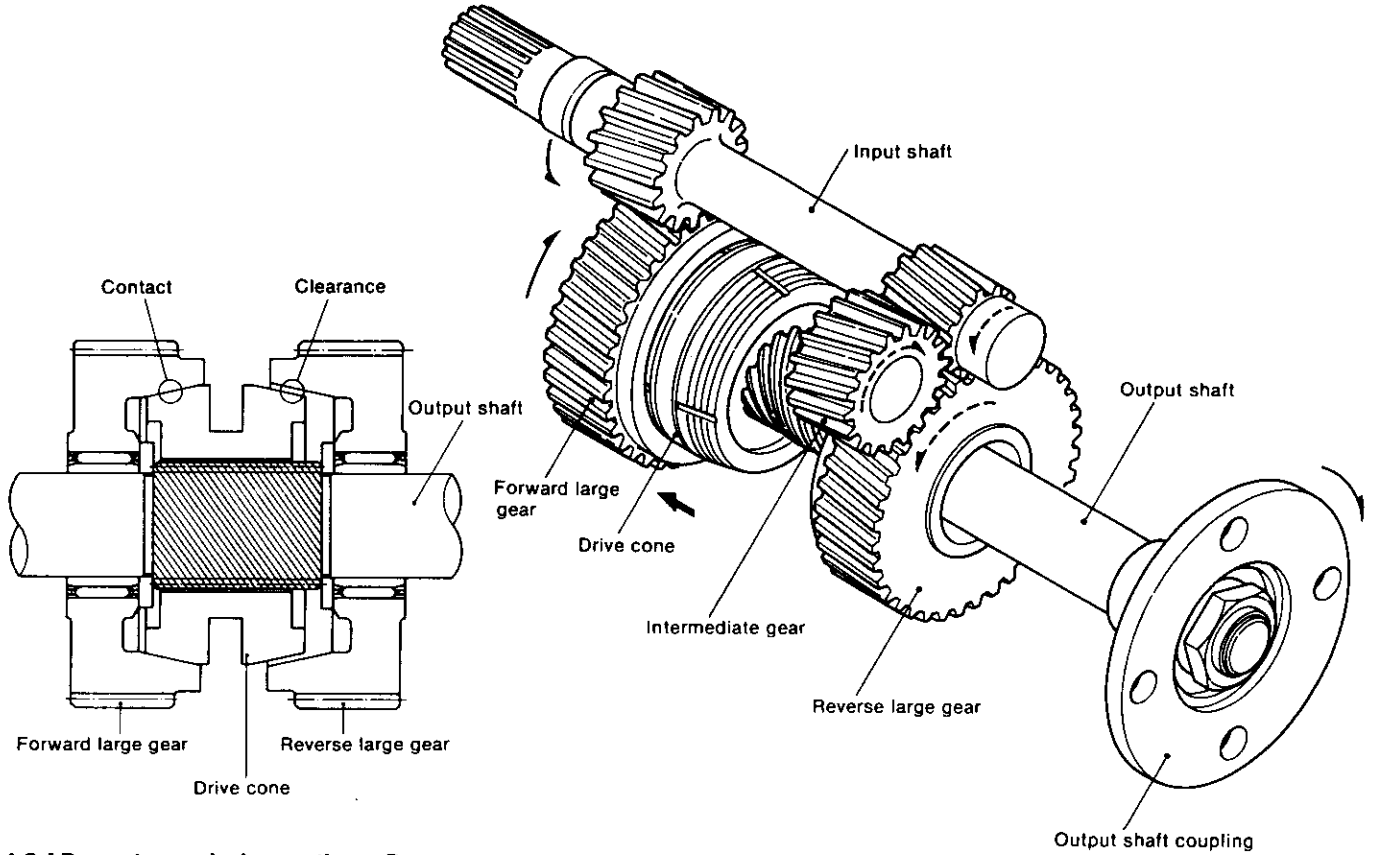
Forward

Model	No. of teeth of forward small gear Z_{if}	No. of teeth of forward large gear Z_{of}	Reduction ratio Z_{of}/Z_{if}
KM2-C	24	53	$53/24 = 2.21$
	21	55	$55/21 = 2.62$
	18	58	$58/18 = 3.22$
KM3-A	25	59	$59/25 = 2.36$
	23	60	$60/23 = 2.61$
	20	64	$64/20 = 3.20$

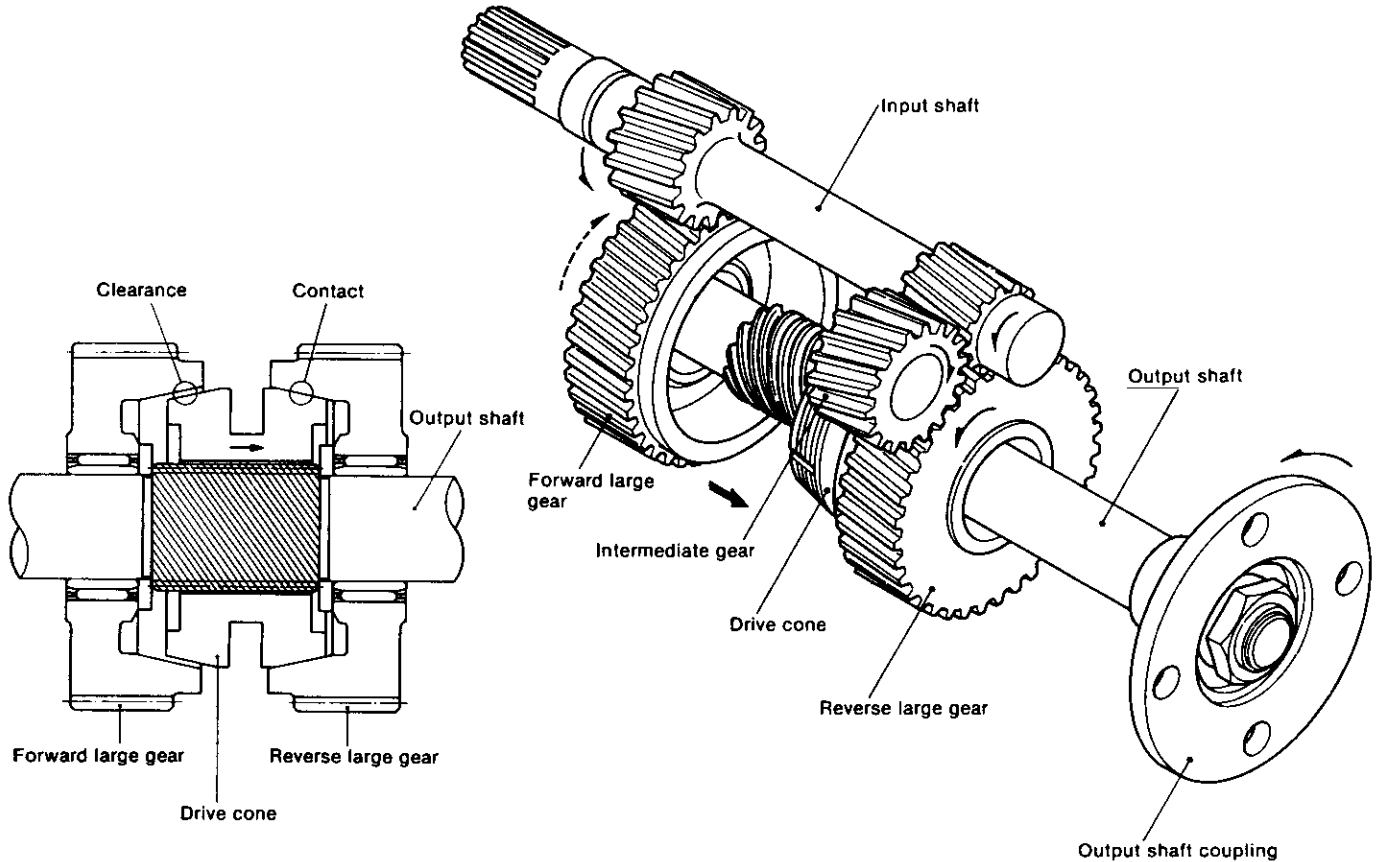
Reverse

Model	No. of teeth of reverse small gear Z_{ir}	No. of teeth of intermediate shaft gear Z_i	No. of teeth of reverse large gear Z_{dr}	Reduction ratio $Z_i/Z_{ir} \cdot Z_{dr}/Z_i$
KM2-C	18	26	55	$55/18 = 3.06$
KM3-A	19	26	60	$60/19 = 3.16$

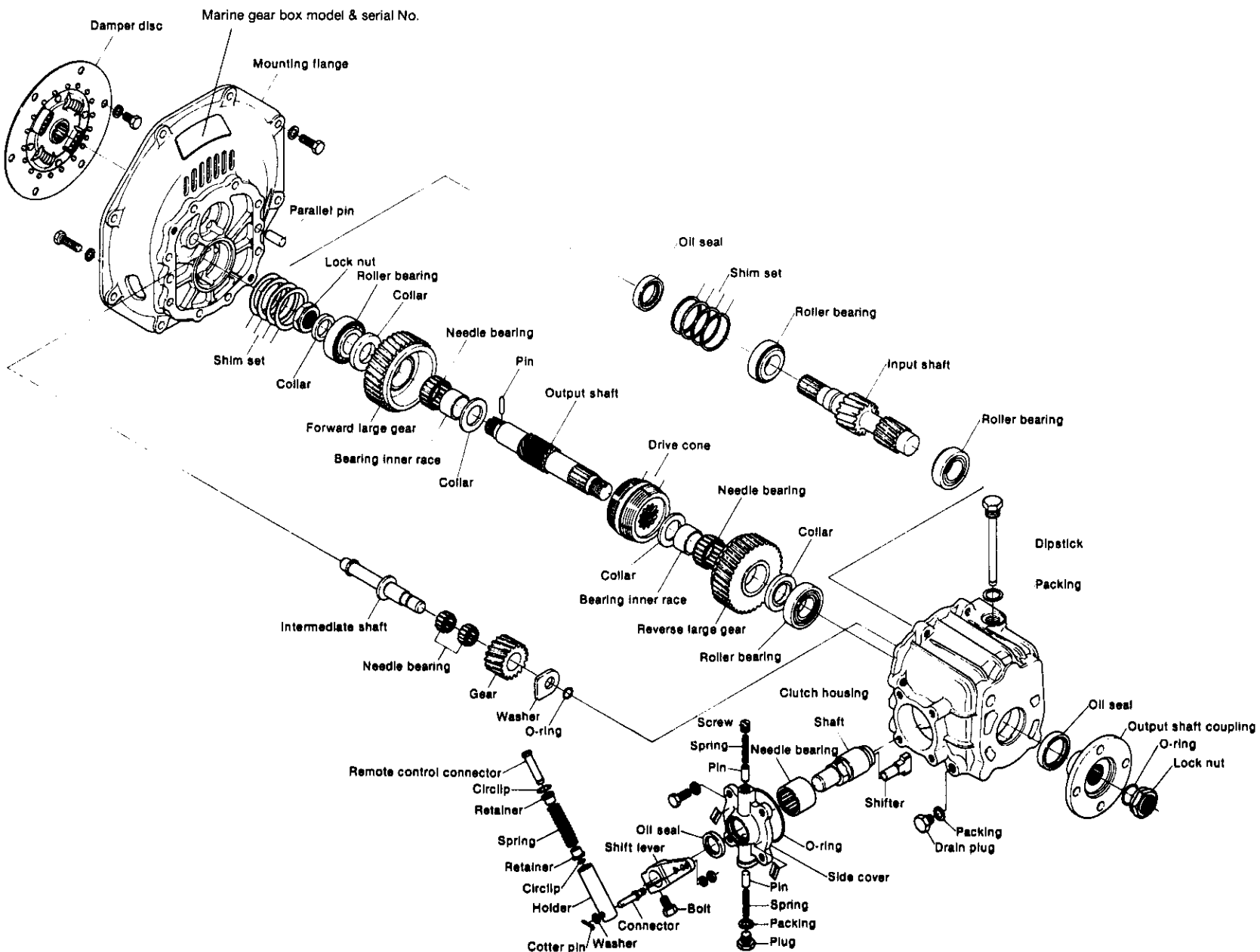
1-3.3 Power transmission routine — Forward

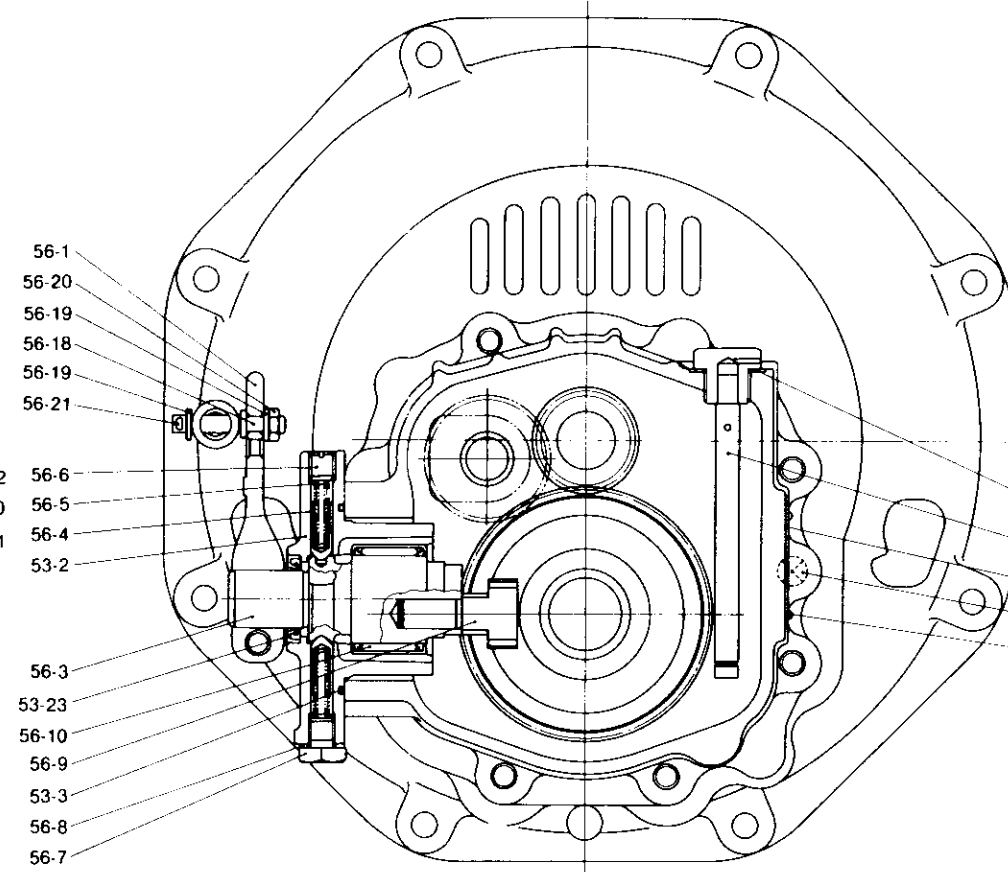
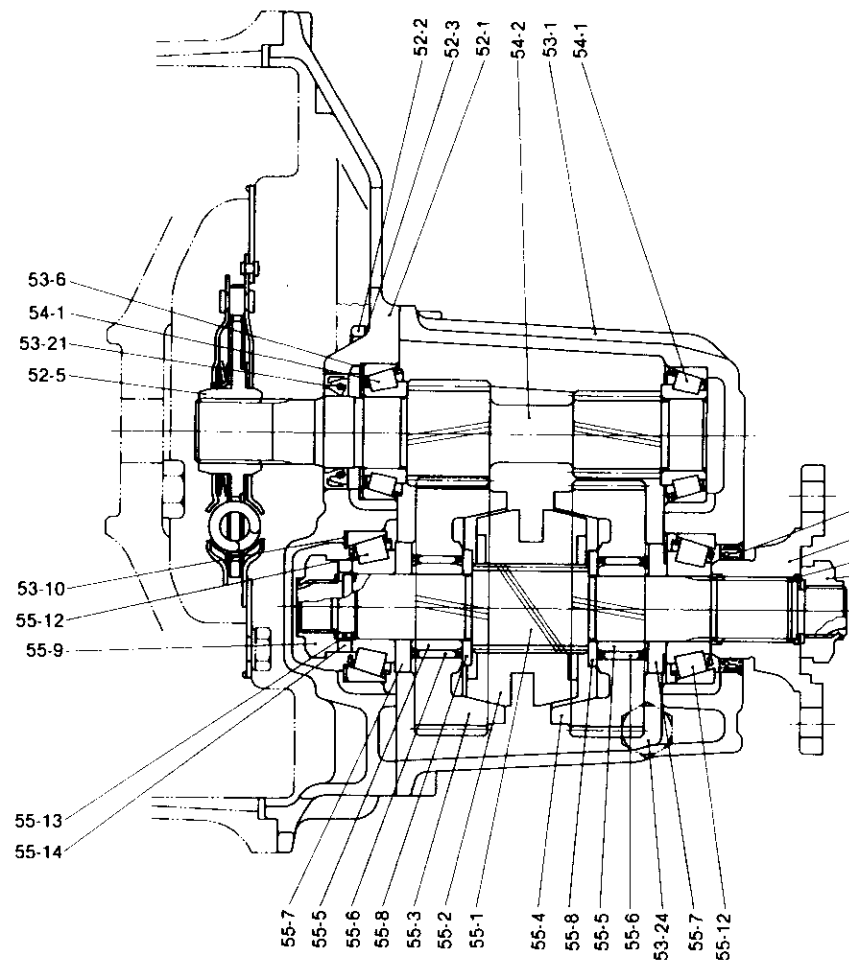


1-3.4 Power transmission routine — Reverse



1-4 Drawing





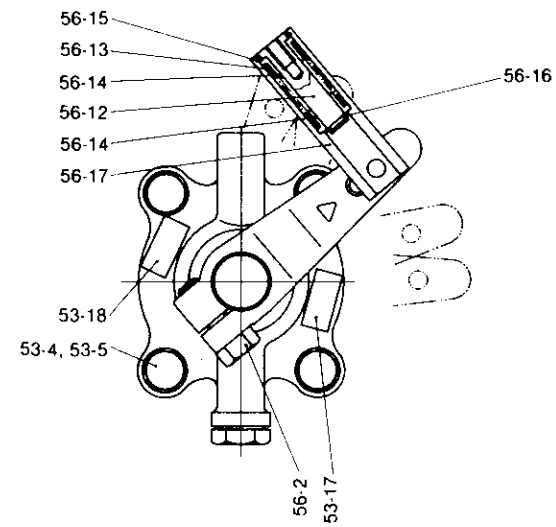
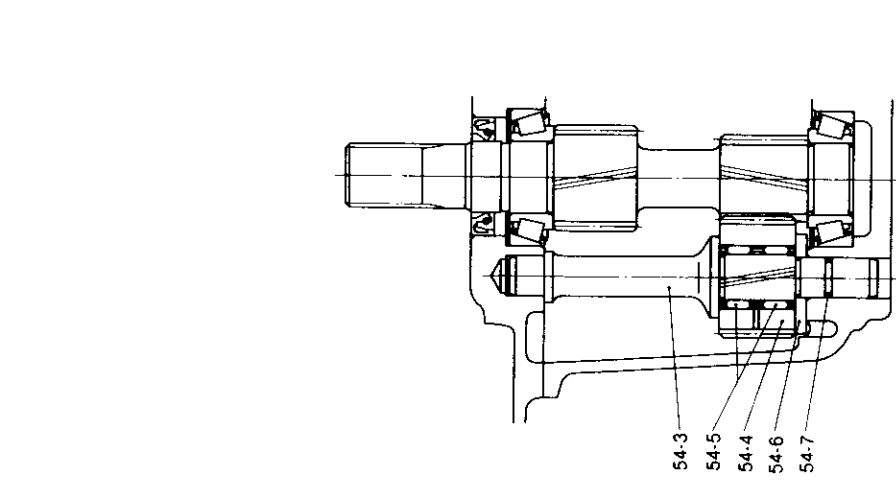
- 52-1 MOUNTING FLANGE
- 52-2 BOLT M8 × 25
- 52-3 WASHER 8
- 52-4 PARALLEL PIN 10 × 16
- 52-5 DAMPER DISK

- 53-1 CLUTCH HOUSING
- 53-2 SIDE COVER
- 53-3 O-RING 60-S
- 53-4 BOLT M8 × 20
- 53-5 WASHER 8
- 53-6 SHIM SET
- 53-10 SHIM SET
- 53-15 DIPSTICK
- 53-16 PACKING 16
- 53-17 LABEL, forward
- 53-18 LABEL, reverse
- 53-19 LABEL, clutch model
- 53-20 RIVET
- 53-21 OIL SEAL SC25408
- 53-22 OIL SEAL MHA34448
- 53-23 OIL SEAL SC20305
- 53-24 PLUG M10

- 54-1 ROLLER BEARING #32005
- 54-2 INPUT SHAFT
- 54-3 INTERMEDIATE SHAFT
- 54-4 GEAR
- 54-5 NEEDLE BEARING #K162213
- 54-6 WASHER
- 54-7 O-RING 12-S

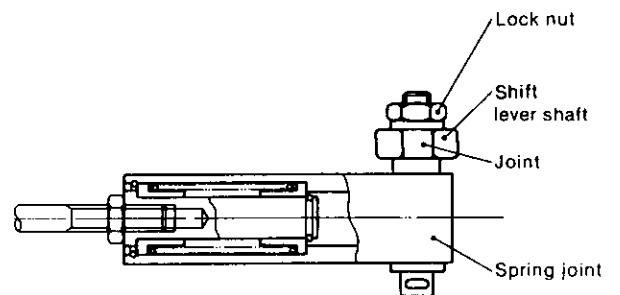
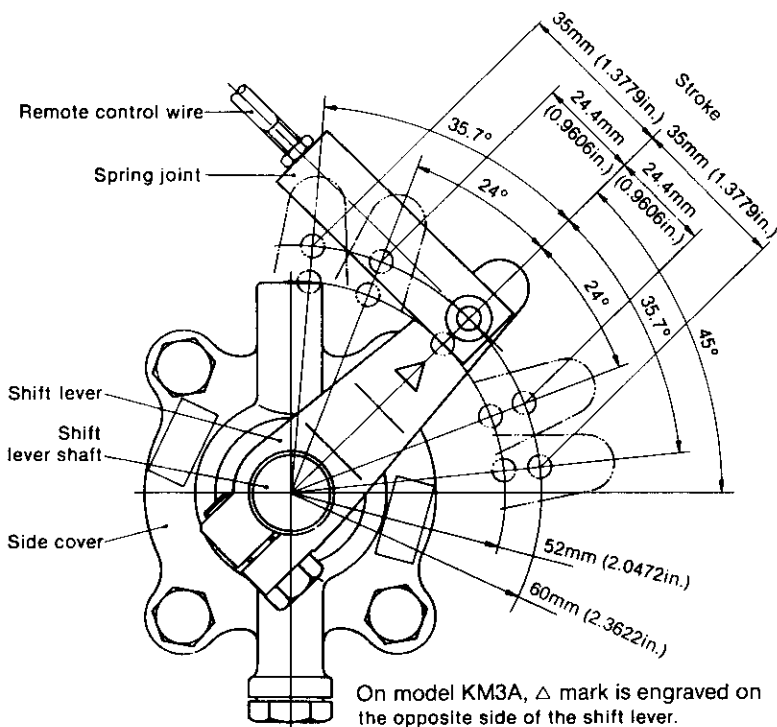
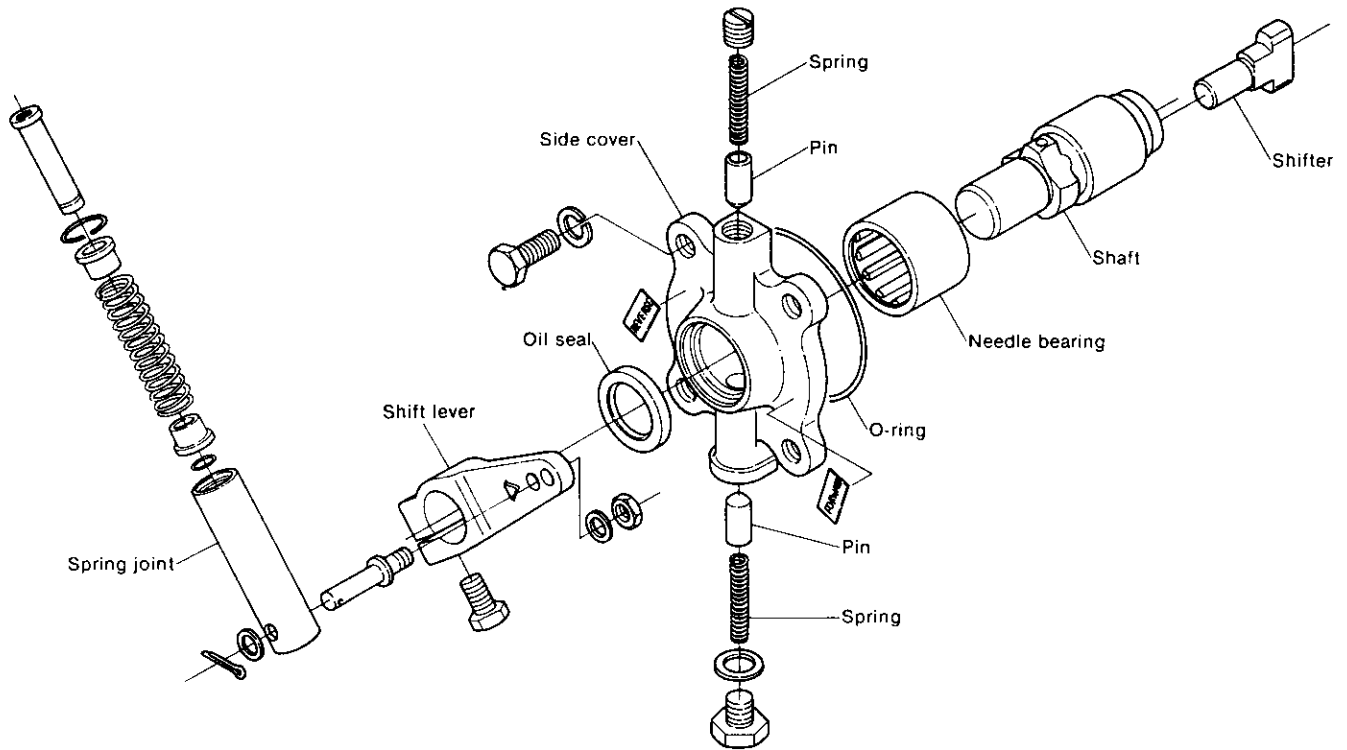
- 55-1 OUTPUT SHAFT
- 55-2 DRIVE CONE
- 55-3 FORWARD LARGE GEAR
- 55-4 REVERSE LARGE GEAR
- 55-5 BEARING INNER RACE
- 55-6 NEEDLE BEARING #K303517
- 55-7 COLLAR
- 55-8 COLLAR
- 55-9 LOCK NUT
- 55-10 OUTPUT SHAFT COUPLING
- 55-11 O-RING 18-P
- 55-12 ROLLER BEARING #07087/07204
- 55-13 PIN
- 55-14 COLLAR

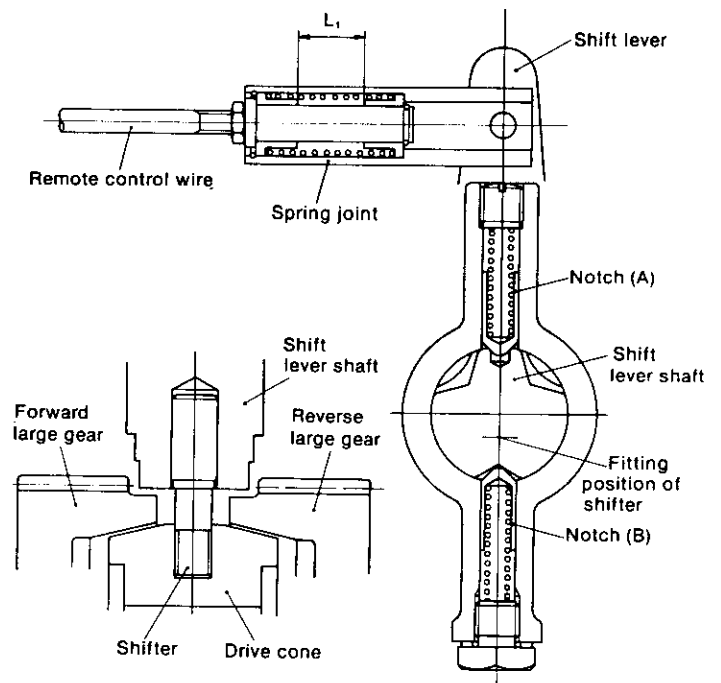
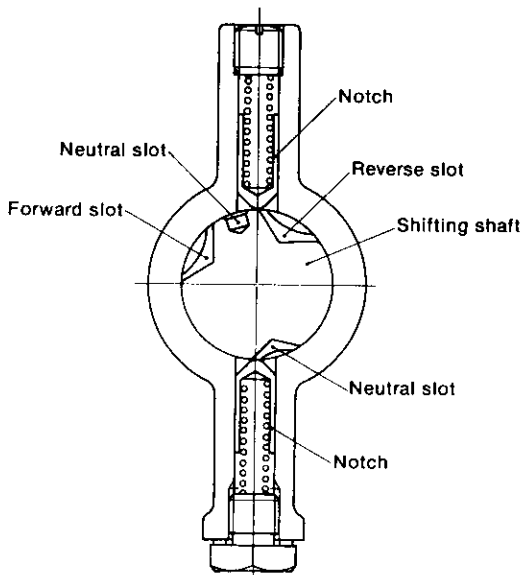
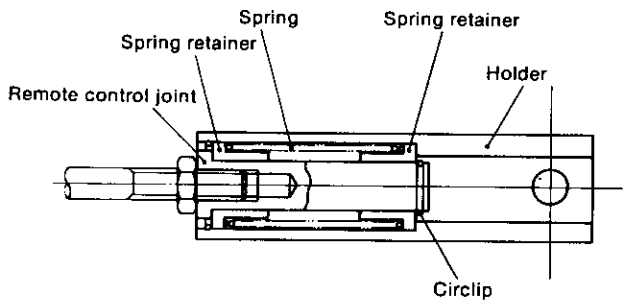
- 56-1 SHIFT LEVER
- 56-2 BOLT M8 × 25
- 56-3 SHAFT
- 56-4 PIN
- 56-5 SPRING
- 56-6 SCREW M10 × 10
- 56-7 PLUG M10
- 56-8 PACKING 10
- 56-9 SHIFTER
- 56-10 NEEDLE BEARING #HK3026
- 56-12 REMOTE CONTROL CONNECTOR
- 56-13 SPRING
- 56-14 RETAINER
- 56-15 CIRCLIP
- 56-16 CIRCLIP
- 56-17 HOLDER
- 56-18 CONNECTOR
- 56-19 WASHER 6
- 56-20 LOCK NUT M6
- 56-21 COTTER PIN 2.5 × 15



2. Shifting Device

2-1 Construction of shifting device





Neutral position

The shift lever is kept securely in the neutral position by notches (A) and (B).

Changing the power transmitting direction to forward is explained below.

When pushed forward, the remote control joint moves the spring retainers. The spring is compressed until the two spring retainers touch.

The shift lever shaft is supported by the side cover in which it rotates. Around the shift lever shaft, there are slots which engage the notch in order to control transmission of rotary power either forward or reverse, or to keep it in neutral. The notch engages each slot by the force of the notch spring.

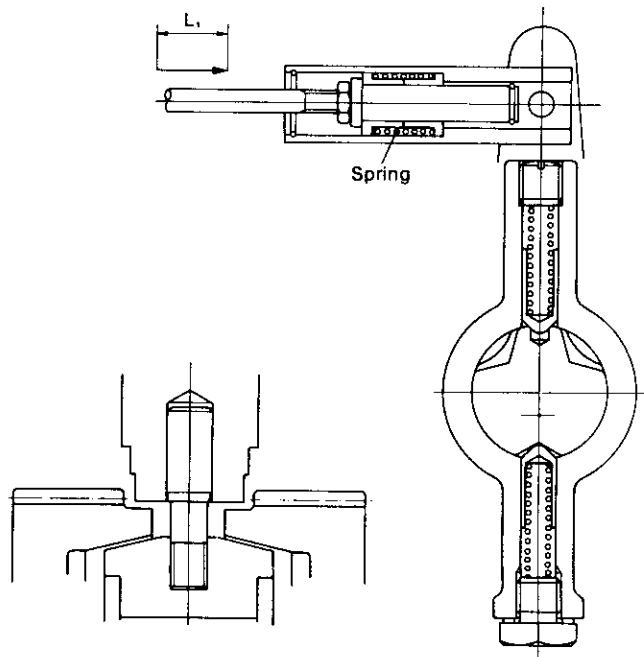
The shifter is set at the end of the shift lever shaft eccentric to the shaft center line and the angular movement of the shift shaft (i.e. rotation). The shifter is moved forward or backward along the line of the output shaft and this in turn moves the drive cone forward or backward.

The spring joint contains a spring and 2 spring retainers in the holder, and the remote control joint is connected to the spring retainers so that it can slide a fixed distance. By pushing or pulling the remote control joint with the holder fixed, the remote control joint moves to a position where the two spring retainers touch.

2-2 Action of the shifting device

2-2.1 Changing from neutral to forward

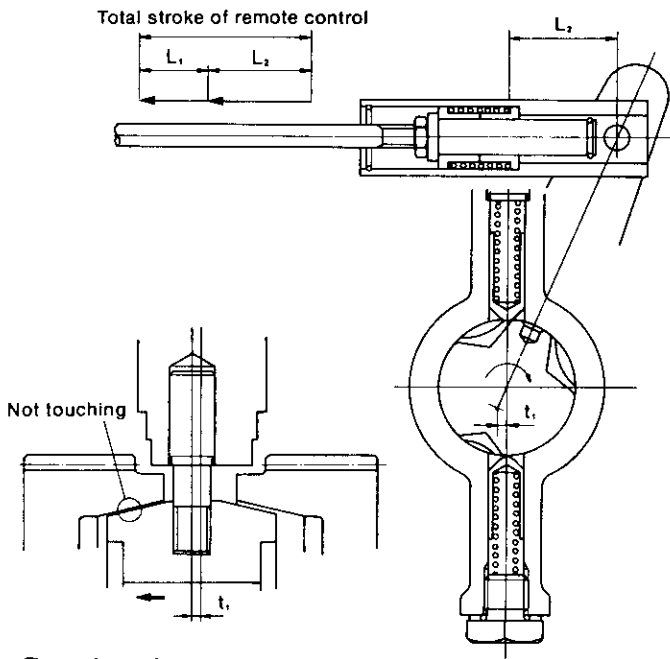
The relationship between the spring joint and the notch is as shown in the following figure, and the two spring retainers are the maximum distance apart.



L, position of remote operation stroke

The spring in the spring joint is compressed, but the shift lever does not move.

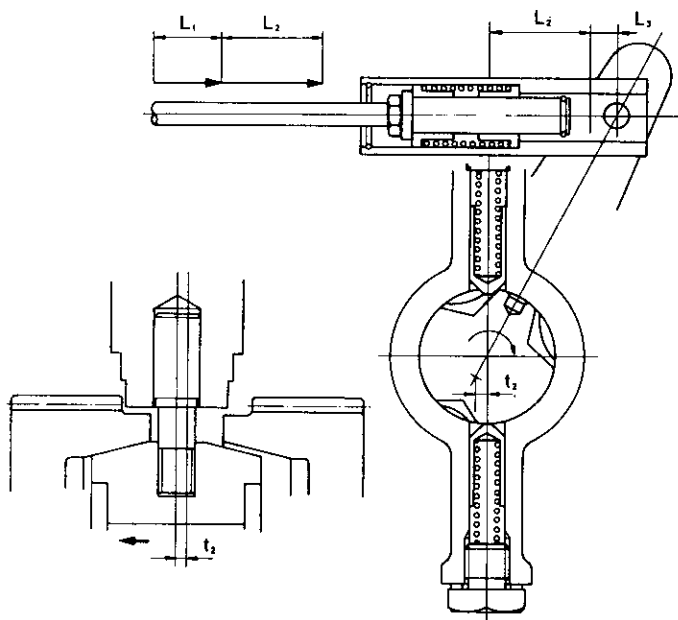
By pushing the remote control joint the holder moves, and the shift lever and the shift lever shaft also move to disengage the notch from the neutral position.



Forced moving position

When the shift lever is forcibly moved through distance L_2 the shifter moves distance t_1 . In this position, the drive cone has not yet made contact. However, notches (A) and (B) are disengaged from the neutral notch slot, and notch (A) is positioned on the tapered surface.

The shift lever shaft is turned by the movement of the remote control joint. When the notch touches the tapered part of the forward setting slot, it is pushed by the notch spring force and turns the shift lever forward. At the same time, as the remote control joint is fixed by the two retainers of the spring joint being in contact with each other,



the holder is moved by the spring reaction so that the shift lever is pushed forward.

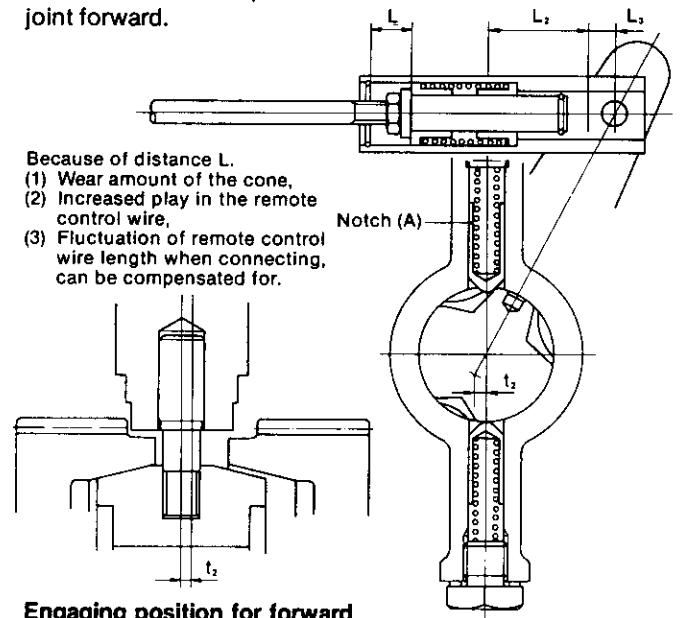
By the actions of the notch spring and spring joint, the shifter maintains pressure on the drive cone.

Engaging position for forward

By means of the shift lever shaft turning force which is caused by the spring in the joint and the notch (A), the shifter is moved distance L_3 , and engagement is complete. Pressure is maintained on the drive cone after engagement.

2-2.2 Engagement from forward to neutral

Engagement for reverse is the same as for forward, that is, return to the neutral position and move the remote control joint forward.

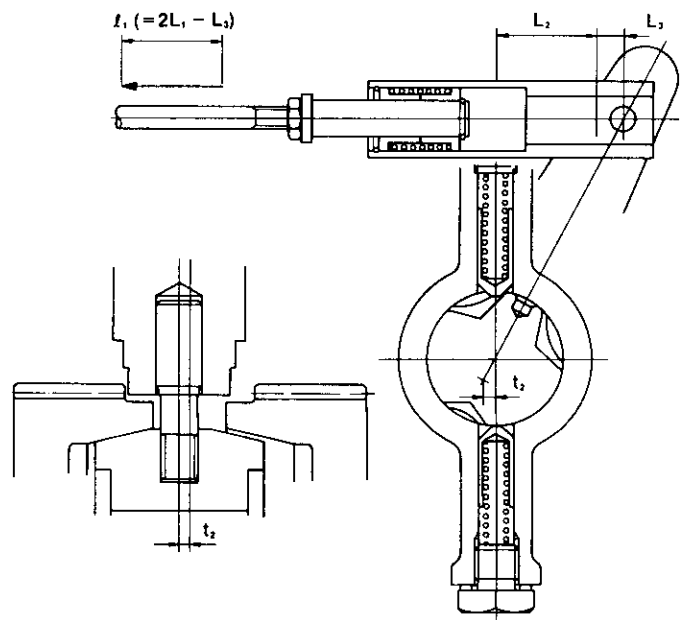


Because of distance L_3 .

- (1) Wear amount of the cone,
 - (2) Increased play in the remote control wire,
 - (3) Fluctuation of remote control wire length when connecting,
- can be compensated for.

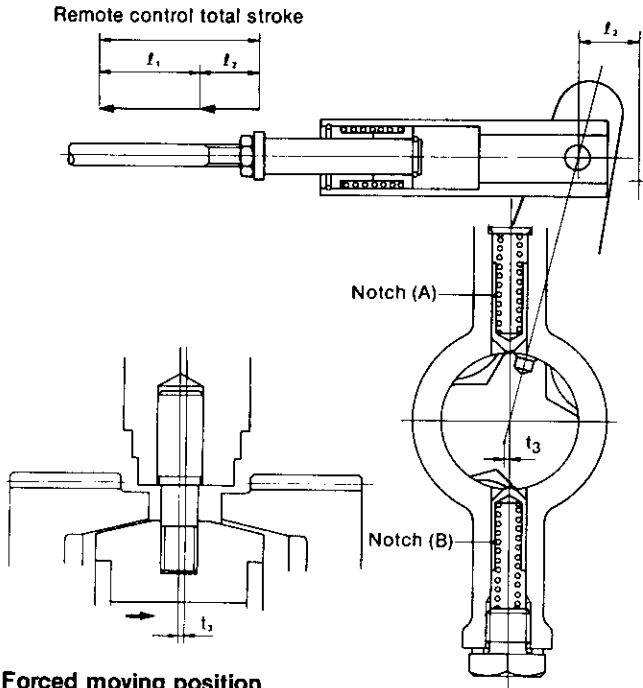
Engaging position for forward

The drive cone, which is moved by the spring in the joint and notch (A), is kept under force until distance L_3 becomes zero even when the cone is worn.



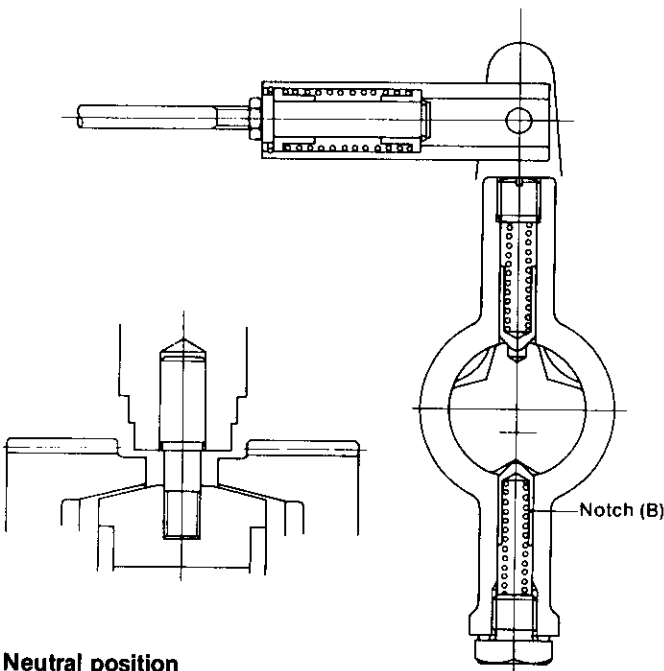
Position of remote control stroke l_1

The shift lever does not move although the spring in the joint is compressed. The cone is kept in contact due to the transmission of torque when idling.



Forced moving position

The shift lever is forcibly moved through distance l_2 , overcoming light friction due to the transmitting torque and the drive cone separates. Notch (A) disengages and notch (B) engages.



Neutral position

The shift lever is returned to neutral by the turning force generated on the shift lever shaft by the spring in the joint and notch (B).

2-3 Clutch shifting force

(reference value) [Engine at 1000rpm]

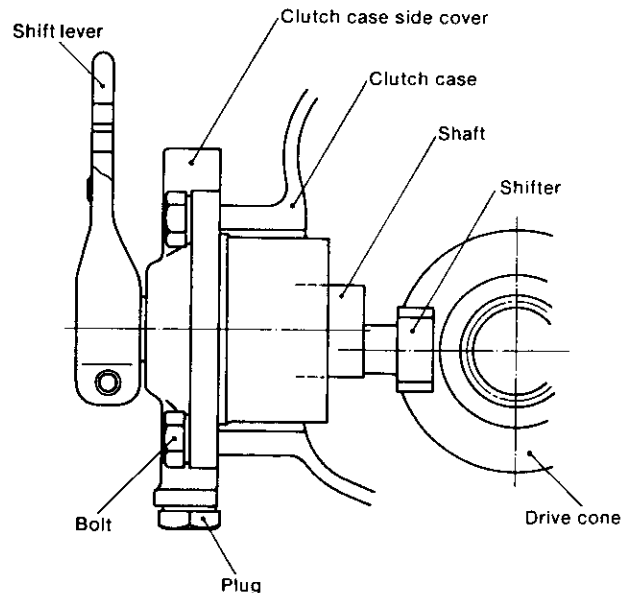
Shifting Position	Shift lever position at 60mm	Remote control handle position at 170mm (cable length, 5m)
Shifting Direction		
Engaging stroke	Approx. 3kg (6.6 lbs)	3 ~ 4kg (6.6 ~ 8.8 lbs)
Disengaging stroke	—	6 ~ 8kg (13.2 ~ 17.6 lbs)

Disengaging stroke:

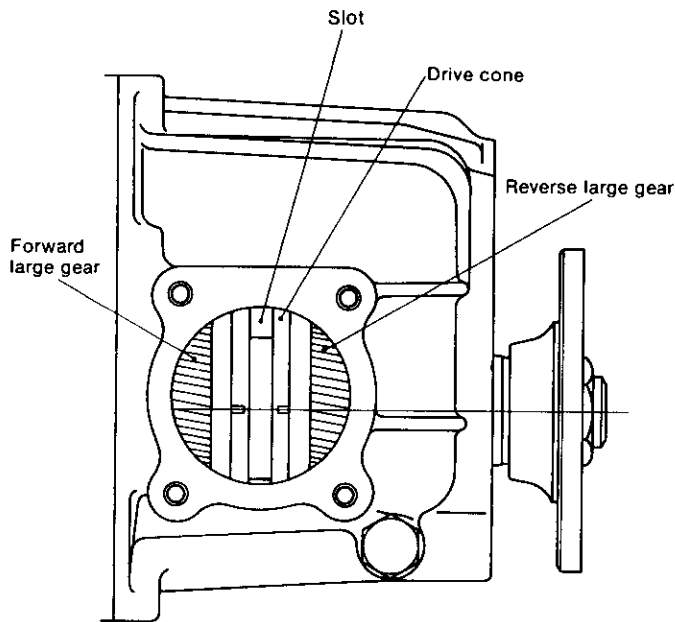
- (1) At the initial stage of usage, the stroke may be heavier than the above value, but the stroke gets light when adopted.
- (2) It varies according to the idling speed of the engine. The lower the rotation becomes, the lighter the stroke becomes.
- (3) The longer the remote control cable, the more bent it becomes, and the smaller the bending radius, the heavier the disengaging stroke.
[33-C minimum bending radius 203.2mm(8")]
- (4) When the spring joint is attached to the shift lever at 52mm distance from the center of the lever shaft, the disengaging stroke will be 15% heavier than when attached at a distance of 60mm.

2-4 Adjustment

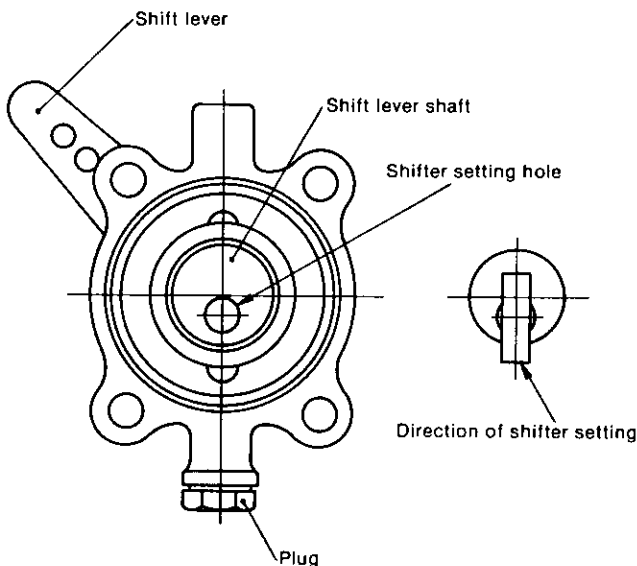
When the clutch side cover is removed, make the following adjustments at the time of reassembly.



- (1) Shift the slot into the drive cone so that it extends as far as the center of the two large gears.

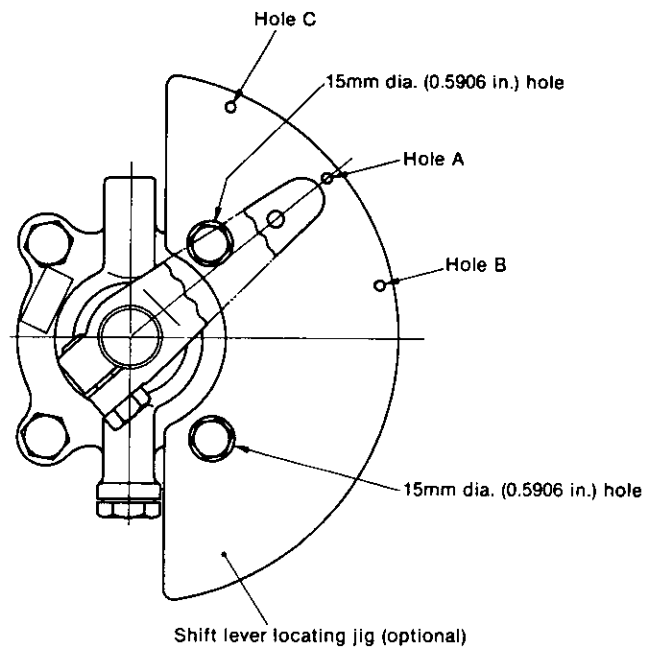


- (2) Set the shift lever at neutral position. (Note that the shift lever can be rotated 360° when it is removed from case.) The neutral position is the position where the shifter comes downwards when the plug is below. When the plug is at the bottom, in the neutral position the shifter points downwards.

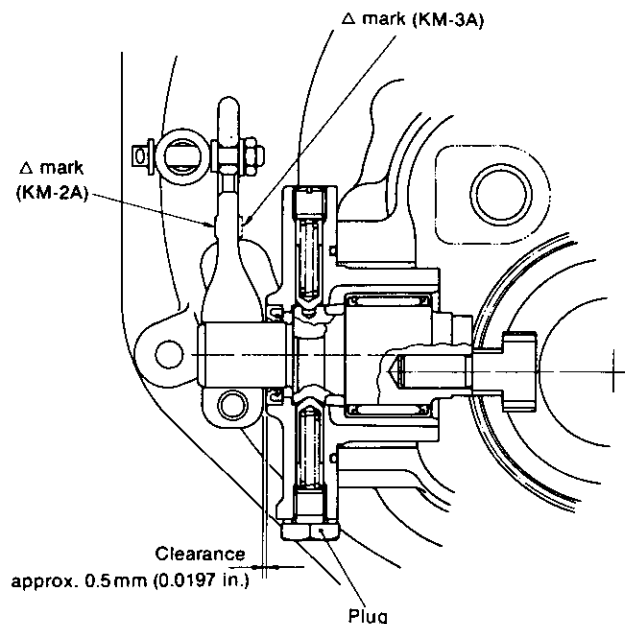


- (3) Put the shifter of the side cover at bottom, and set the shifter to the ditch in the drive cone at the center of the forward and reverse gears. Do not move the drive cone from the center of the two gears at the time of the reassembly. (Note that 2mm diameter clearance is provided in the holes of the side cover, and the gear case.) This is for adjusting the difference between the engaging, and disengaging strokes.)

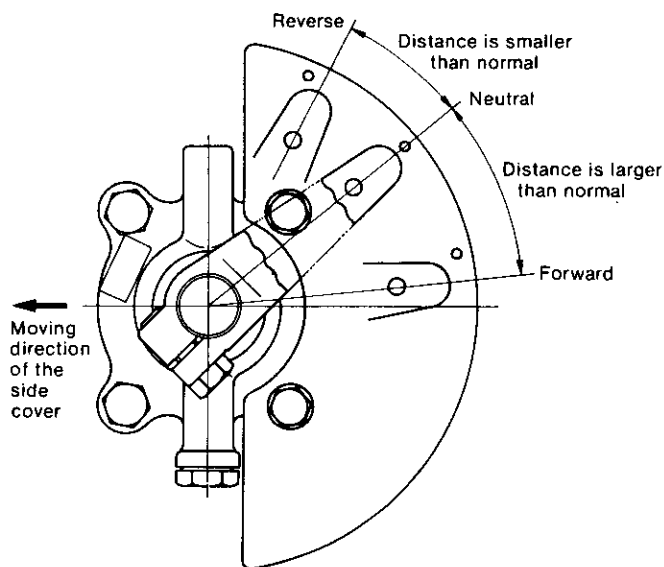
- (4) Fit the shift lever locating jig into the holes of the side cover through the 15mm dia. holes as shown.



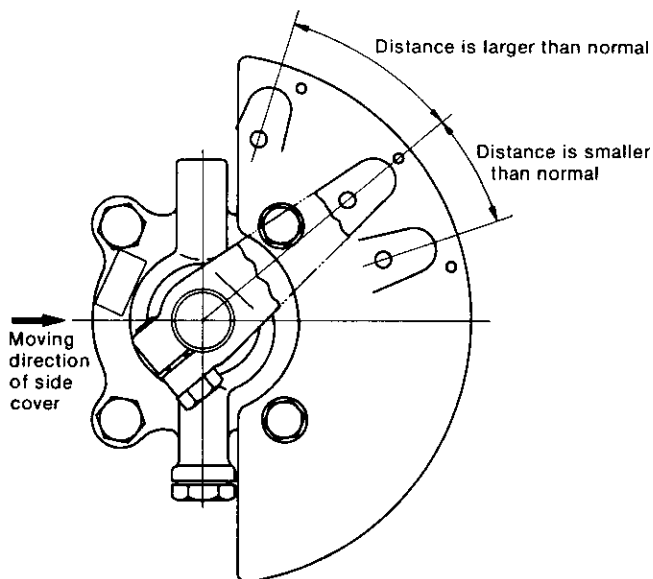
- (5) Put the shift lever in neutral and check that the tip of the lever is aligned with hole A of the jig. If it is not, loosen the fixing bolt on the shift lever, align it, then tighten the bolt. Take care to leave approximately 0.5mm (0.0197 in.) clearance between the shift lever and the side cover.



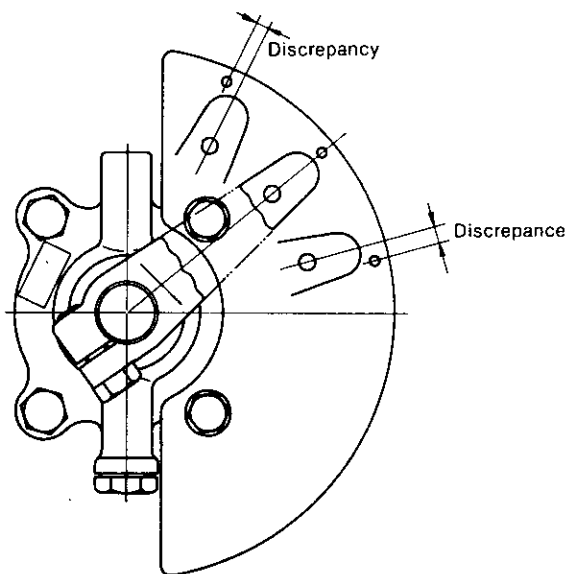
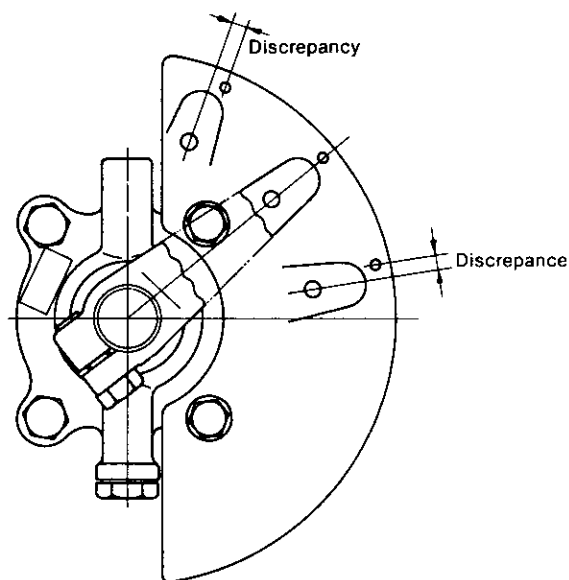
- (6) Move the shift lever forward or back, and visually check the respective distances between the tip of the shift lever and holes B and C. Also check the difference between these distances.
- (7) When these two distances are not equal, slightly loosen the four setting bolts of the side cover so that it can be moved a little in the shaft direction.
- (8) When the distance is larger than normal in the forward setting, move the side cover slightly to the engine side.



- (9) When the distance is larger than normal in the reverse setting, move the side cover slightly to the propeller side.



- (11) Although these distances may be equal both for forward and reverse, there might be some discrepancy between holes B and C due to difference in machining. However, if the discrepancy is the same for forward and reverse there is no problem.



- (12) Install the spring joint on the shift lever.
(Only when it is dismantled in the boat).
NOTE: When the shift device is removed in the boat, the engine must always be stopped.

- (10) When the distances are equal between neutral and forward and neutral and reverse tighten the setting bolts of the side cover.

**2-5 Inspect for the following points
(to be inspected every 2-3 months)**

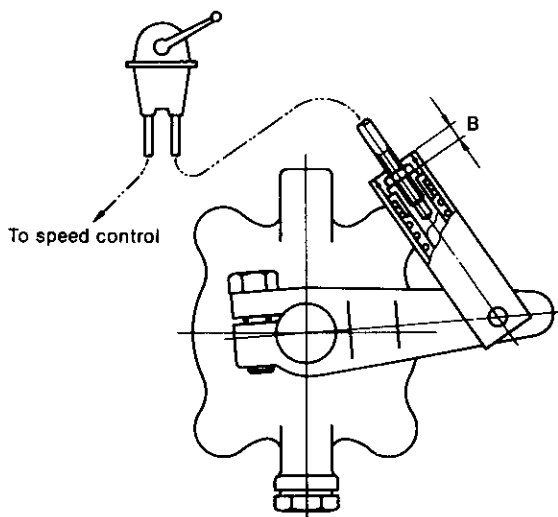
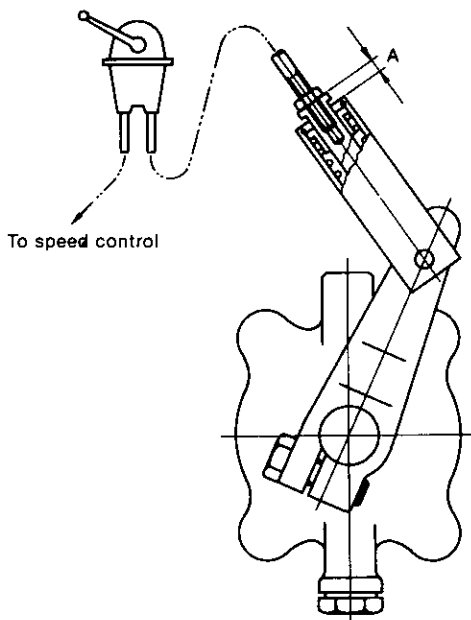
- (1) Looseness at the connection of the spring joint and the remote control cable.
- (2) Looseness of the attaching nut of the spring joint and the shift lever.
- (3) To make sure that the value of A, and B is not "Zero" at the engaging position of the remote control lever. If the value is "Zero", untighten the bolt of the side cover, and adjust according to the steps described in 2-4.

When the cone for the forward side gets worn, the value of B is decreased, and for reverse side, the value of A is decreased. When the play in the remote control system is increased, both values of A and B are decreased.

2-6 Cautions

- (1) Always stop the engine when attaching, adjusting, and inspecting.
- (2) When conducting inspection immediately after stopping the engine, do not touch the clutch. The oil temperature is often raised to around 90°C (194°F).
- (3) Half-clutch operation is not possible with this design and construction. Do not use with the shift lever halfway to the engaged position.
- (4) Set the idling engine speed at between 750 and 800 rpm.

NOTE: The dual (Two) lever remote control device cannot be used.



3. Inspection and Servicing

3-1 Clutch case

- (1) Check the clutch case with a test hammer for cracking. Perform a color check when required. If the case is cracked, replace it.
- (2) Check for staining on the inside surface of the bearing section. Also, measure the inside diameter of the case. Replace the case if it is worn beyond the wear limit.

3-2 Bearing

- (1) Rusting and damage. If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly. If rotation is not smooth, if there is any binding, or if any abnormal sound is evident, replace the bearing.

3-3 Gear

Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.

- (1) Tooth surface wear. Check the tooth surface for pitching, abnormal wear, dents, and cracks. Repair lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact. Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash. Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

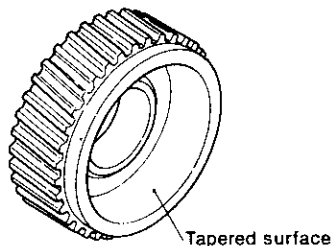
mm (in.)

	Maintenance standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Input shaft reverse gear and intermediate gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Intermediate gear and output shaft reverse gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)

(The same dimensions apply to both KM2-C and KM3-A)

3-4 Forward and reverse large gears

- (1) Contact surface with drive cone. Visually inspect the tapered surface of the forward and reverse large gears where they make contact with the drive cone to check if any abnormal condition or sign of overheating exists. If any defect is found, replace the gear.

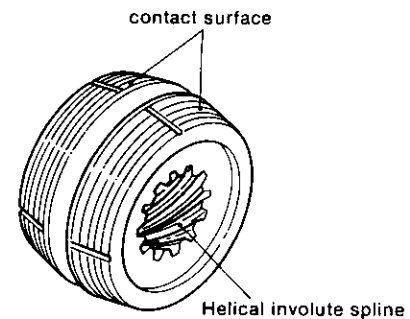


- (2) Forward/reverse gear needle bearing. When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.

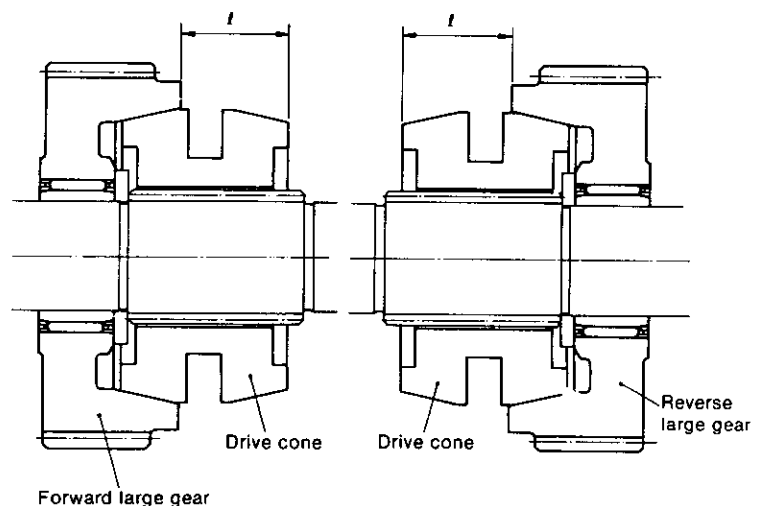


3-5 Drive cone

- (1) Visually inspect that part of the surface that comes into contact with the circumferential triangular slot to check for signs of scoring, overheating or wear. If deep scoring or signs of overheating are found, replace the cone.



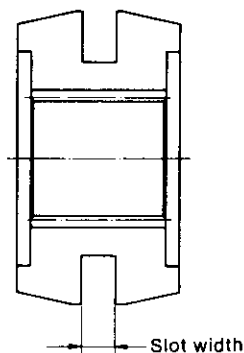
- (2) Check the helical involute spline for any abnormal condition on the tooth surface, and repair or replace the part should any be found.
- (3) Measure the amount of wear on the tapered contact surface of the drive cone, and replace the cone when the wear exceeds the specified limit.



		mm (in.)	
Dimensions <i>l</i>		Standard dimensions	Limited dimensions
		KM2-C	24.4 ~ 24.7 (0.9606 ~ 0.9724)
	KM3-A	29.9 ~ 30.2 (1.1772 ~ 1.1890)	29.6 (1.1654)

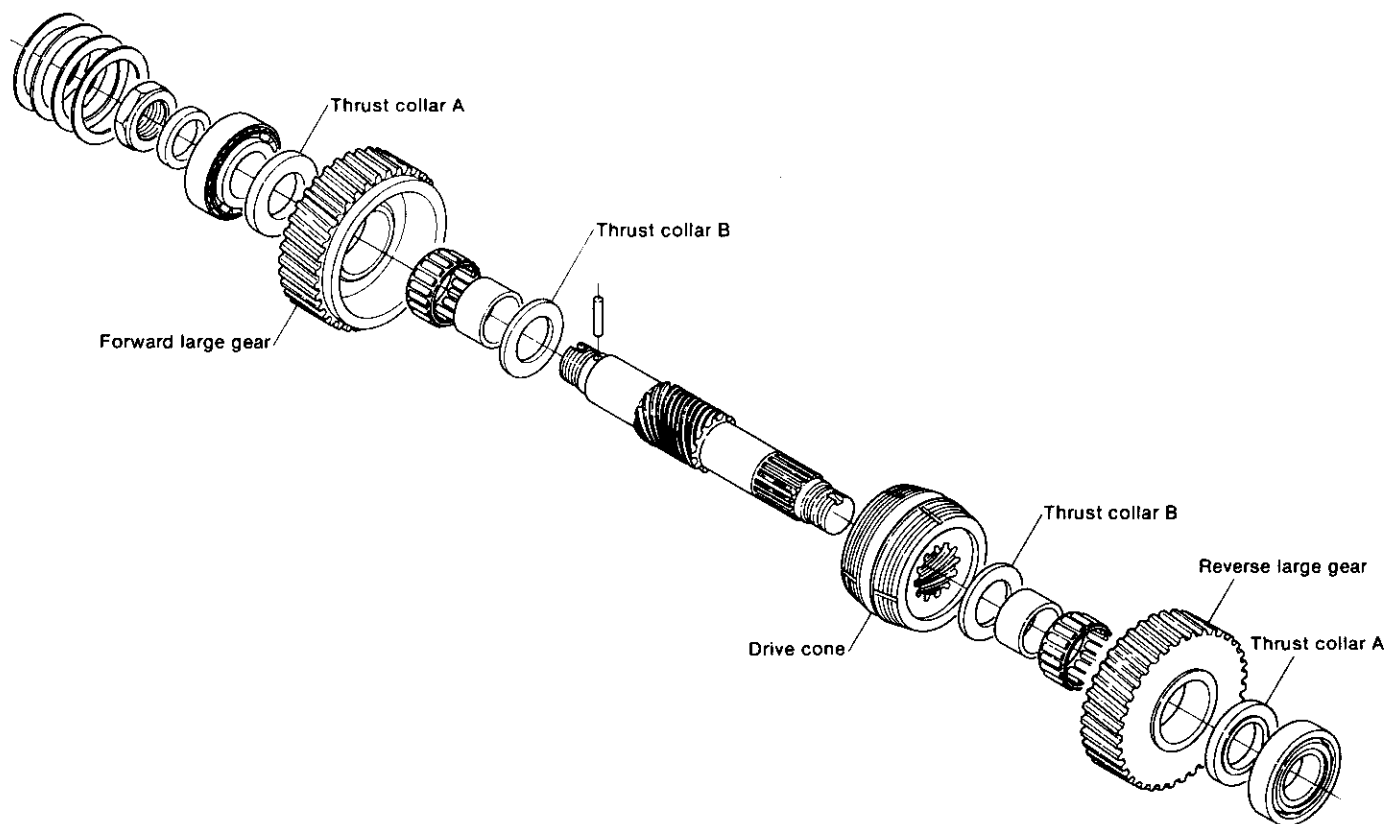
NOTE: When dismantled, the forward or reverse direction of the drive cone must be clearly identified.

(4) Measure the dimension of the slot width of the drive cone, and replace the cone when the dimension is over the specified limit.

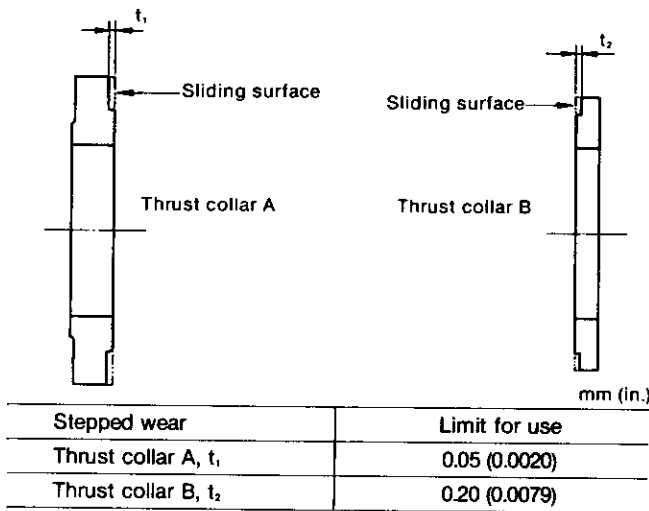


	Standard dimensions	Standard clearance	Allowable clearance	Limited clearance
Slot width of drive cone	$8^{+0.1}_0$ (0.3150 ~ 0.3189)	0.15 ~ 0.3 (0.0059 ~ 0.0118)	0.6 (0.0236)	8.3 (0.3268)
Shifter width	$8^{-0.15}_{-0.20}$ (0.3071 ~ 0.3090)			7.7 (0.3031)

3-6 Thrust collar



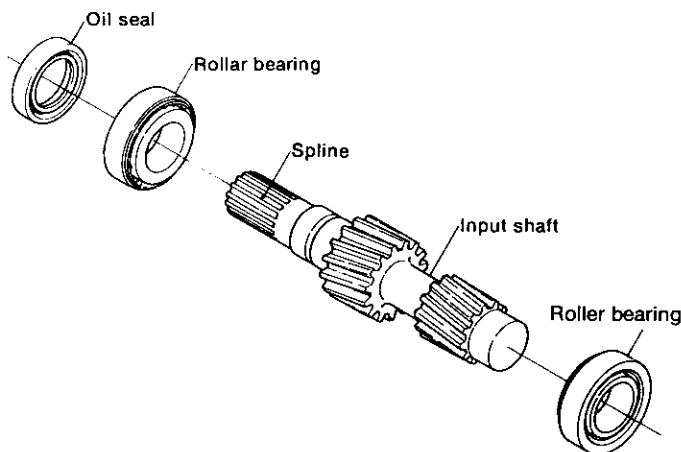
- (1) Visually inspect the sliding surface of thrust collar A or B to check for signs of overheating, scoring, or cracks. Replace the collar if any abnormal condition is found.
- (2) Measure the thickness of thrust collar A or B, and replace it when the dimension exceeds the specified limit.



3-7 Oil seal of output shaft

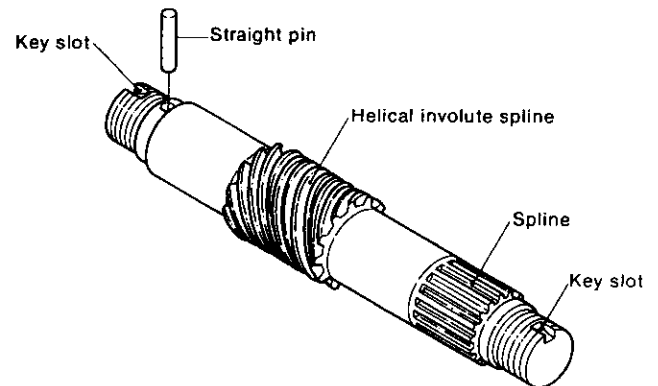
Visually inspect the oil seal of the output shaft to check if there is any damage or oil leakage; replace the seal when any abnormal condition is found.

3-8 Input shaft



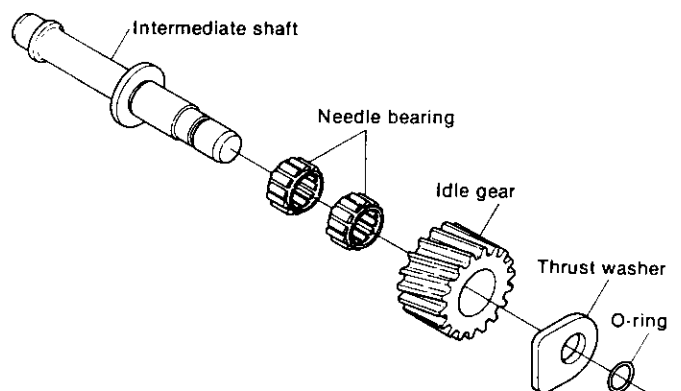
- (1) Spline part.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Surface of oil seal.
If the sealing surface of the oil seal is worn or scratched, replace.

3-9 Output shaft



- (1) Visually inspect the spline and the helical involute spline, and repair or replace a part when any abnormal condition is found on its surface.

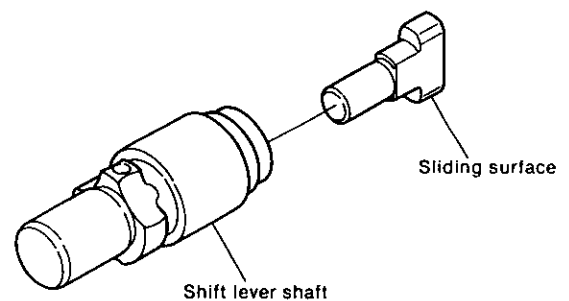
3-10 Intermediate shaft



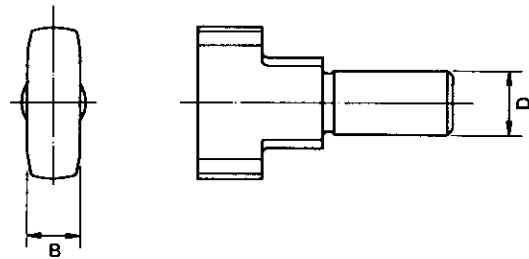
- (1) Needle bearing dimensions, staining.
Check the surface of the roller to see whether the needle bearing sticks or is damaged. Replace if necessary.

3-11 Shifting device

3-11.1 Shifter



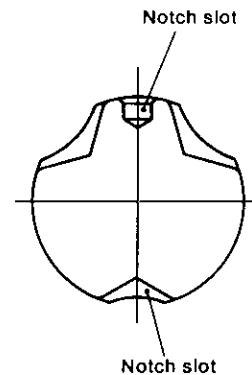
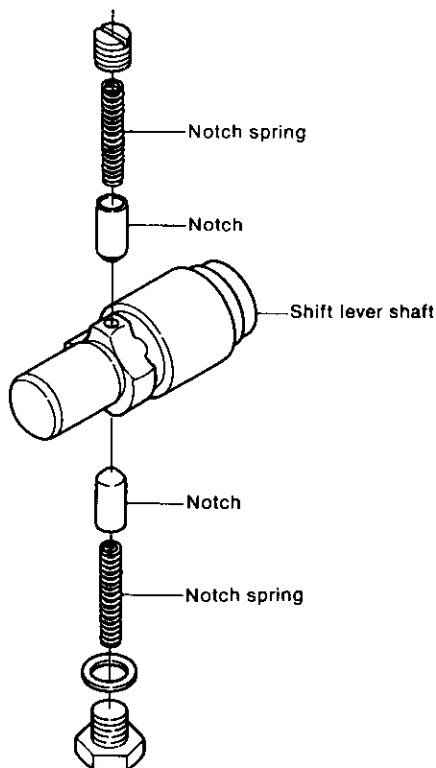
- (1) Visually inspect the surface in contact with the drive cone, and replace the shifter when signs of overheating, damage or wear are found.
- (2) Measure the width of the shifter, and replace it when the wear exceeds the specified limit. Also measure the diameter of the shifter shaft, and replace it when the wear exceeds the specified limit.



	Standard dimensions	Clearance	Allowable clearance	Specified limit
Slot width of drive cone	$8^{+0.1}_0$ (0.3150 ~ 0.3189)	0.15 ~ 0.3 (0.0059 ~ 0.0118)	0.6 (0.0236)	8.3 (0.3268)
Shifter width	$8^{-0.15}_{-0.20}$ (0.3070 ~ 0.3091)			7.7 (0.3031)
Shifter shaft diameter	$10^{-0.005}_{-0.014}$ (0.3931 ~ 0.3935)	0.005 ~ 0.029 (0.0002 ~ 0.0011)	0.05 (0.0020)	9.95 (0.3917)
Shift lever shaft diameter	$10^{+0.015}_0$ (0.3937 ~ 0.3943)			10.05 (0.3957)

3-11.2 Notch slot of shift lever shaft

Visually inspect the notch slot of the shift lever shaft to check for any abnormal wear or cracking, replace any defective part if found.



3-11.3 Notch

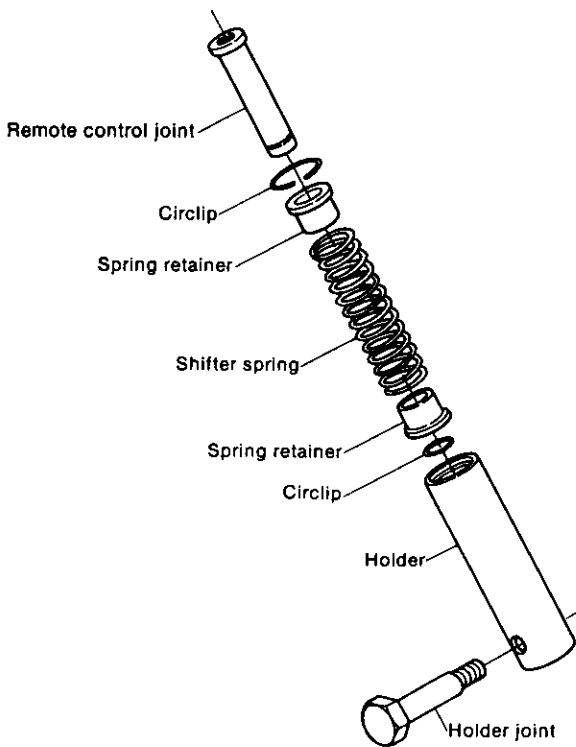
Visually inspect the tip of the notch to check for wear, damage or deformation. Replace the notch if it is found to be defective in any way.

3-11.4 Notch spring

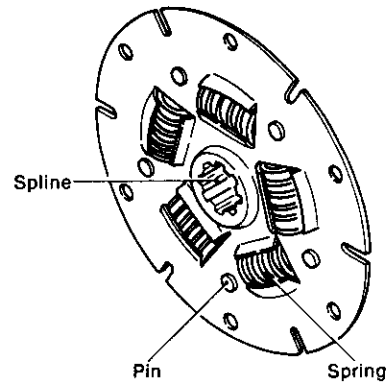
Visually inspect the notch spring to check for any damage, corrosion or permanent set; replace the spring when it is found to be defective.

Free length	34mm (1.3386in.)
Spring coefficient	0.459kg (0.992 lb)
Set length	25.5mm (1.0039in.)
Set load	3.90kg (8.598 lb)

3-12 Spring joint

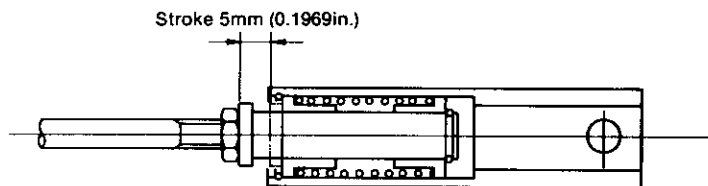
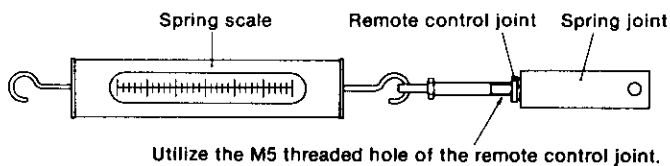


3-13 Damper disc



- (1) Spline part.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Spring.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (4) Whenever a crack or damage to the spring slot is found replace the defective part with a new one.

- (1) Check each part for abnormal play, and replace if play is excessive.
- (2) When the movement of each part is not smooth, measure the tension and replace as a complete unit when it exceeds the specified limit.

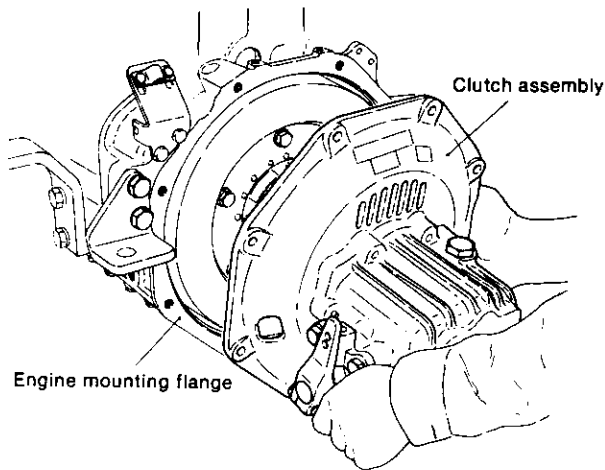


	kg (lb)	
	Standard value	Limit value
Tension (at the position of 5mm stroke)	2.8 (6.17)	2.5 (5.51)

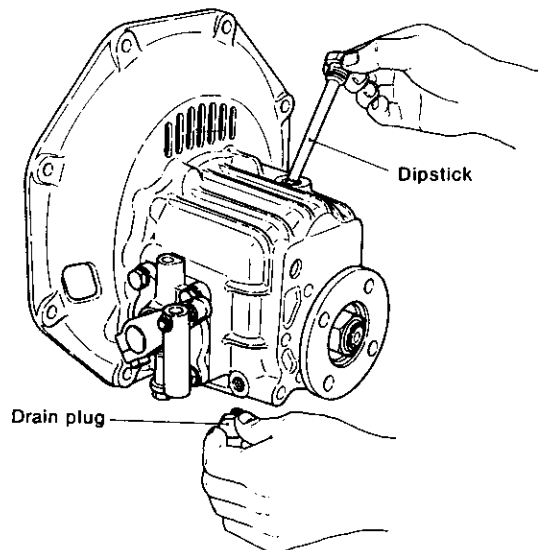
4. Disassembly

4-1 Dismantling the clutch

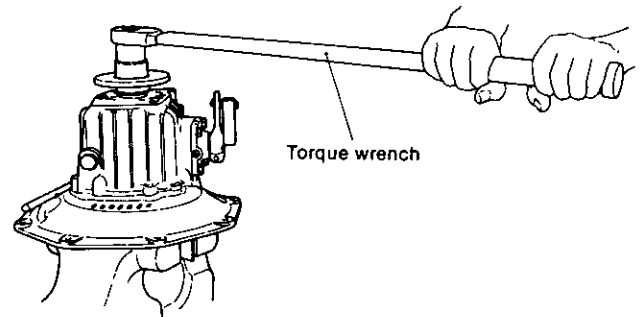
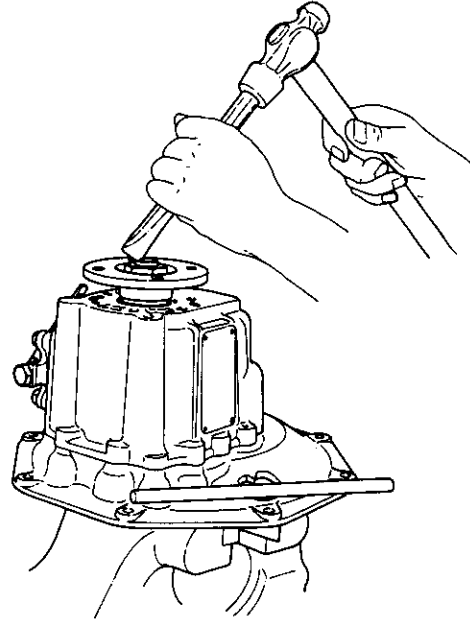
- (1) Remove the remote control cable.
- (2) Remove the clutch assembly from the engine mounting flange.



- (3) Drain the lubricating oil.
Drain the lubricating oil by loosening the plug at the bottom of the clutch case.

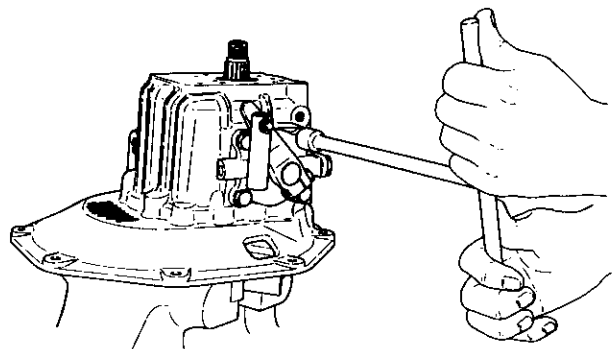


- (4) Remove the end nut and output shaft coupling.

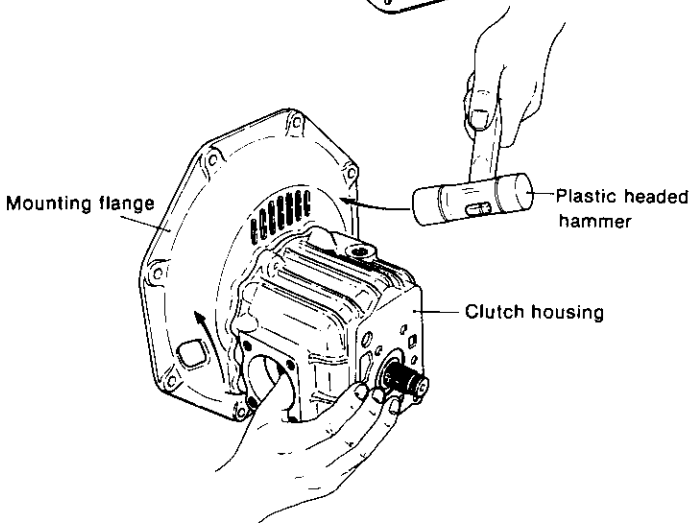
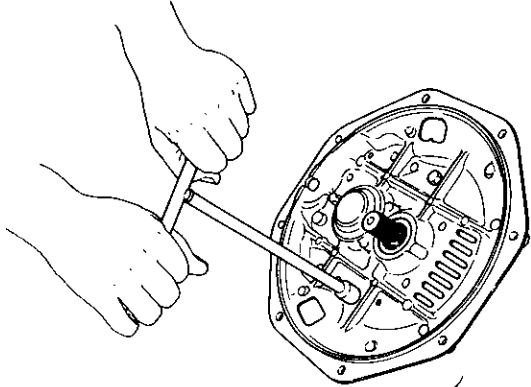


NOTE: Take care as it has a left-handed thread.

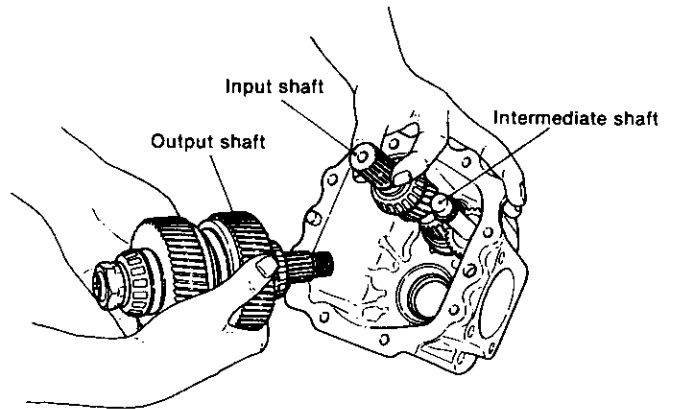
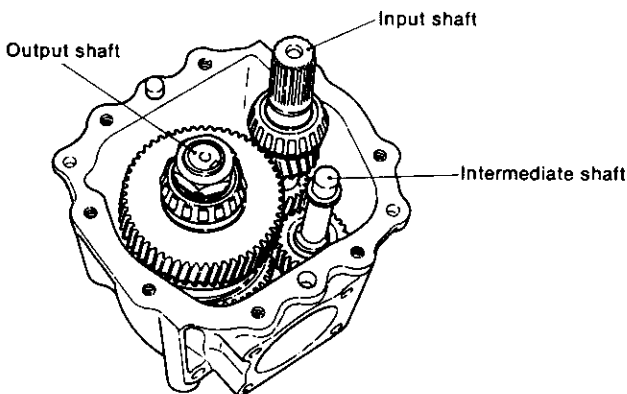
- (5) Remove the oil dip stick and packing.
- (6) Remove the fixing bolts on the side cover, and also remove the shift lever shaft, shift lever and shifter.



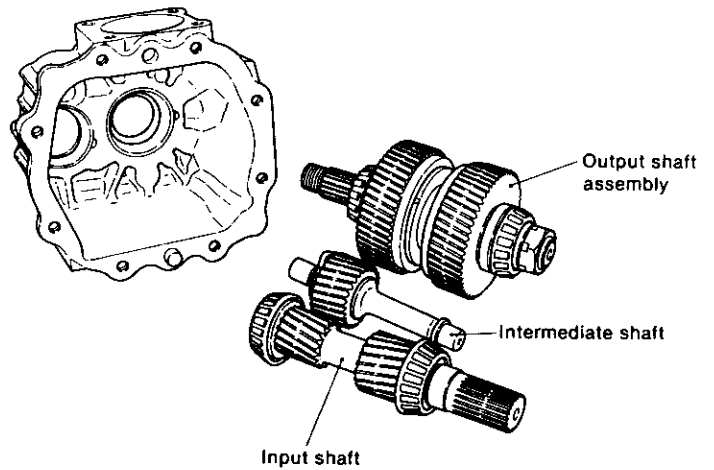
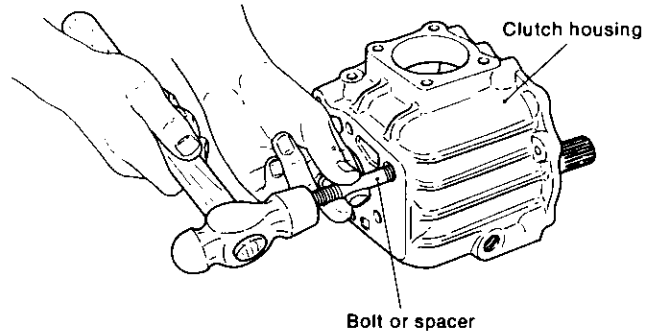
(7) Remove the bolts which secure the mounting flange to the case body, give light taps to the left and right with a plastic headed hammer while supporting the clutch case with your hand, then remove the mounting flange.



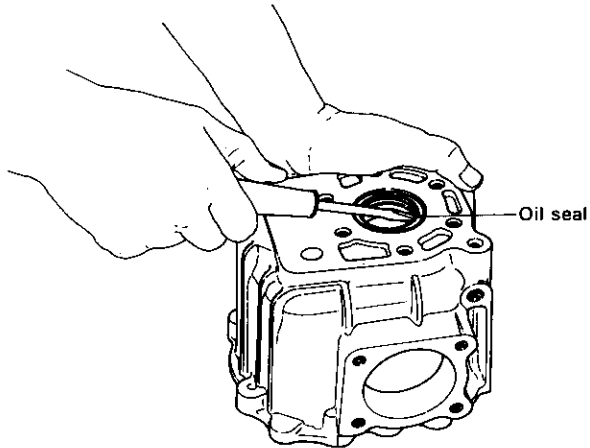
(8) Withdraw the output shaft assembly.



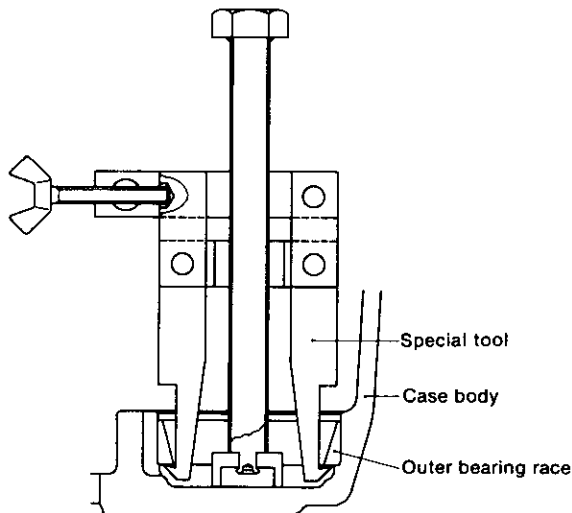
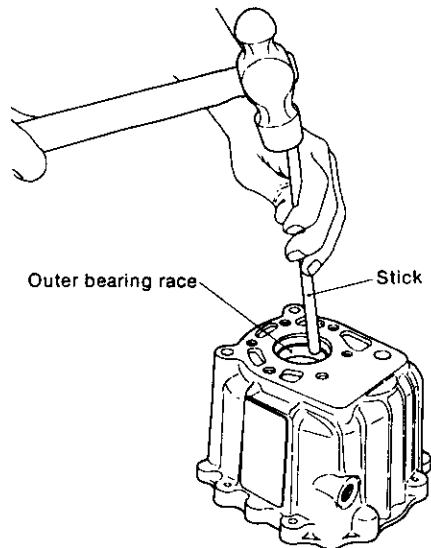
(9) Take out the intermediate shaft and input shaft. When taking out the intermediate shaft, place a bolt or spacer on the shaft hole of the case, and drive the shaft out by tapping it lightly.



- (10) Remove the oil seal of the output shaft from the case body.



- (11) Remove the outer bearing race from the case body by using the special tool.

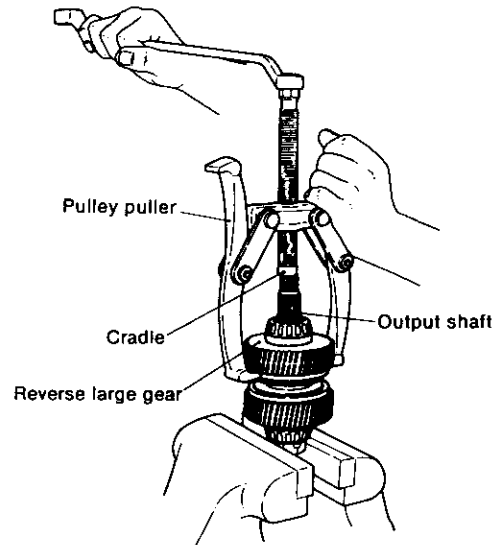


- (12) Remove the oil seal of the input shaft from the mounting flange.
(13) Remove the outer bearing race from the mounting flange in the same way as with the case body.
(14) Remove each adjusting plate from the input or output shaft.

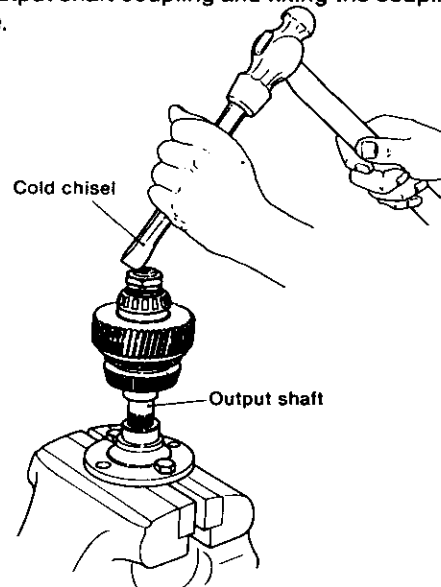
NOTE: The same adjusting plates can be reused when the following parts are not replaced. When any part is replaced however, re-adjustment is necessary.

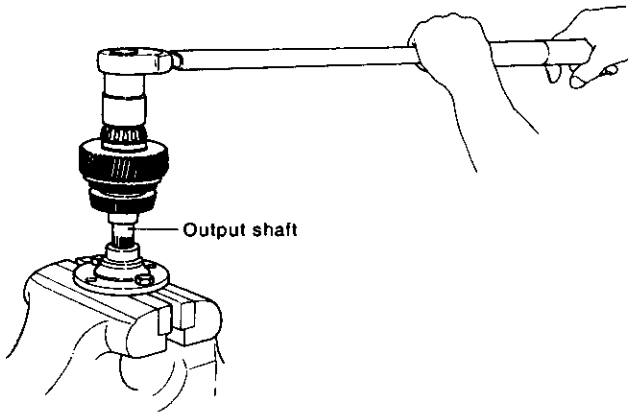
4-2 Removal of the output shaft

- (1) Take out the reverse large gear, thrust collar A and inner bearing race.
The reverse large gear must be withdrawn using a pulley extractor, by fixing the nut at the forward end in a vice.

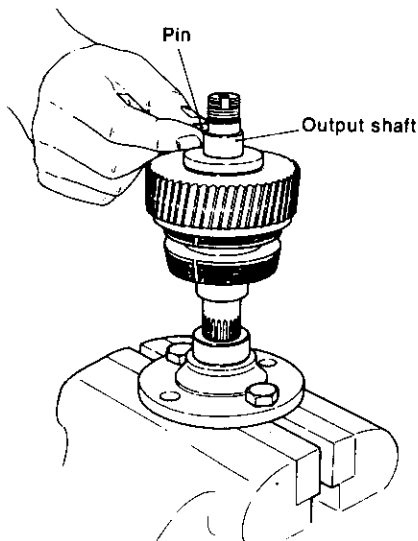
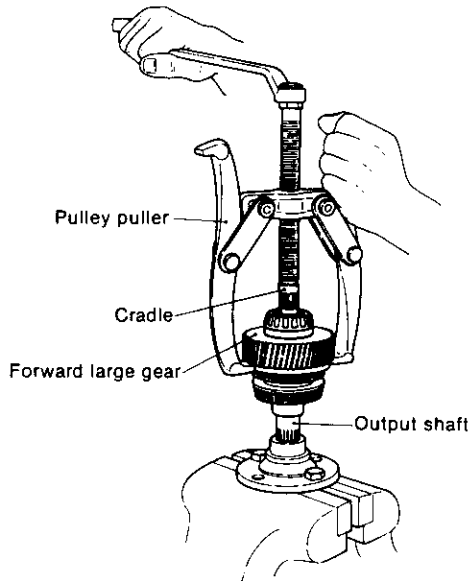


- (2) Loosen the calking of the forward nut and remove the nut and spacer.
Remove the nut by using a torque wrench after setting the output shaft coupling and fixing the coupling bolt in a vice.

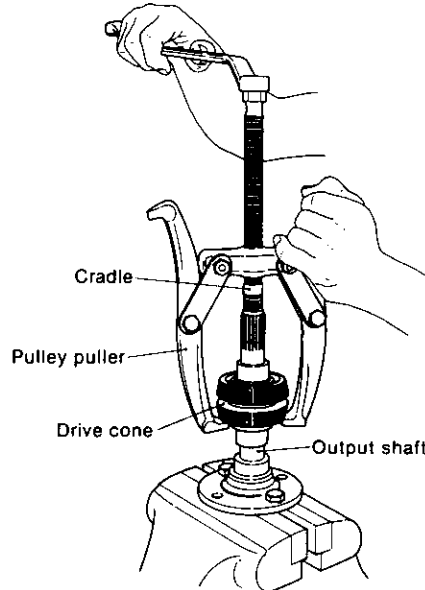
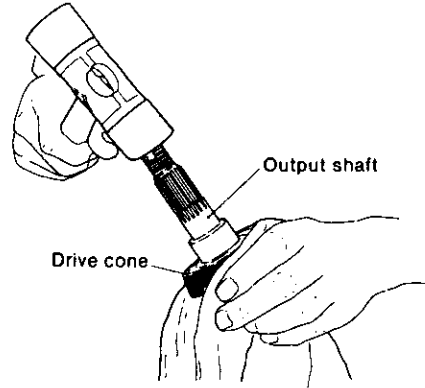




(3) Place the pulley extractor against the end surface of the forward large gear, and withdraw the forward large gear, thrust collar A and inner bearing race.

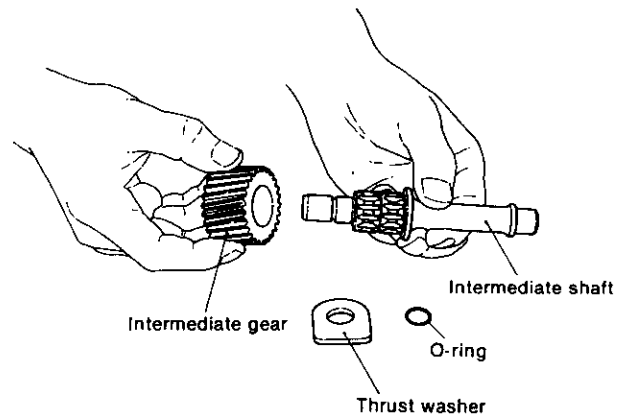


(4) While gripping the drive cone, tap the end of the shaft with a plastic beaded hammer, and withdraw the thrust collar B and inner needle bearing race. A pulley extractor may be used.



4-3 Removal of the intermediate shaft

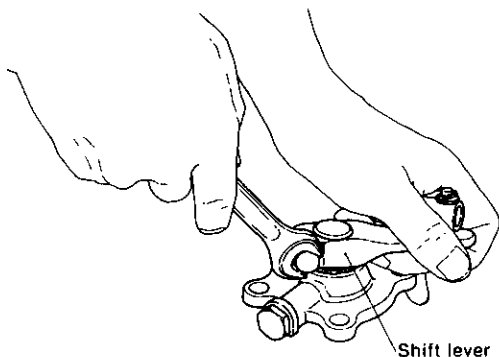
- (1) Remove the "O" ring.
- (2) Remove the thrust washer.
- (3) Remove the intermediate gear and needle bearing.



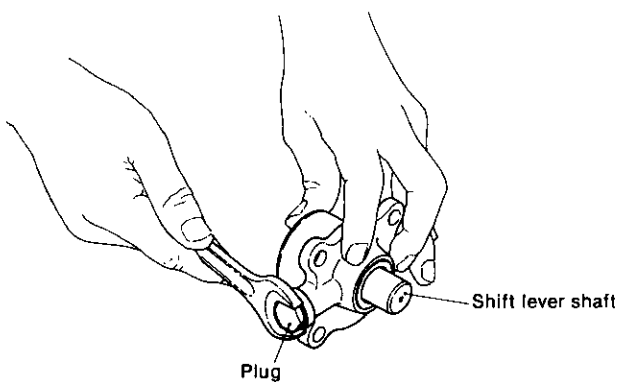
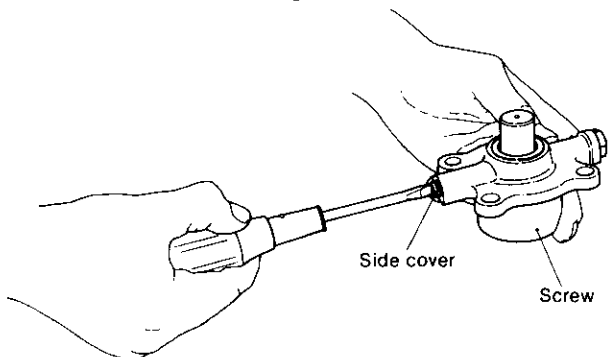
NOTE: Take care as the nut has left-handed thread.

**4-4 Dismantling the side cover assembly
(Shifting device)**

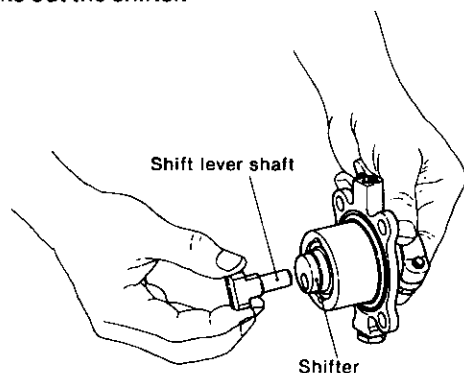
(1) Loosen the bolt of the shift lever, and remove the shift lever from the shaft.



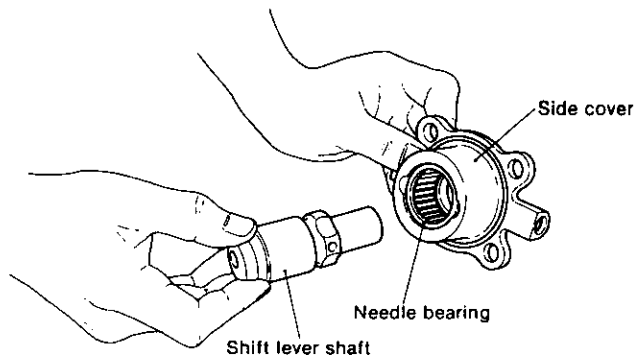
(2) Remove the stop screw for the notch and plug, and take out the notch and spring.



(3) Take out the shifter.

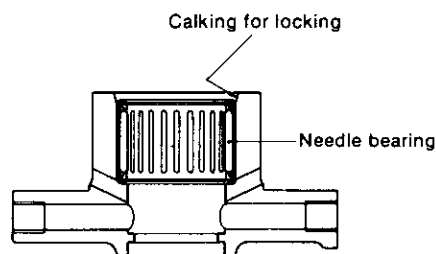


(4) Withdraw the shift lever shaft.



(5) Remove the oil seal.

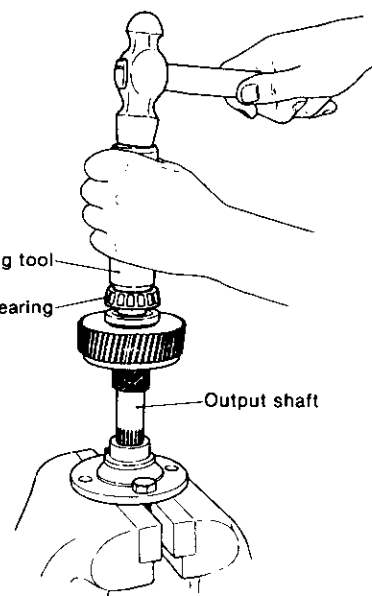
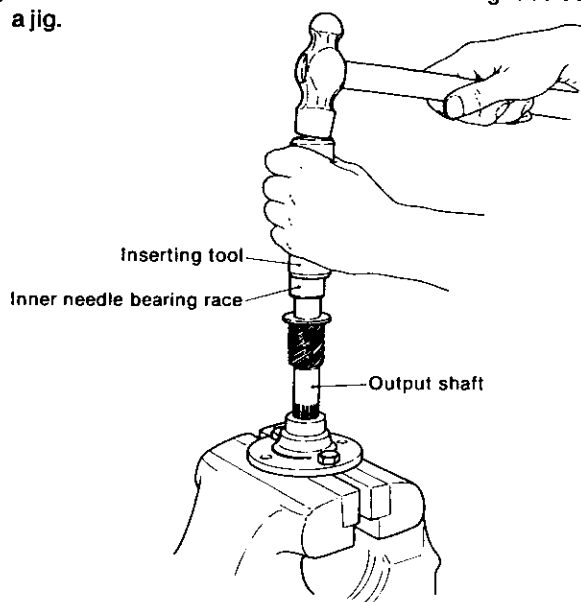
(6) After removing the calking for locking, heat the needle bearing portion up to about 100°C, and extract the needle bearing from the side cover.



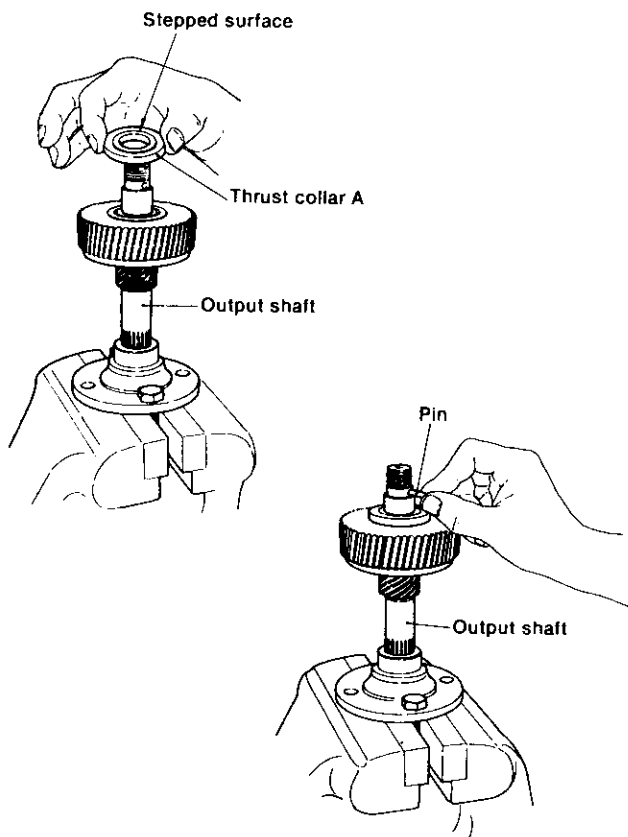
5. Reassembly

5-1 Reassembly of output shaft

- (1) Fit the forward side thrust collar B onto the shaft.
- (2) Drive in the forward end inner needle bearing race using a jig.



- (3) Assemble the needle bearing and forward large gear.
NOTE: Check that the forward large gear rotates smoothly.
- (4) Fit the thrust collar A and pin, and drive in the inner bearing race using a jig.



NOTES: 1) Drive in with a plastic headed hammer. Do not hit it hard.

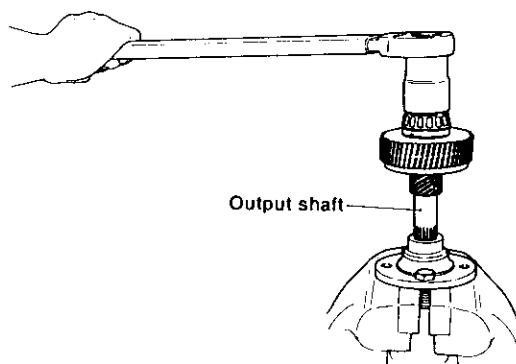
2) When fitting the thrust collar A, note the fitting direction. Fit it keeping the stepped surface toward the bearing side.

3) Note that the pin cannot be fitted after the inner bearing race has been driven in.

(5) Assemble the collar and pin so that the pin is in the groove of the collar.

(6) Set and tighten the forward end nut. Insert the bolt into the coupling, and fix it in a vice, keeping the spline part upward.

Insert the shaft into the spline of the coupling, fit the spacer, and tighten the nut with a torque wrench.



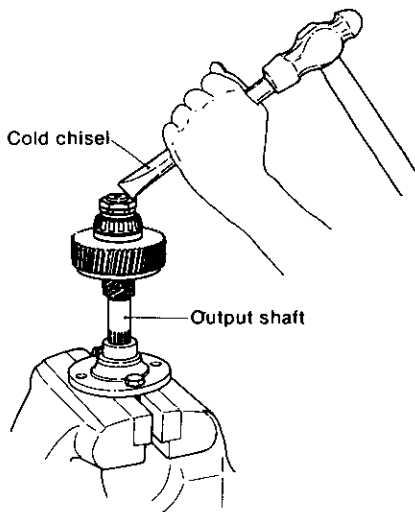
Tightening torque

10 ± 1.5 kgf-m
(61.5 ~ 83.2 ft-lb)

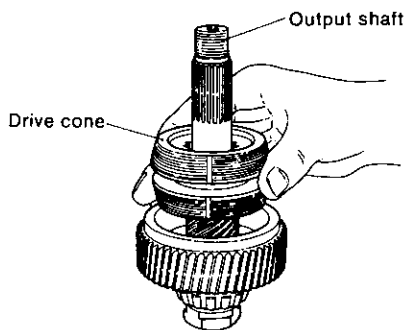
(The same torque applies to both models KM2-C and KM3-A).

NOTES: 1) Take care as it is a left-handed thread.

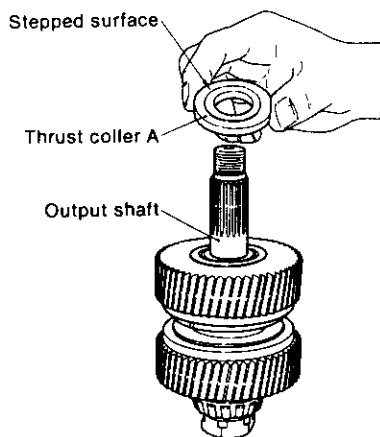
2) Use the reverse side nut used before dismantling as the forward end nut. This is so as not to match the calked portion to the same point.



(7) Insert the drive cone while keeping the output shaft set for reverse.



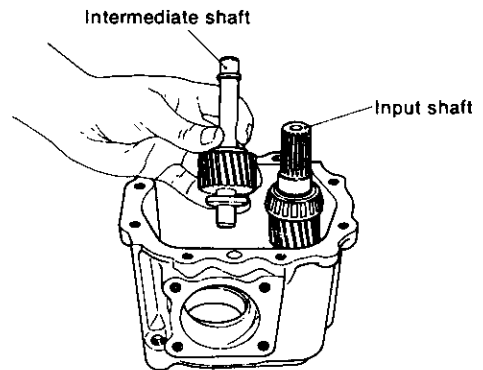
(8) Apply procedures 1 through 4 to the forward end.



NOTE: Fit thrust collar A so that the stepped surface faces the bearing side.

5-2 Reassembly of the clutch

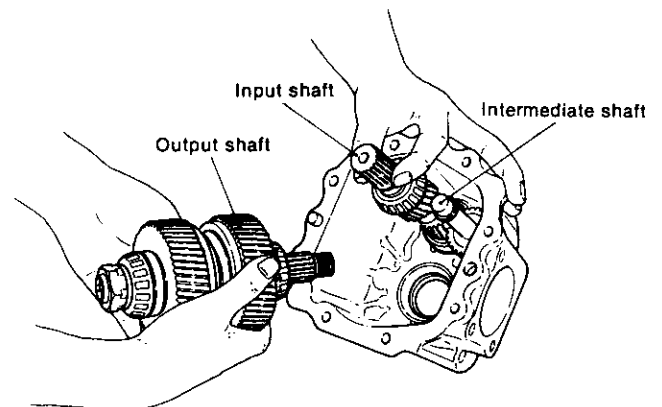
- (1) Fit the oil seal and bearing outer race in the clutch case.
- (2) Insert the input shaft into the clutch case.
- (3) Drive the intermediate shaft into the clutch case.



NOTES: 1) If the output shaft is not fitted into the clutch case before driving-in the intermediate shaft, it cannot be assembled.

2) Note the assembly direction of the thrust washer.

- (4) Insert the output shaft into the clutch case.

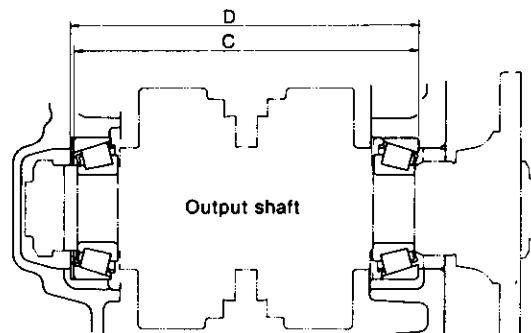
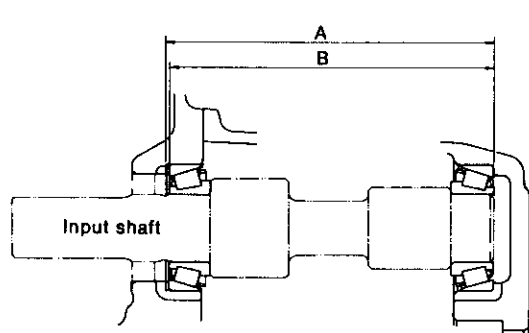


- (5) Check the thickness of shims for both input and output shafts. When the component parts are not replaced after dismantling, the same shims can be reused. When the clutch case flange or any one of the following parts is replaced, the thickness of shim must be determined in the following manner.

For input shaft parts: input shaft, bearing.

For output shaft parts: output shaft, thrust collar A, thrust collar B, gear, bearing.

- 1) Measure the distance between the clutch case body and the mounting flange, A or D for each shaft.
- 2) Fit the outer bearing race to each shaft, and measure the distance (B or C) between bearings.



mm (in.)

	A	B	C	D
KM2-C	116.40 ~ 116.75 (4.5827 ~ 4.5964)	115.2 ~ 116.1 (4.5354 ~ 4.5709)	121.48 ~ 122.53 (4.7827 ~ 4.8240)	122.60 ~ 122.95 (4.8268 ~ 4.8406)
KM3-A	127.4 ~ 127.75 (5.0157 ~ 5.0295)	126.2 ~ 127.1 (4.9685 ~ 5.0039)	134.56 ~ 136.0 (5.2976 ~ 5.3543)	136.0 ~ 136.35 (5.3543 ~ 5.3681)

- 3) Determine the thickness of shim so that the values of clearance and interference after fitting comply with the values in the following table.

Clearance (or interference) for each shaft mm (in.)

Input shaft	± 0.05 (± 0.0020)
Output shaft	$0 \sim -0.1$ ($0 \sim -0.0039$)

NOTE: Negative value shows interference.

Adjusting plate

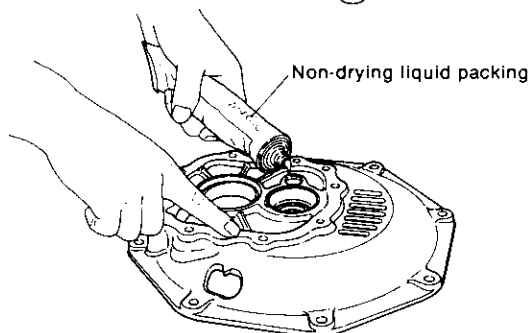
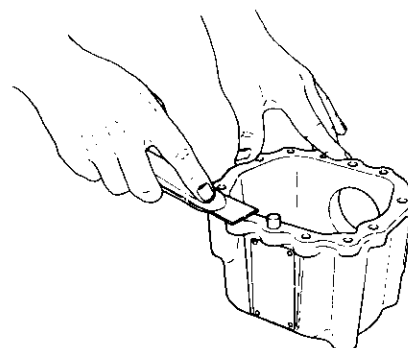
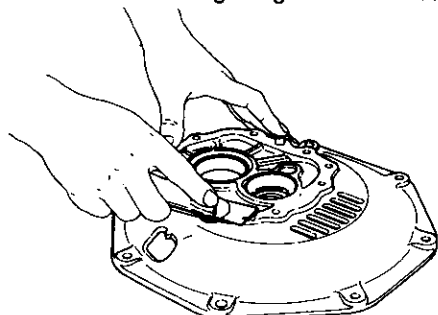
	Part No.	Thickness mm (in.)	No. of shims
Input shaft	177088-02350	0.5 (0.0197)	1
		0.4 (0.0157)	1
		0.3 (0.0118)	2
Output shaft	177090-02250	1.0 (0.0394)	1
		0.5 (0.0197)	1
		0.3 (0.0118)	1
		0.1 (0.0039)	2

- (6) Fit the adjusting plate to the mounting flange, and drive in the outer bearing race.

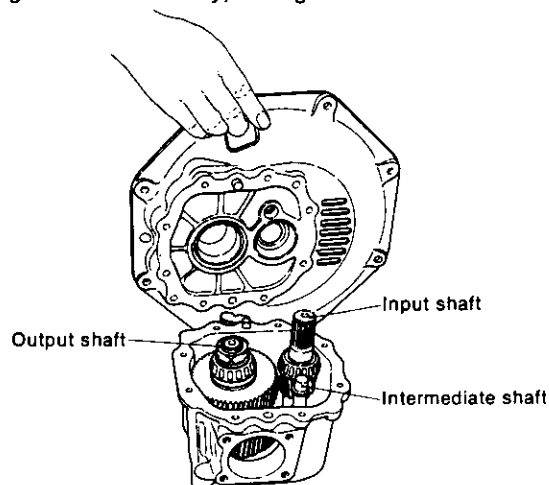
NOTE: The outer bearing race can be easily driven in by heating the mounting flange to about 100°C, or by cooling the outer race with liquid hydrogen.

- (7) Apply non-drying liquid packing around the outer surface of the oil seal, and insert the oil seal into the mounting flange while keeping the spring part of the oil seal facing the inside of the case.

- (8) Apply non-drying liquid packing to the matching surfaces of the mounting flange and the case body.

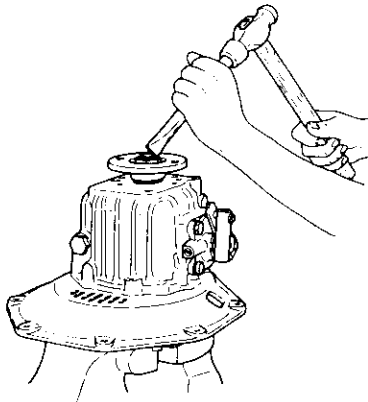
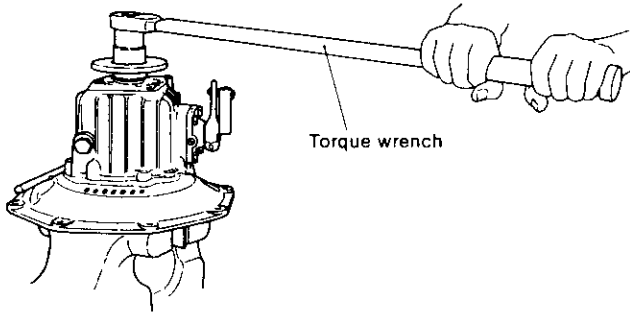


- (9) Insert the input shaft and output shaft into the shaft holes of the mounting flange, assemble the mounting flange on the case body, and tighten the bolt.



NOTE: Apply non-drying liquid packing to either the mounting flange or the case body.

- (10) Assemble the output shaft coupling on the output shaft, and fit the O-ring.
- (11) Tighten the end nut by using a torque wrench, then calk it.



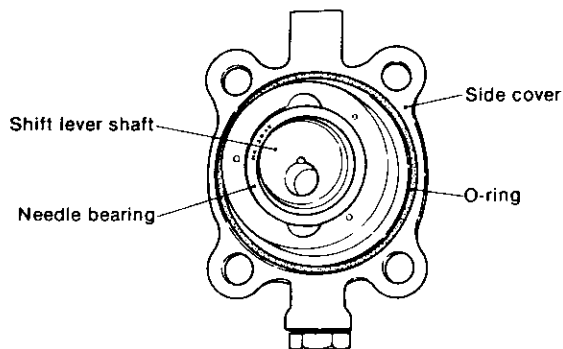
NOTE: Take care as it is a left-handed thread.

Tightening torque	10 ± 1.5 kgf-m (61.5 ~ 83.2 ft-lb)
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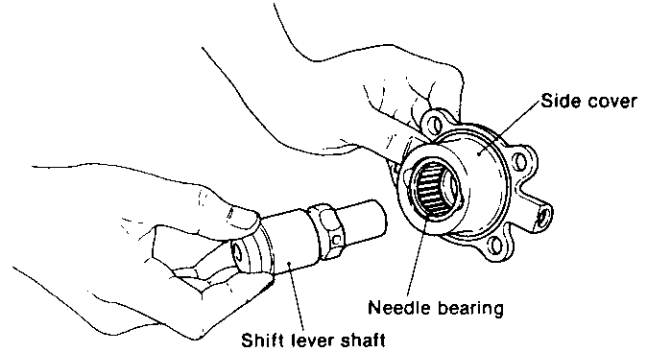
(The same torque applies to both models KM2-C and KM3-A).

5-3 Reassembly of the shifting device

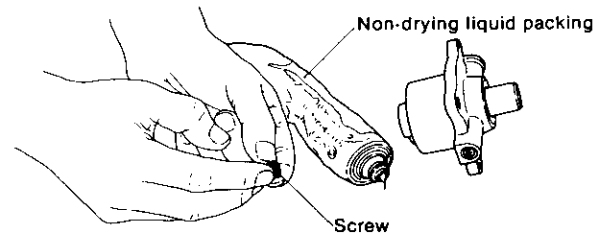
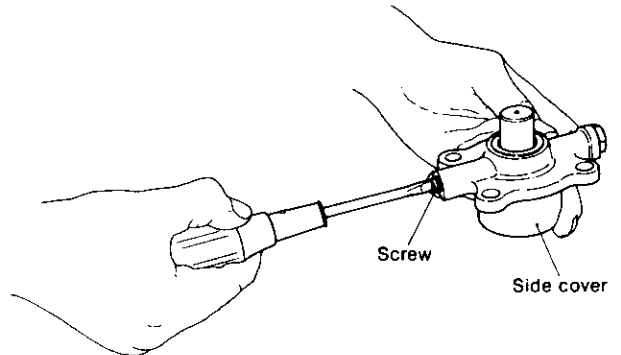
- (1) Fit the oil seal and needle bearing to the side cover.



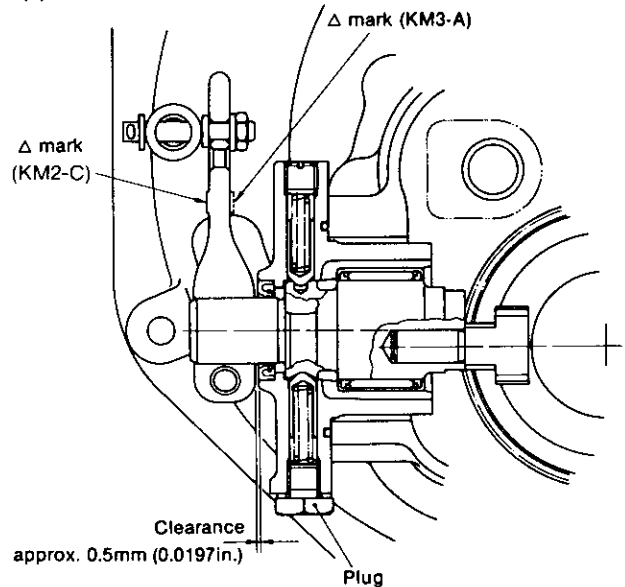
- (2) Fit the shift lever.



- (3) Fit the notch and spring, and screw in the plug and stop screw.

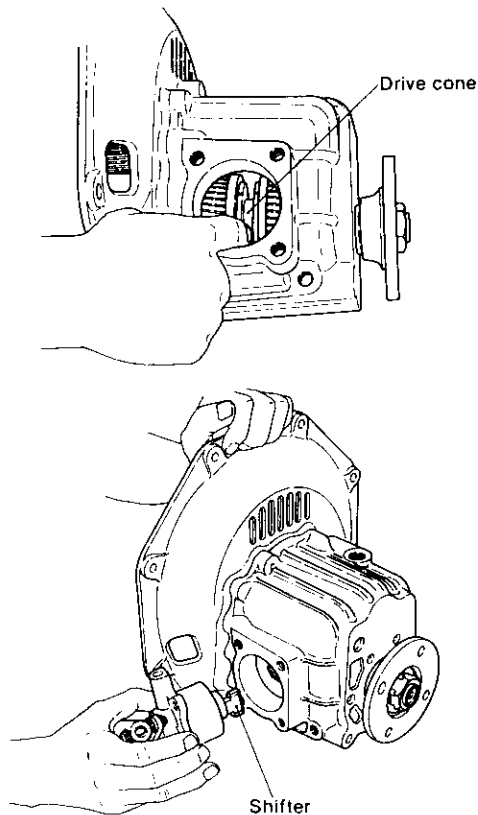


- (4) Fit the shift lever and set the bolt.



NOTE: The clearance between the surface of the side cover and the operation lever is to be 0 ~ 0.5mm (0 ~ 0.0197in.)

- (5) Fit the shifter to the shift lever shaft.
- (6) Fit the side cover to the clutch case. Ensure that the shifter engages the groove of the drive cone.



- (7) Check that the lever turns smoothly.
NOTE: The lever may not turn smoothly if the housing is not filled with lubricating oil.
- (8) Fit the spring joint, and set the remote control cable after adjusting.
For fitting and adjustment refer to the detailed explanation in the appropriate section.

For model 3HM35(F)

1. Construction

1-1 Construction

The Kanzaki-Carl Hurth KMW10 reduction reversing gear was developed jointly by Kanzaki Precision Machine Co., Ltd, a subsidiary of Yanmar and one of Japan's leading gear manufacturers, and Carl Hurth Co.

The KBW10 consists of a multi-disc clutch and reduction gear housed in a single case. It is small, light, simply constructed and extremely reliable.

*The force required to shift between forward and reverse can be controlled by a cable type remote control system much smaller and simpler than other types of

reduction reversing gears.

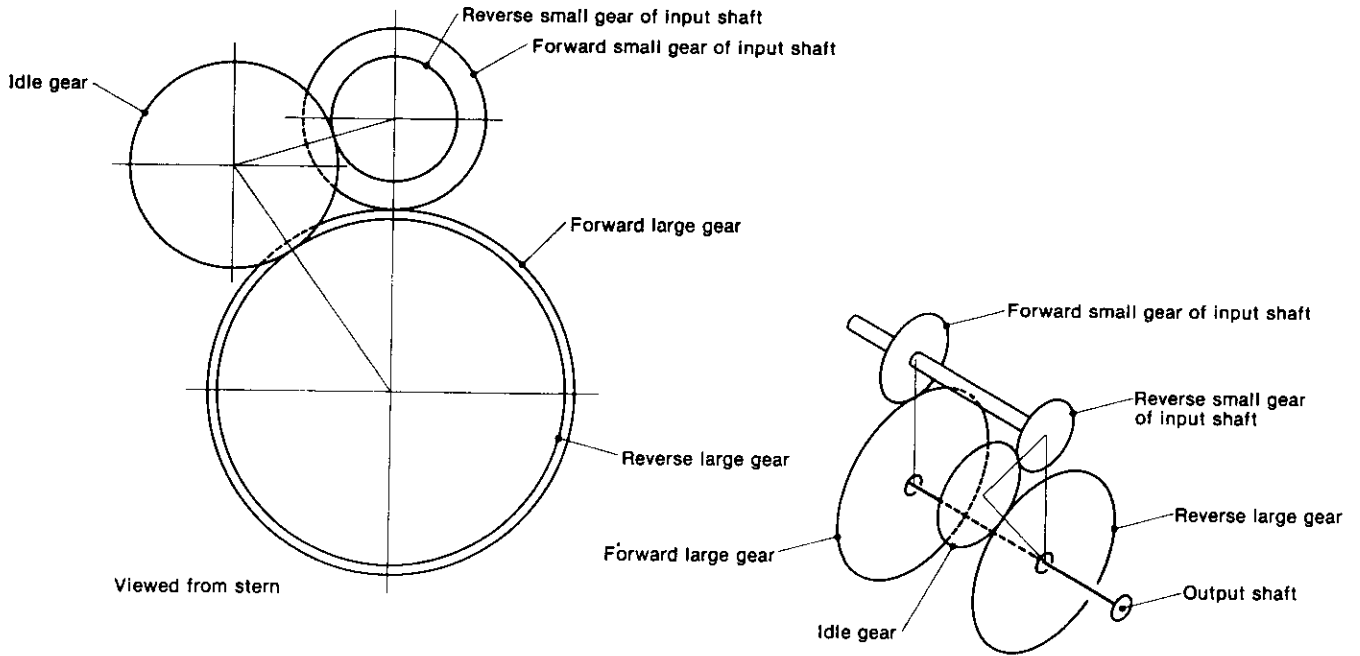
*The friction discs are durable sinter plates, and the surface of the steel plates are corrugated in a sine curve shape to ensure positive engagement and disengagement and minimum loss of transmission force.

*Because of the special construction of this gear, the optimum pressure is automatically applied to the clutch plate in direct proportion to the input shaft torque.

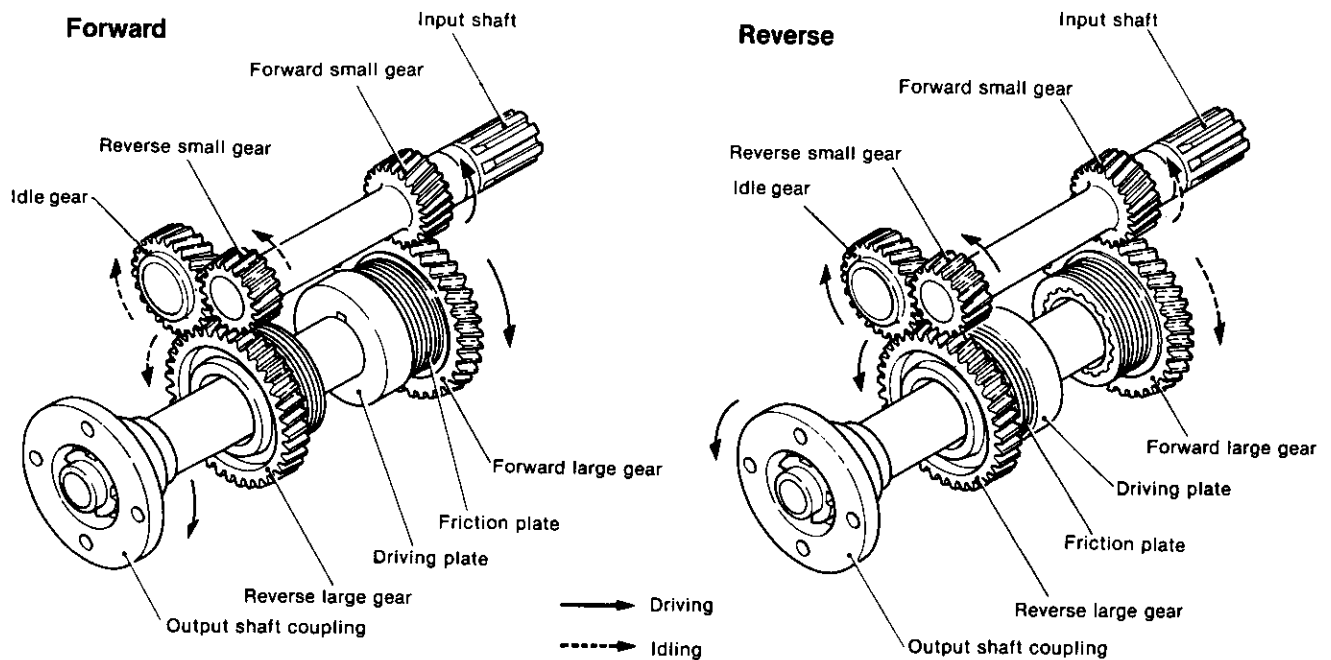
1-2 Specifications

Engine model			3HM35(F)	
Nomenclature			KBW10E	
Reduction system			One-stage reduction, helical gear	
Reversing system			Constant mesh gear	
Clutch			Wet type multi-disc, mechanically operated	
Reduction ratio	Forward		2.14	2.83
	Reverse		2.50	
Direction of rotation	Input shaft		Counterclockwise as viewed from stern	
	Output shaft	Forward	Clockwise as viewed from stern	
		Reverse	Counterclockwise as viewed from stern	
Lubricating oil			DEXRON·ATF	
Lubricating oil capacity			0.7 L	

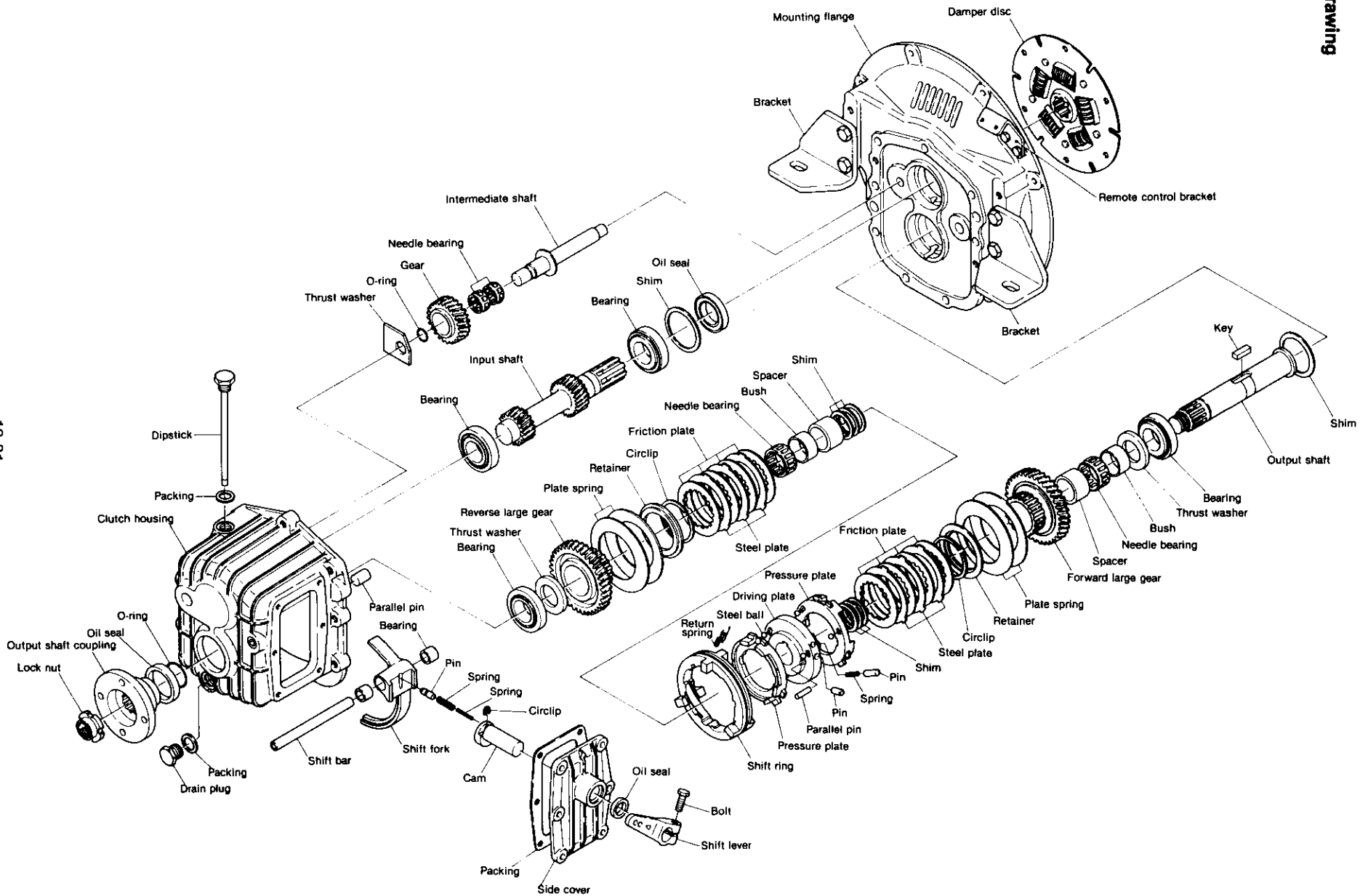
1-3 Power transmission system



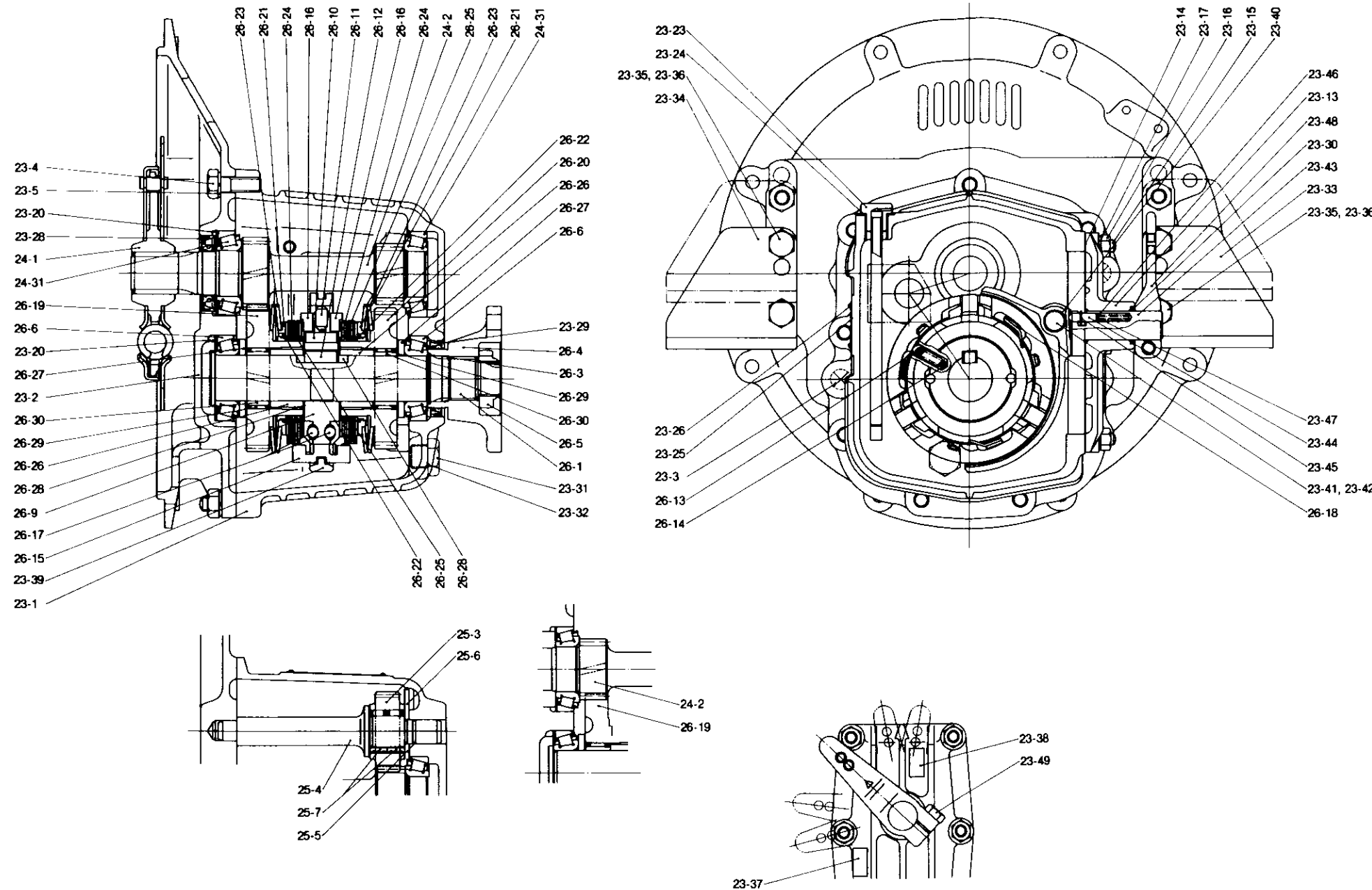
Forward			Reverse			
Number of teeth		Reduction ratio	Number of teeth			Reduction ratio
Forward small gear of input shaft	Forward large gear		Reverse small gear of input shaft	Idle gear	Reverse large gear	
22	47	$47/22 = 2.14$	18	25	45	$45/18 = 2.50$
18	51	$51/18 = 2.83$				



1-4 Drawing



KBW10-E



- | | |
|--|--|
| 23-1 HOUSING, clutch | 24-1 DISC, damper |
| 23-2 FLANGE, mounting | 24-2 INPUT SHAFT |
| 23-3 PARALLEL PIN | 24-31 ROLLER BEARING
LM67048/LM67010 |
| 23-4 BOLT M10 × 30 | 25-3 IDLE GEAR |
| 23-5 LOCK WASHER 10 | 25-4 SHAFT, idle gear |
| 23-13 COVER (side) | 25-5 O-RING S—15 |
| 23-14 PACKING, cover | 25-6 WASHER, thrust |
| 23-15 STUD M8 × 22 | 25-7 NEEDLE BEARING |
| 23-16 NUT M8 | 26-1 OUTPUT SHAFT |
| 23-17 LOCK WASHER 8 | 26-3 O-RING S—30 |
| 23-20 SHIM SET, output
& input shaft | 26-4 COUPLING, output |
| 23-22 DIPSTICK
w/BREATHER,
lube oil | 26-5 LOCK NUT |
| 23-24 PACKING 16 | 26-6 ROLLER BEARING
LM67048/LM67010 |
| 23-25 LABEL | 26-8 PLATE, assembly
driving (inc. 26-9 ~ 11) |
| 23-26 RIVET | 26-9 PLATE, driving |
| 23-28 OIL SEAL (TC30528),
input shaft | 26-10 PARALLEL PIN |
| 23-29 OIL SEAL (TC40528),
output shaft | 26-11 PARALLEL PIN |
| 23-30 OIL SEAL (SD 20264),
cover | 26-12 KEY |
| 23-31 PLUG M16 | 26-13 PIN |
| 23-32 PACKING 16 | 26-14 SPRING |
| 23-33 BRACKET (A) | 26-15 RING, shifting |
| 23-34 BRACKET (B) | 26-16 PLATE, pressure |
| 23-35 BOLT M10 × 30 | 26-17 STEEL BALL (8mm) |
| 23-36 LOCK WASHER 10 | 26-18 SPRING, return |
| 23-37 LABEL, FORWARD | 26-19 GEAR |
| 23-38 LABEL, REVERSE | 26-20 GEAR |
| 23-39 FORK Assembly,
shift (inc. 23-40) | 26-21 RETAINER |
| 23-40 DRY BEARING | 26-22 CIRCLIP |
| 23-41 SHAFT, shift | 26-23 SPRING |
| 23-42 PLUG | 26-24 DISC, friction |
| 23-43 CAM, shift | 26-25 PLATE, steel |
| 23-44 PIN | 26-26 SPACER |
| 23-45 CIRCLIP | 26-27 WASHER, thrust |
| 23-46 SPRING (A) | 26-28 SHIM SET, output, shaft |
| 23-47 SPRING (B) | 26-29 NEEDLE BEARING |
| 23-48 LEVER, shift | 26-30 RACE, inner |
| 23-49 BOLT M8 × 25 | |

2. Installation

2-1 Installation angle

During operation the angular inclination of the gearbox in the longitudinal direction must be less than 20° relative to the water line.

2-2 Remote control unit

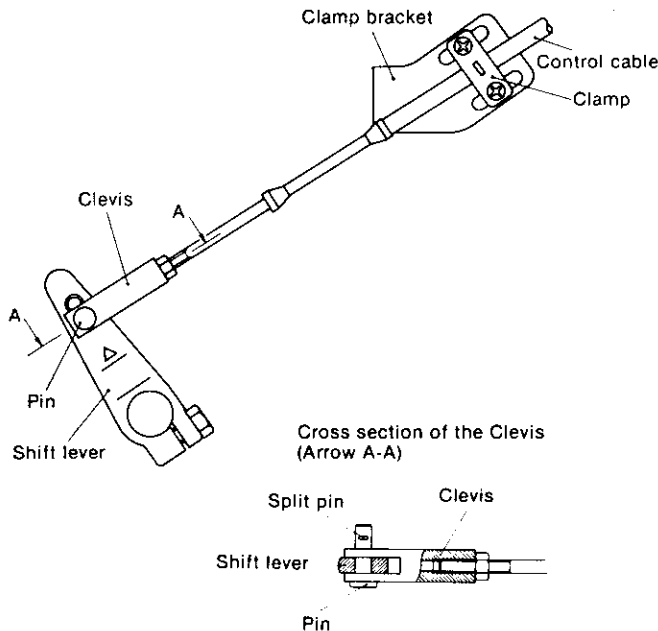
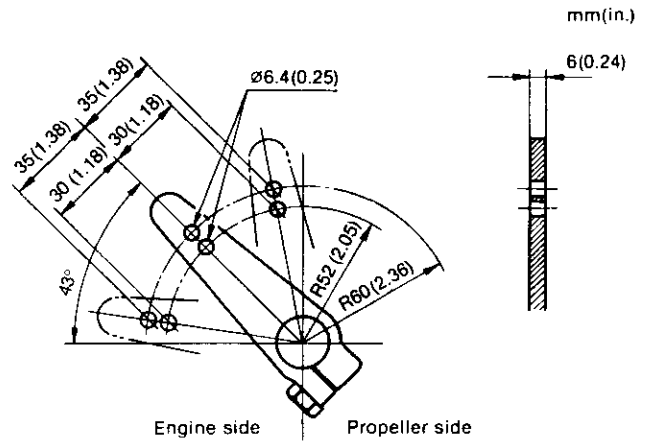
This marine gearbox is designed for single lever control to permit reversing at full engine speed (e.g. to avoid danger, etc.). Normally, Morse or Teleflex single lever control is employed. During installation, make sure that the remote control lever and shift lever on the marine gearbox are coordinated. Shifting the lever toward the propeller side produces forward movement, while moving the lever toward the engine side causes the vessel to move in the reverse direction.

To connect the linkage, the operating cable must be positioned at right angles to the shift lever when the shift lever is in the neutral position.

The shift play, measured at the pivot point of the shift lever, must be at least 35mm on each side (reverse and forward) of the neutral position. Greater shift play has no adverse effect on the marine gearbox. After connecting the linkage, confirm that the remote control and the shift lever on the marine gearbox work properly.

A typical linkage arrangement is illustrated in the figure below.

When the cable is attached to the hole 52mm (2.0472in.) from the center of the rotation of the shift lever, these strokes must be 30mm (1.1811in.)



NOTE: Since the cable stroke may be insufficient, two holes are drilled in the shift lever.

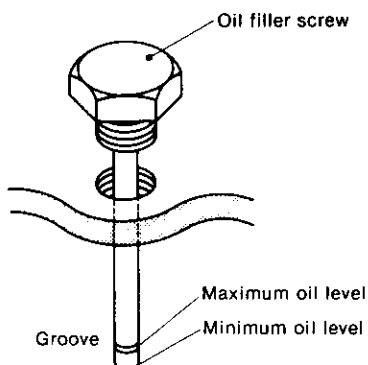
When the cable is attached to the hole 60mm (2.3622in.) from the center of the rotation of the shift lever, the strokes from the center to the forward and reverse sides must both be 35mm (1.3780in.).

3. Operation and Maintenance

3-1 Lube oil

(1) Oil level

The oil level should be checked each month and must be maintained between the groove and the end of the dipstick. The groove indicates the maximum oil level and the end of the dipstick is the minimum oil level. When checking the oil level with the dipstick, do not screw in the oil filler screw; it should rest on top of the oil filler hole.



(2) Oil change

Change the oil after the first 100 hours of operation, and every 300 hours of operation thereafter. When adding oil between oil changes, always use the same type of oil that is in the marine gearbox.

(3) Recommended brands of lube oil

Supplier	Brand name
SHELL	SHELL DEXRON
CALTEX	TEXAMATIC FLUID (DEXRON)
ESSO	ESSO ATF
MOBIL	MOBIL ATF220
B.P. (British Petroleum)	B.P. AUTRAN DX

3-2 Precautions

Do not stop the shift lever halfway between the neutral and forward or reverse positions. The lever must be set to the neutral position or shifted into forward or reverse in a single motion.

3-3 Side cover

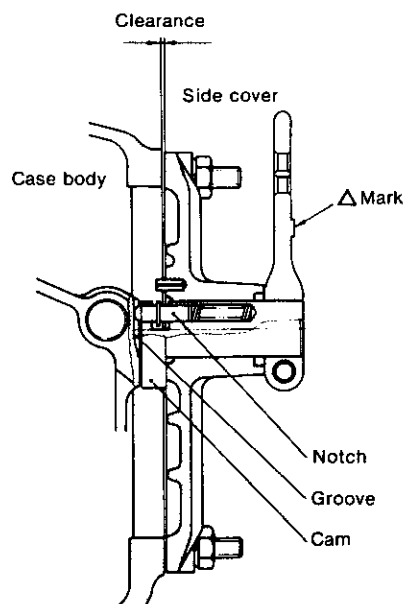
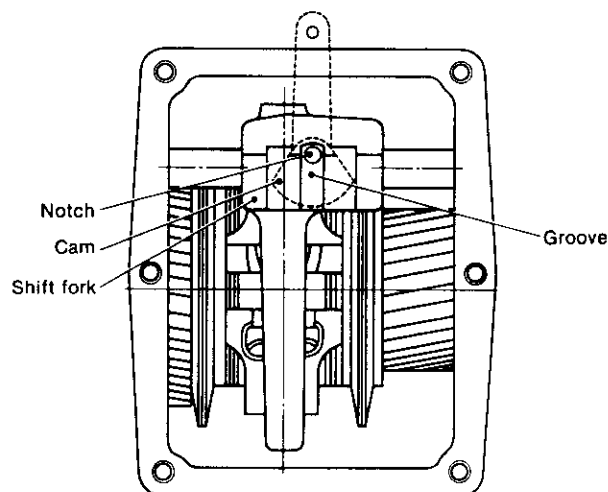
The internal shifting mechanism has been carefully aligned at the factory. Improper removal of the side cover can cause misalignment. If the side cover must be removed, proceed as follows:

—Before removing the cover, put alignment marks on the side cover and the case to facilitate accurate installation.

—When installing the side cover, put the shift lever in neutral so that the cam lobe on the shift lever engages the groove on the internal shift mechanism. When the cam

lobe and groove are engaged properly there will be no clearance between the body and the side cover. Do not use packing or gaskets when installing the side cover.

—After making sure that the cam lobe and notches are aligned properly, securely tighten all the bolts. After tightening the bolts, move the lever back and forth. Positive contact should be felt and a click should be clearly audible as the gears shift; otherwise, the cam and notch are not properly engaged, and the cover must be loosened and readjusted until proper engagement is achieved.



4. Inspection and Servicing

4-1 Clutch case

- (1) Check the clutch case with a test hammer for cracking. Perform a color check when required. If the case is cracked, replace it.
- (2) Check for staining on the inside surface of the bearing section. Also, measure the inside diameter of the case. Replace the case if it is worn beyond the wear limit.

4-2 Bearing

- (1) Rusting and damage
If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly. If rotation is not smooth, if there is any binding, or if an abnormal sound is heard, replace the bearing.

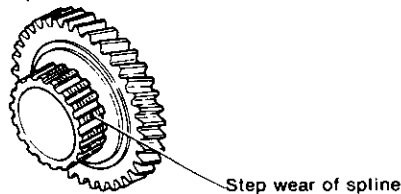
4-3 Gear

- (1) Tooth surface wear
Check the tooth surface for pitching, abnormal wear, dents, and cracks. Repair lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact
Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash
Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

	mm (in.)	
	Maintenance standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.1 ~ 0.2 (0.0040 ~ 0.0079)	0.3 (0.0118)
Input shaft reverse gear and intermediate gear	0.1 ~ 0.2 (0.0040 ~ 0.0079)	0.3 (0.0118)
Intermediate gear and output shaft reverse gear	0.1 ~ 0.2 (0.0040 ~ 0.0079)	0.3 (0.0118)

(4) Forward/reverse gear spline

- 1) Check the spline for damage and cracking.
- 2) Step wear of spline
Step wear depth limit: 0.1mm (0.0040in.)



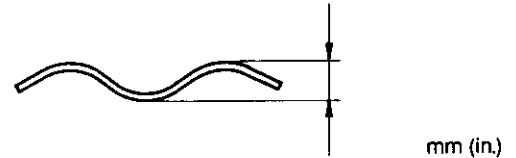
(5) Forward/reverse gear needle bearing

When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.



4-4 Steel plate

- (1) Burning, scratching, cracking
Replace any steel plates that are discolored or cracked.
- (2) Warping measurement

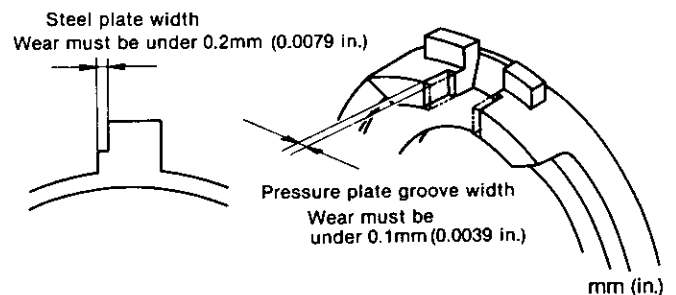


	Maintenance standard	Wear limit
Warping	1.6 ^{+0.10} / _{-0.11} (0.05870 ~ 0.067)	1.4 (0.0551)

(3) Steel plate pawl width measurement



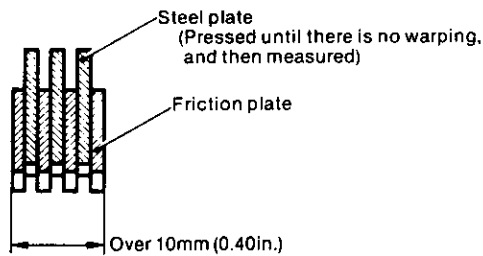
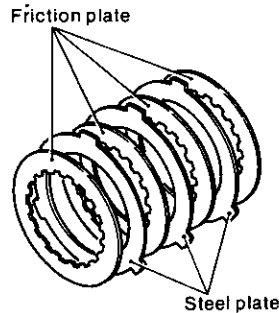
Measure the width of the steel plate pawl and the width of the pressure plate; replace the plate when the clearance exceeds the wear limit.



	Maintenance standard	Wear limit
Steel plate width	12 ⁰ / _{-0.2} (0.4646 ~ 0.4724)	Worn 0.2 (0.0079)
Pressure plate groove	12 ^{+0.1} / ₀ (0.4724 ~ 0.4764)	Worn 0.1 (0.0039)
Clearance	0 ~ 0.3 (0 ~ 0.0118)	0.3 ~ 0.6 (0.0118 ~ 0.0236)

4-5 Friction plate

- (1) Check the friction plate for burning, scoring, or cracking. Repair the plate when the damage is light and replace the plate if the damage is heavy.
- (2) Friction surface wear
Measure the thickness of the friction plate, and replace the plate when it is worn beyond the wear limit.



	mm (in.)	
	Maintenance standard	Wear limit
Friction plate thickness	1.7 $\begin{smallmatrix} 0 \\ -0.05 \end{smallmatrix}$ (0.0650 ~ 0.0670)	1.5 (0.0591)

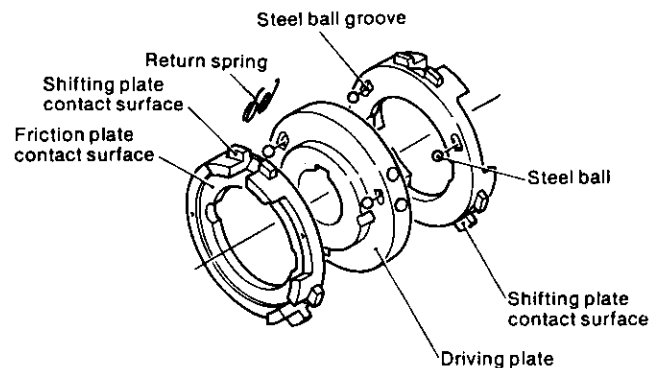
The assembled friction plate and steel plate dimensions must be over 10mm (0.0040in.).

Both sides of the friction plate have a 0.35mm copper sintered layer. Replace the friction plate when this layer is worn more than 0.2mm on one side (standard thickness 1.7 $\begin{smallmatrix} 0 \\ -0.05 \end{smallmatrix}$ mm). However, the sum of the wear of the four friction plates must not exceed 0.8mm. When this value is exceeded, replace all friction plates. In unavoidable circumstances, it is permissible to replace only the friction plate with the greatest amount of wear.

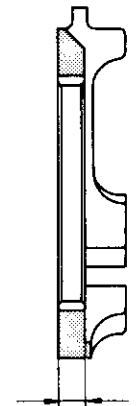
- (3) Friction plate and gear spline back clearance
Measure the clearance between the friction plate spline collar and the output shaft gear spline, and replace the plate or spline when they are worn beyond the wear limit.

	mm (in.)	
	Maintenance standard	Wear limit
Standard backlash	0.20 ~ 0.61 (0.0079 ~ 0.0240)	0.9 (0.0354)

4-6 Pressure plate

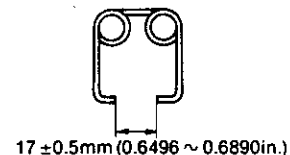


- (1) Steel ball groove
Check the steel ball groove for stains and wear. Replace the pressure plate if the groove is noticeably worn.
- (2) Friction plate contact surface
Check the contact face for stains and damage.
- (3) Shifting plate contact surface
- (4) Worn parts measurement

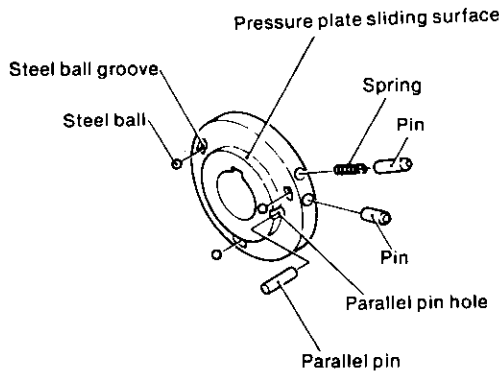


	mm (in.)	
	Maintenance standard	Wear limit
Thickness: t	6.6 $\begin{smallmatrix} 0 \\ -0.2 \end{smallmatrix}$ (0.2520 ~ 0.2598)	6.3 (0.2480)

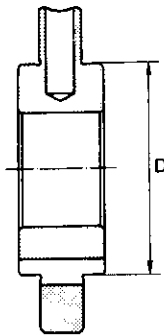
- (5) Return spring permanent strain.
Make sure the length (free length) is within the values specified in the figure.



4-7 Driving plate



- (1) Check the key groove for scoring and cracking, and the output shaft fitting section for burning. Repair if the damage is light and replace the driving plate if the damage is heavy.
- (2) Outside diameter of pressure plate sliding part; others



	mm (in.)	
	Maintenance standard	Wear limit
Outside diameter: D	$\varnothing 59 \begin{smallmatrix} -0.060 \\ -0.134 \end{smallmatrix}$ (2.3176 ~ 2.3205)	$\varnothing 58.8$ (2.3150)

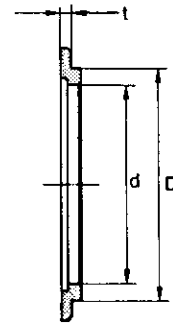
- (3) Steel ball groove wear and stains.
- (4) Determine the amount of wear and play of both the axial and circumferential direction pins.
- (5) Permanent spring strain.

	mm (in.)	
	Maintenance standard	Wear limit
Spring free length	32.85 (1.2933)	32 (1.2598)

- (6) Pin end wear.

4-8 Retainer

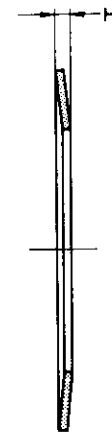
- (1) Check for stains and damage on the friction plate contact surface.
- (2) Check for wear and cracking on the plate spring contact surface.
- (3) Measurement of dimensions



	mm (in.)	
	Maintenance standard	Wear limit
d	$\varnothing 57.5 \begin{smallmatrix} +0.106 \\ +0.060 \end{smallmatrix}$ (2.2661 ~ 2.2680)	$\varnothing 57.8$ (2.2756)
D	$\varnothing 66 \begin{smallmatrix} 0 \\ -0.1 \end{smallmatrix}$ (2.5945 ~ 2.5984)	$\varnothing 65.7$ (2.5866)
t	$2.8 \begin{smallmatrix} 0 \\ -0.08 \end{smallmatrix}$ (0.1071 ~ 0.1102)	2.6 (0.1024)

4-9 Plate spring

- (1) Permanent strain

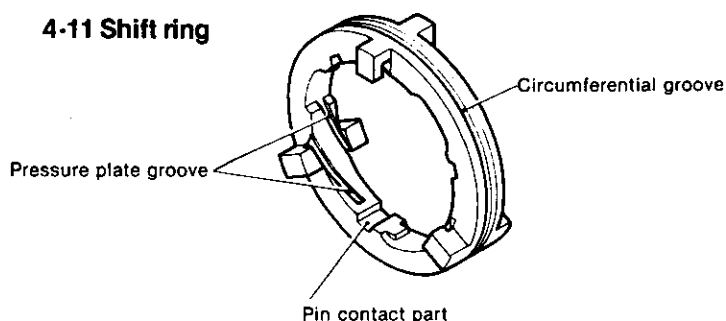


	mm (in.)	
	Maintenance standard	Wear limit
H: when plate spring is free	6.25 ± 0.1 (0.2421 ~ 0.2500)	6.0 (0.2362)

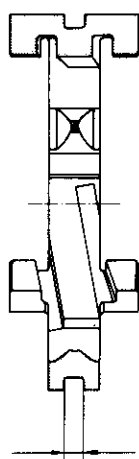
4-10 Thrust collar

The gear side of the thrust washer has a 0.3mm copper sintered layer. Replace the thrust collar when the thickness is less than 4.75mm (standard thickness: $5 \begin{smallmatrix} 0 \\ -0.1 \end{smallmatrix}$ mm).

4-11 Shift ring



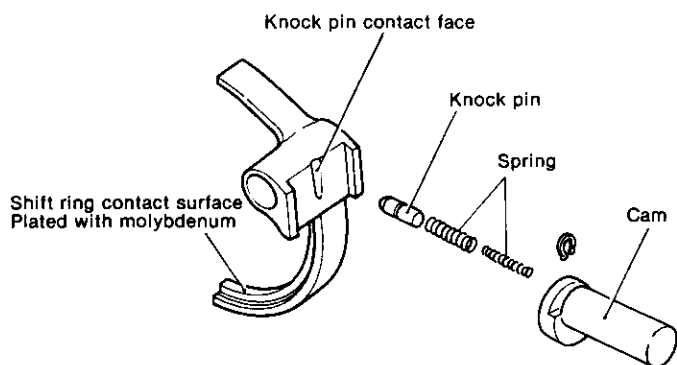
(1) Circumferential groove wear.



	Maintenance standard	Wear limit
Shifting groove:w	6 ^{+0.1} ₀ (0.2362 ~ 0.2402)	6.3 (0.2480)

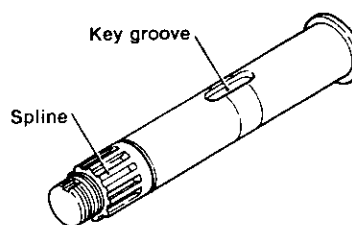
- (2) Pressure plate groove wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Parallel pin contact part wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-12 Shift fork and shift lever



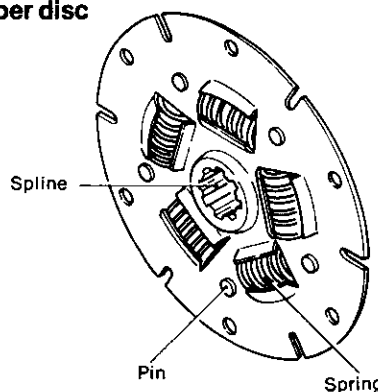
- (1) End wear.
The shift ring contact surface of the shift fork is plated with molybdenum (thickness: 0.04—0.05mm). If this plating is peeled or worn to such an extent that the base metal of the shift fork is exposed, replace the shift fork.
- (2) Cam surface wear and stains.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin part play.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (4) Notch end wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-13 Output shaft



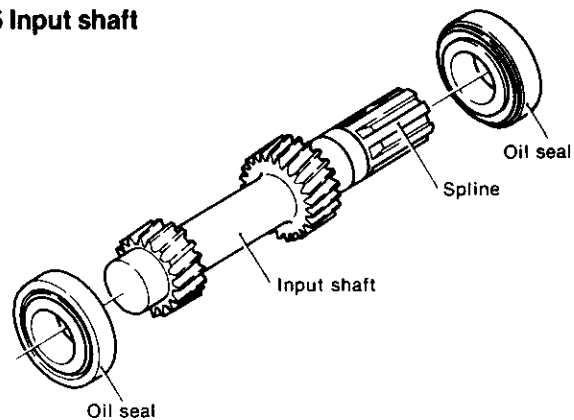
- (1) Key groove.
Whenever uneven cracks and/or stains are found, replace with a new part.

4-14 Damper disc



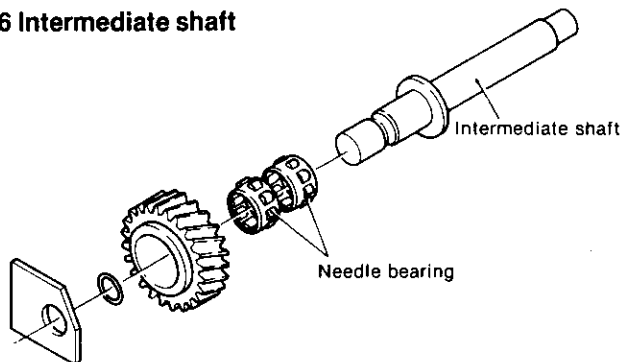
- (1) Spline part
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Spring.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-15 Input shaft



- (1) Spline part
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Surface of oil seal.
If the sealing surface of the oil seal is worn or scratched, replace.

4-16 Intermediate shaft

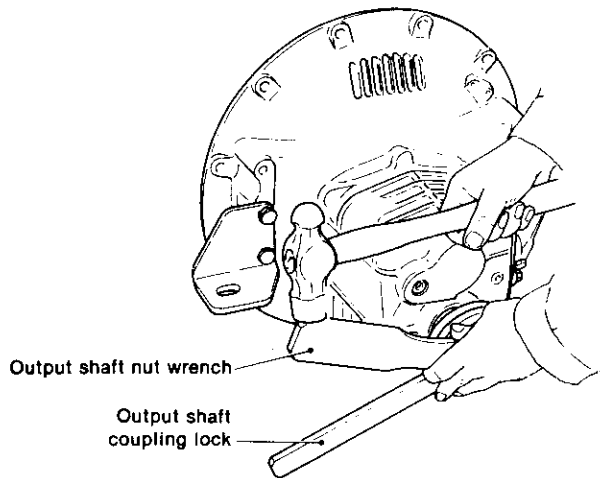
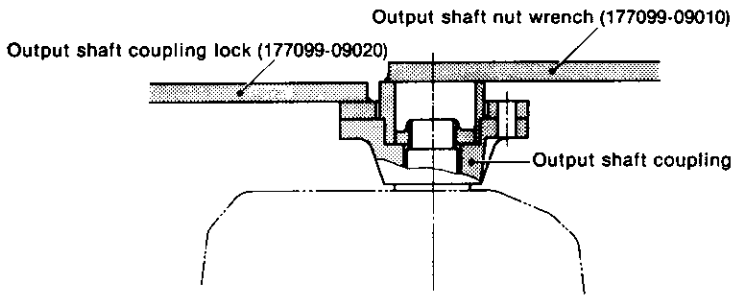


- (1) Needle bearing dimensions, staining.
Check the surface of the roller to see whether the needle bearing sticks or is damaged. Replace if necessary.

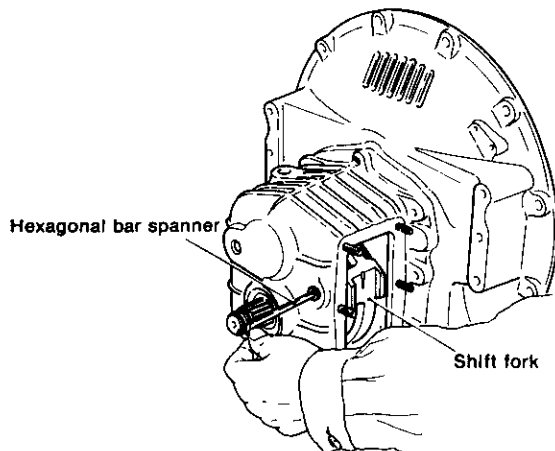
5. Disassembly

5-1 Disassembling the clutch and accessories

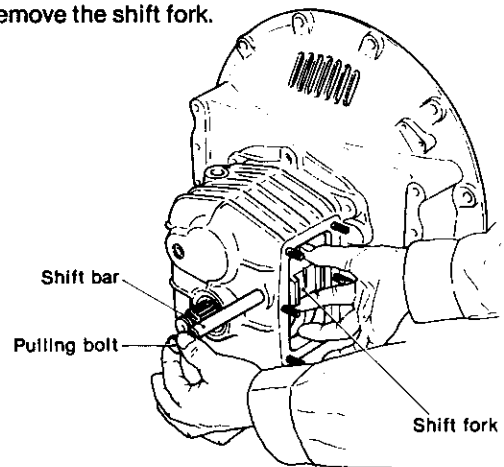
- (1) Remove the drain plug and packing, and drain the oil from the clutch.
- (2) Uncaulk the output shaft lock nut, and remove the nut using a disassembly tool.



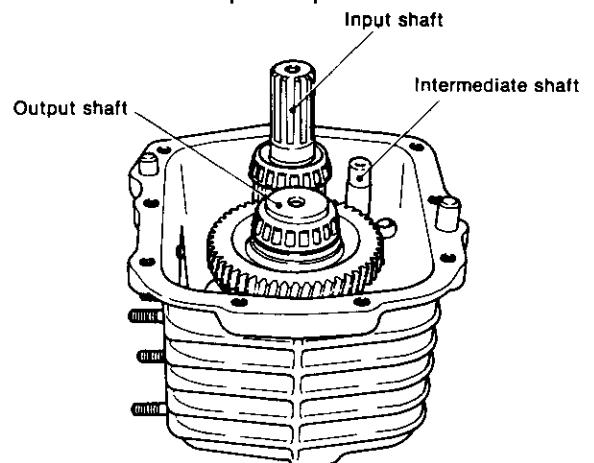
- (3) Remove the output coupling.
- (4) Remove the dipstick and packing.
- (5) Remove the case cover M8 nut super lock washer; remove the case cover, with the operating lever, shift cam, etc. in position.
- (6) Remove the shift bar plug with a hexagonal bar spanner (width across flats: 8mm (0.0394in.)), and pull the shift bar from the case, using the M10 pulling bolt at the end of the shift bar.



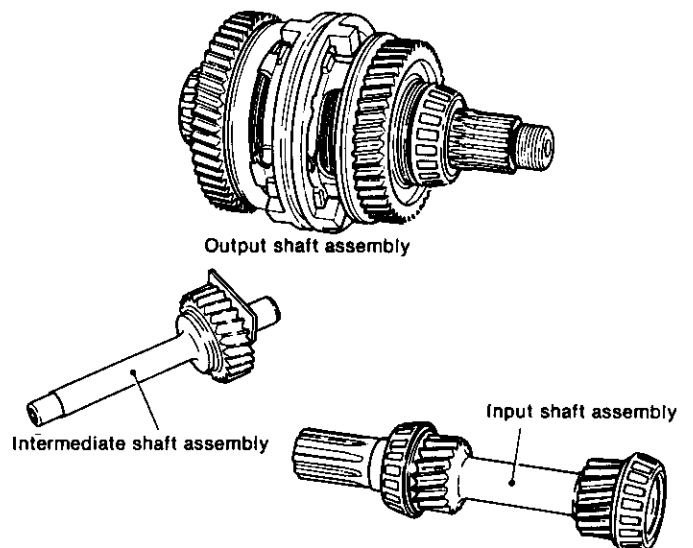
- (7) Remove the shift fork.



- (8) Remove the M10 bolt and super lock washer on the mounting flange.
- (9) Screw the M10 bolt into the M10 pulling bolt hole of the mounting flange, and remove the mounting flange. Do not remove the parallel pin.



- (10) Remove the output shaft, intermediate shaft, and input shaft from the case, in that order.



- (11) Heat the case body to about 100°C and remove the outer race of the input shaft and output shaft bearings. If the outer races are difficult to remove, tap them out with a plastic hammer from the rear of the case, or pull them by using the pulling groove in the case at the rear of the races.
- (12) Remove the outer race of the bearing from the mounting flange as described in step (11) above.
- (13) Remove the input shaft and output shaft adjusting plates.

NOTE: If the following parts are not replaced, the adjusting plates may be reused without readjustment. However, if even one part is replaced, readjustment is necessary.

Input shaft part: 24-2, 24-31

Output shaft part: 26-6, 26-9, 26-26, 26-27, 26-28, 26-30

- (14) Pull the oil seal from the case.
- (15) Pull the oil seal from the mounting flange.

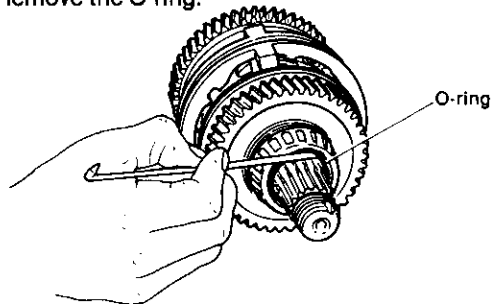
5-2 Disassembling the input shaft

Pull the bearing from the input shaft.

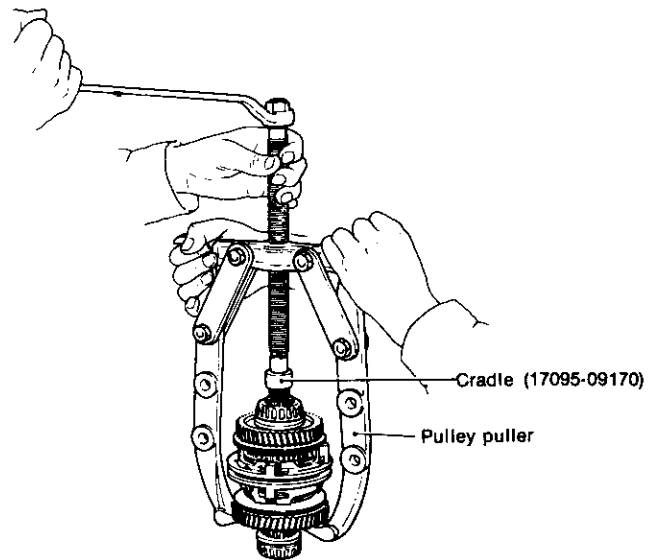
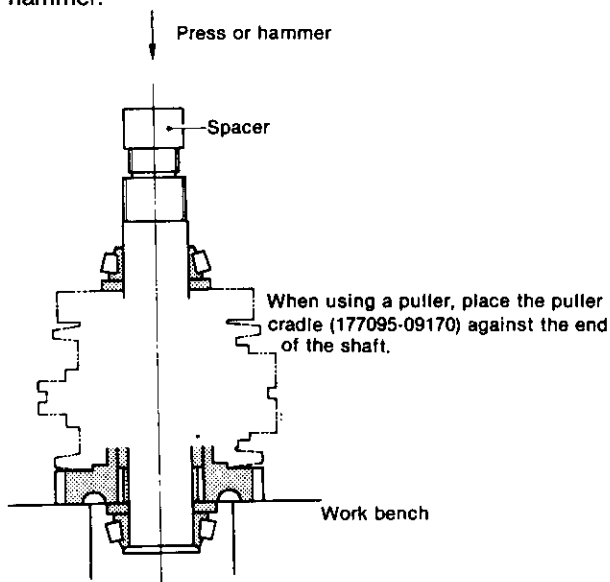
NOTE: Do not disassemble unless the input shaft parts are damaged.

5-3 Disassembling the output shaft

- (1) Remove the O-ring.



- (2) Remove the output shaft by pressing the threaded end of the output shaft with a press, or tapping it with a hammer.



NOTE 1: When removing the shaft, place spacers between the shaft and the press to prevent damage.

NOTE 2: Make sure that the forward large gear parts and reverse large gear parts are not mixed together once they are removed.

- (3) Remove the adjusting plate.

NOTE: Record the thickness of the adjusting plate to facilitate reassembly.

If the parts are not replaced, the adjusting plate may be reused without readjustment. However, if even one part is replaced, readjustment is required.

- (4) Remove the key.

To facilitate removal, clamp the key with a vice.

- (5) Remove the adjusting plate.

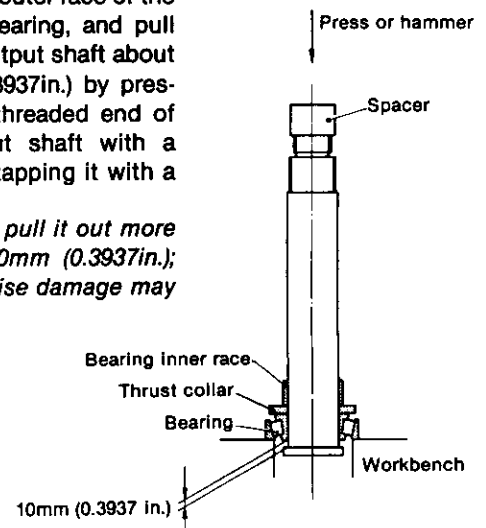
NOTE: Record the thickness of the adjusting plate to facilitate reassembly.

If the parts are not replaced, the adjusting plate may be reused without adjustment. However, if even one part is replaced, readjustment is required.

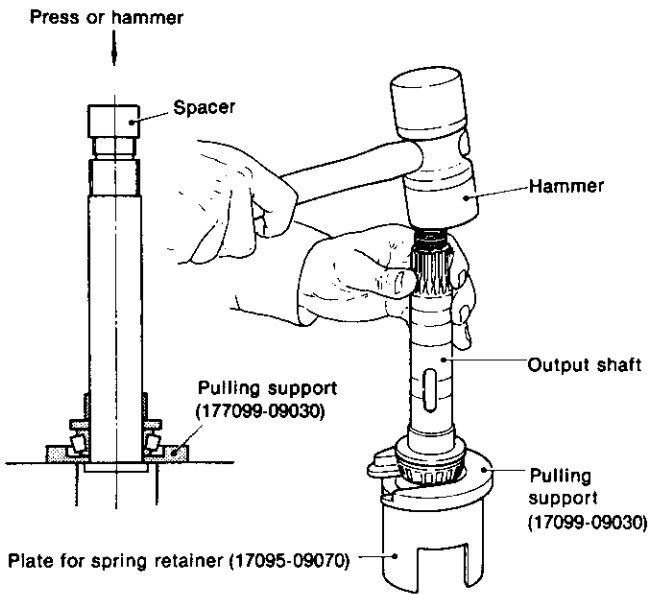
- (6) Remove the spacer and needle bearing.

- (7) Cover the outer race of the forward bearing, and pull out the output shaft about 10mm (0.3937in.) by pressing the threaded end of the output shaft with a press, or tapping it with a hammer.

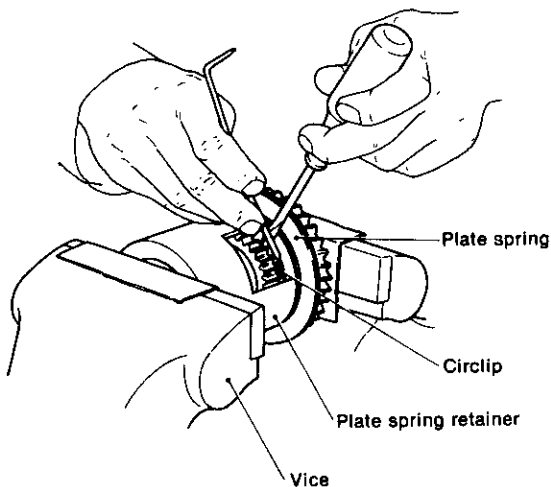
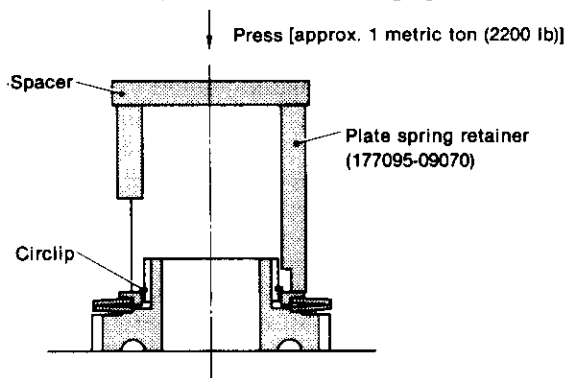
NOTE: Do not pull it out more than 10mm (0.3937in.); otherwise damage may result.



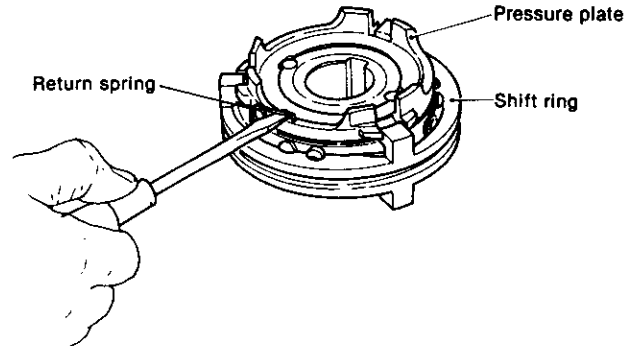
- (8) Insert the disassembly tool between the collar of the output shaft and the bearing; next remove the bearing inner race, thrust collar, and bearing from the output shaft with a press or hammer.



- (9) Remove the friction plates and steel plates from the forward large gear.
(10) Using a disassembly tool, compress the plate spring and remove the circlip from the forward large gear.



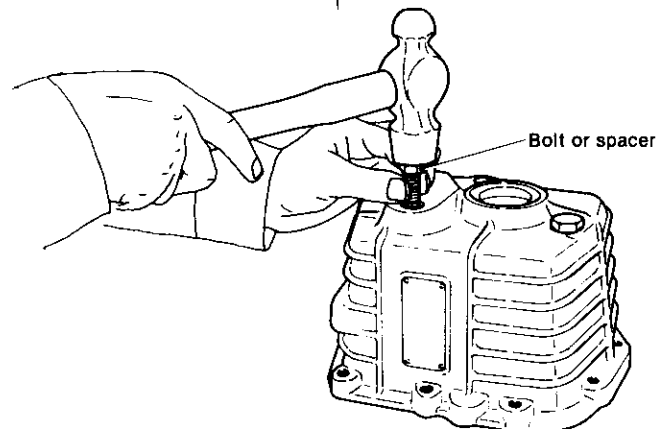
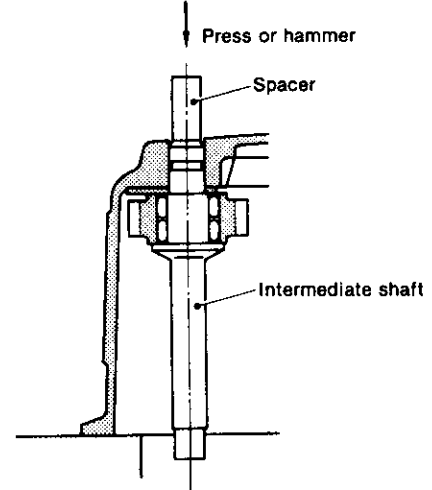
- (11) Remove the retainer and plate spring.
(12) Remove the parts from the reverse large gear as described in steps (9)—(11) above.
(13) Remove the pressure plate return spring; remove the pressure plate and steel ball.



- (14) Remove the shift ring.
To disassemble, remove the three knock pins. When disassembling the shift ring, cover it with a cloth to prevent it being lost.
(15) Remove the knock pin and spring from the driving plate.

5-4 Disassembling the intermediate shaft

- (1) Place a spacer against the case side end of the intermediate shaft and remove the shaft from the case by tapping the spacer with a hammer.



- (2) Remove the O-ring.
- (3) Remove the idle gear, needle bearing, and thrust washer.

5-5 Disassembling the operating system

- (1) Loosen the M8 bolt of the shift lever; remove the shift lever.
- (2) Pull the shift cam.
- (3) Push in the knock pin and remove the circlip.
- (4) Remove the knock pin and spring.
- (5) Pull the oil seal from the case side cover.

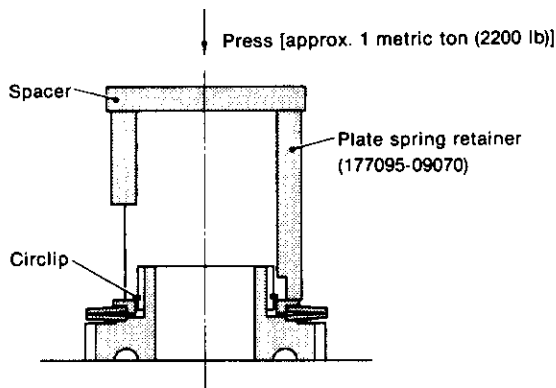
6. Reassembly

6-1 Reassembly precautions

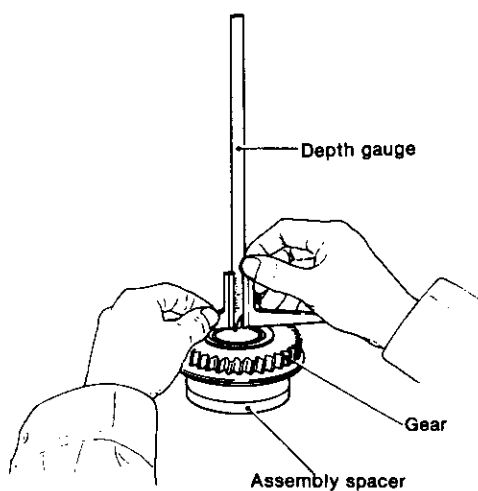
- (1) Before reassembling, clean all parts in washing oil, and replace any damaged or worn parts.
Remove non-dry packing agent from the mating surface with a blunt knife.
- (2) Pack the oil seal and O-ring parts with grease.
- (3) Coat the mating surfaces of the case with wet packing.

6-2 Reassembling the output shaft

- (1) Reassembling forward large gear and plate spring
 - 1) Insert the two plate springs of the forward large gear so that their large diameter sides are opposite each other.
 - 2) Insert the retainer and install the circlip.
 - 3) Compress the plate spring, using the disassembly tool, and snap the circlip into the groove on the outside of the spline of the forward large gear.

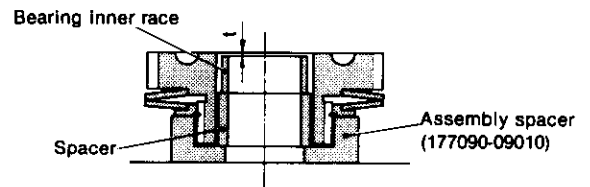


- (2) Reassemble the reverse large gear and plate spring, retainer, and circlip as described in step (1) above.
- (3) Determining the forward adjusting plate thickness



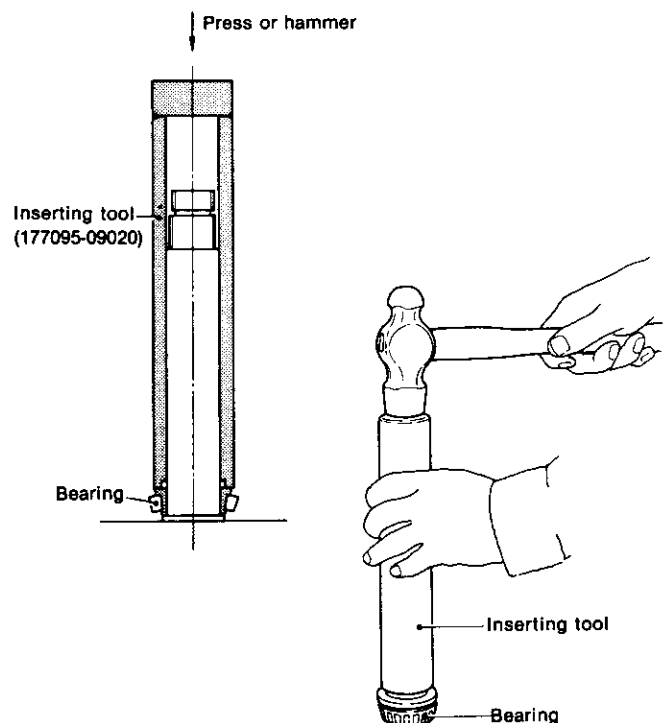
NOTE: As mentioned in section 5-3. (5), if no parts need to be replaced, the adjusting plate can be reused without adjustment.

- 1) Position the assembled large gear on the assembly tool so that the spline part is on the bottom; insert the spacer and bearing inner race into the gear.

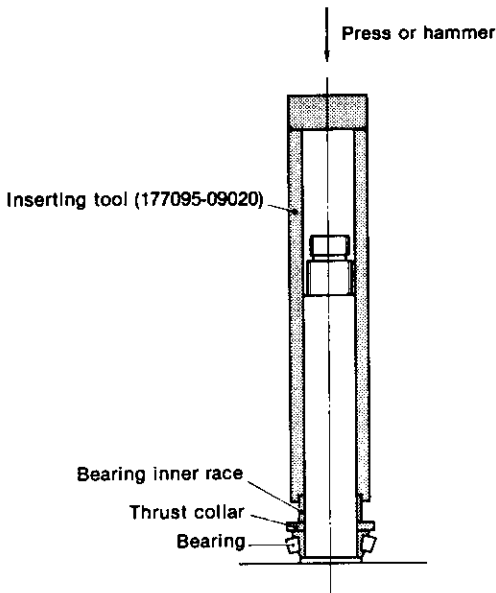


- 2) Adjust the thickness of the adjusting plate until it conforms to the dimension shown in the figure.
- 3) Two adjustment plates of 0.5mm (0.0197in.) and 0.3mm (0.0118in.) are available.
Combine these plates to obtain the "t" dimension.
- (4) Determine the thickness of the reverse adjusting plate by following the procedure described in step(3)above.
- (5) First, insert a friction plate into the spline part of the forward large gear; next insert steel plates and friction plates alternately. Finally, insert a friction plate (four friction plates and three steel plates).
- (6) Insert the friction plates and steel plates into the spline part of the reverse large gear in the same manner as described in step (5) above (four friction plates and three steel plates).
- (7) Press the inner race of the bearing onto the output shaft up to the collar, using an assembly tool.

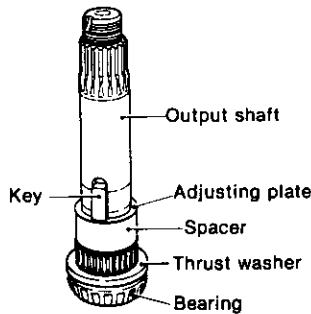
NOTE: The inner race can be installed easily by preheating it to approximately 100°C.



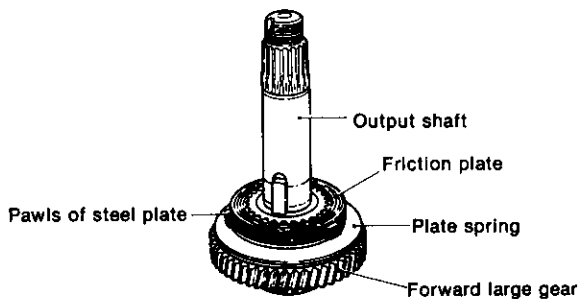
- (8) Insert the thrust collar, with the sintered surface (brown surface) facing the gear side.
- (9) Press the bearing inner race onto the output shaft, using an assembly tool.



- (10) Insert the needle bearing.
- (11) Insert the spacer and adjusting plate.
- (12) Fit the key so that the fillet side is facing the threaded part of the output shaft.



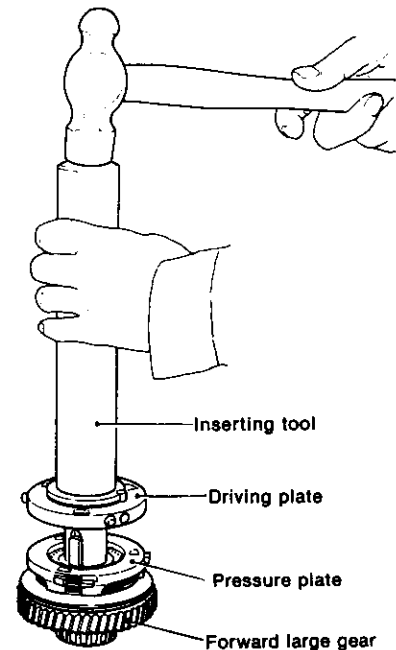
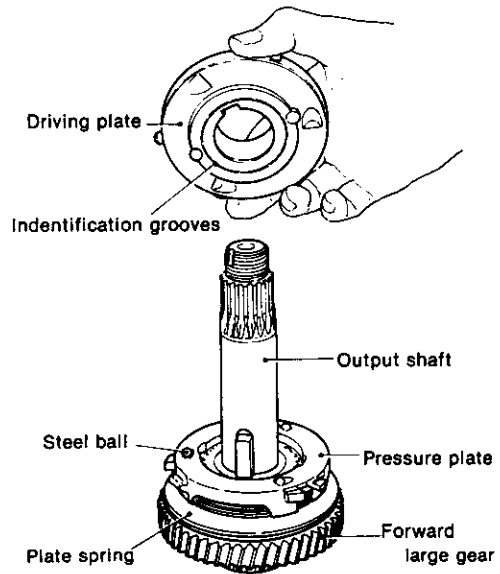
- (13) Insert the forward large gear, together with the friction plates and steel plates. At this time, align the three pawls on the outside of the steel plates.



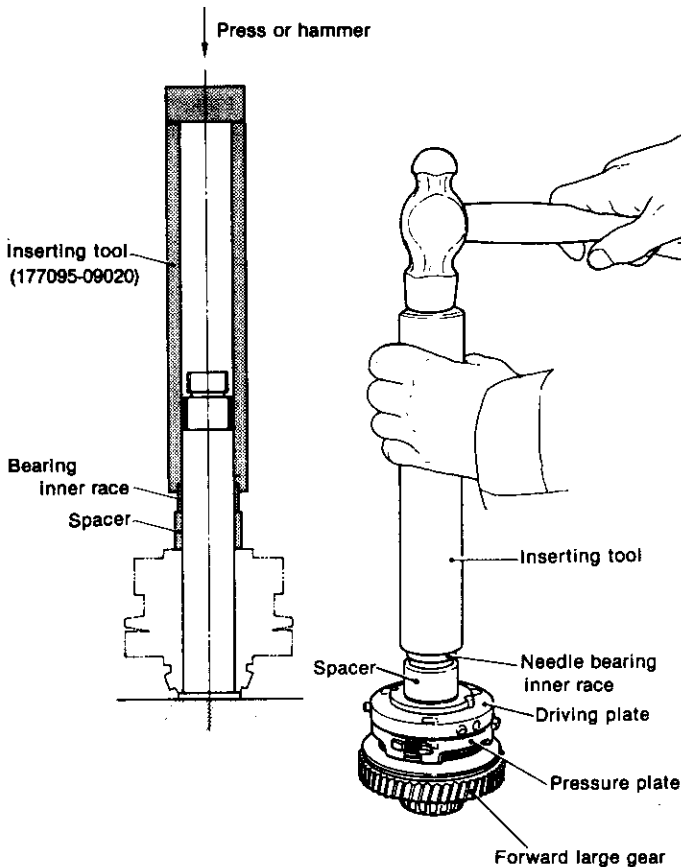
- (14) Cover the friction plates and steel plates with the pressure plate so that the pawls of the steel plate fit into the three notches on the pressure plate.
- (15) Insert the three steel balls into the three grooves in the pressure plate.

- (16) Insert the drive plate into the output shaft so that the side with the identification groove faces the forward large gear side.

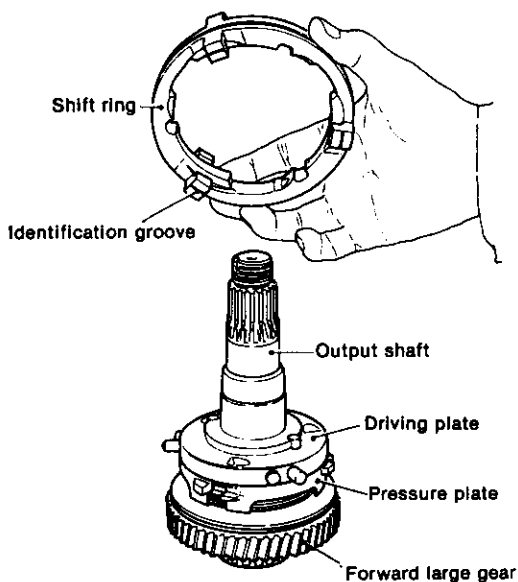
NOTE: Make sure that the three steel balls are in the three grooves of the driving plate. At the same time, make sure that the pin for the driving plate fits into the groove of the torque limiter for the pressure plate.



- (17) Insert the adjusting plate and spacer.
- (18) Press the bearing inner race, using an assembly tool.

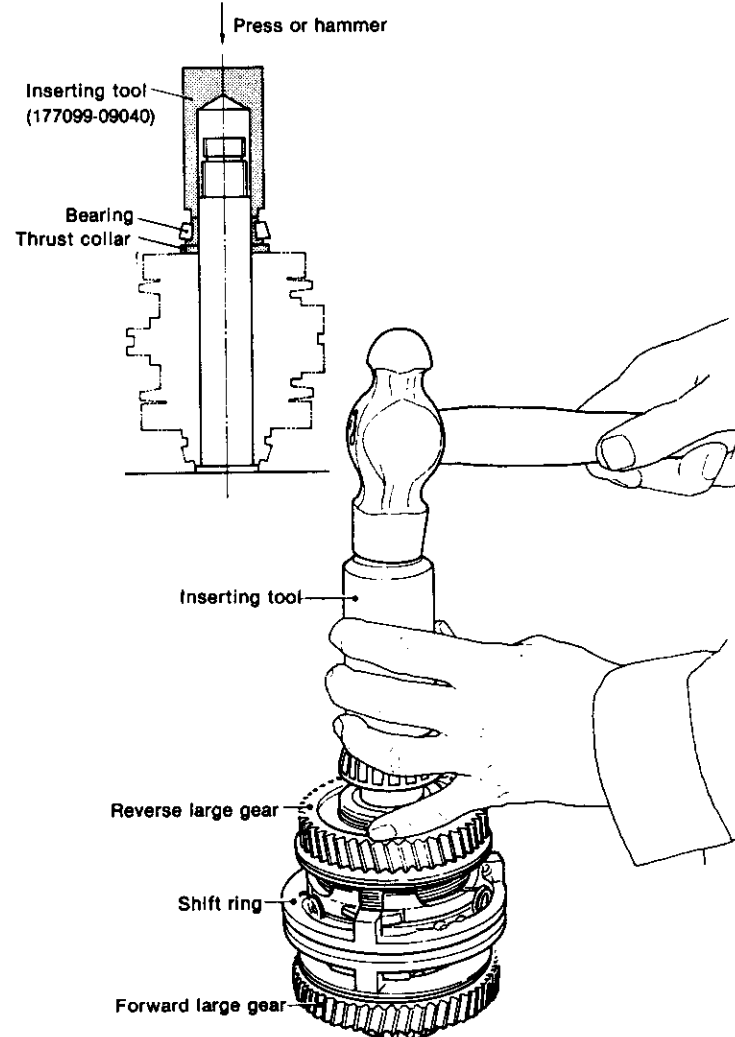


- (19) Insert the knock pins and springs into the three holes around the circumference of the driving plate.
- (20) Cover the driving plate with the shift ring so that the side with the identification groove faces the forward large gear side; install the ring so that the knock pins are pushed in.



- (21) Insert the three steel balls into the three grooves in the driving plate.
- (22) Place the pressure plate onto the driving plate so that the steel balls enter the three grooves of the pressure plate.
- (23) Insert the three pressure plate return springs between the shift ring and the driving plate, and attach them to the small holes in the side of the pressure plate.
- (24) Insert the reverse large gear [see step (6)] so that the three pawls of the steel plates enter the notches around the circumference of the pressure plate.
- (25) Insert the needle bearing.
- (26) Insert the thrust washer so that the sintered side (brown side) faces the gear side.
- (27) Press the inner race of the bearing, using an assembly tool. Make sure that the direction of the bearing is correct.

NOTE: The bearing inner race can be installed easily by preheating it to approximately 100°C.



- (28) Insert the O-ring.
- (29) With the shift ring in the reverse position, check the forward large gear to make sure it rotates smoothly. Next, with the shift ring in the forward position, check the reverse large gear to make sure it rotates smoothly.

6-3 Reassembling the input shaft

Press the inner race of the bearing onto the input shaft.
Make sure that the direction of the bearing is correct.

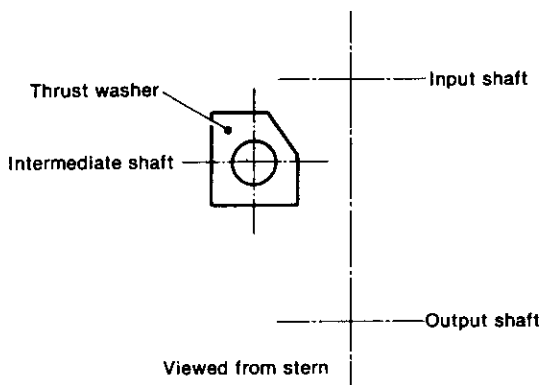
NOTE: The bearing inner race can be easily installed by preheating it to approximately 100°C.

6-4 Reassembling the intermediate shaft

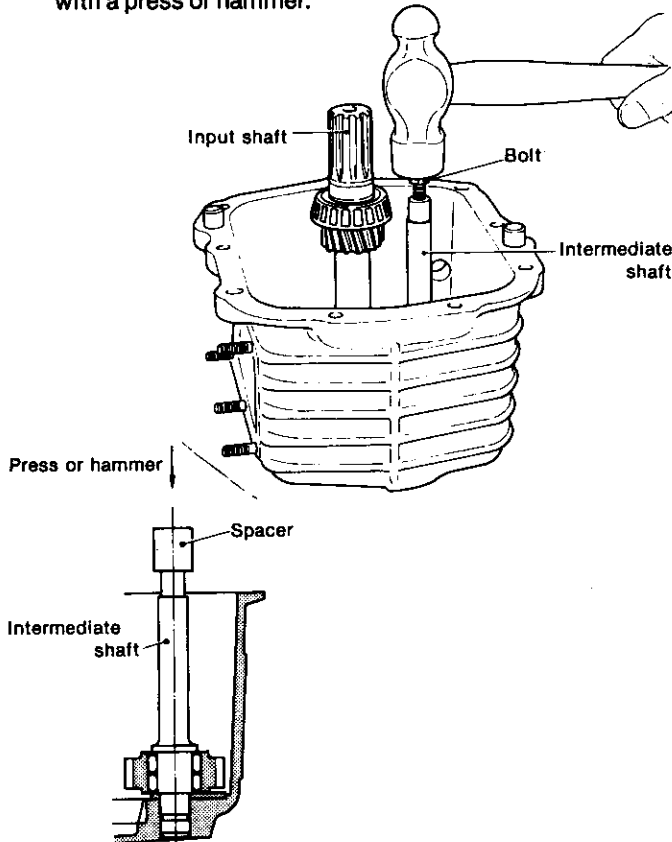
NOTE: Assemble the intermediate shaft as described in section 6-5. (5).

(1) Insert the needle bearing and idle gear on the intermediate shaft. Then insert the thrust washer.

NOTE: Pay careful attention to the assembling direction of the thrust washer.



- (2) Insert the O-ring.
- (3) Press the assembled intermediate shaft into the case with a press or hammer.



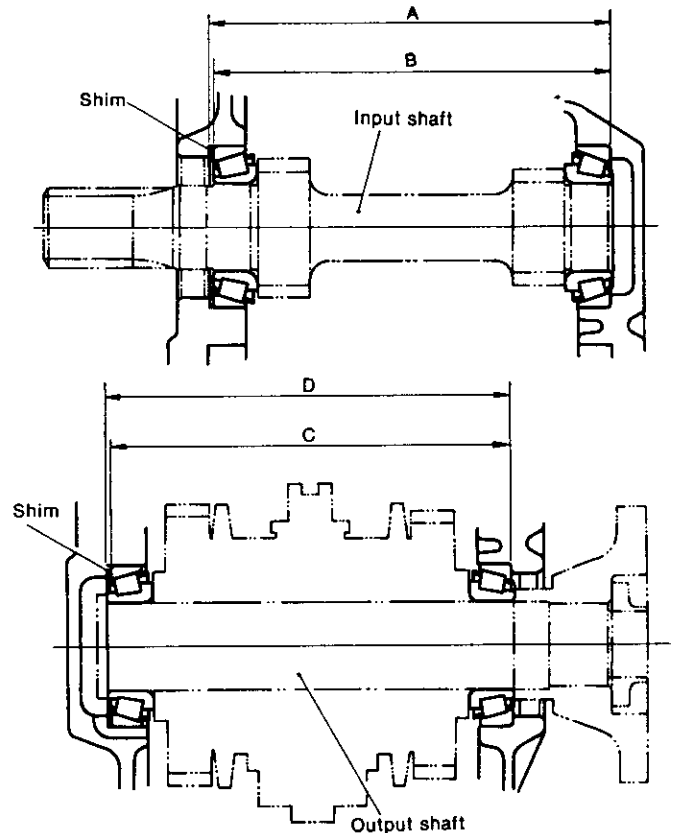
(4) Make sure that the idle gear rotates smoothly.

6-5 Installing the input shaft and output shaft

(1) Determining the thickness of the input shaft adjusting plate and output shaft adjusting plate

NOTE: As mentioned in section 5-1. (13), when none of the parts are replaced, the adjusting plate can be reused without readjustment.

- 1) Measure length "A" "D" between the cases of each shaft of the case body and mounting flange.
- 2) Cover each bearing with the bearing outer race, and measure length "B" "C" between the bearings.



- 3) Adjust the input shaft adjusting plate thickness so that the clearance or tightening allowance is less than 0.05mm (0.0020in.).
- 4) Adjust the output shaft adjusting plate thickness so that the tightening allowance is within 0 ~ 0.1mm (0~0.0040in.).
- 5) Four adjusting plates of 1mm (0.0394in.), 0.5mm (0.0197in.), 0.3mm (0.0118in.) and 0.1mm (0.0040in.) are available.

Combine these plates to obtain the desired adjusting plate measurement.

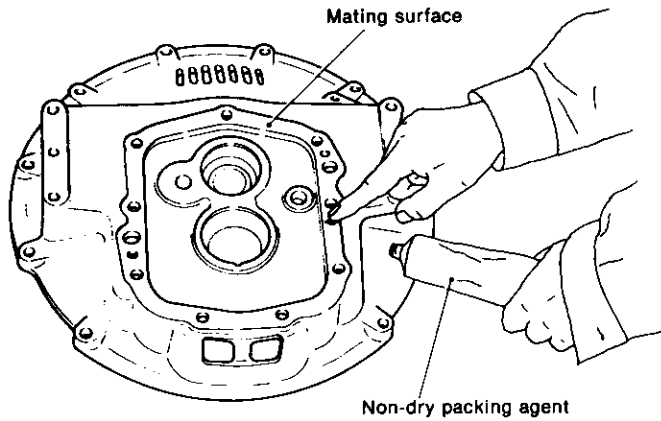
(2) Insert the adjusting plate into the mounting flange, and press the outer race of the bearing.

Also, press the outer race of the bearing into the case.

NOTE: The outer race can be installed easily by heating the mounting flange and case to approximately 100°C, or by cooling the bearing outer race with liquid nitrogen, etc.

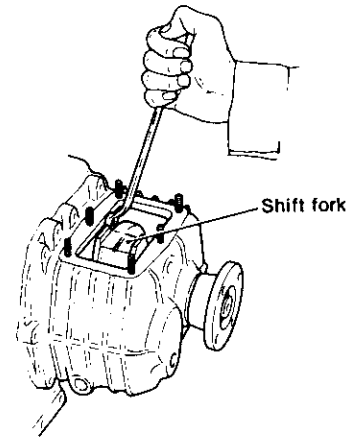
(3) Coat the circumference of the oil seal with a non-dry packing agent, and press it onto the mounting flange and case so that the spring part of the oil seal is inside the case.

- (4) Coat the mating surfaces of the mounting flange and case with a non-dry packing agent. Wipe off oil and dirt on the mating surface of the case and coat with a thin film of non-dry packing agent.



- (2) Coat the threaded part of the shift bar plug with a non-dry packing agent and secure it to the case with a hexagonal bar spanner (width across flats: 8mm (0.3150in.).

NOTE: Put the shift fork into neutral before installing.

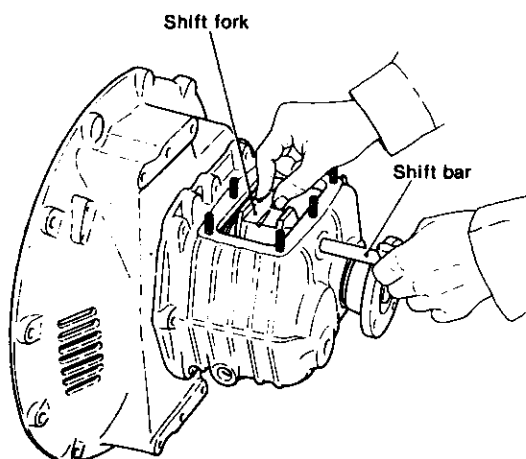


- (5) Insert the input shaft into the case, assemble the intermediate shaft as described in section 6-4 and then insert the output shaft into the case.
(6) Align the mounting flange with the case, and insert the parallel pin by tapping the mounting flange with a plastic hammer.
(7) Insert the super lock washer and tighten the M10 bolt.
(8) Install the dipstick and packing.
(9) Install the drain plug and packing.

6-6 Reassembling and installing the operating system

- (1) Insert the shift fork into the case from the side, insert the shift bar.

NOTE: Insert the shift bar with the threaded end towards the outside (output shaft coupling side).



- (3) Coat the circumference of the oil seal with a non-dry packing agent and press the seal to the case cover.
(4) Insert the spring into the shift cam.
(5) Insert the knock pin into the shift cam from the front end, and lock with the circlip.
(6) Insert the assembled shift cam into the case cover.
(7) Fit the shift lever to the shift cam, and tighten the M8 bolt.

NOTE: The shift cam must rotate smoothly.

- (8) Replace the packing if it is damaged.
(9) Attach the case side cover together with the operating system to the case body.

At this time, make sure that the shift cam is fitted to the shift fork, and that the shift lever is in neutral.

NOTE: Put the shift fork into neutral before installing.

- (10) Insert the super lock washer, and tighten the M8 nut.
(11) Shift the shift lever to forward and reverse to make sure that the lever operates normally.

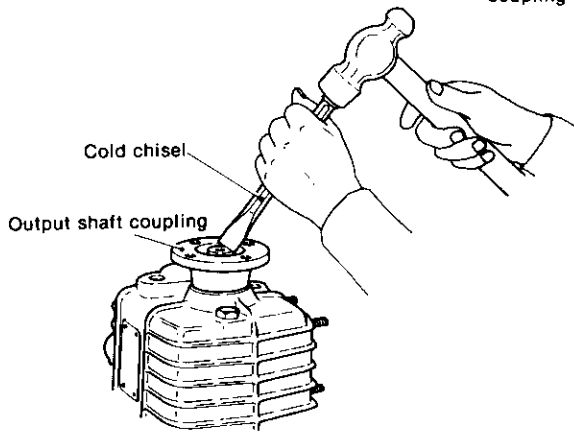
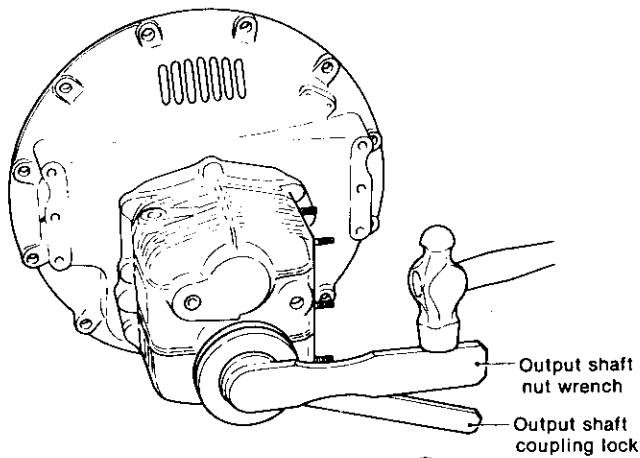
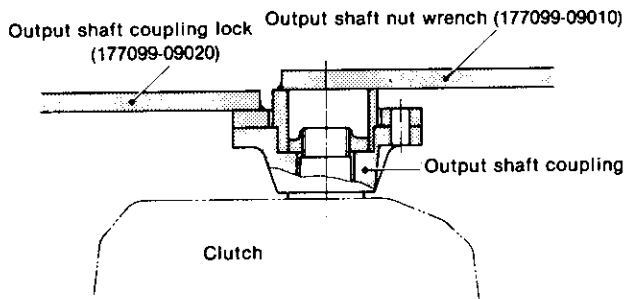
If the lever does not operate normally, loosen the M8 nut, slide the case side cover forward, backward, and to the left and right, then re-tighten with the M8 nut in the position at which the lever operates normally.

NOTE: If the lever operates normally a click will be heard when it is put into forward and reverse.

6-7 Installing the output shaft coupling

- (1) Install the output shaft coupling on the output shaft.
- (2) Tighten and caulk the output shaft lock nut, using the assembly tool.

Tightening torque..... 9.5kgf-m (68.7ft-lb)



- (3) Shift the shift lever to the neutral position and make sure the clutch engages when the shift lever is put into forward and reverse.
The input/output shafts will not rotate smoothly if the side gap of the bearing is too small in relation to the thickness of the adjusting plate.

[C] Marine Gear Models

KM2P, KM3P and KM3V

for Engine Models 1GM10, 2GM20(F) and 3GM30(F)

Applicable Engine Models & Serial Nos.

(Effective from:)

KM2P 1GM10 E/# 03413 and after Aug. 1985
KM2P 2GM20(F) E/# 03567 and after Aug. 1985
KM3P 3GM30(F) E/# 01888 and after Aug. 1985

1. Construction

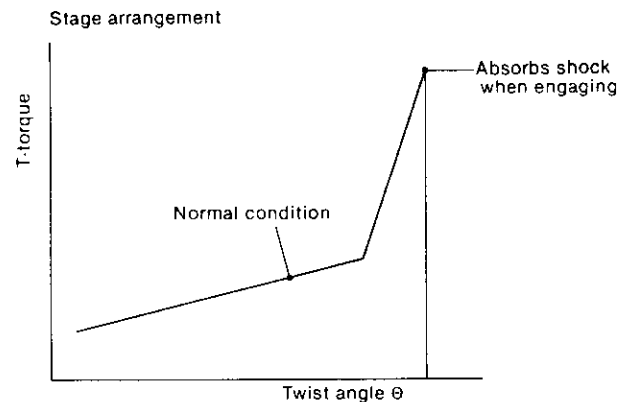
1-1 Construction

This clutch is a cone-type, mechanically operated clutch. When the drive cone (which is connected to the output shaft by the lead spline) is moved forward or backward, its taper contacts with the large gear and transfers power to the output shaft.

The construction is simple when compared with other types of clutch and it serves to reduce the number of components, making for a lighter, more compact unit which can be operated smoothly. Although it is small, the power transmission efficiency is high even under a heavy load. Its durability is high and it is reliable as high grade materials are used for the shaft and gear, and a taper roller bearing is incorporated. Power transmission is smooth as connection with the engine is made through the damper disc.

- The drive cone is made from special aluminum bronze which has both higher wear-resistance and durability. The drive cone is connected with the output shaft through the thread spline. The taper angle, diameter of the drive cone, twist angle, and diameter of the thread spline, are designed to give the greatest efficiency, thus ensuring that the drive cone can be readily engaged or disengaged.
- Helical gears are used for greater strength. The intermediate shaft is supported at 2 points to reduce deflection and gear noise.
- The clutch case and mounting flange are made from an aluminum alloy of special composition to reduce weight. It is also anticorrosive against seawater.
- As the damper disc is fitted to the output shaft, power can be transmitted smoothly. For the damper disc, springs of different strengths are used so that two stages of torque and twist angle are applied. That is, in the first stage, only the weak spring is used, and the strong spring comes into action for a torque higher than a predetermined value.

This prevents gear noise due to torsional vibration as well as absorbing shock when engaging.



- There is a small clearance between the dipstick and the inside of the dipstick tube. A small hole in the dipstick works as a breather.
- When the load on the propeller is removed, the engagement of the drive cone and the large gear is maintained by the shifter and V-groove of the drive cone. Even when the drive cone's tapered area and V-groove are worn, this engagement is maintained by the shift lever device and accordingly no adjustment of the remote control cable is required.
- The cup spring on the rear of the larger gear absorbs rotational fluctuations and stabilizes the engagement of the drive cone and the larger gear. Thus, the durability of the cone against wear is enhanced.

1-2 Specifications

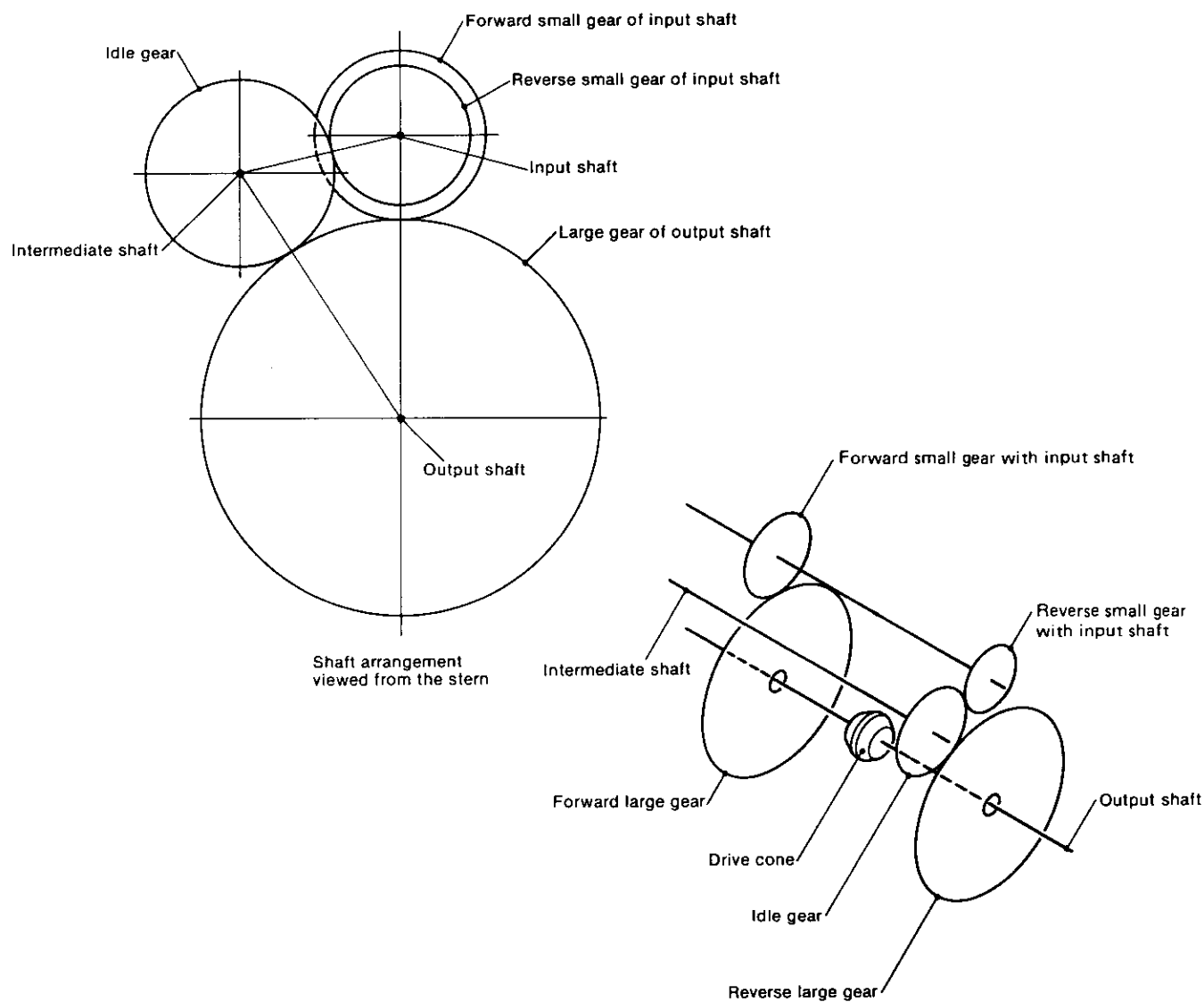
Model		KM2 P			KM3 P		
For engine models		1GM10, 2GM20(F)			3GM30(F)		
Clutch		Constant mesh gear with servo cone clutch (wet type)					
Reduction ratio	Forward	2.21	2.62	3.22	2.36	2.61	3.20
	Reverse	3.06	3.06	3.06	3.16	3.16	3.16
Propeller shaft rpm (Forward)		1540	1298	1055	1441	1303	1063
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern				
	Output shaft	Forward	Clockwise, viewed from stern				
		Reverse	Counter-clockwise, viewed from stern				
Remote control	Control head		Single lever control				
	Cable		Morse, 33-C (cable travel 76.2mm or				
	Clamp		YANMAR made, standard accessory				
	Cable connector		YANMAR made, standard accessory				
Output shaft coupling	Outer diameter		ø100mm (3.93")				
	Pitch circle diameter		ø78mm (3.07")				
	Connecting bolt holes		4—ø10.5mm (4—ø0.41")				
Position of shift lever		Left side, viewed from stern					
Lubricating oil		SAE #10W-30, CC class					
Lubricating oil capacity		0.3 l			0.35 l		
Dry weight		10.3 kg (22.7 lbs)			11.5 kg (25.4 lbs)		

Models KM2P and KM3P reduction and reverse gear boxes, shafts and gears are the same except for the following items:

- No. of gear teeth
- Distance between bearings for input and output shafts.
- Clutch case, mounting flange.

1-3 Power transmission system

1-3.1 Arrangement of shafts and gears



1-3.2 Reduction ratio

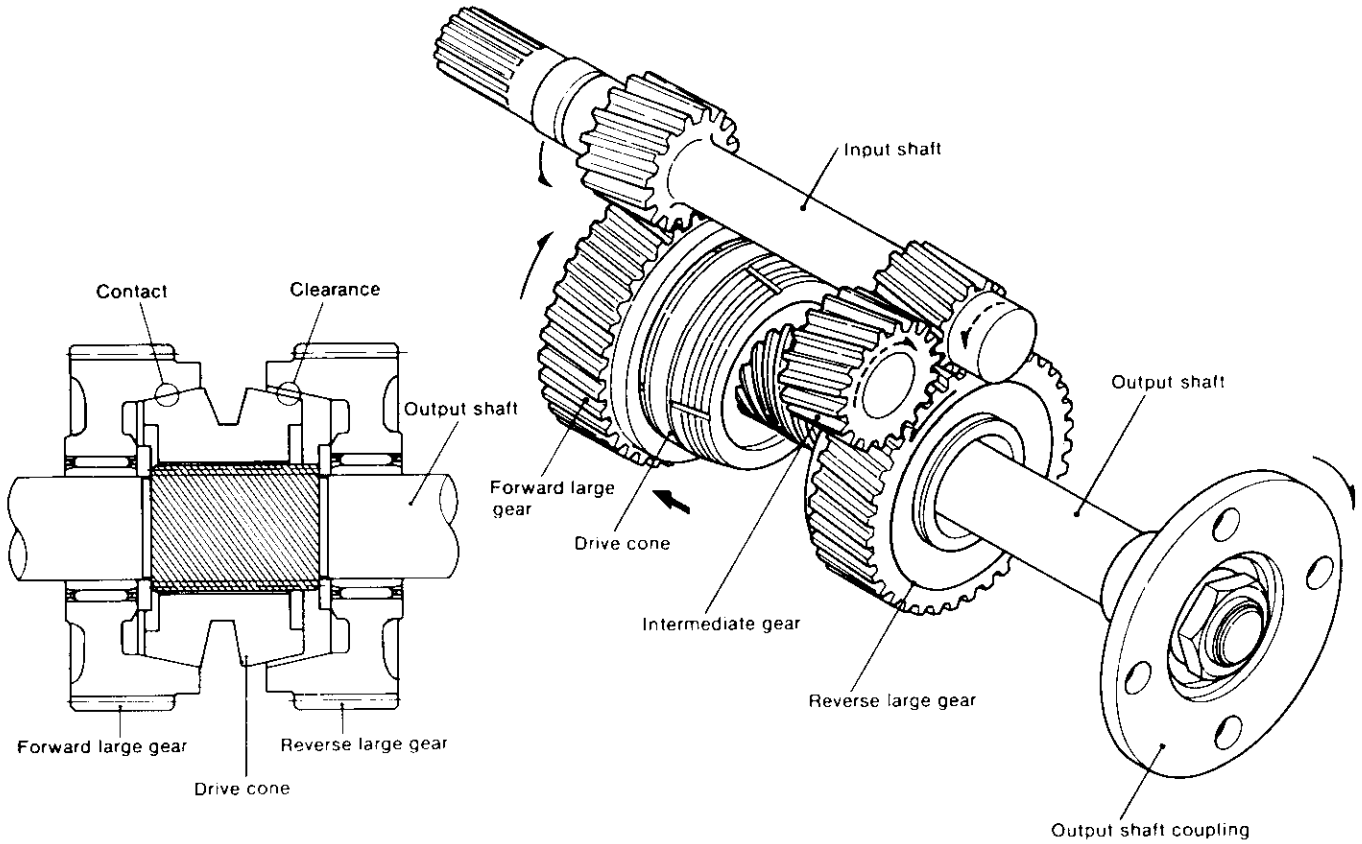
Forward

Model	No. of teeth of forward small gear Z_{if}	No. of teeth of forward large gear Z_{of}	Reduction ratio Z_{of}/Z_{if}
KM2P	24	53	$53/24 = 2.21$
	21	55	$55/21 = 2.62$
	18	58	$58/18 = 3.22$
KM3P	25	59	$59/25 = 2.36$
	23	60	$60/23 = 2.61$
	20	64	$64/20 = 3.20$

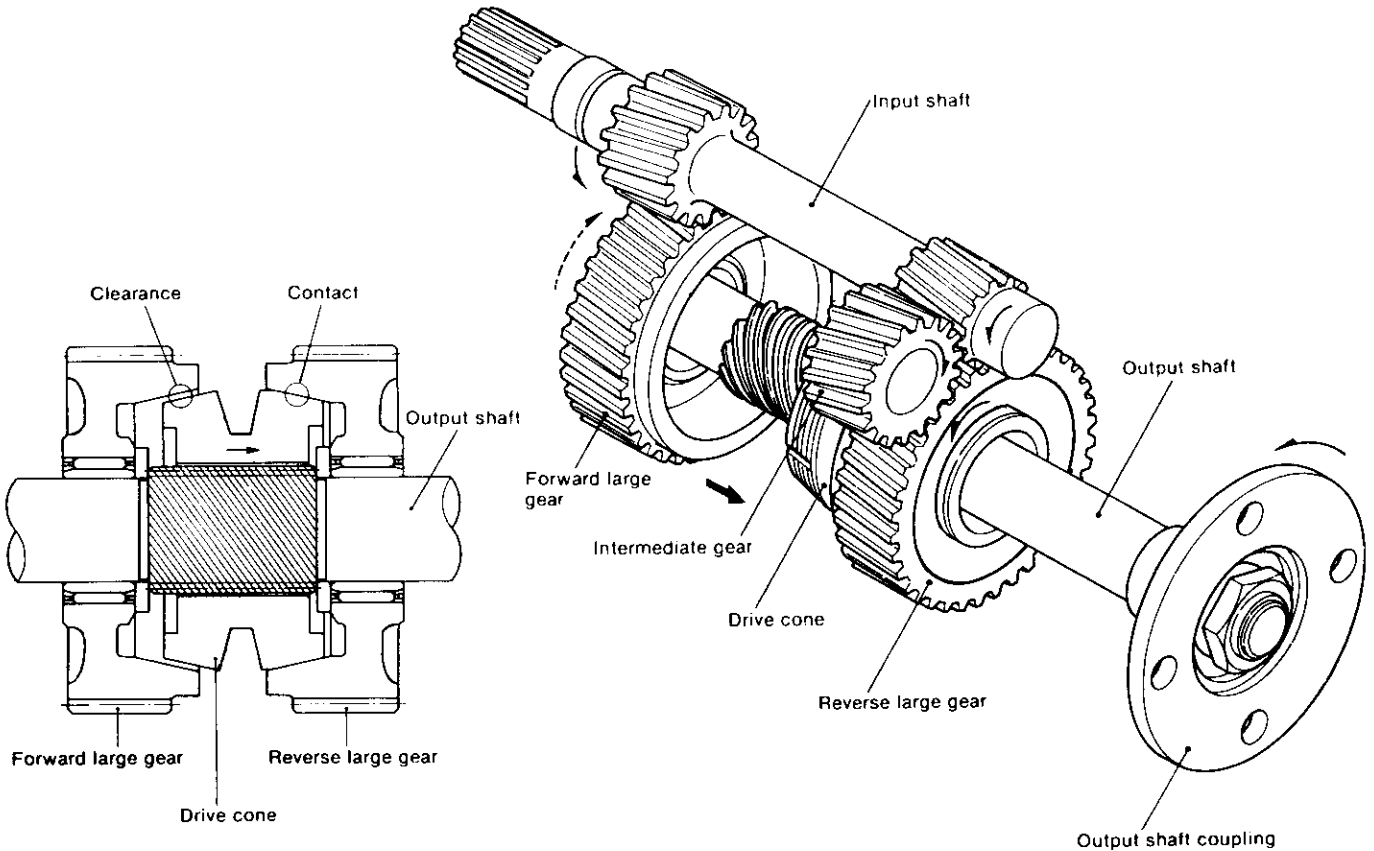
Reverse

Model	No. of teeth of reverse small gear Z_{ir}	No. of teeth of intermediate shaft gear Z_i	No. of teeth of reverse large gear Z_{dr}	Reduction ratio $Z_i/Z_{ir} \cdot Z_{dr}/Z_i$
KM2P	18	26	55	$55/18 = 3.06$
KM3P	19	26	60	$60/19 = 3.16$

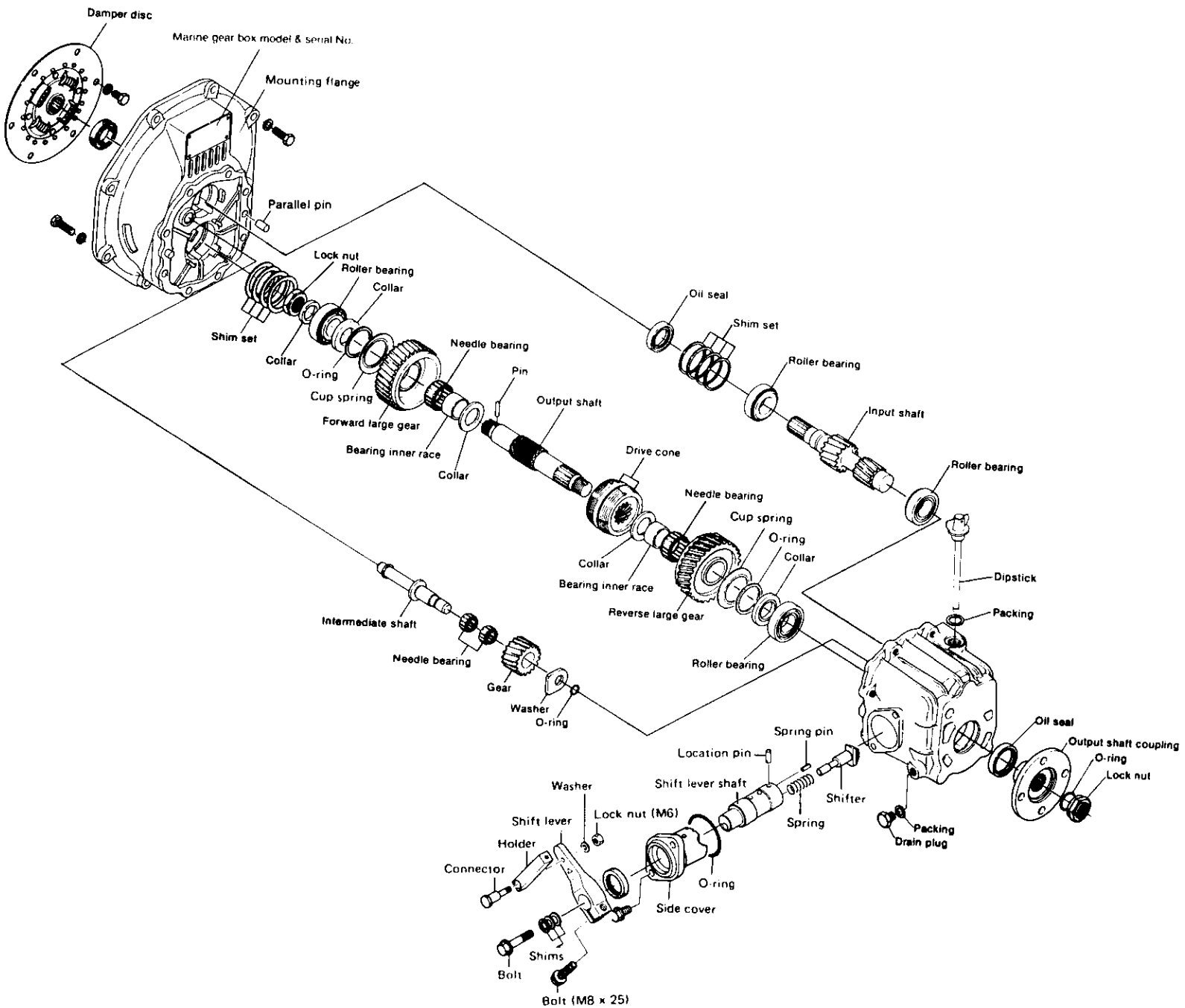
1-3.3 Power transmission routine—Forward



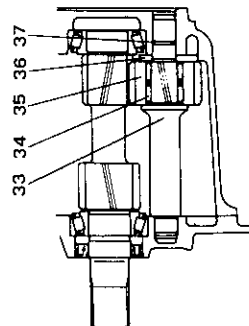
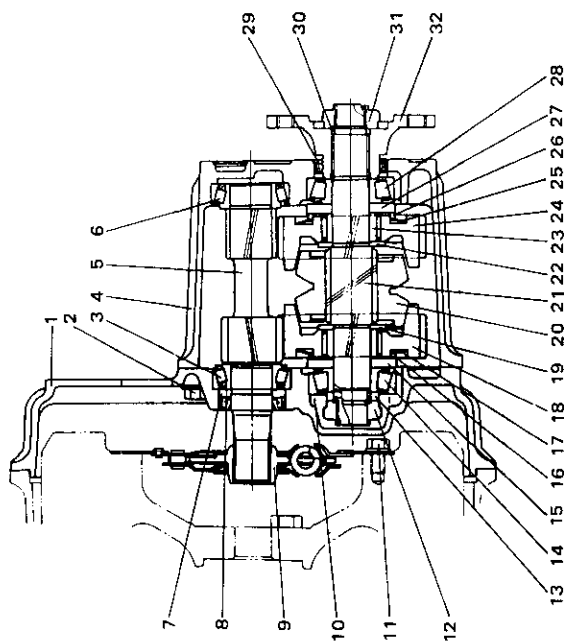
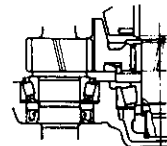
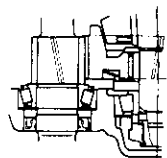
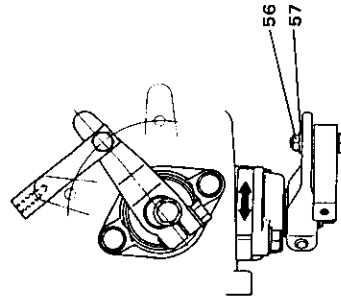
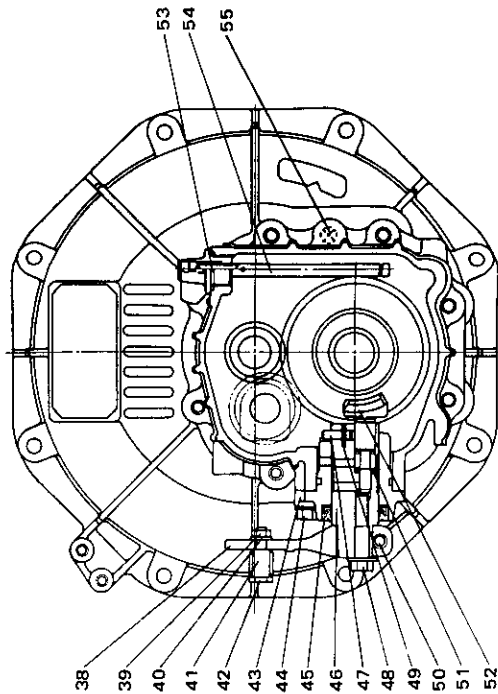
1-3.4 Power transmission routine—Reverse



1-4 Drawing



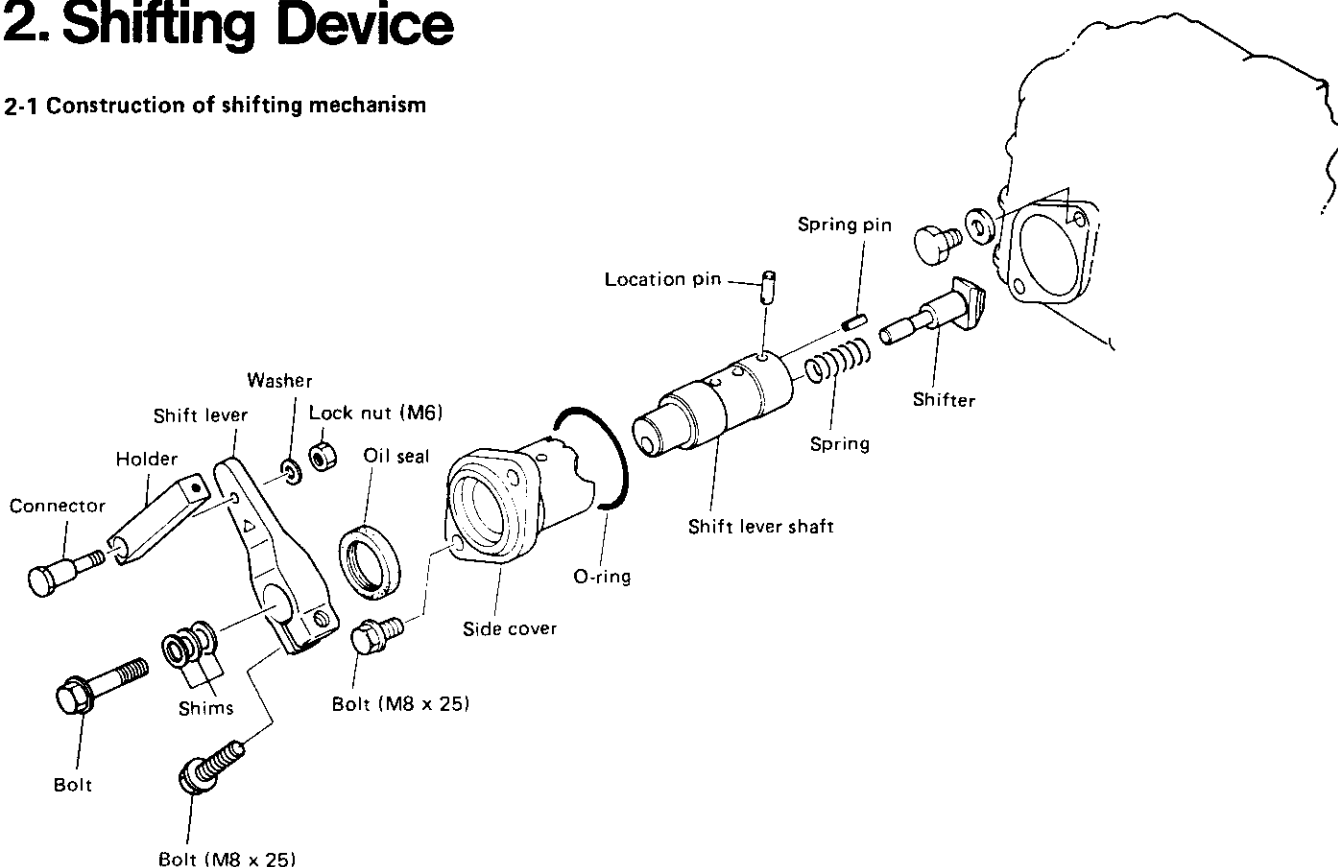
1-5 Sectional view



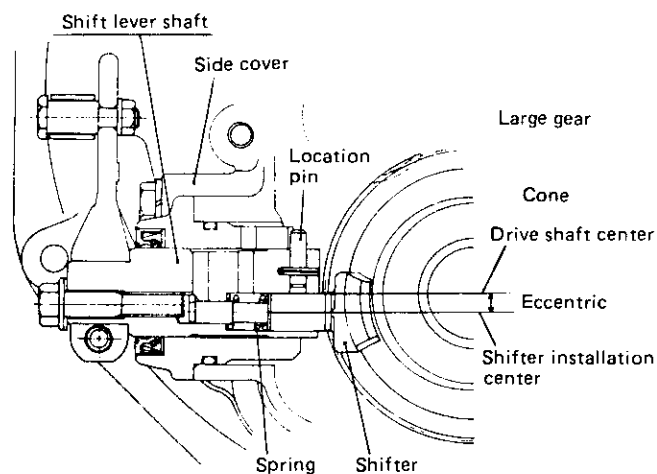
- 1 Mounting flange
- 2 Bolt M8 x 25
- 3 Bearing
- 4 Clutch case
- 5 Input shaft
- 6 Bearing
- 7 Oil seal
- 8 Shim
- 9 Dumper disk
- 10 Shim
- 11 Bolt M8 x 14
- 12 Lock nut
- 13 Collar
- 14 Bearing
- 15 Thrust collar A
- 16 Spring retainer
- 17 Cup spring
- 18 Forward gear
- 19 Thrust collar B
- 20 Drive cone
- 21 Output shaft
- 22 Thrust collar B
- 23 Inner rase
- 24 Reverse gear
- 25 Cup spring
- 26 Spring retainer
- 27 Thrust collar A
- 28 Bearing
- 29 Oil seal
- 30 O-ring
- 31 Lock nut
- 32 Coupling
- 33 Idle gear shaft
- 34 Bearing
- 35 Idle gear
- 36 Thrust washer
- 37 O-ring
- 38 Shift lever
- 39 Lock nut
- 40 Washer
- 41 Holder
- 42 Connector
- 43 Side cover
- 44 Bolt M8 x 25
- 45 Oil seal
- 46 Shift lever shaft
- 47 Location pin
- 48 Stopper bolt
- 49 Spring pin
- 50 Bolt M8 x 25
- 51 Spring
- 52 Shifter
- 53 Washer
- 54 Dipstick
- 55 Parallel pin
- 56 Lock nut
- 57 Washer

2. Shifting Device

2-1 Construction of shifting mechanism

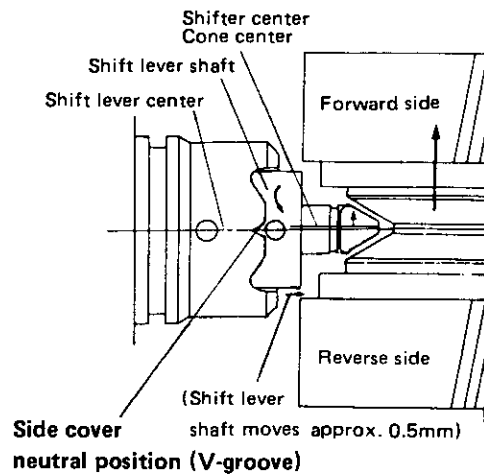


The shift lever shaft is installed on the side cover with neutral, forward and reverse positions provided on this cover. The neutral, forward and reverse location pins of the shift lever shaft are constantly inserted into their respective grooves on the shift lever by the tension of the shifter spring. The shifter is set on the eccentric hole of the shift lever shaft and moves the drive cone in the neutral position either to the forward or reverse positions, and then back to the neutral position. (The shift lever shaft moves slightly to the shift lever or drive cone side when the shift lever is placed in the forward or reverse positions.)

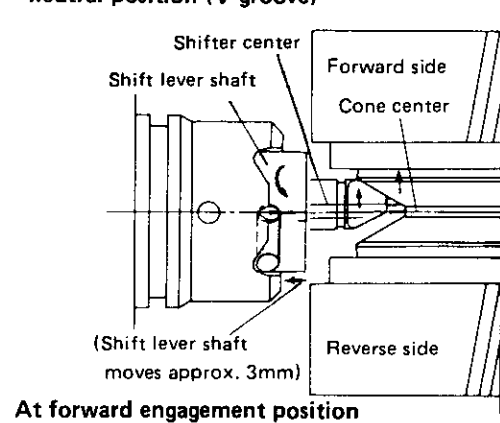


2-2 Forward and reverse clutch operation
(Neutral ⇒ Forward; Neutral ⇒ Reverse)

When the shift lever is moved to the forward position from the neutral position, the shift lever shaft starts to revolve, and the location pin disengages from the neutral V-groove position of the side cover. (Shift lever moves approx. 0.5mm to the drive cone side.) At this time the shifter which is set on the eccentric hole of the shift lever shaft, moves the drive cone's V-groove to the forward large gear.

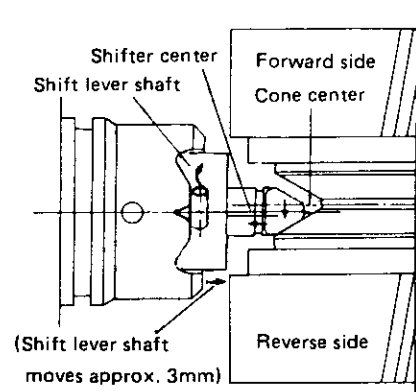


When the location pin of the shift lever shaft falls in the forward position groove of the side cover, (the shift lever shaft moves to the shift lever side approx. 3mm), and the shifter starts to press the drive cone V-groove to the forward large gear side through the spring force.

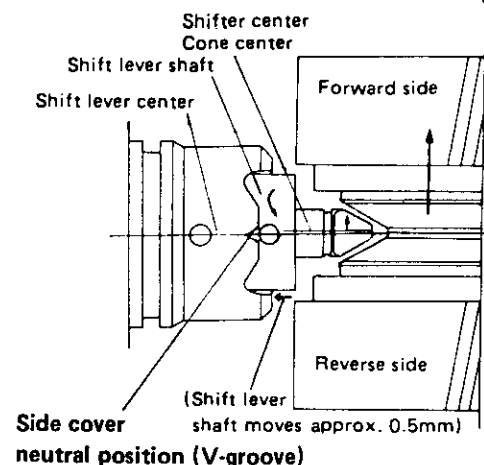


2-3 Engagement and disengagement of clutch
(Forward ⇒ Neutral; Reverse ⇒ Neutral)

When the shift lever is moved to the forward position from the neutral position, the shift lever shaft starts to revolve, and the location pin disengages from the forward position groove of the side cover. (The shift lever shaft moves approx. 3mm to the drive cone side.) At this time, the shifter which is set on the eccentric hole of the shift lever shaft is moved to the neutral side (reverse large gear side). The drive cone, however, is engaged with the forward large gear through the torque force produced by the revolving centrifugal force.

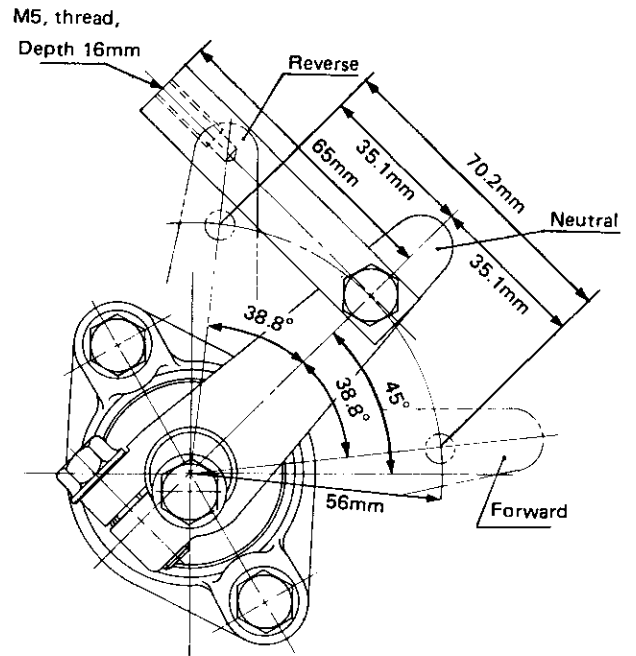


Further, when the shift lever shaft starts to revolve, and the positioning pin falls in to the neutral V-groove position of the side cover (the shift lever shaft travels approx. 5mm to the shift lever side), the shifter moves to the shift lever side (to the spring side) while moving the V-groove of the drive cone to the reverse large gear side. The movement of the shifter to the shift lever side, however, is stopped when the shifter end contacts the stopper bolt. The shifter only works to press the V-groove of the drive cone to the reverse large gear side. Thus, the drive cone is disengaged from the forward large gear. After this disengagement, the transmission torque of the drive cone is decreased to zero and the shift lever is returned to the neutral position by the spring force.



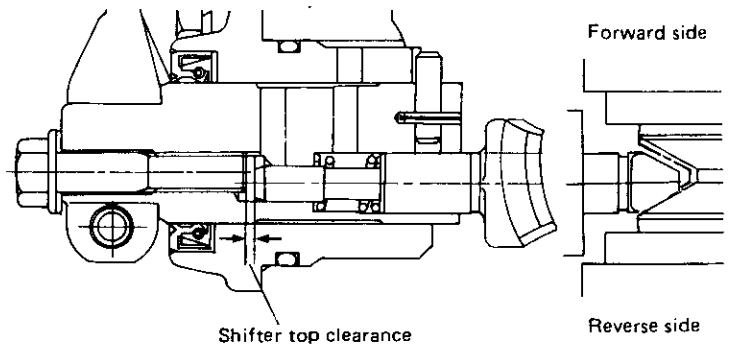
2-4 Clutch shifting force

Shifting position Shifting direction	Shift lever position at 56mm	Remote control handle position at 170mm (Cable length, 4m)
Engaging force at 1000 rpm	3 ~ 4 kg (6.6 ~ 8.8 lbs)	4 ~ 5 kg (8.8 ~ 11.0 lbs)
Disengaging force at 1000 rpm	3.5 ~ 5 kg (7.7 ~ 11.0 lbs)	4 ~ 6 kg (8.8 ~ 13.2 lbs)



2-5 Adjustment of shifting device

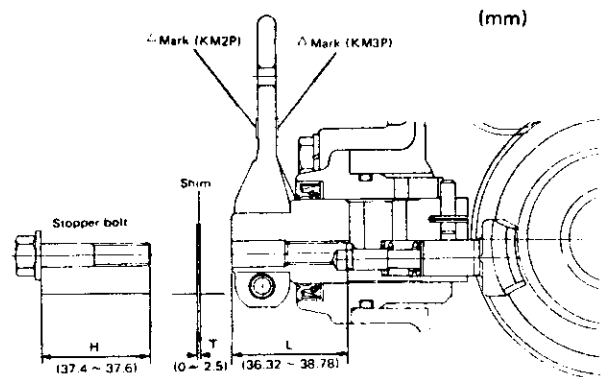
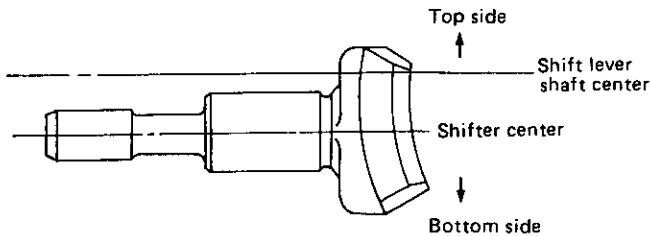
Whenever the side cover, shift lever shaft, shifter, stopper bolt or drive cone is replaced, be sure to adjust the clearance between the shifter end and the stopper bolt by using shims. When the adjustment of this clearance is not proper the drive cone may not be properly fitted when the shift lever is moved to the neutral position either from the forward or reverse position.



2-5.1 Measurement and adjustment of clearance

(a) Assemble the shifting mechanism (without installing the stopper bolt of the shifter) to the marine gear case.

NOTE: Ensure the correct direction of the shifter before assembly.



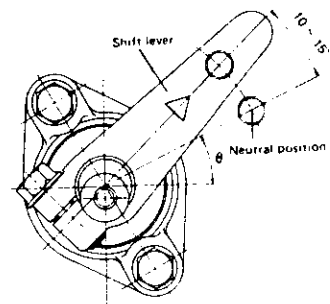
- (b) Turn the shift lever 10 ~ 15 degrees either to the forward or reverse position from the neutral position.
- (c) Measure the L-distance between the shift lever shaft end surface and the shifter's end.
- (d) Measure the H-distance (the distance from the neck of the stopper bolt to its end).
- (e) Obtain the shim thickness "T" by the following formula.

$$T = (H - L + 1.25) \pm 0.1\text{mm} (0.004\text{in.})$$

NOTE: Shim set includes one piece each of 1mm, 0.4mm, 0.3mm, 0.25mm shims.
(YANMAR Part No.177088-06380)

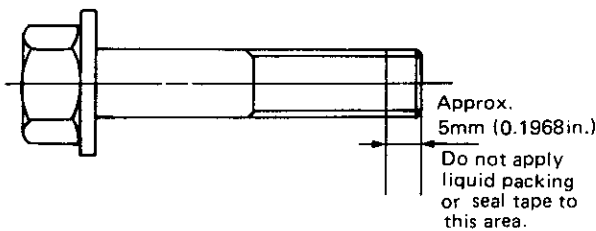
(f) Insert shim (s) of proper thickness to the stopper bolt side and tighten it to the shift lever shaft.

NOTE: When tightening the stopper bolt, apply either a non-drying type liquid packing (TREE BOND No.1215), or a seal tape around the bolt threads.



NOTE. Shift lever must be installed in the direction of the Δ-mark ensuring the specified installation angle (θ).

θ =	KM2P	KM3P
	40°	45°

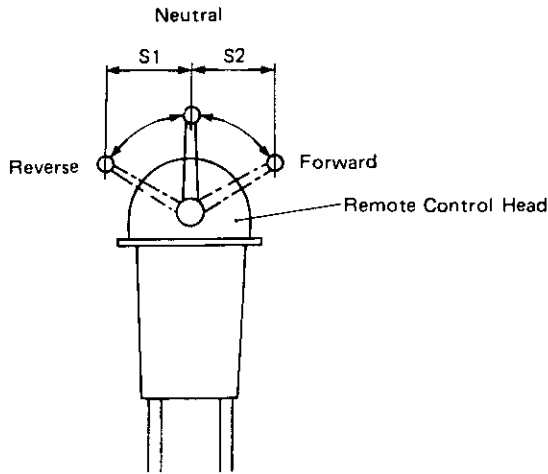


2-5.2 Inspect for the following points
(to be inspected every 2-3 months)

- (1) Looseness at the connection of the cable connector and the remote control cable.
- (2) Looseness of the attaching nut of the cable connector and the shift lever.

2-6 Adjustment of the remote control head
Marine gearbox control side

(1) Equal distribution of the control lever stroke.

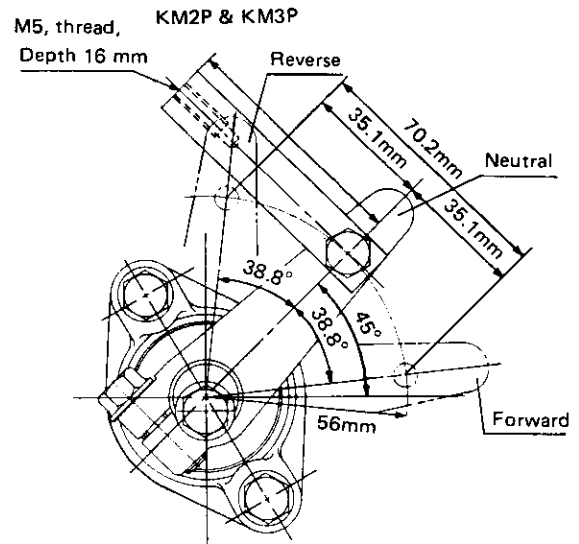
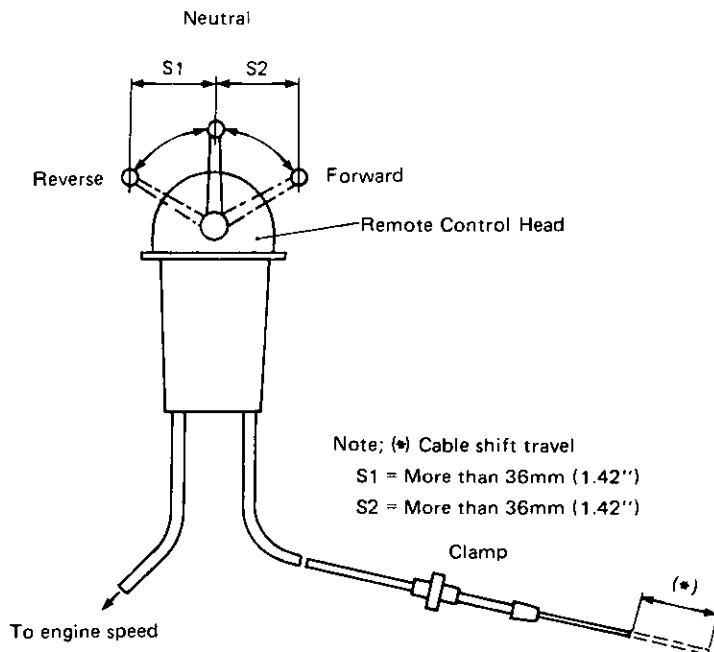


The stroke between the neutral position → forward position (S2), and the neutral position → reverse position (S1) must be equalized.

When either stroke is too short, clutch engagement becomes faulty.

(2) Equalizing the travel distance of the control cable.

After ensuring the equal distribution of the stroke described in (1), connect the cable to the control head. Adjust that the cable shift travel of the S1 and S2 control lever strokes becomes identical.



2-7 Cautions

- (1) Always stop the engine when attaching, adjusting, and inspecting.
- (2) When conducting inspection immediately after stopping the engine, do not touch the clutch. The oil temperature is often raised to around 90°C (194°F).
- (3) Half-clutch operation is not possible with this design and construction. Do not use with the shift lever halfway to the engaged position.
- (4) Set the idling engine speed at between 750 and 800 rpm.

NOTE: The dual(Two) lever remote control device cannot be used.

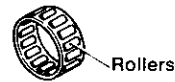
3. Inspection and Servicing

3-1 Clutch case

- (1) Check the clutch case with a test hammer for cracking. Perform a color check when required. If the case is cracked, replace it.
- (2) Check for staining on the inside surface of the bearing section. Also, measure the inside diameter of the case. Replace the case if it is worn beyond the wear limit.

3-2 Bearing

- (1) Rusting and damage. If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly. If rotation is not smooth, if there is any binding, or if any abnormal sound is evident, replace the bearing.



3-3 Gear

Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.

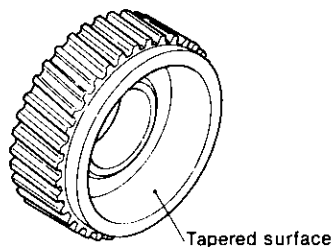
- (1) Tooth surface wear. Check the tooth surface for pitting, abnormal wear, dents, and cracks. Repair the lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact. Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash. Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

	Maintenance standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
input shaft reverse gear and intermediate gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Intermediate gear and output shaft reverse gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)

(The same dimensions apply to both KM2P and KM3P)

3-4 Forward and reverse large gears

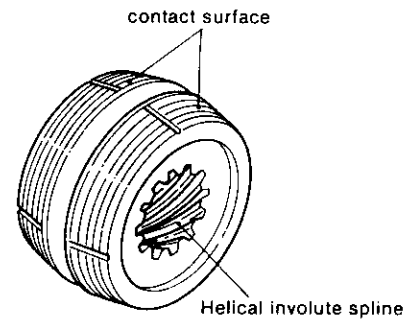
- (1) Contact surface with drive cone. Visually inspect the tapered surface of the forward and reverse large gears where they make contact with the drive cone to check if any abnormal condition or sign of overheating exists. If any defect is found, replace the gear.



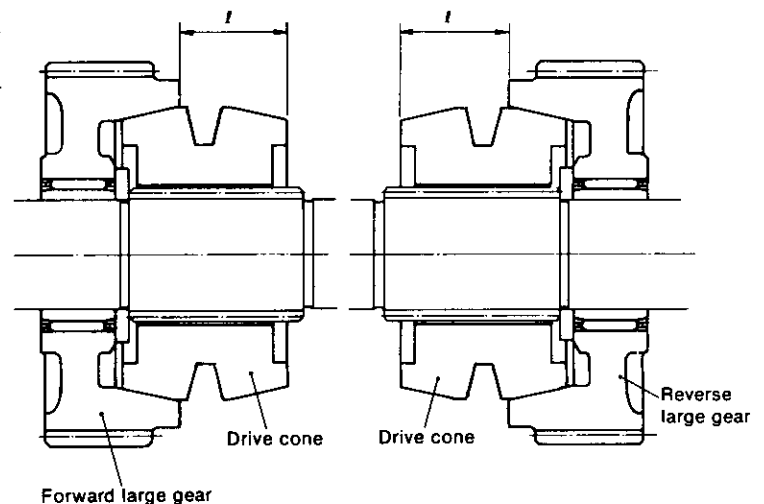
- (2) Forward/reverse gear needle bearing. When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.

3-5 Drive cone

- (1) Visually inspect that part of the surface that comes into contact with the circumferential triangular slot to check for signs of scoring, overheating or wear. If deep scoring or signs of overheating are found, replace the cone.



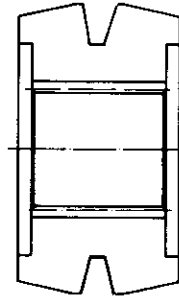
- (2) Check the helical involute spline for any abnormal condition on the tooth surface, and repair or replace the part should any defect be found.
- (3) Measure the amount of wear on the tapered contact surface of the drive cone, and replace the cone when the wear exceeds the specified limit.



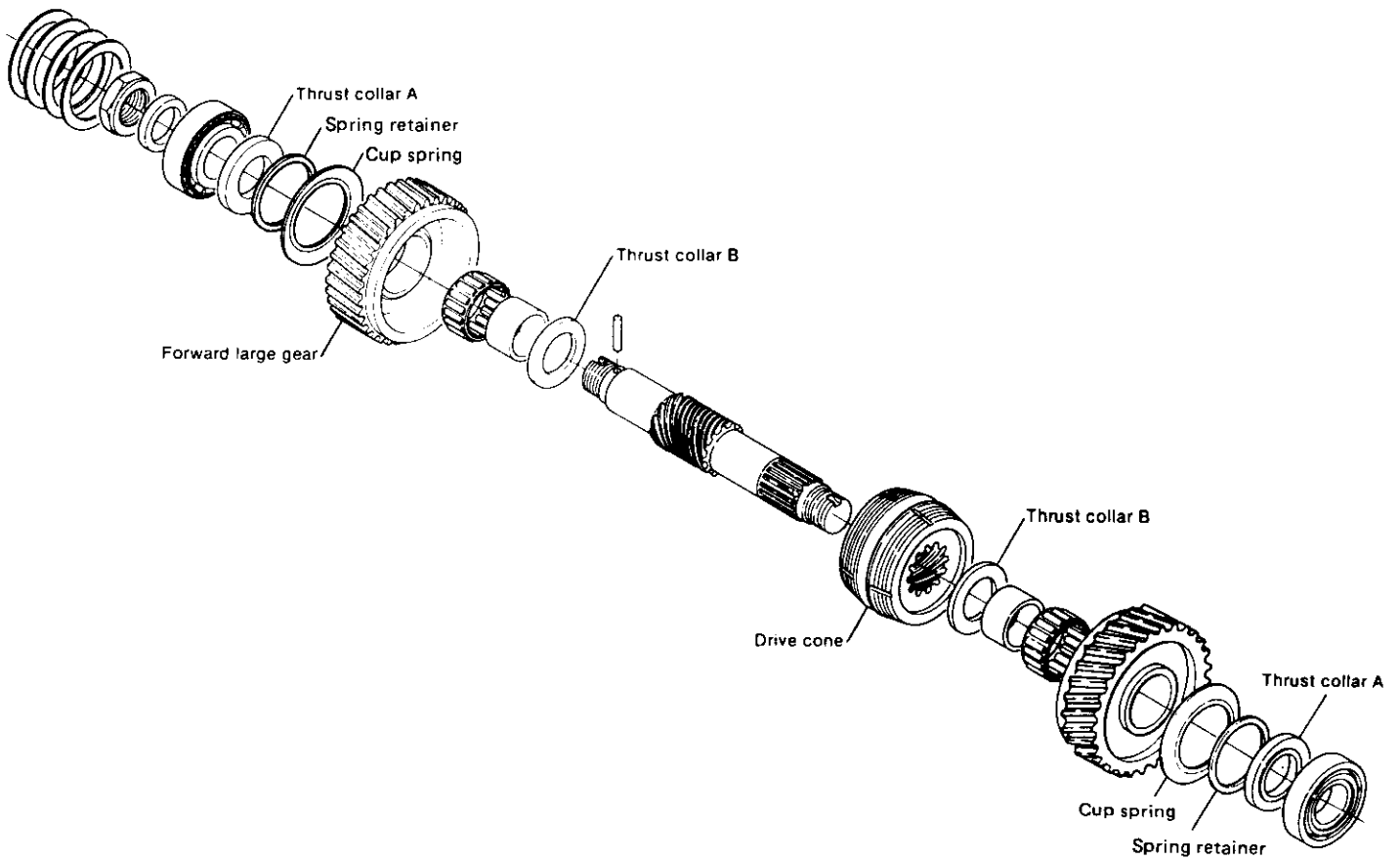
		mm (in.)	
Dimensions <i>l</i>		Standard dimensions	Limited dimensions
		KM2P	29.2 ~ 29.8 (1.1496 ~ 1.1732)
	KM3P	32.7 ~ 33.3 (1.2874 ~ 1.3110)	32.4 (1.2756)

NOTE: When dismantled, the forward or reverse direction of the drive cone must be clearly identified.

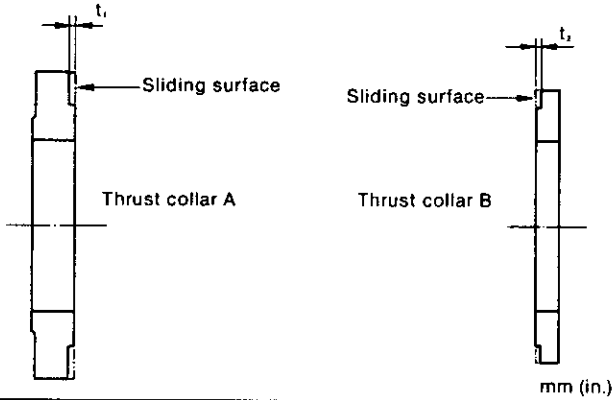
(4) If the wear of the V-groove of the drive cone is excessive, replace the part.



3-6 Thrust collar



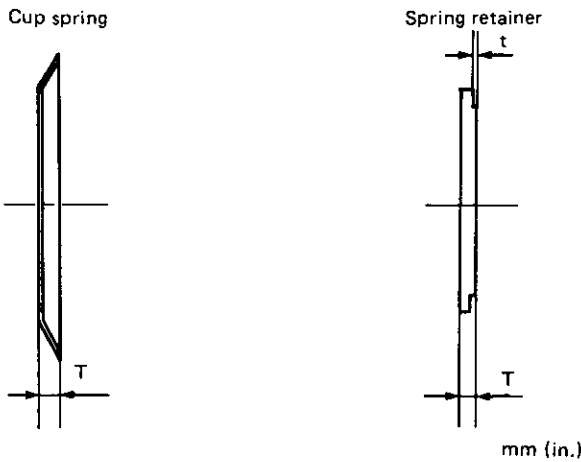
- Visually inspect the sliding surface of thrust collar A or B to check for signs of overheating, scoring, or cracks. Replace the collar if any abnormal condition is found.
- Measure the thickness of thrust collar A or B, and replace it when the dimension exceeds the specified limit.



Stepped wear	Limit for use
Thrust collar A, t_1	0.05 (0.0020)
Thrust collar B, t_2	0.20 (0.0079)

3-7 Cup spring and spring retainer

- Check for cracks and damage to the cup spring and spring retainer. Replace the part if defective.
- Measure the free length of the cup spring and the thickness of the spring retainer. If the length or the thickness deviates from the standard size, replace the part.

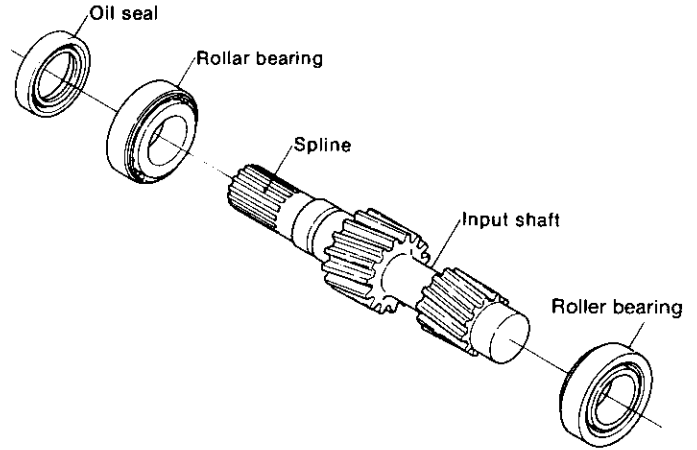


	Standard	Limit
Cup spring, T	2.8 ~ 3.1 (0.1102 ~ 0.1220)	2.6 (0.1024)
Spring retainer, T	2.92 ~ 3.08 (0.1150 ~ 0.1213)	2.8 (0.1102)
Spring retainer, t	—	0.1 (0.0040)

3-8 Oil seal of output shaft

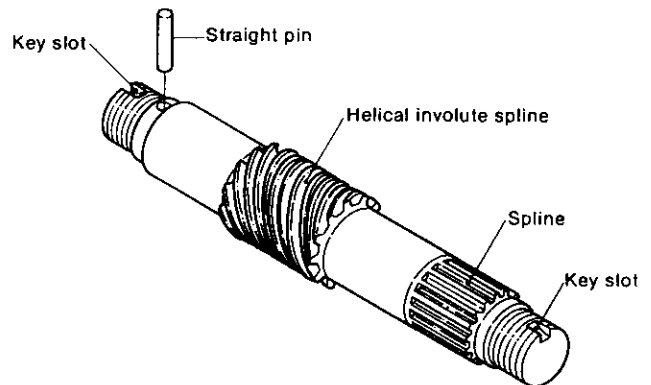
Visually inspect the oil seal of the output shaft to check if there is any damage or oil leakage; replace the seal when any abnormal condition is found.

3-9 Input shaft



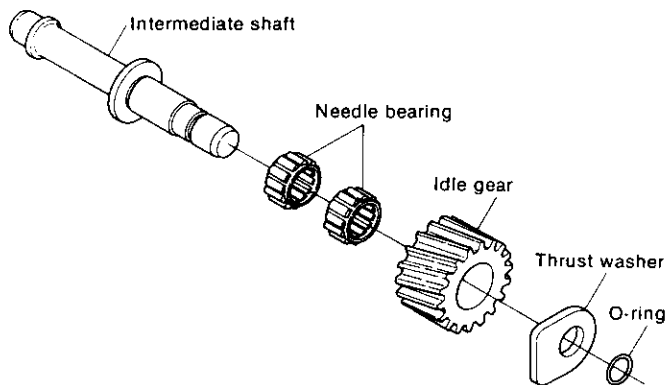
- Spline part.**
Whenever uneven wear and/or scratches are found, replace with a new part.
- Surface of oil seal.**
If the sealing surface of the oil seal is worn or scratched, replace.

3-10 Output shaft

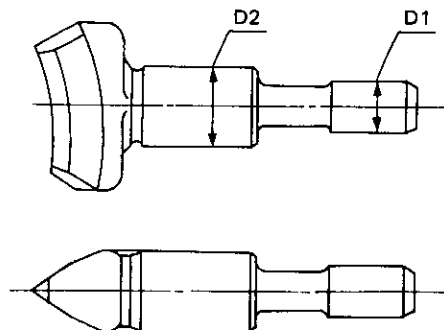


- Visually inspect the spline and the helical involute spline, and repair or replace a part when any abnormal condition is found on its surface.

3-11 Intermediate shaft



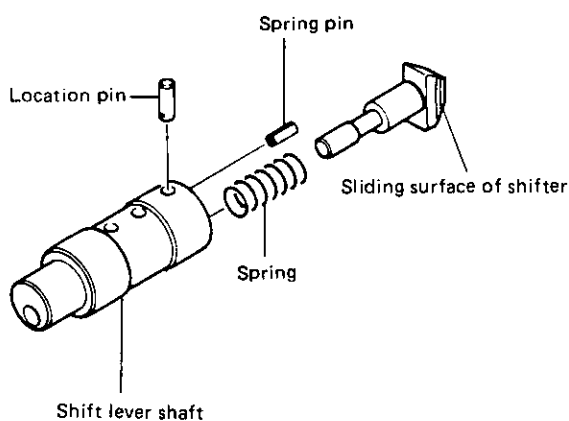
(1) Needle bearing dimensions, staining.
Check the surface of the roller to see whether the needle bearing sticks or is damaged. Replace if necessary.



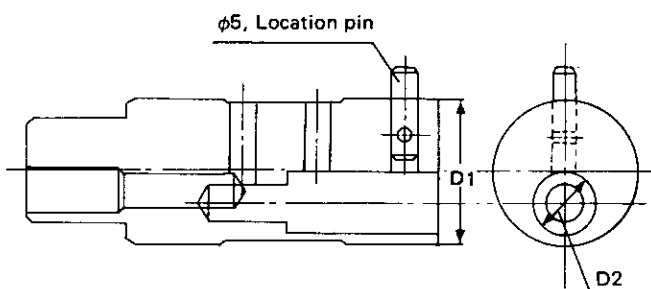
	mm (in.)	
	Standard	Limit
D1	66.9 ~ 67.0 (2.6338 ~ 2.6378)	65 (2.5591)
D2	11.966 ~ 11.984 (0.4711 ~ 0.4718)	11.95 (0.4705)
Shift lever shaft, Shifter insert hole	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)

3-12 Shifting device

3-12.1 Shifter



(1) Visually inspect the surface in contact with the drive cone, and replace the shifter when signs of overheating, damage or wear are found.
(2) Measure the shaft diameter of the shifter. Replace the shaft if the size deviates from the standard.



	mm (in.)	
	Standard	Limit
D1	27.959 ~ 27.98 (1.1001 ~ 1.1016)	27.90 (1.0984)
D2	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Side cover, Shifter insert hole	28.0 ~ 28.021 (1.1024 ~ 1.1032)	28.08 (1.1055)

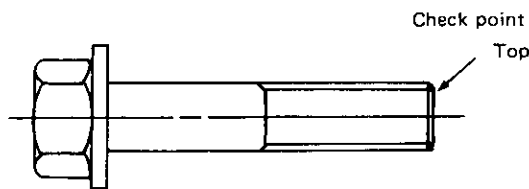
3-12.3 Shifter spring

- (1) Check the spring for scratches or corrosion.
- (2) Measure the free length of the spring.

Shifter spring	Standard	Limit
Free length	22.6 mm (0.890in.)	19.8 mm (0.780in.)
Spring constant	0.864 kgf/mm (1.88 lbs/0.04in.)	—
Length when attached	14.35 mm (0.5650 in.)	—
Load when attached	7.046 kg (15.54 lbs)	6.08 kg (13.41 lbs)

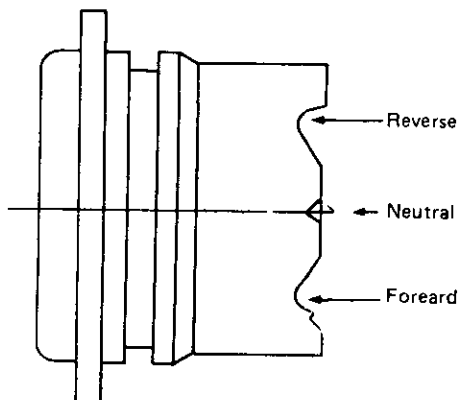
3-12.4 Stopper bolt

Check the stopper bolt. If it is worn or stepped, replace.

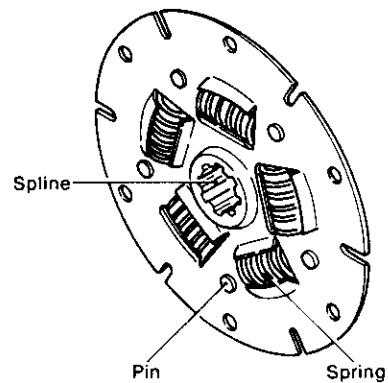


3-12.5 Side cover and oil seal

- (1) Check the neutral, forward and reverse position grooves. Replace if the grooves are worn.
- (2) Measure the insertion hole of the shift lever shaft. Replace if the size deviates from the standard value.
- (3) Check the oil seal and the O-ring for damage. Replace if the part is defective.



3-13 Damper disc



- (1) Spline part.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Spring.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (4) Whenever a crack or damage to the spring slot is found, replace the defective part with a new one.

3-14 Shim adjustment for output and input shafts

Check the thickness of shims for both input and output shafts. When the component parts are not replaced after dismantling, the same shims can be reused. When the clutch case and flange or any one of the following parts is replaced, the thickness of shim must be determined in the following manner.

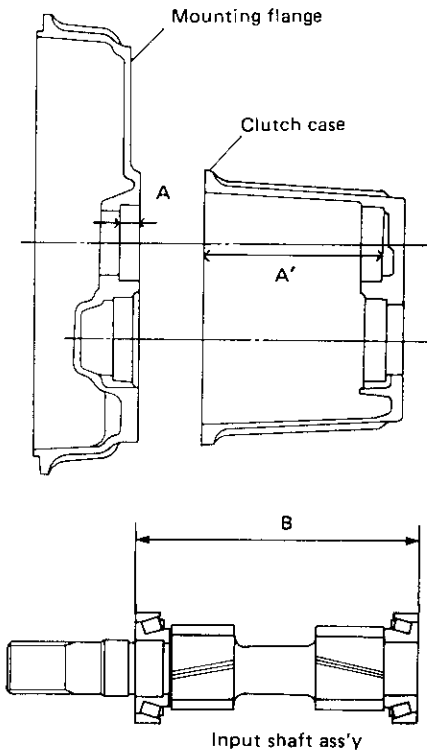
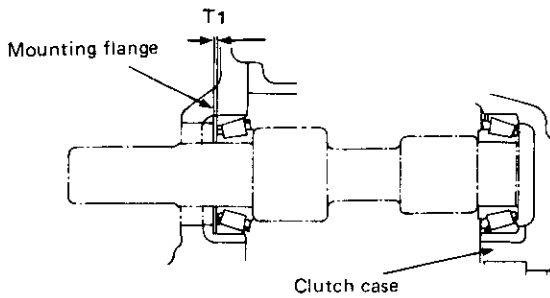
For input shaft parts: input shaft, bearing.

For output shaft parts: output shaft, thrust collar A, thrust collar B, gear, bearing.

(1) Shim thickness (T1) measurement of input shaft

- (a) Measure the bearing insertion hole depth (A) of the mounting flange, and the bearing insertion hole depth (A') of the clutch case.
- (b) Measure the length (B) between the bearing outer races of the input shaft assembly.
- (c) Obtain the (T1) thickness by the following formula:

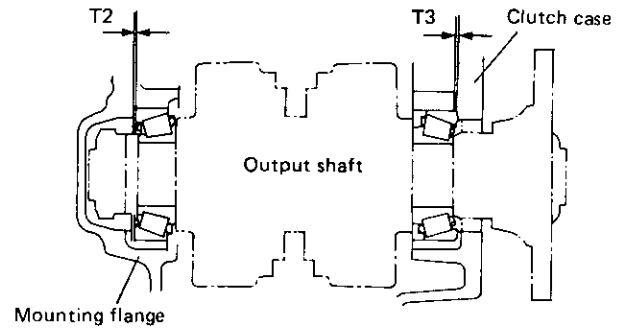
$$T1 = A + A' - B \quad (T1: \text{Clearance } \pm 0.05\text{mm})$$



(2) Shim thickness (T2, T3) measurement of output shaft

- (a) Measure the bearing insertion hole depth (C) of the mounting flange, and the bearing insertion hole depth (C') of the clutch case.
- (b) Measure the length (D) between the bearing outer races.

NOTE: Tighten the mounting flange nut of the output shaft assembly with the specified torque. Press-fit the inner race of the clutch case roller bearing to the large gear side.



- (c) Measure the (F) and (E) length from the outer race end of the clutch case bearing included in the output shaft assembly.

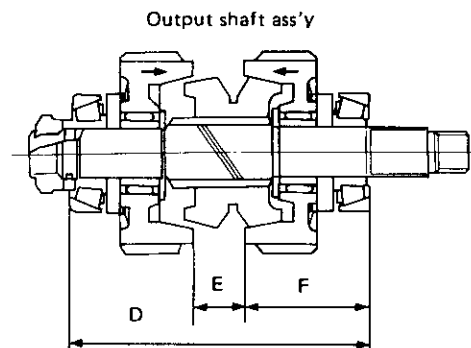
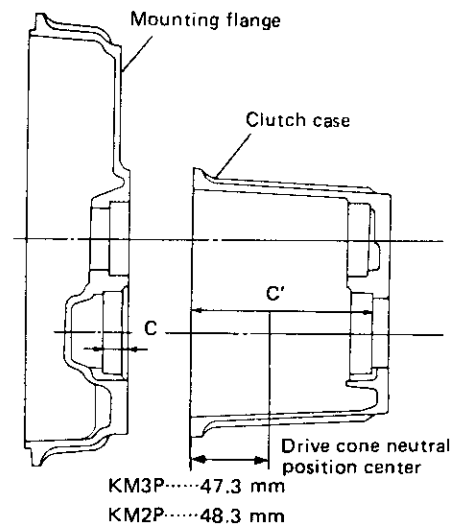
NOTE: Before measuring the (F) and (E) length, press the forward large gear and the reverse large gear to the drive cone until there is no clearance among them.

- (d) Obtain the (T2) and (T3) thickness by the following formulas:

$$T2 = C + C' - D - T3 \quad (\text{Clearance } \pm 0.1\text{mm})$$

$$T3 \text{ (KM2P)} = C' - 48.3 - \frac{E}{2} - F \quad (\text{Clearance } \pm 0.05\text{mm})$$

$$T3 \text{ (KM3P)} = C' - 47.3 - \frac{E}{2} - F \quad (\text{Clearance } \pm 0.05\text{mm})$$



Chapter 10 Reduction and Reversing Gear
3. Inspection and Servicing

SM/GM(F)(C)-HM(F)(C)

(3) Standard size of parts

							mm (in.)
	A + A'	B	C + C'	D	E	F	Drive corn neutral center position
KM2P	123.40 ~ 123.75	122.20 ~ 123.10	129.80 ~ 130.15	128.07 ~ 129.53	20.50 ~ 21.10	53.59 ~ 54.41	48.3
	(4.8583 ~ 4.8720)	(4.8110 ~ 4.8465)	(5.1102 ~ 5.1240)	(5.0421 ~ 5.0996)	(0.8071 ~ 0.8307)	(2.1098 ~ 2.1421)	(1.9016)
KM3P	132.40 ~ 132.75	131.20 ~ 132.10	141.20 ~ 141.55	139.56 ~ 141.00	23.50 ~ 24.10	57.83 ~ 58.65	47.3
	(5.2126 ~ 5.2264)	(5.1654 ~ 5.2008)	(5.5591 ~ 5.5728)	(5.4945 ~ 5.5512)	(0.9252 ~ 0.9488)	(2.2768 ~ 2.3091)	(1.8622)

NOTE: Compare your measurements with the above standard size. If your measurements largely differ from the standard sizes, measurements may not be correct. Check and measure again.

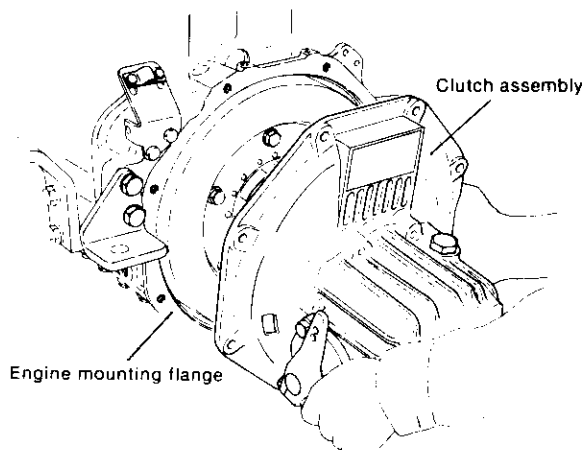
(4) Adjusting shim set

	Part No.	Thickness.mm(in.)	No. of shims
Input shaft	177088-02350	0.5 (0.0197)	1
		0.4 (0.0157)	1
		0.3 (0.0118)	2
Output shaft	177088-02300	1.0 (0.0394)	1
		0.5 (0.0197)	1
		0.3 (0.0118)	2
		0.1 (0.0039)	3

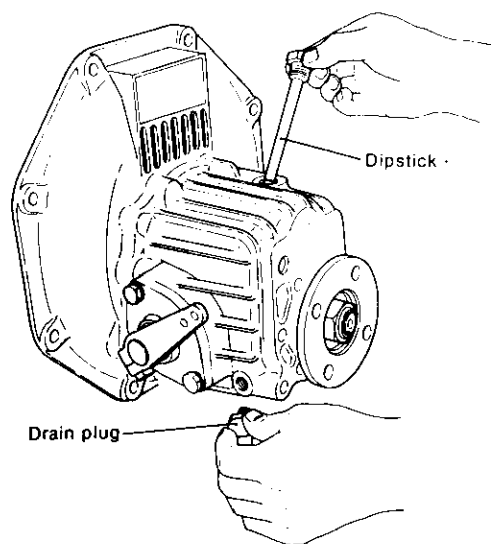
4. Disassembly

4-1 Dismantling the clutch

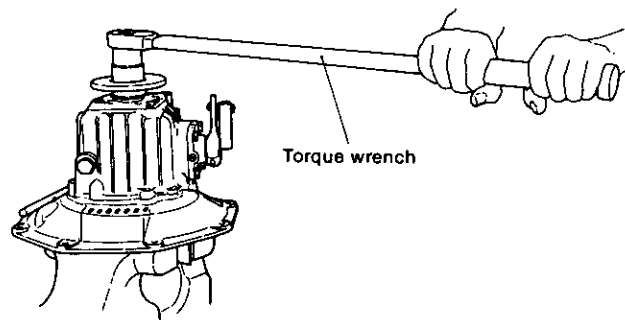
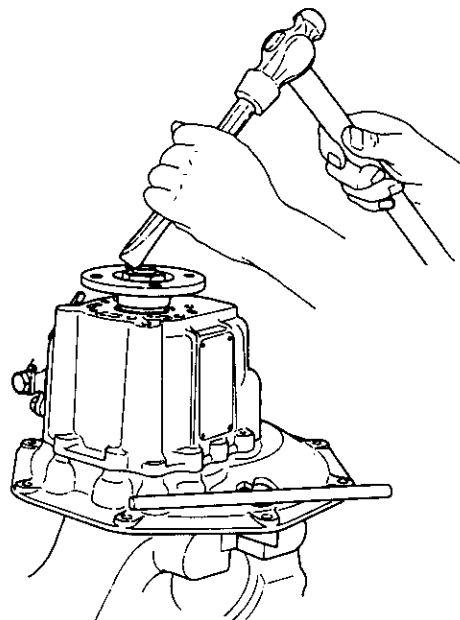
- (1) Remove the remote control cable.
- (2) Remove the clutch assembly from the engine mounting flange.



- (3) Drain the lubricating oil.
Drain the lubricating oil by loosening the plug at the bottom of the clutch case.

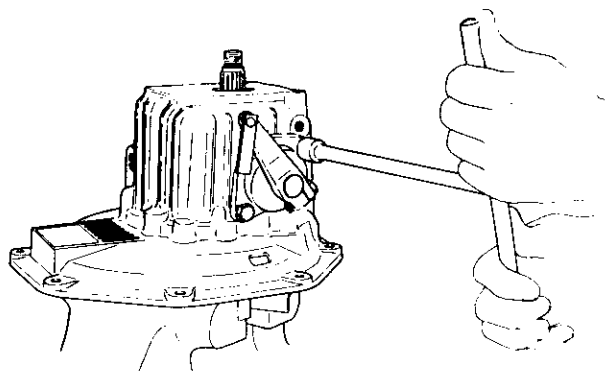


- (4) Remove the end nut and output shaft coupling.

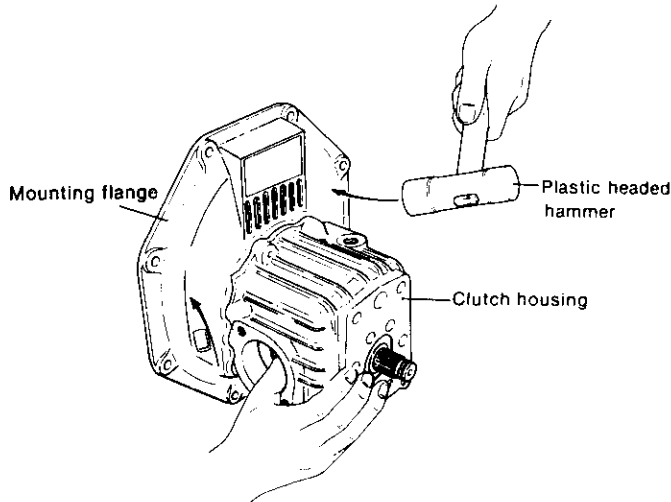
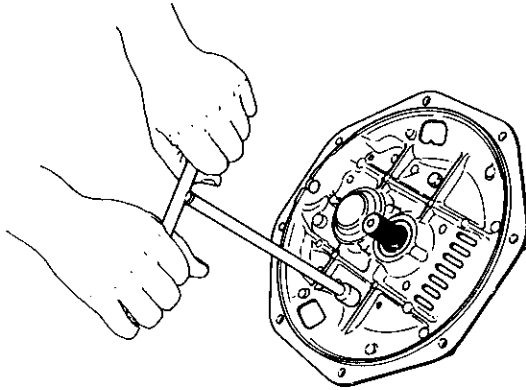


NOTE: Take care as it has a left-handed thread.

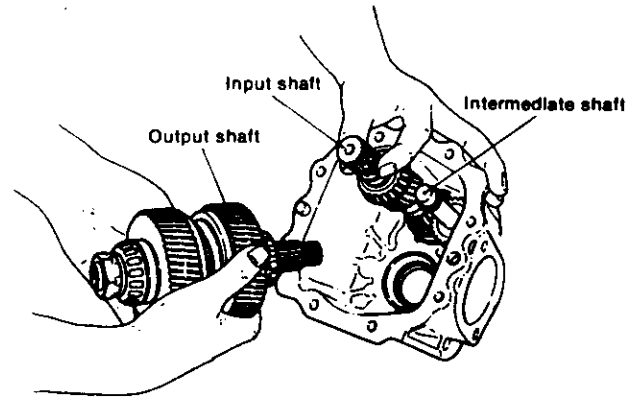
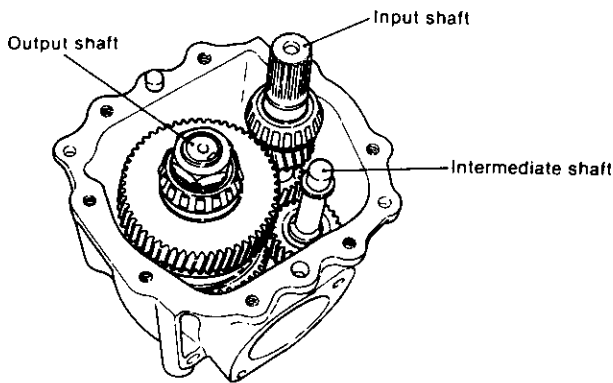
- (5) Remove the oil dip stick and O-ring.
- (6) Remove the fixing bolts on the side cover, and also remove the shift lever shaft, shift lever and shifter.



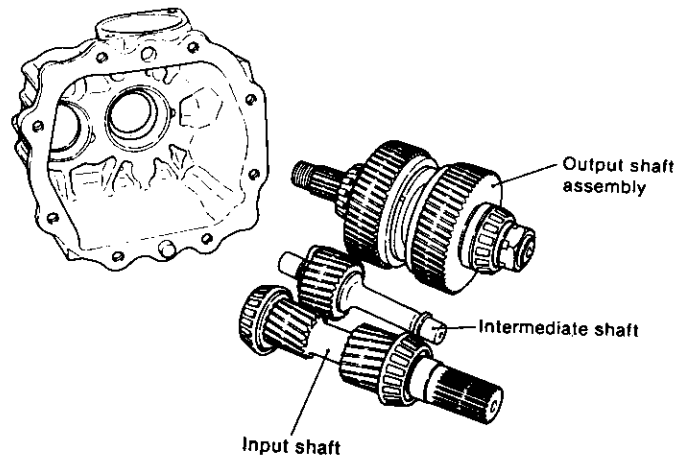
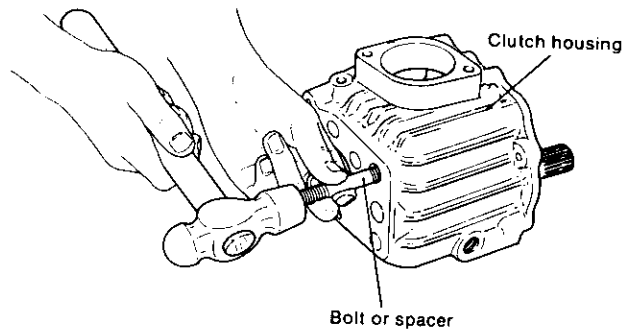
(7) Remove the bolts which secure the mounting flange to the case body, give light taps to the left and right with a plastic headed hammer while supporting the clutch case with your hand, then remove the mounting flange.



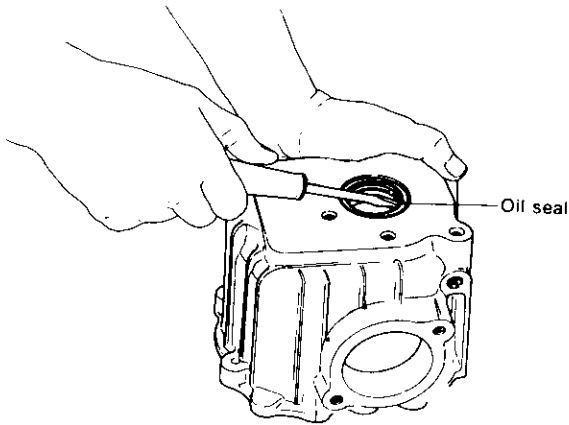
(8) Withdraw the output shaft assembly.



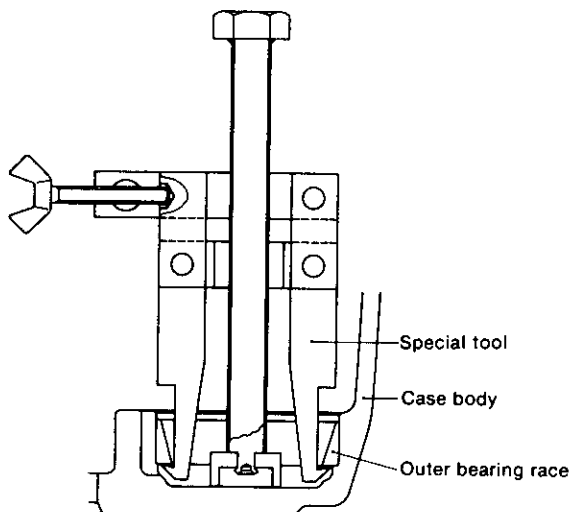
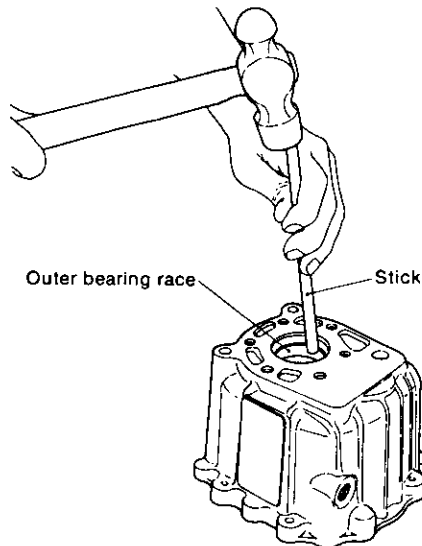
(9) Take out the intermediate shaft and input shaft. When taking out the intermediate shaft, place a bolt or spacer on the shaft hole of the case, and drive the shaft out by tapping it lightly.



- (10) Remove the oil seal of the output shaft from the case body.



- (11) Remove the outer bearing race from the case body by using the special tool.

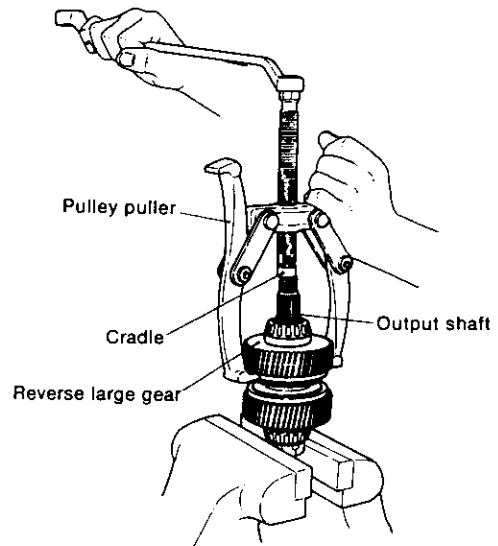


- (12) Remove the oil seal of the input shaft from the mounting flange.
(13) Remove the outer bearing race from the mounting flange in the same way as with the case body.
(14) Remove each adjusting plate from the input or output shaft.

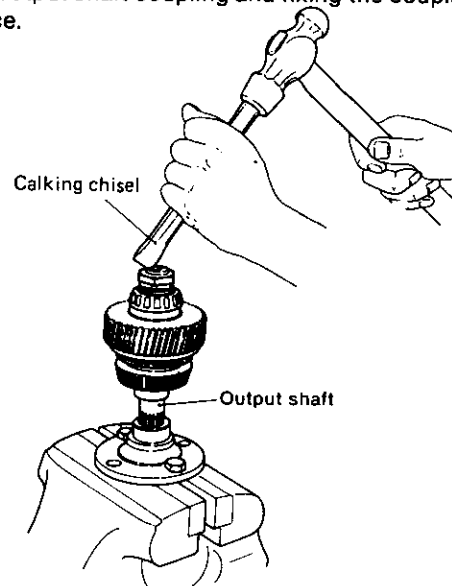
NOTE: The same adjusting plates can be reused when the following parts are not replaced. When any part is replaced however, re-adjustment is necessary.

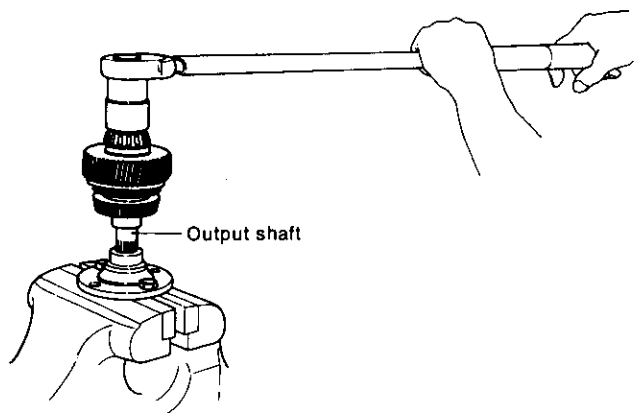
4-2 Removal of the output shaft

- (1) Take out the reverse large gear, thrust collar A, cup spring, spring retainer and inner bearing race.
The reverse large gear must be withdrawn using a pulley extractor, by fixing the nut at the forward end in a vice.

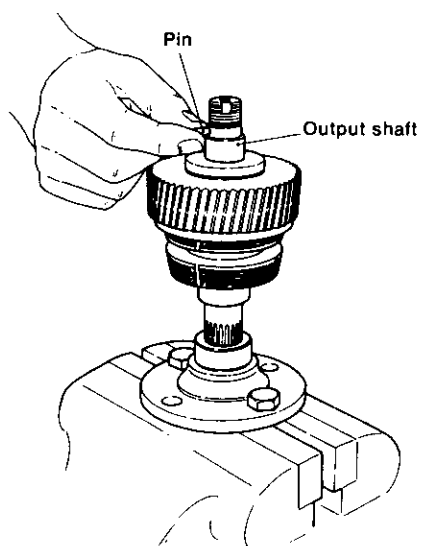
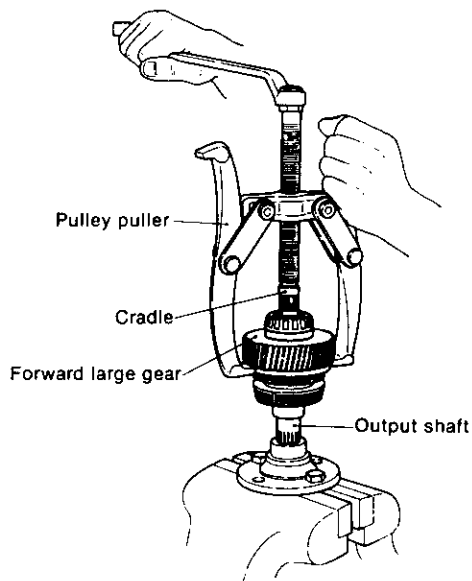


- (2) Loosen the calking of the forward nut and remove the nut and spacer.
Remove the nut by using a torque wrench after setting the output shaft coupling and fixing the coupling bolt in a vice.

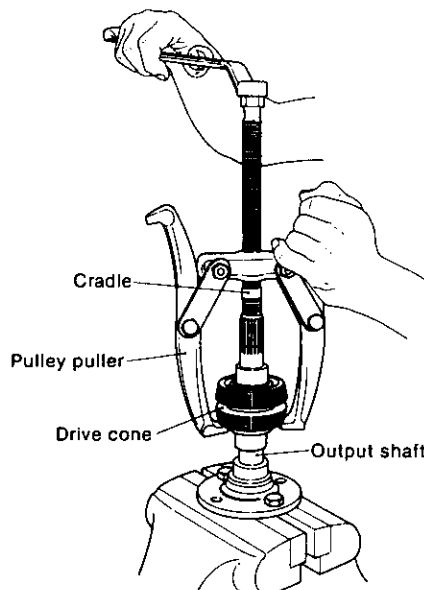
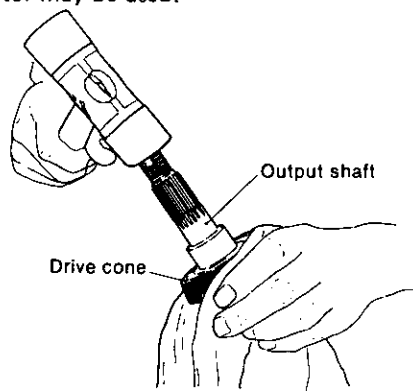




(3) Place the pulley extractor against the end surface of the forward large gear, and withdraw the forward large gear, thrust collar A, cup spring, spring retainer and inner bearing race.

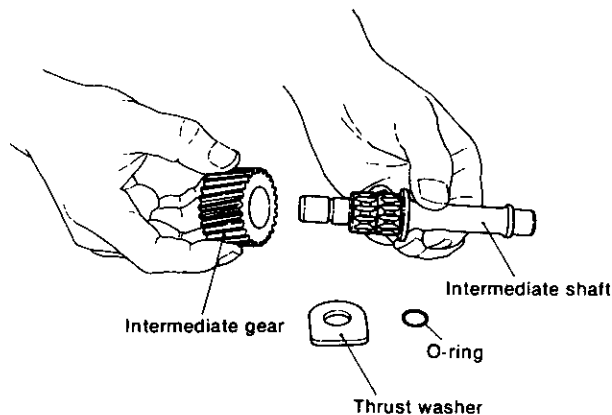


(4) While gripping the drive cone, tap the end of the shaft with a plastic headed hammer, and withdraw the thrust collar B and inner needle bearing race. A pulley extractor may be used.



4-3 Removal of the intermediate shaft

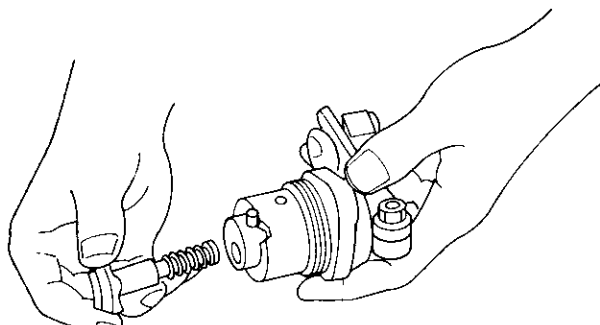
- (1) Remove the "O" ring.
- (2) Remove the thrust washer.
- (3) Remove the intermediate gear and needle bearing.



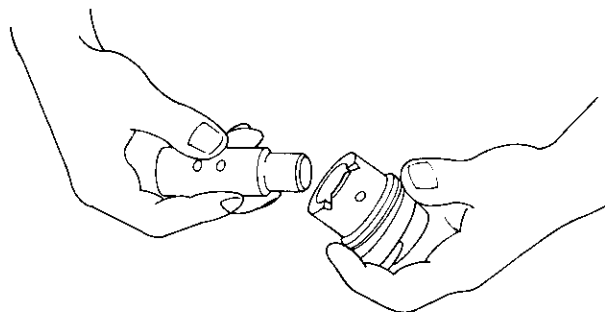
NOTE: Take care as the nut has left-handed thread.

4-4 Dismantling the shifting device

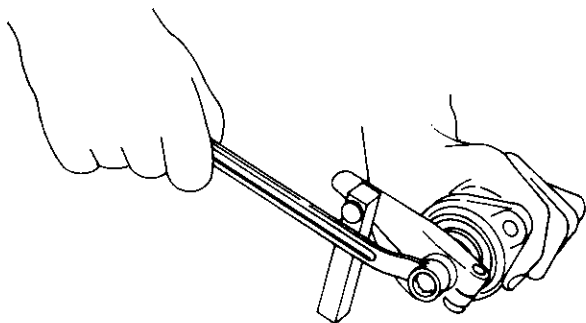
(1) Take out the shifter and shifter spring.



(4) Remove the shift lever to the anti-shift lever side.

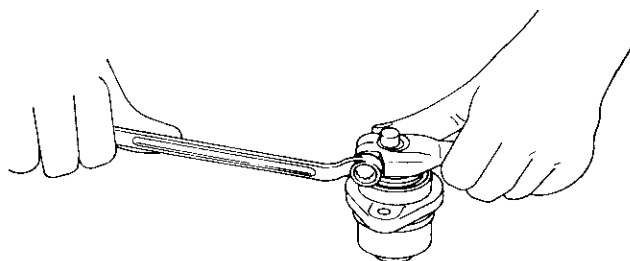


(2) Remove the stopper bolt of the shifter and shim.



(5) Remove the oil-seal and O-ring.

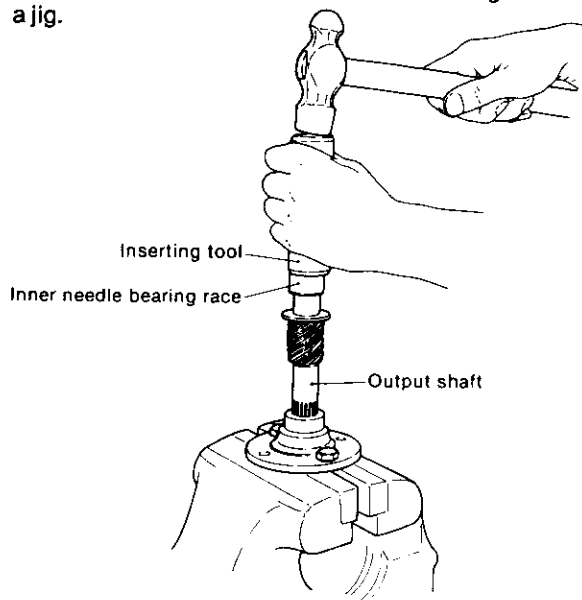
(3) Loosen the bolt of the shift lever and remove the shift lever from the shift lever shaft.



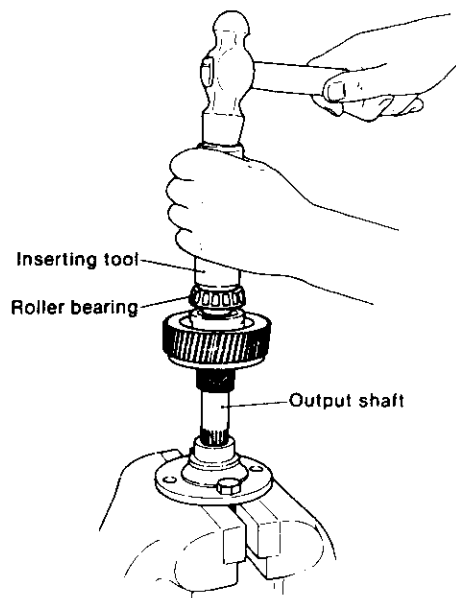
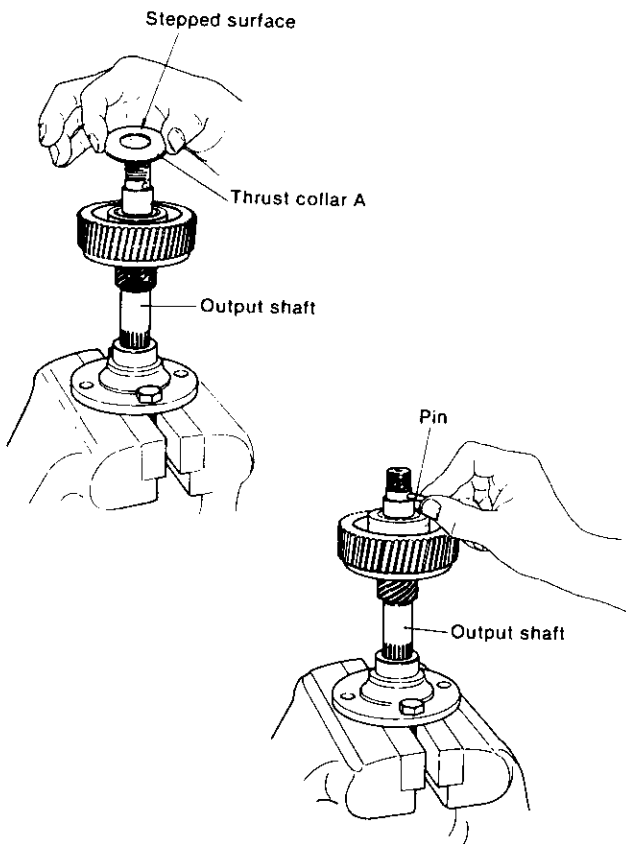
5. Reassembly

5-1 Reassembly of output shaft

- (1) Fit the forward side thrust collar B onto the shaft.
- (2) Drive in the forward end inner needle bearing race using a jig.



- (3) Assemble the needle bearing and forward large gear.
- (4) Fit the cup spring, spring retainer, thrust collar A and pin, and drive in the inner bearing race using a jig.



NOTE: 1) Drive in with a plastic headed hammer. Do not hit it hard.

2) When fitting the thrust collar A, note the fitting direction. Fit it keeping the stepped surface toward the roller bearing side.

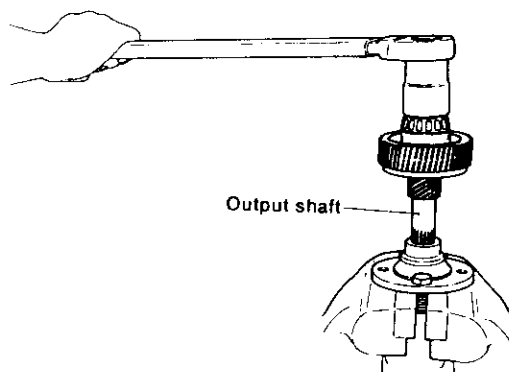
3) Note that the pin cannot be fitted after the inner bearing race has been driven in.

4) Check that the forward large gear rotates smoothly.

(5) Assemble the collar and pin so that the pin is in the groove of the collar.

(6) Set and tighten the forward end nut. Insert the bolt into the coupling, and fix it in a vice, keeping the spline part upward.

Insert the shaft into the spline of the coupling, fit the spacer, and tighten the nut with a torque wrench.

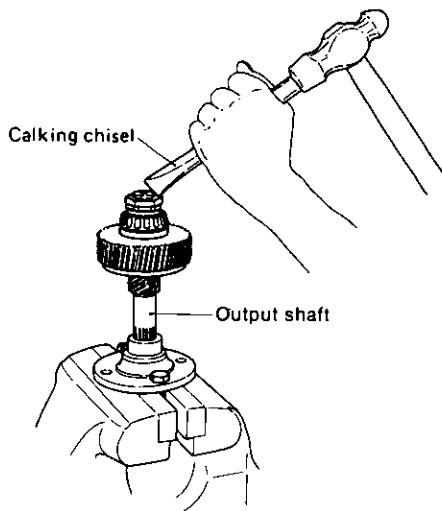


Tightening torque	10 ± 1.5 kgf-m (81.5 ~ 83.2 ft-lb)
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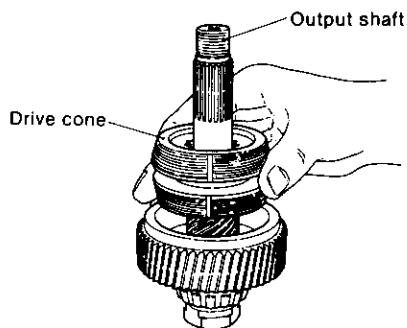
(The same torque applies to both models KM2P and KM3P)

NOTES: 1) Take care as it is a left-handed thread.

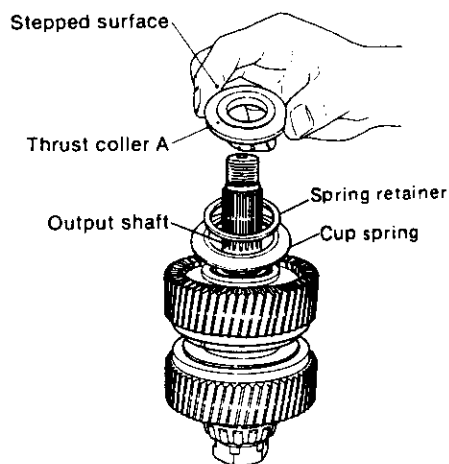
2) Use the reverse side nut used before dismantling as the forward end nut. This is so as not to match the calked portion to the same point.



(7) Insert the drive cone while keeping the output shaft set for reverse.



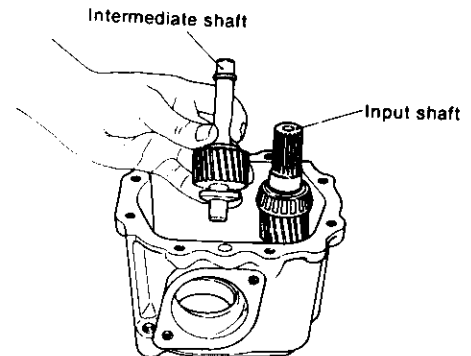
(8) Apply procedures 1 through 4 to the forward end.



NOTE: 1) Fit thrust collar A so that the stepped surface faces the roller bearing side.
2) Check that the reverse large gear rotates smoothly.

5-2 Reassembly of the clutch

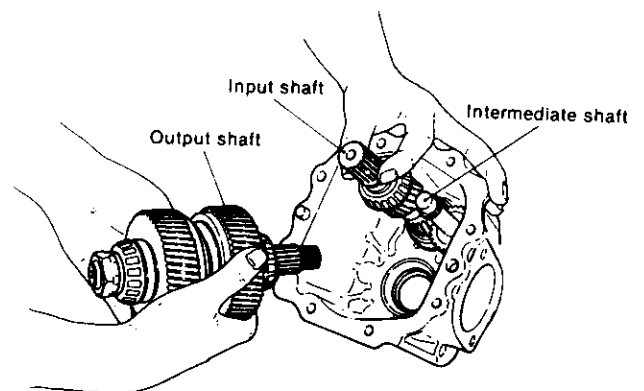
- (1) Fit the oil seal, bearing outer races and shim (output shaft side) in the clutch case.
- (2) Insert the input shaft into the clutch case.
- (3) Drive the intermediate shaft into the clutch case.



NOTES: 1) If the output shaft is not fitted into the clutch case before driving-in the intermediate shaft, it cannot be assembled.

2) Note the assembly direction of the thrust washer.

(4) Insert the output shaft into the clutch case.

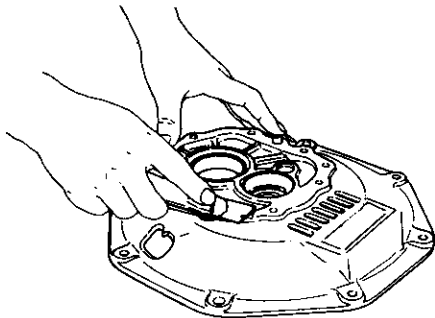


(5) Fit the adjusting plate to the mounting flange, and drive in the outer bearing race.

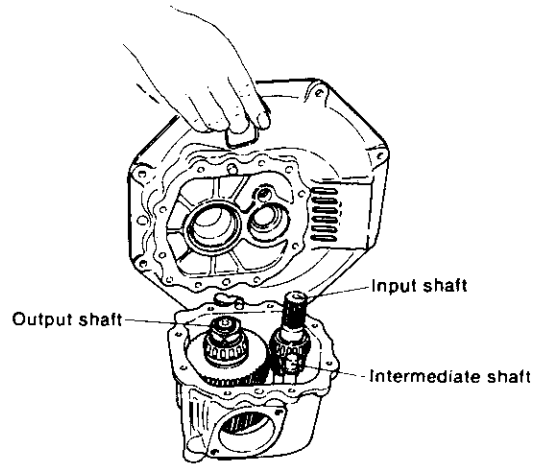
NOTE: The outer bearing race can be easily driven in by heating the mounting flange to about 100°C, or by cooling the outer race with liquid hydrogen.

(6) Apply non-drying liquid packing around the outer surface of the oil seal, and insert the oil seal into the mounting flange while keeping the spring part of the oil seal facing the inside of the case.

(7) Apply non-drying liquid packing to the matching surfaces of the mounting flange and the case body.



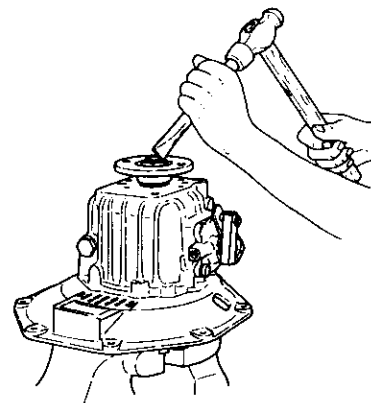
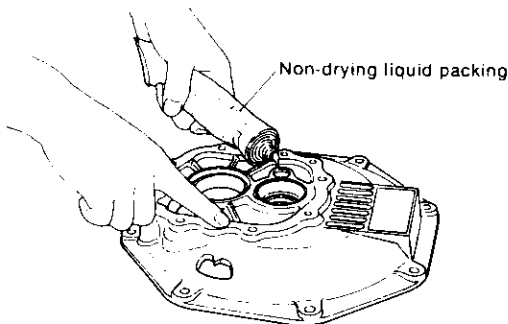
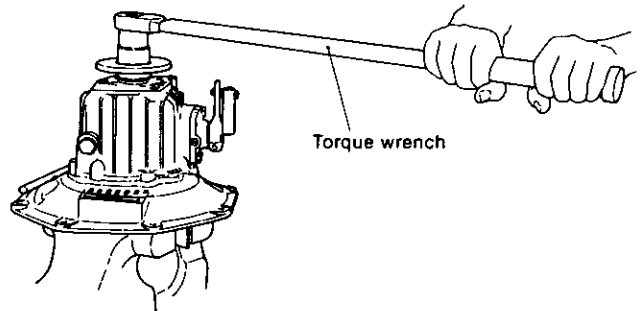
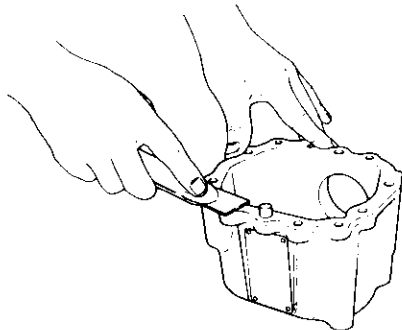
(8) Insert the input shaft and output shaft into the shaft holes of the mounting flange, assemble the mounting flange on the case body, and tighten the bolt.



NOTE: Apply non-drying liquid packing to either the mounting flange or the case body.

(9) Assemble the output shaft coupling on the output shaft, and fit the O-ring.

(10) Tighten the end nut by using a torque wrench, then calk it.



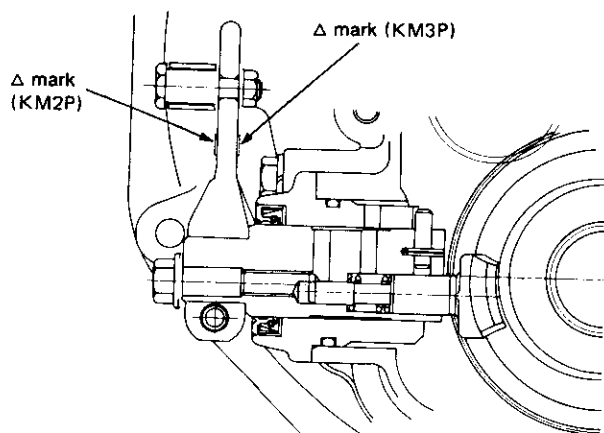
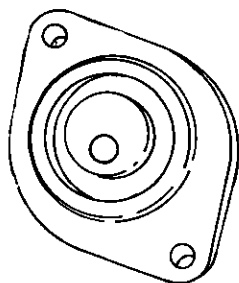
NOTE: Take care as it is a left-handed thread.

Tightening torque	10 ± 1.5 kgf-m (81.5 ~ 83.2 ft-lb)
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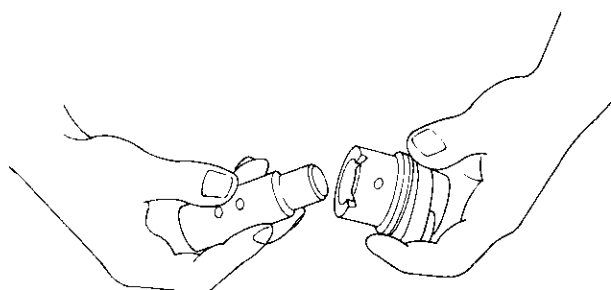
(The same torque applies to both models KM2P and KM3P).

5-3 Reassembly of the shifting device

(1) Fit the oil seal and O-ring to the side cover.



(2) Insert the shift lever shaft to the side cover.



(4) Insert the shifter spring and shifter to the shift lever shaft.

(5) Fit the side cover assembly to the clutch case.

NOTE: 1) Check the direction of the shifter (Top and bottom side).

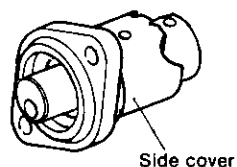
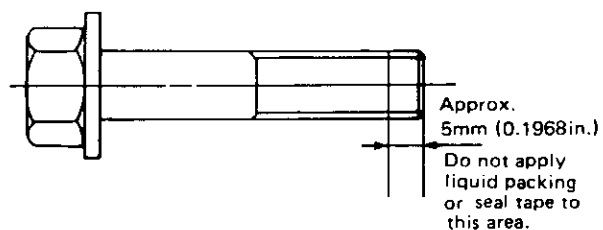
2) The shift lever may not turn smoothly if the clutch case is not filled with lubricating oil.

(6) Fit the shim and stopper bolt to the shift lever shaft.

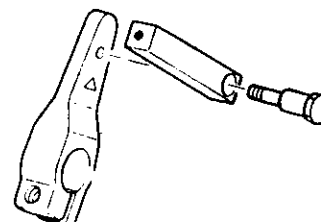
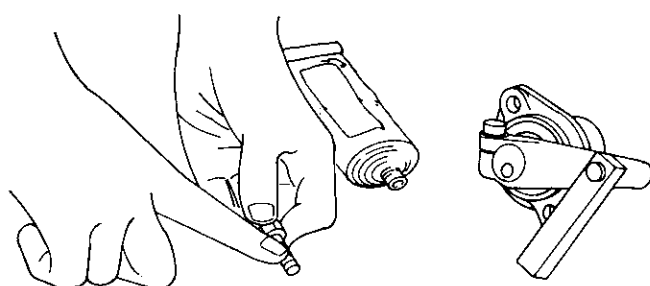
NOTE: Apply non-drying liquid packing or seal-tape to the thread of the stopper bolt.

(3) Fit the shift lever to the shift lever shaft.

NOTE: Check the direction of the shift lever Δ mark.



(7) Fit the cable connector to the shift lever.



[D] V-drive Gear, Model KM3V

Applicable Engine Models: 1GM10V,2GM20(F)V,3GM30(F)V

1. Construction

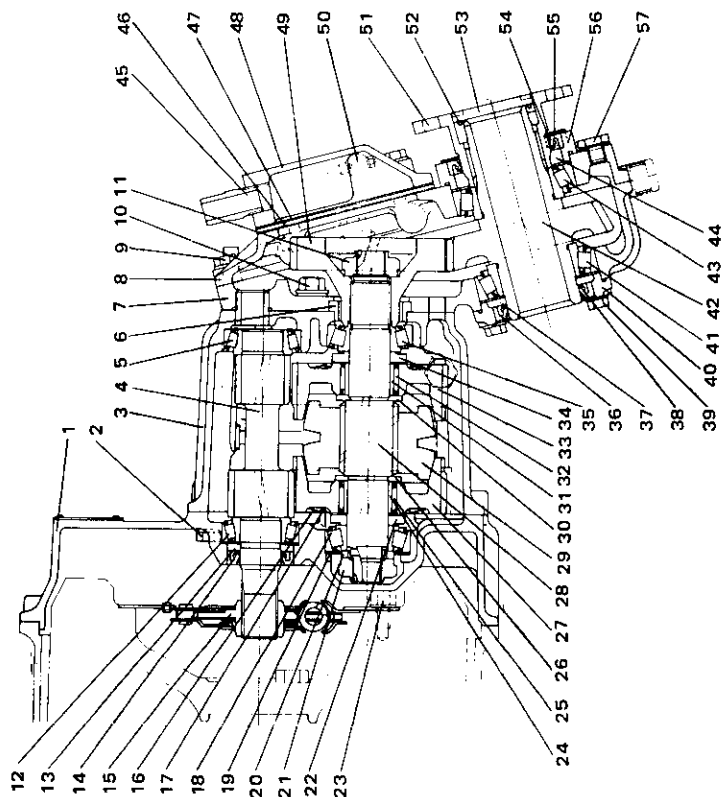
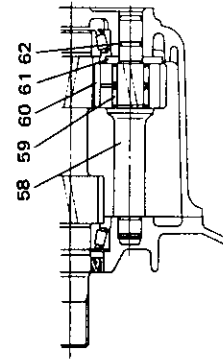
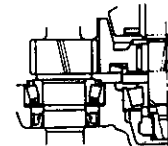
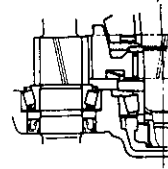
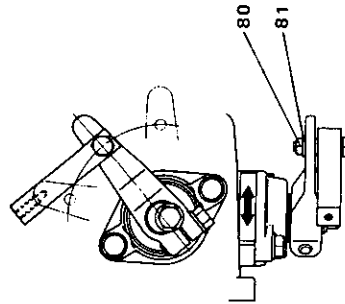
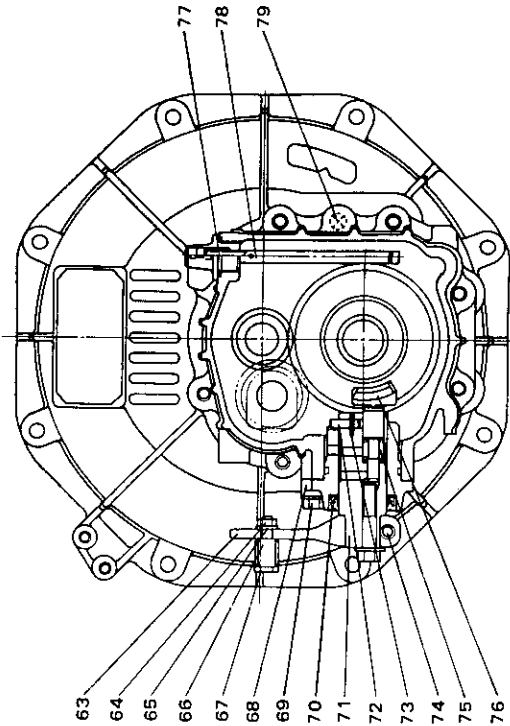
1-1 Construction

Basically, the construction of the KM3V V-drive Gear is the combination of the KM3P mechanical cone type clutch, and the V-drive case. (However, there is no interchangeability between the KM3P clutch case and the KM3P.) The output shaft coupling of the KM3P is changed to the drive gear, and the power transmission is made through the drive gear connected with the conical gear inside the V-drive case. The conical gear is of mono-block construction with the V-drive output shaft.

The KM3V is equipped with the lube oil cooler which controls the lube oil temperature to a proper level in order to increase the durability of bearings, oil-seals, gears, and other relative parts.

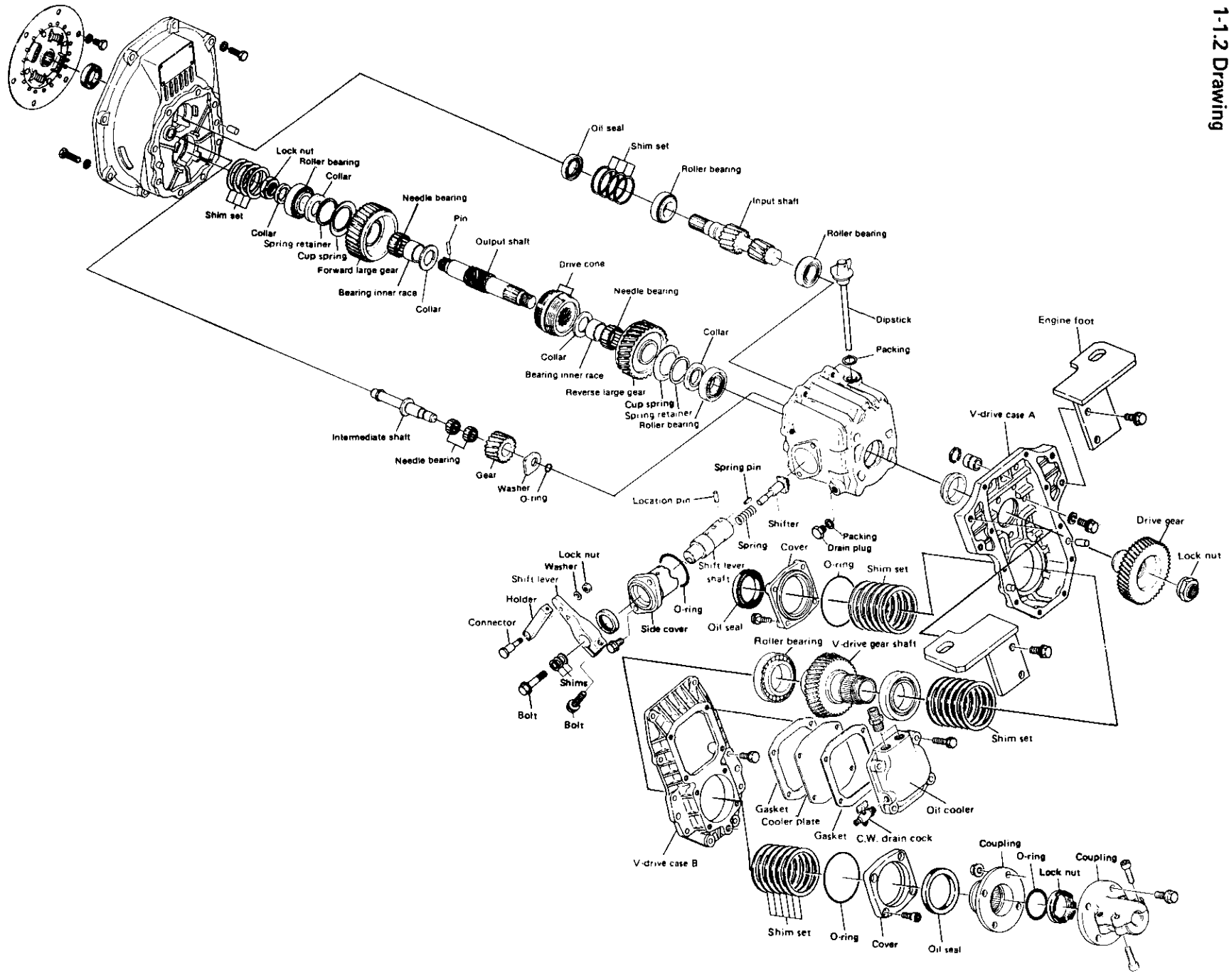
The lube oil cooler is cooled by the cooling water coming from the engine's sea water pump. Cooling water flows as follows: Sea-water pump ⇒ Lube oil cooler ⇒ Engine side 3-way joint (for 1GM 10V), L-type joint (for 2GM20V, 3GM30V), or Heat exchanger (for 2GM20FV, 3GM30FV). In order to prevent cracking by freezing, the oil cooler is equipped with a drain cock which facilitates easy water draining.

1-1.1 KM3V Sectional View



- 1 Mounting flange
- 2 Bolt M8 x 25
- 3 Clutch case
- 4 Input shaft
- 5 Bearing
- 6 Bush
- 7 V-drive case A
- 8 V-drive case B
- 9 Bolt M8 x 25
- 10 Bolt M10 x 25
- 11 Lock nut
- 12 Bearing
- 13 Shim
- 14 Oil seal
- 15 Dumper disk
- 16 Cup spring
- 17 Spring retainer
- 18 Bearing
- 19 Shim
- 20 Collar
- 21 Lock nut
- 22 Thrust collar A
- 23 Bolt M8 x 14
- 24 Inner rase
- 25 Bearing
- 26 Thrust collar B
- 27 Forward gear
- 28 Output shaft
- 29 Drive cone
- 30 Thrust collar B
- 31 Inner rase
- 32 Bearing
- 33 Reverse gear
- 34 Thrust collar A
- 35 Bearing
- 36 Oil seal
- 37 Shim
- 38 O-ring
- 39 Bolt M8 x 25
- 40 Cover A
- 41 Bearing
- 42 V-drive gear shaft
- 43 Bearing
- 44 Shim
- 45 Joint
- 46 Cooler plate
- 47 Gasket
- 48 Cooler body
- 49 Drive gear
- 50 Drain cock
- 51 Coupling
- 52 O-ring
- 53 Lock nut
- 54 O-ring
- 55 Oil seal
- 56 Cover B
- 57 Drain plug
- 58 Idle gear shaft
- 59 Bearing
- 60 Gear
- 61 Thrust washer
- 62 O-ring
- 63 Shift lever
- 64 Lock nut
- 65 Washer
- 66 Holder
- 67 Connector
- 68 Side cover
- 69 Bolt M8 x 25
- 70 Oil seal
- 71 Shift lever shaft
- 72 Location pin
- 73 Spring pin
- 74 Bolt M8 x 25
- 75 Spring
- 76 Shifter
- 77 Gasket 16
- 78 Dipstick
- 79 Parallel pin 10 x 6
- 80 Lock nut
- 81 Washer

1-1.2 Drawing

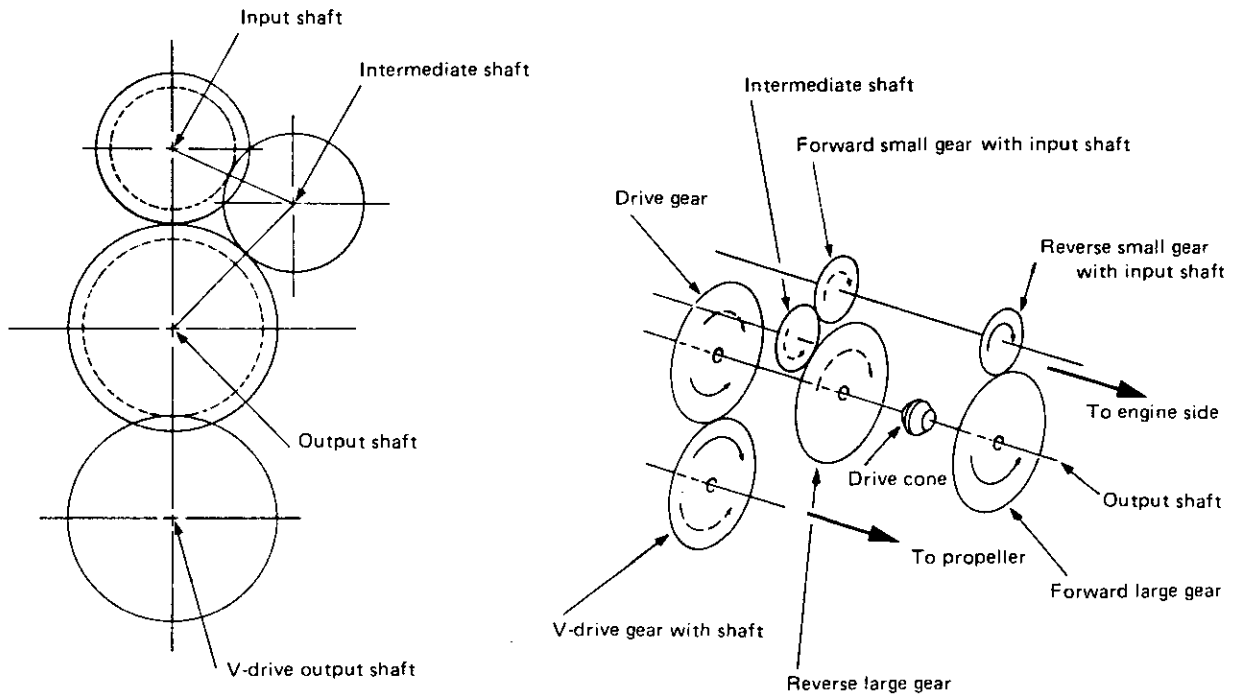


2. Specifications

Model		KM3V		
For engine models		1GM10V, 2GM20(F)V, 3GM30(F)V		
Clutch		Constant mesh gear with servo cone clutch (wet type)		
Reduction ratio	Forward	2.36	2.61	3.20
	Reverse	3.16	3.16	3.16
Propeller shaft rpm (Forward) rpm		1441	1303	1063
Direction of rotation	Input shaft		Clockwise, viewed from stern	
	V-drive output shaft	Forward	Clockwise, viewed from stern	
		Reverse	Counter-clockwise, viewed from stern	
Remote control	Control head		Single lever control	
	Cable		Morse, 33-C (Cable travel 76.2mm or 3 in)	
	Clamp		YANMAR made, standard accessory	
	Cable connector		YANMAR made, standard accessory	
Output shaft coupling	Outer diameter		ø100mm (3.93")	
	Pitch circle diameter		ø78mm (3.07")	
	Connecting bolt holes		4—ø10.5mm (4—ø0.41")	
Position of shift lever		Right side, viewed from stern		
Lubricating oil		SAE #10W-30, CC class		
Lubricating oil capacity		0.8ℓ		
Dry weight		19.5 kg (43 lbs)		

3. Power transmission system

3-1 Arrangement of shaft and gears



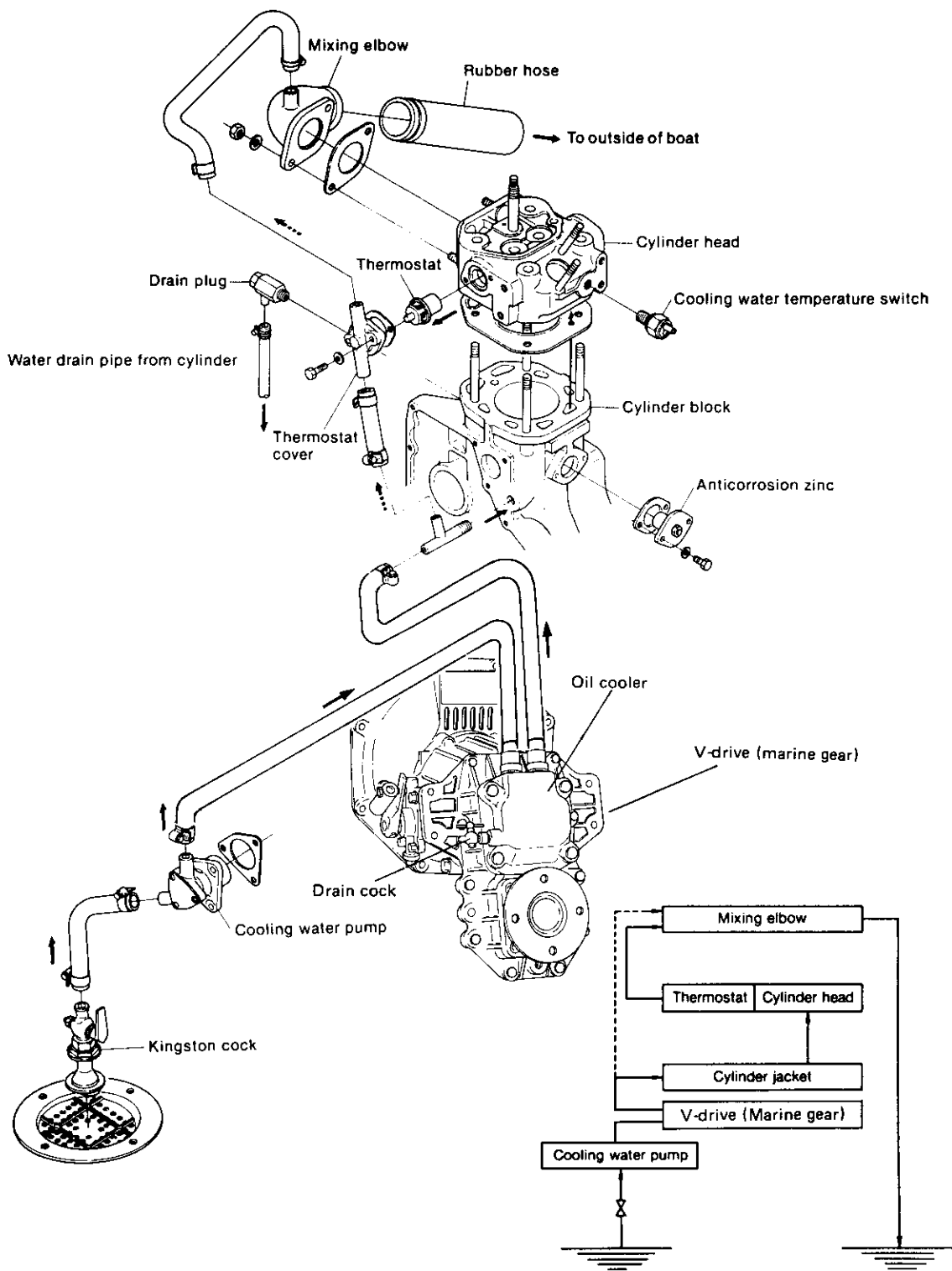
[Shaft arrangement viewed from the stern]

3-2 Reduction ratio

	Small gear		Large gear	Drive gear	V-drive gear	Reduction ratio
Forward	25		59	46	46	$59/25 = 2.36$
	23		60	46	46	$60/23 = 2.61$
	20		64	46	46	$64/20 = 3.20$
Reverse	19	26 Intermediate gear	60	46	46	$60/19 = 3.16$

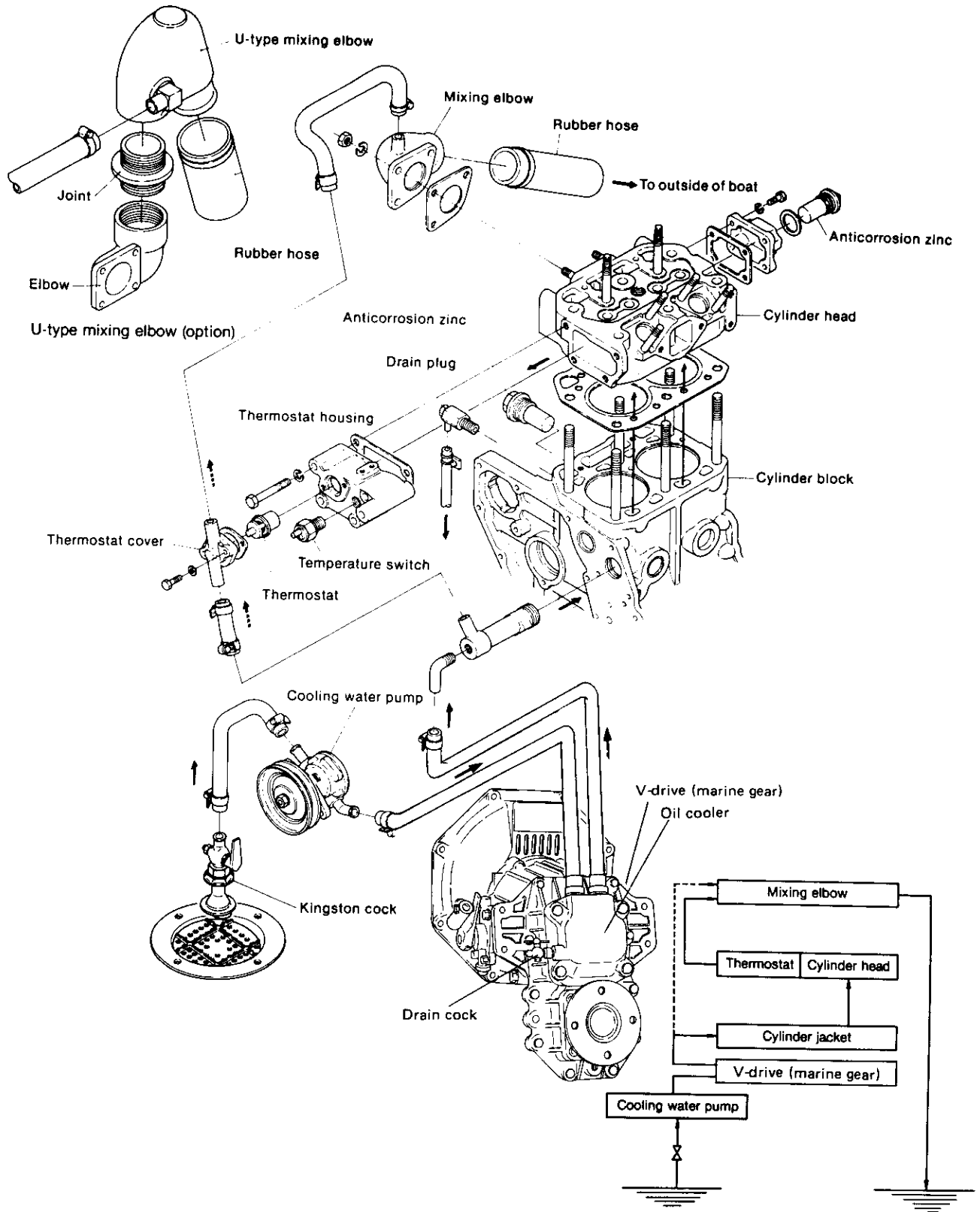
4. Cooling system (Sea-water Cooling Engine)

4-1 Cooling water passage of engine model 1GM10V



← When the cooling water is at the correct temperature
 ←... When the cooling water temperature is lower than the correct temperature

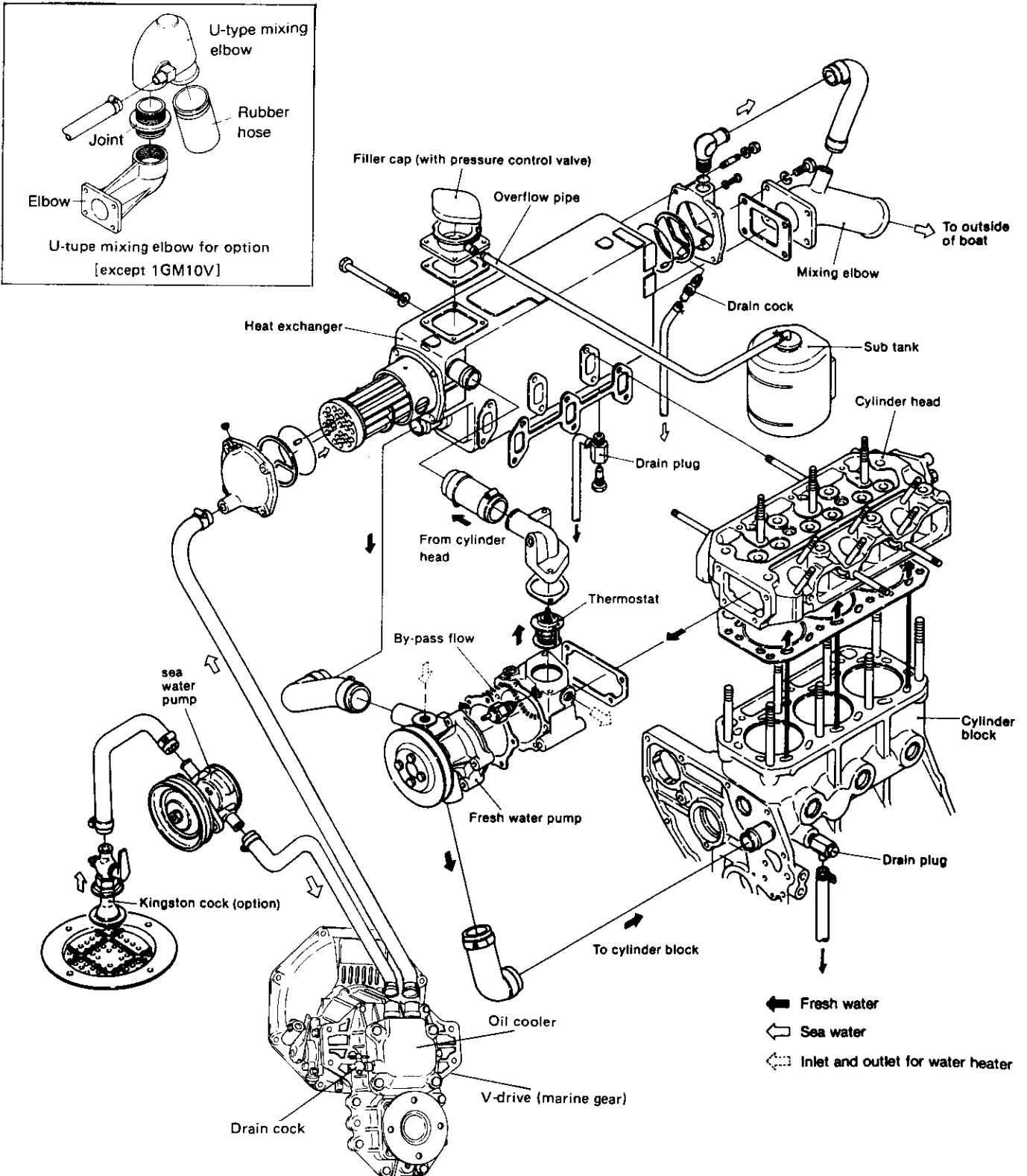
4-2 Cooling water passage of engine model 2GM20V and 3GM30V



← When the cooling water is at the correct temperature
 ←--- When the cooling water temperature is lower than the correct temperature

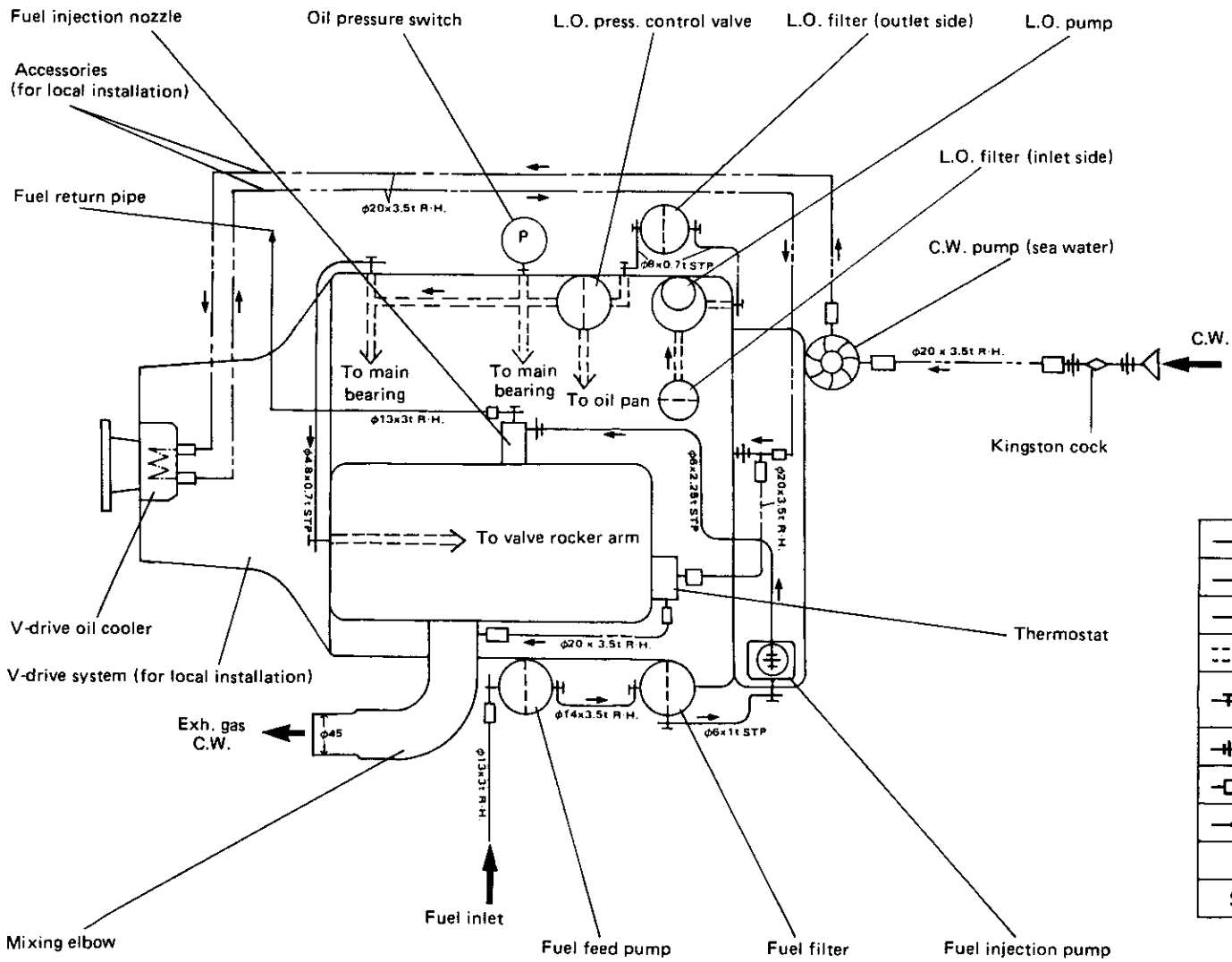
4-3 Cooling system (Fresh water cooling engine)
 System Diagrams

Models 2GM20FV and 3GM30FV are constructed from different parts but use the same water flow.

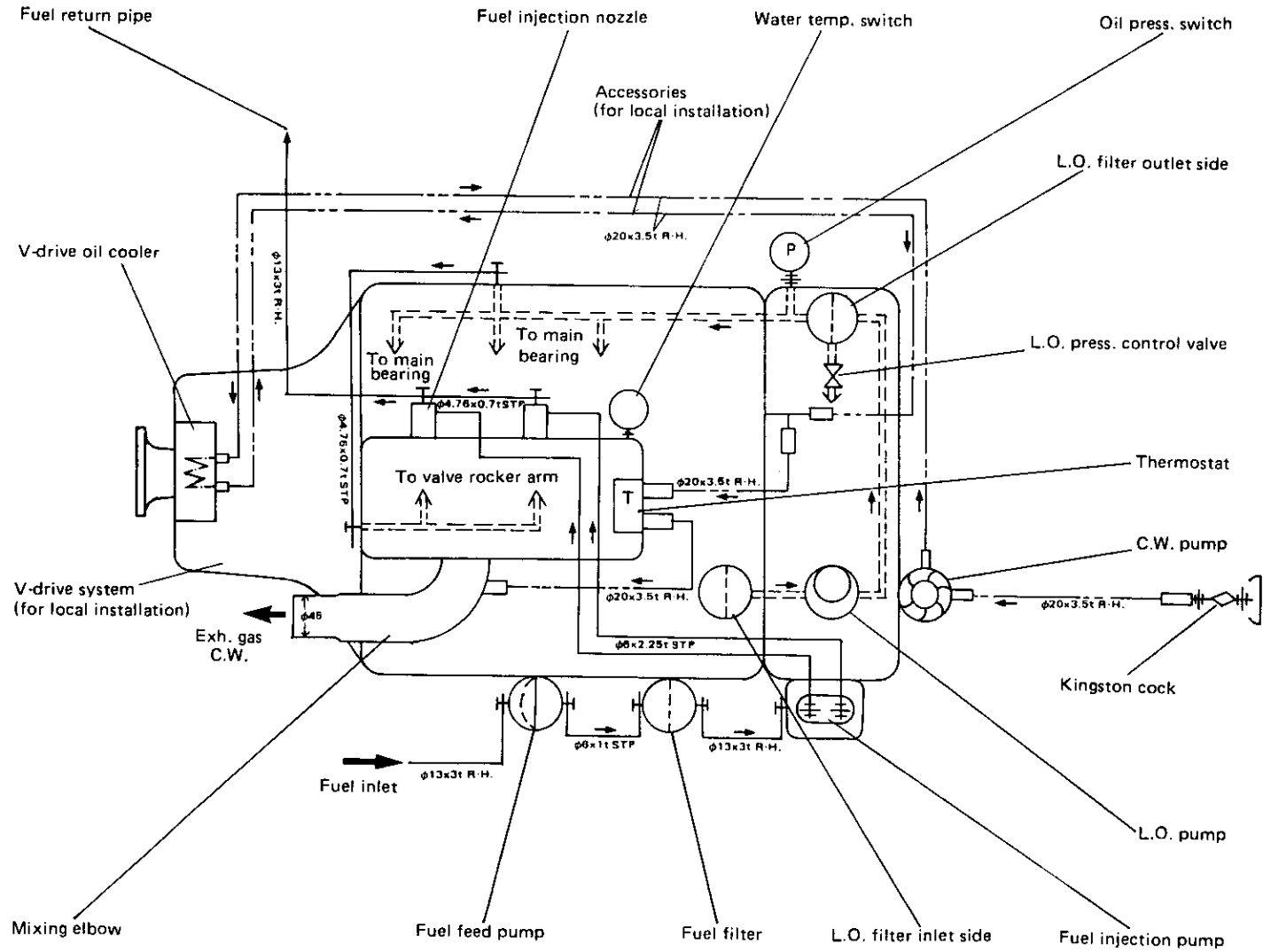


5. Piping Diagrams

5-1 1GM10V

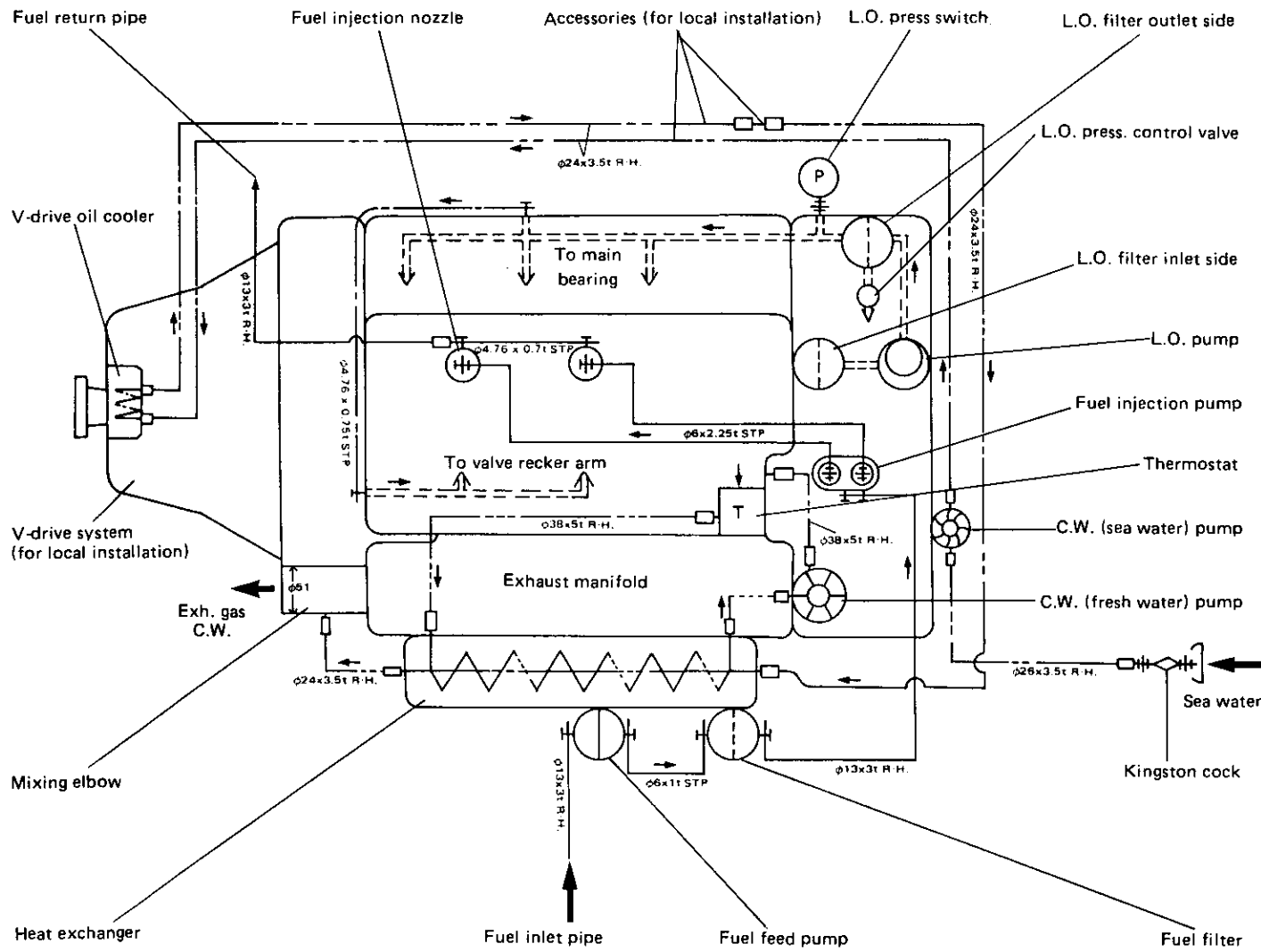


	Fuel oil pipe
	L.O. pipe
	C.W. pipe
	Drilled hole
	Spherical pipe joint
	Screwed joint
	Spigot joint
	Cock
	Rubber hose
	Steel pipe



	Fuel oil pipe
	L.O. pipe
	C.W. pipe
	Drilled hole
	Spherical pipe joint
	Screwed joint
	Spigot joint
	Cock
RH	Rubber hose
STP	Steel pipe

5-3 2GM20FV

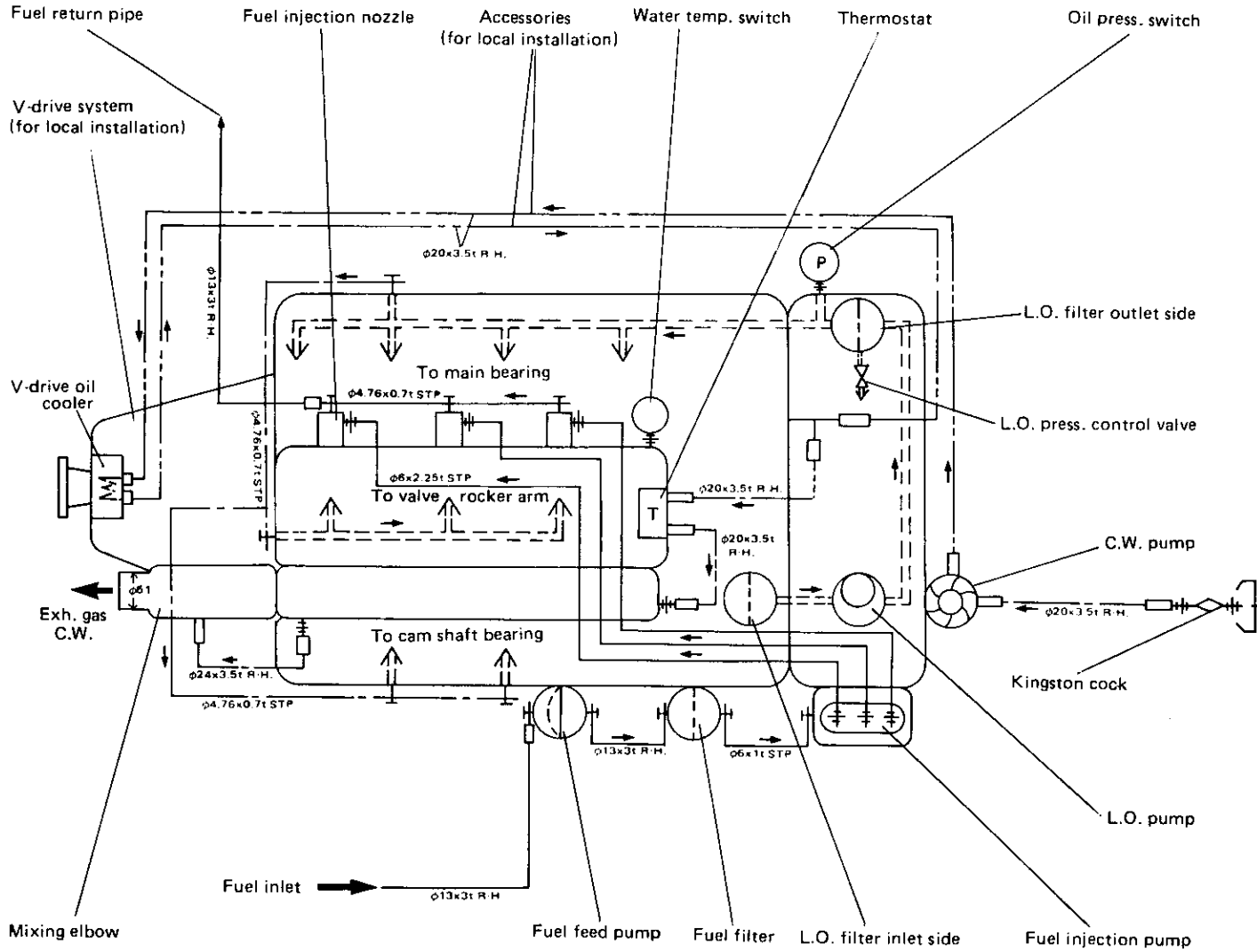


	Fuel oil pipe
	L.O. pipe
	C.W. pipe (Sea water)
	C.W. pipe (Fresh water)
	Drilled hole
	Spherical pipe joint
	Screwed joint
	Spigot joint
	Cock
RH	Rubber hose
STP	Steel pipe

SM/M(F)/C-HM(F)/C

1087

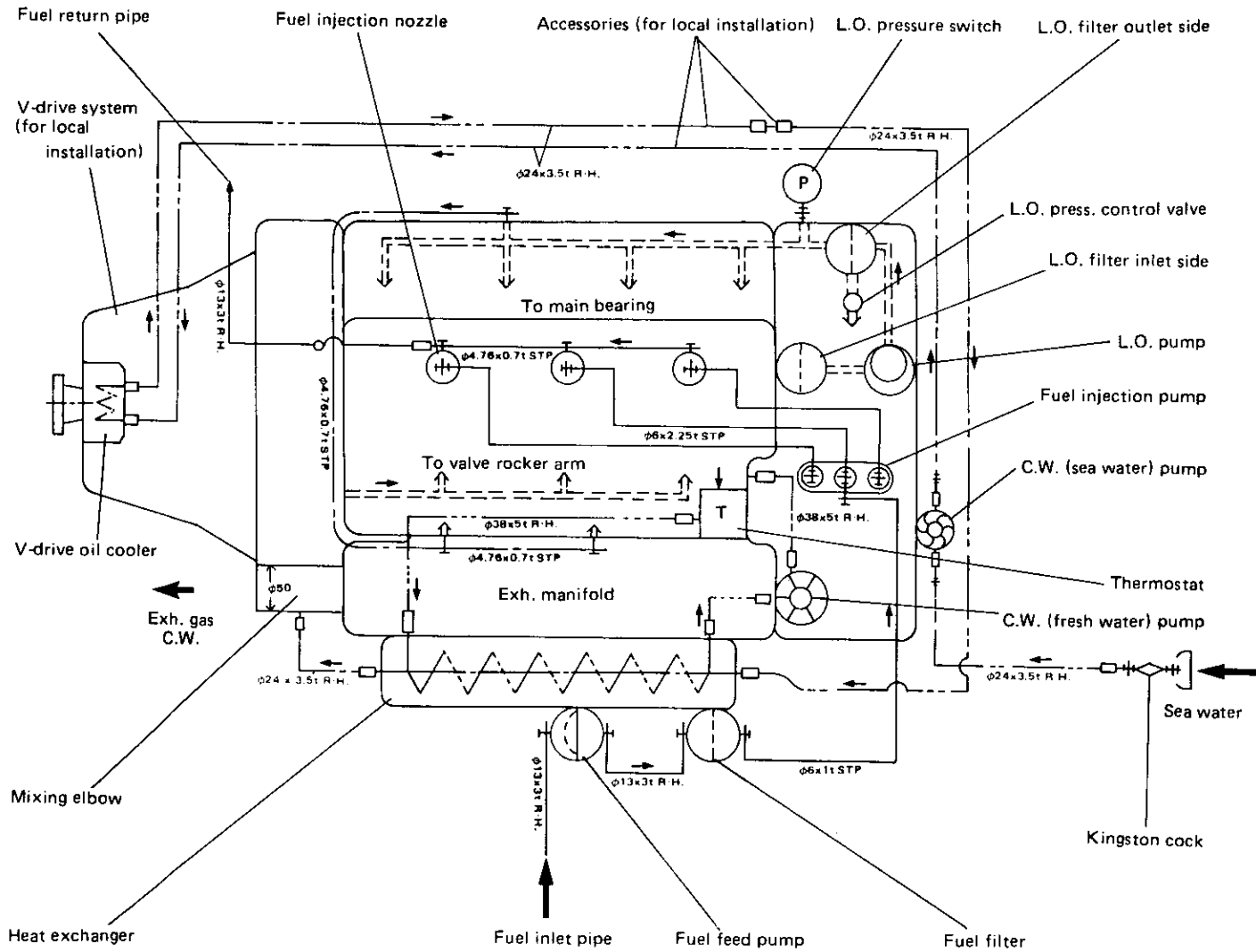
5-4 3GM30V



	Fuel oil pipe
	L.O. pipe
	C.W. pipe
	Drilled hole
	Spherical pipe joint
	Screwed joint
	Spigot joint
	Cock
	RH
	STP

SM/GM(F)(C)-HM(F)(C)

5-4 3GM30FV



	Fuel pipe
	L.O. pipe
	C.W. pipe (Sea water)
	C.W. pipe (Fresh water)
	Drilled hole
	Spherical pipe joint
	Screwed joint
	Spigot joint
	Cock
RH	Rubber hose
STP	Steel pipe

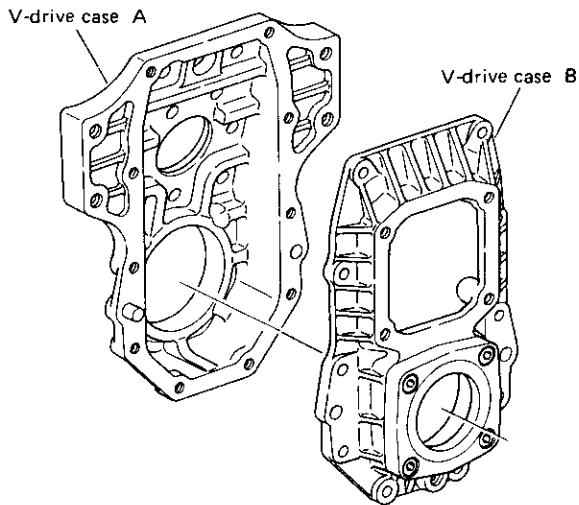
SM/GM(F)/CJ-HM(F)/C

6. Inspection and Servicing

The KM3V V-Drive Gear is the combination of the V-drive system with the KM3P parallel drive gear. Accordingly, the explanation of this section is limited only to the V-drive system. Explanations for other parts excluding the V-drive system are identical to those described under the sections for model KM3P.

6-1 V-drive case

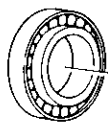
- (1) Check the V-drive case with a test hammer for cracking. Perform a color check when required. If the case is cracked, replace it.
- (2) Check for staining on the inside surface of the bearing section. Also, measure the inside diameter of the case. Replace the case if it is worn beyond the wear limit.



6-2 Bearing

- (1) Rusting and damage. If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly. If rotation is not smooth, if there is any binding, or if any abnormal sound is evident, replace the bearing.

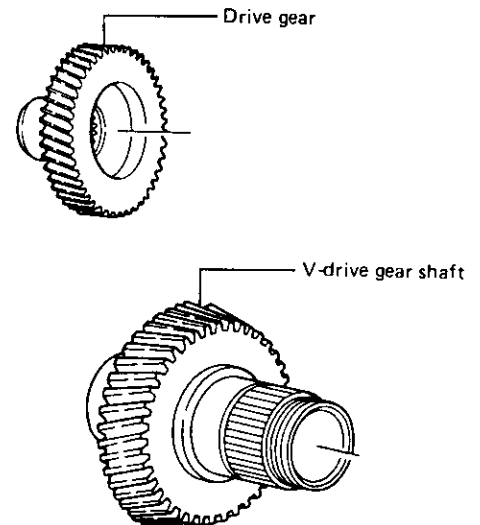
Bearing of V-drive gear shaft



6-3 Gear

Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.

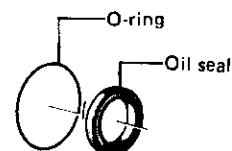
- (1) Tooth surface wear. Check the tooth surface for pitting, abnormal wear, dents and cracks. Repair both the lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact. Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash. Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.



mm (in.)		
Backlash	Maintenance standard	Wear limit
Drive gear and V-drive gear	0.08 ~ 0.16 (0.0031 ~ 0.0063)	0.3 (0.0118)

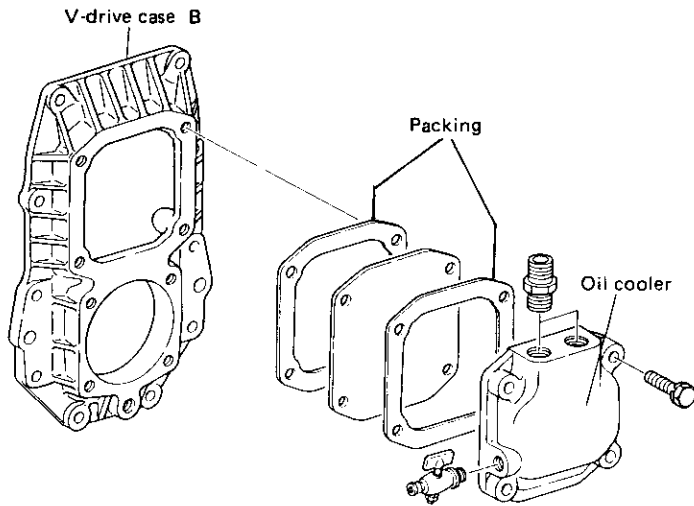
6-4 Oil seal and O-ring

Check the sealing surface of the oil seals and O-ring. If worn and/or scratched, replace.



6-5 Packing

Check the oil cooler packings. If there are cracks, and/or scratches, repair.

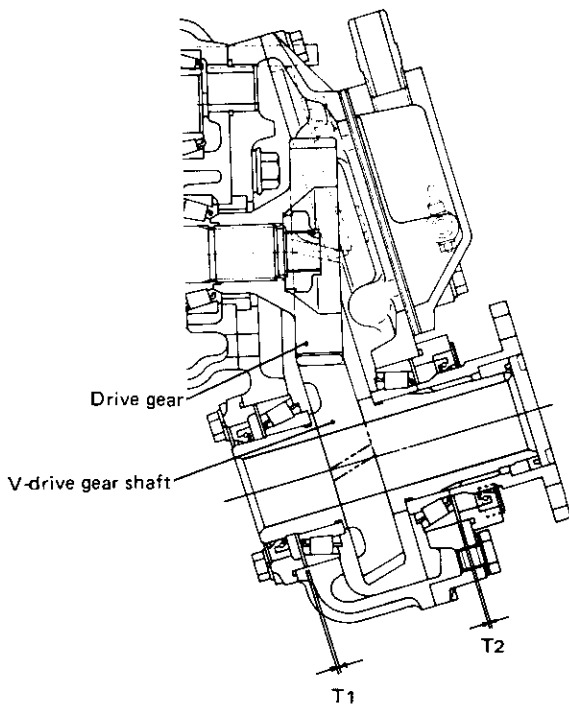


7. Shim adjustment for V-drive gear shaft, and backlash adjustment for V-drive gear shaft and drive gear

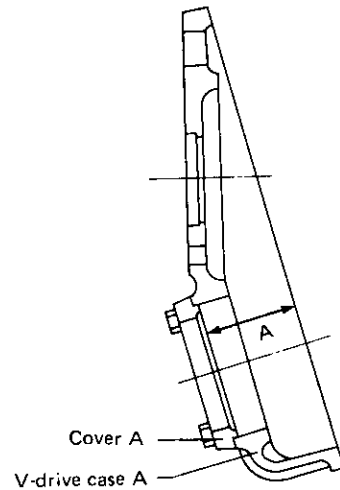
Check the thickness of shims for V-drive gear shaft. When the components are not replaced after dismantling, the same shims can be reused. When the clutch case, flange, V-drive case A and B or any of the following parts is replaced, the thickness of shim must be determined in the following manner.

For input shaft parts : input shaft, bearing
For output shaft parts : output shaft, thrust collar A, thrust collar B, gear, bearing
For V-drive gear shaft parts : V-drive gear shaft, cover A, cover B, bearing

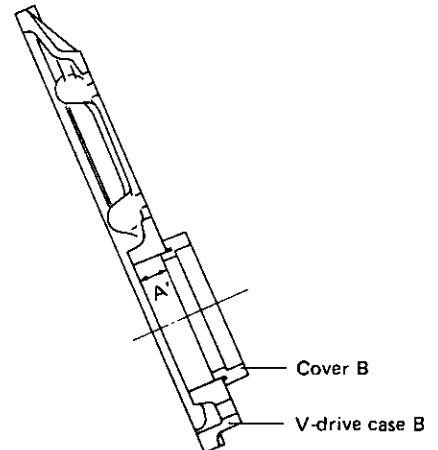
7-1 Measuring method of shim thickness(T1, T2) of V-drive gear shaft



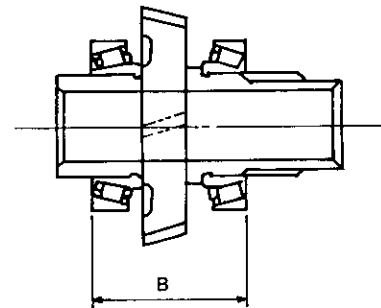
- (1) Install the cover A to the V-drive case A, and measure the bearing insertion hole depth A.



- (2) Install the cover B to the V-drive case B, and measure the bearing insertion hole depth A'.



- (3) Insert bearings into the V-drive gear shaft, and measure the B-length between the bearing outer races.



(4) Obtain the thickness T₁, and T₂ by the following formulas:

$$T = A + A' - B$$

Where: $T = T_1 + T_2$

Tolerance of T-dimension ± 0.1

$$T_2 = T - T_1 \text{ (0.8 mm)}$$

T₁ standard dimension 0.8 mm

(5) Standard dimensions

	A	A'	B	T	T ₁
KM3V	49.8 ~ 50.2 (1.937 ~ 1.976)	20.8 ~ 21.2 (0.819 ~ 0.835)	68.7 ~ 69.3 (2.705 ~ 2.728)	1.3 ~ 2.7 (0.051 ~ 0.106)	0.8 (0.0315)

NOTE. If the measured values differ largely from the above values, your measurements may be incorrect. Measure again correctly.

(6) Adjusting shim set

Part No.	Thickness. mm(in.)	No. of shim
177070-02860	1.0 (0.0039)	1
	0.3 (0.0118)	3
	0.2 (0.0079)	2

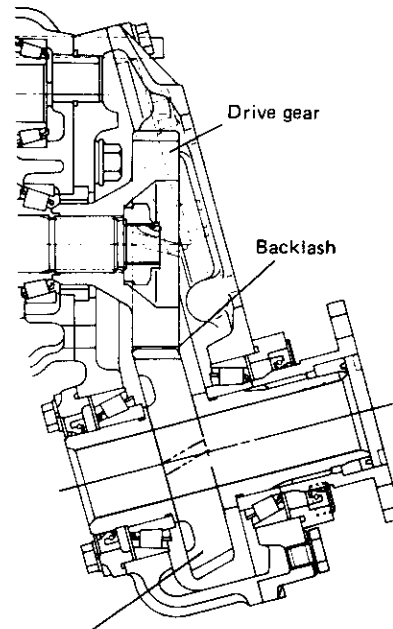
7-2 Backlash adjustment for V-drive gear shaft and drive gear

(1) Insert the fuse wire into the interval between the Drive gear and the V-drive gear from the cooler installation window. Turn the gear, and pull out the fuse wire. Measure the pressed thickness of the fuse wire with a micrometer.

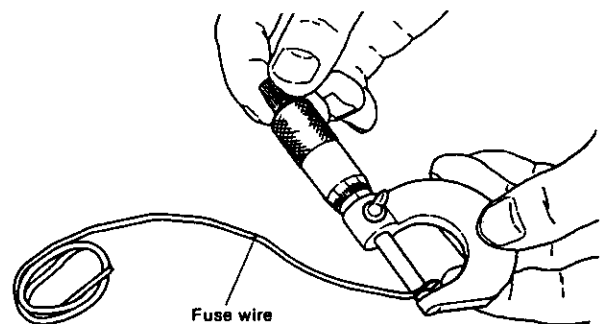
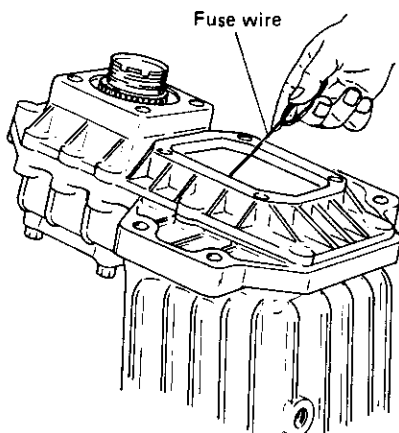
Backlash standard: 0.08 ~ 0.16 mm
 (0.0032 ~ 0.0063 in.)

(2) When the backlash is larger than the standard value, move the T₂ shim to the T₁ side.
 When the backlash is smaller than the standard value, move the T₁ shim to the T₂ side.

NOTE: By moving the T₁, or T₂ shim by 0.1mm, the backlash is varied by about 0.016 mm (0.0006 in.).



V-drive gear shaft

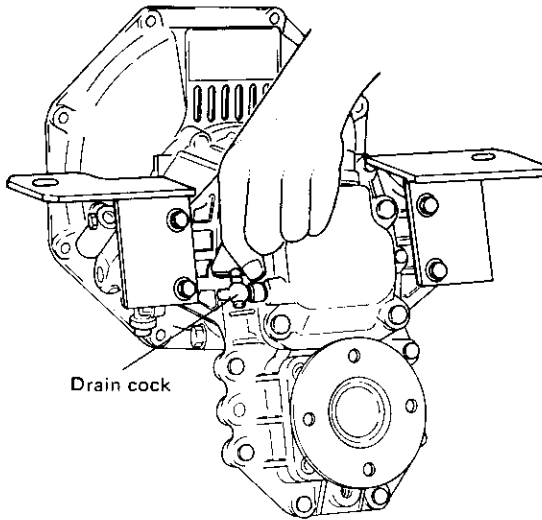


8. Disassembly

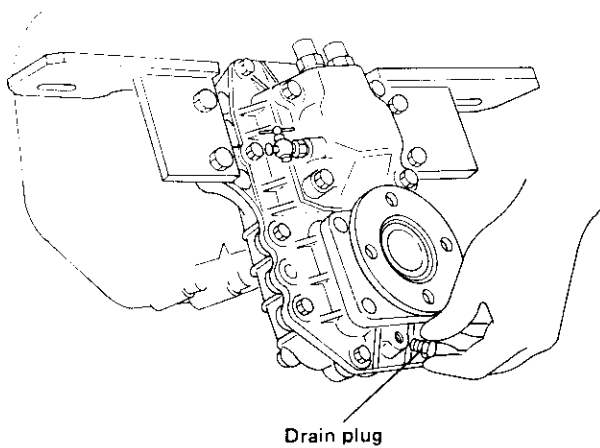
8-1 Dismantling the V-drive assembly

- (1) Remove the remote control cable.
- (2) Remove the cooling water hose of lube oil cooler.
- (3) Remove the V-drive assembly from the engine mounting flange.

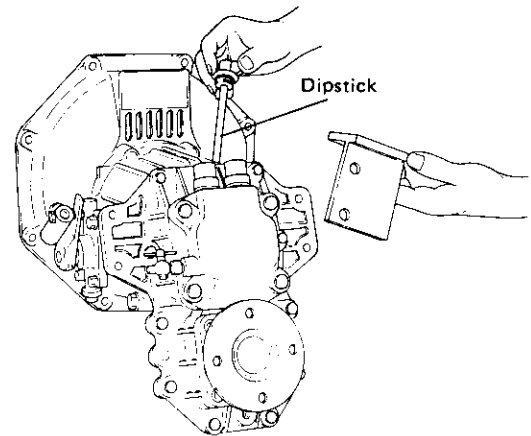
8-2 Drain the cooling water from the lube oil cooler.



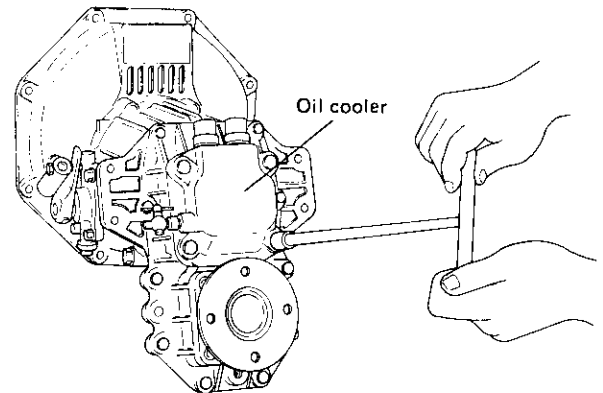
8-3 Loosen the plug at the bottom of the V-drive case, and drain the lube oil.



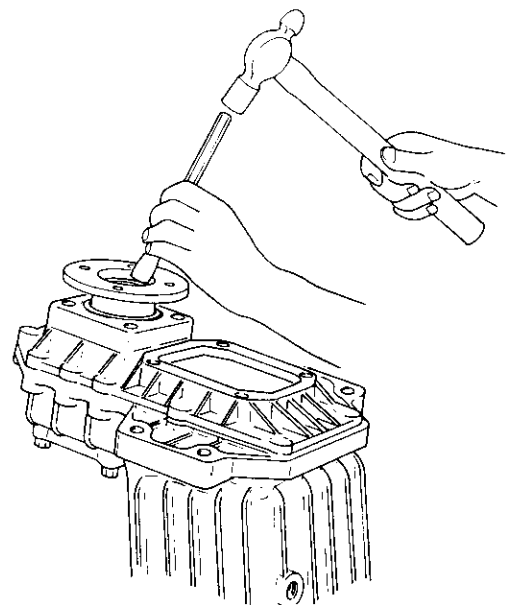
8-4 Remove the engine feet, lube oil dipstick, and O-ring.



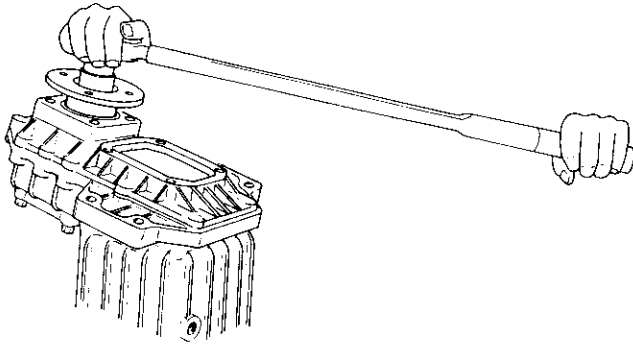
8-5 Remove the lube oil cooler fixing bolts, and then remove the lube oil cooler body, packings, and plate.



8-6 Loosen the V-drive shaft end nut.

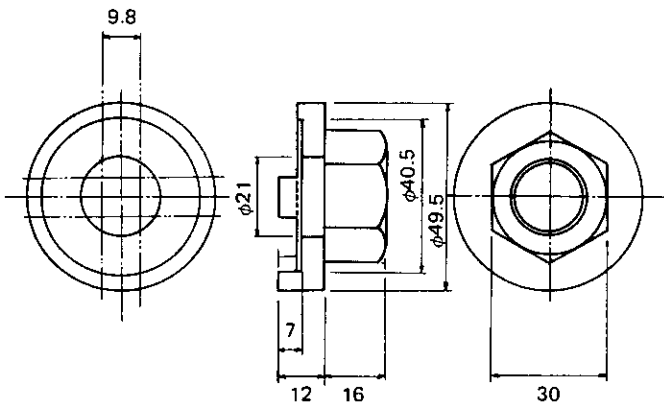


8-7 Remove the end nut, output shaft coupling, and O-ring.

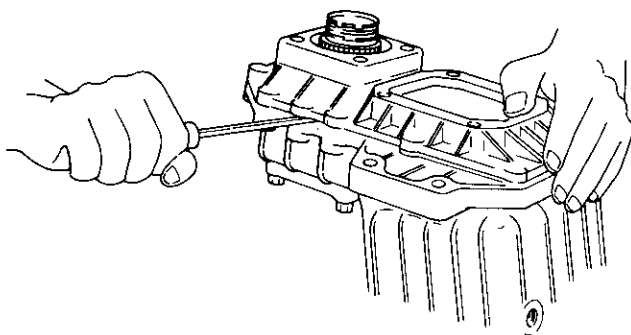


NOTE: 1) Use the special tool to remove the end nut from the V-drive shaft.
2) Special tool (option part) Part No.177070-09010

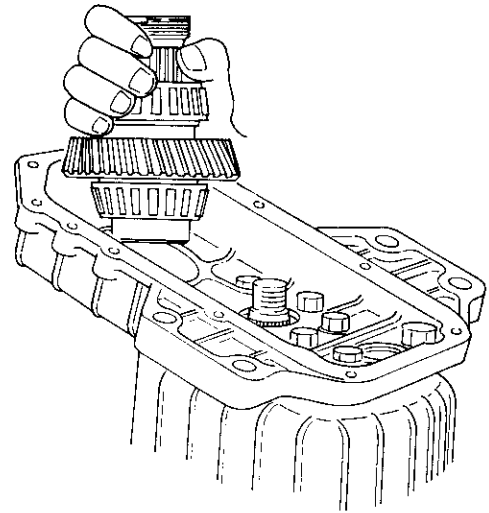
Dimension: mm
Material: Carbon steel
Hardness: HB 203 ~ 258
HS 31 ~ 38
(Hardening)



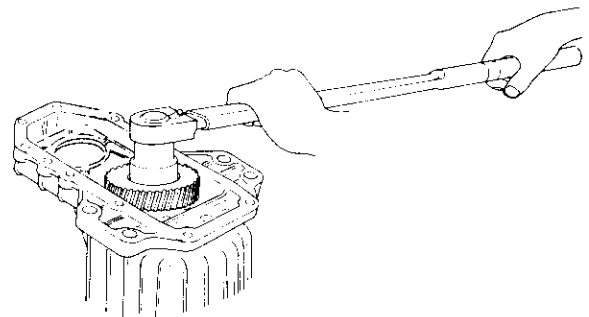
8-8 Remove the fixing bolts on the V-drive case B, and also remove the V-drive case B.



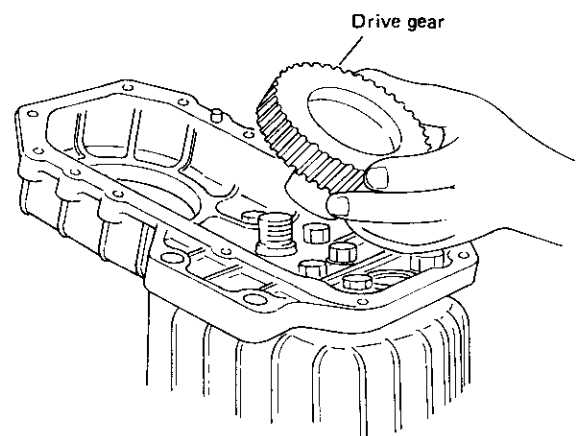
8-9 Remove the V-drive shaft.



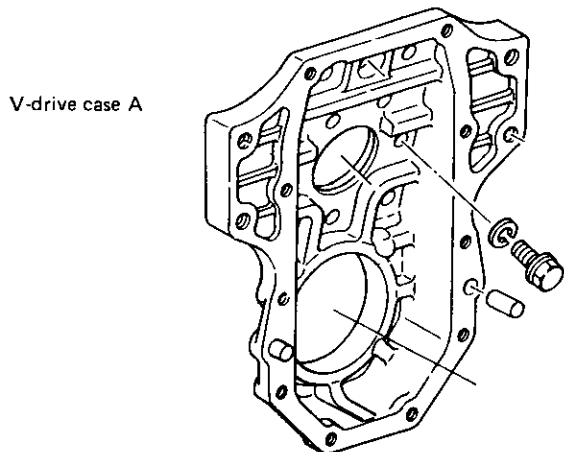
8-10 Remove the end nut, and drive gear from the output shaft.



NOTE: Note that the end nut has a left-handed thread.

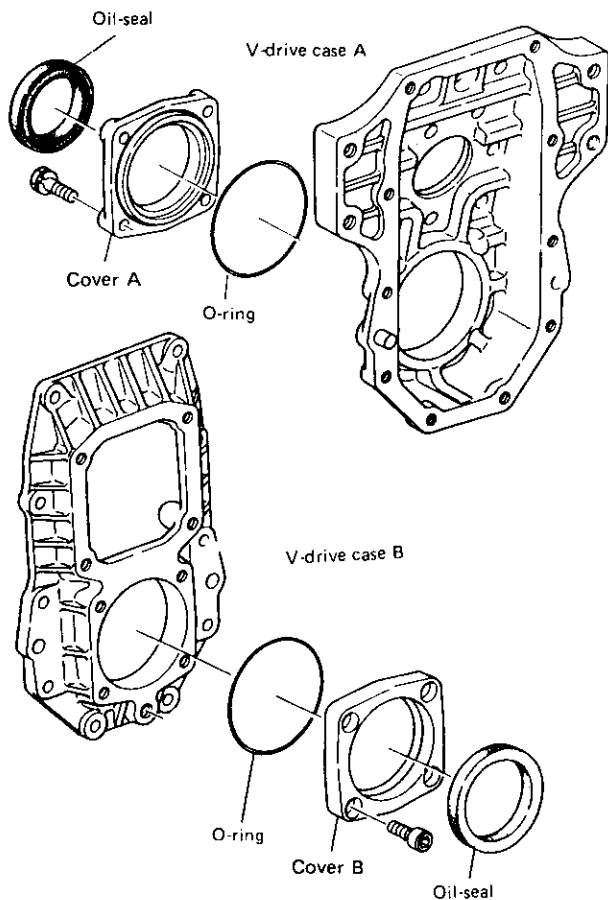


8-11 Remove the V-drive case A fixing bolts, and remove the V-drive case A.

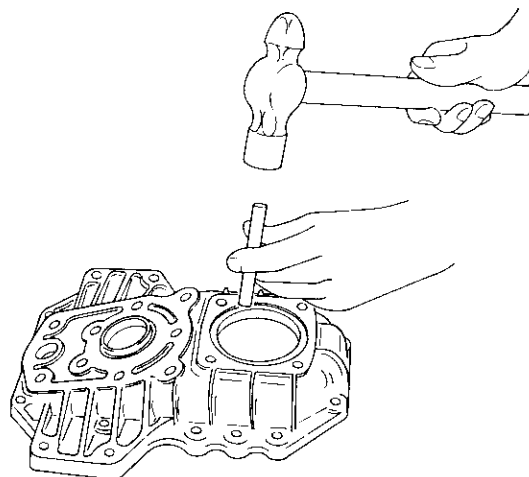


8-12 Disassembly of clutch assembly.
Follow to the same procedures described for model KM3P. (Refer to the sections under KM3P)

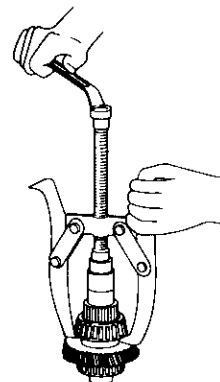
8-13 Remove the covers, O-rings, and oil-seals from the V-drive cases A and B.



8-14 Remove the bearing outer races from the V-drive cases A and B.



8-15 Remove the bearing inner races from the V-drive gear shaft.

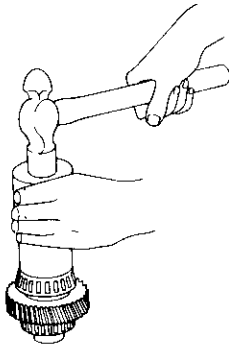


9. Reassembly

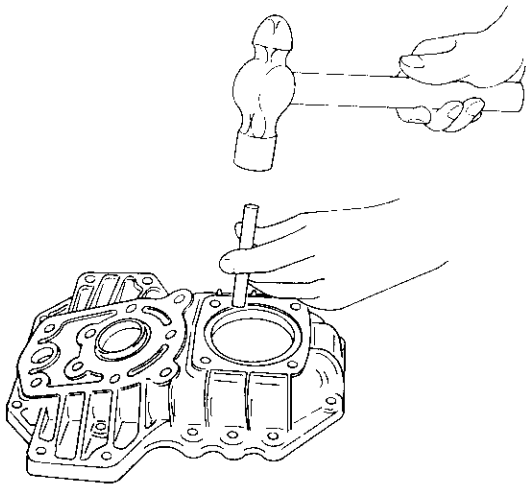
9-1 Reassembly of the clutch unit

Follow to the same procedures described for model KM3P. (Refer to sections under KM3P)

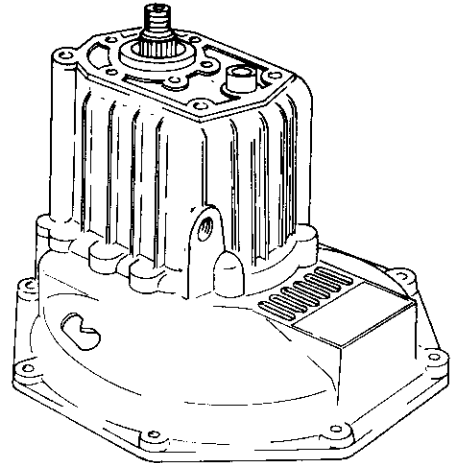
9-2 Fit the bearing inner races in the V-drive gear shaft.



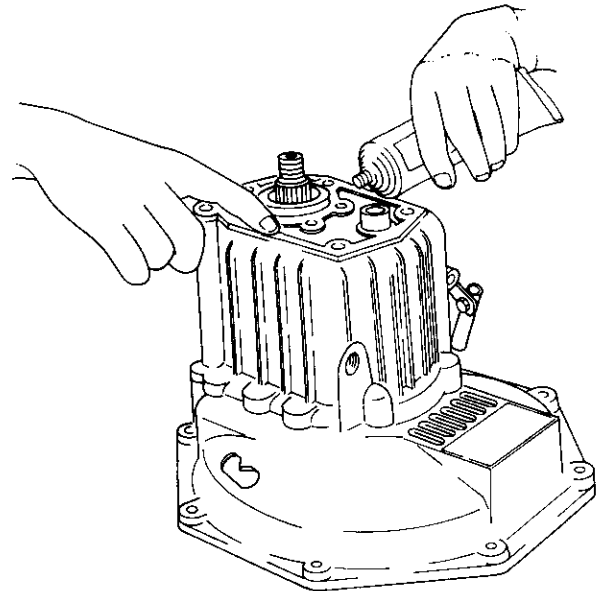
9-3 Fit the bearing outer races in the V-drive cases A and B.



9-4 Insert the center bush and location pin to the clutch case end holes.

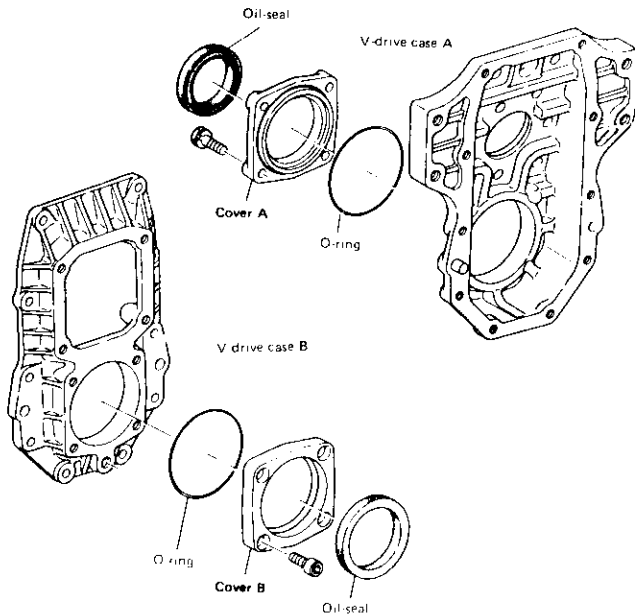


9-5 Fit the V-drive case A to the clutch case.

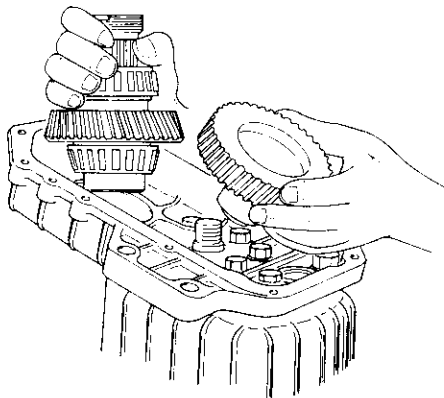


NOTE: Apply a non-drying type liquid packing to the matching surfaces of the case A and the clutch case.

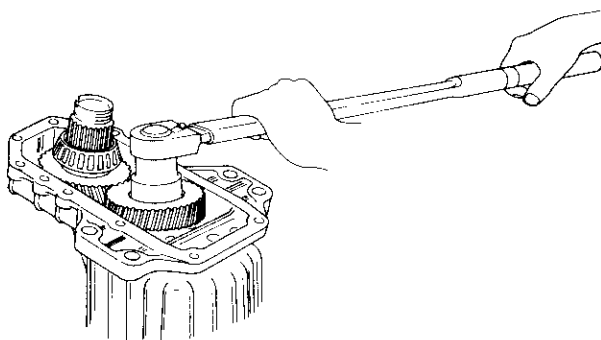
96 Fit the covers, O-rings, oil seals and shims into the V-drive cases A and B.



97 Insert the V-drive shaft into the V-drive case A, and insert the V-drive gear into the output shaft.



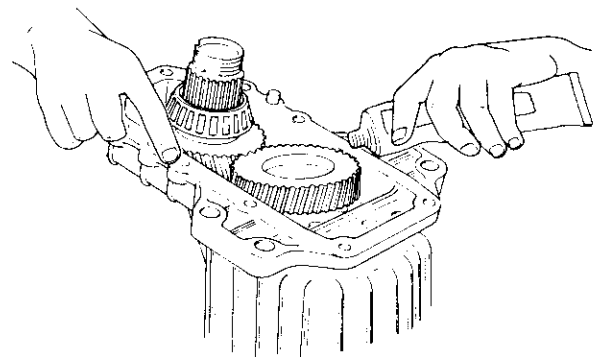
98 Tighten the end nut with a torque wrench



Tightening torque	8.5 ~ 11.5 kgf-m (61.5 ~ 83.2 ft-lb)
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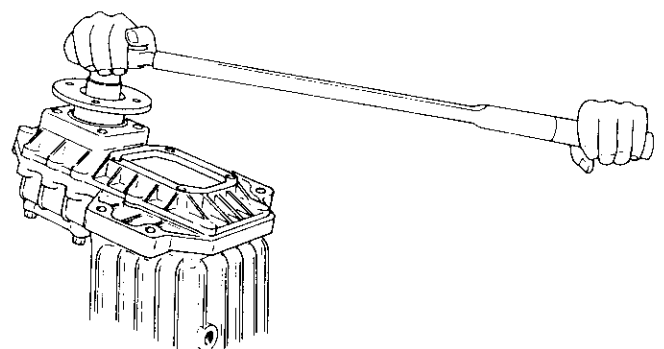
NOTE: Note that the end nut has a left-handed thread.

99 Fit the V-drive case B to the V-drive case A.



NOTES: 1) Apply a non-drying type liquid packing to the matching surfaces of the V-drive cases A and B.
2) Measure the backlash of the drive gear and V-drive gear. (Refer to the procedures under the foregoing 6-2.)

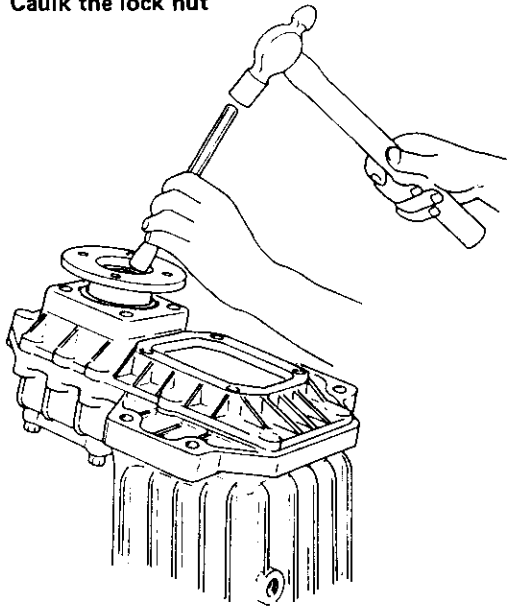
9-10 Insert the O-ring and output shaft coupling.
Tighten the lock nut. Use the special tool and the torque wrench.



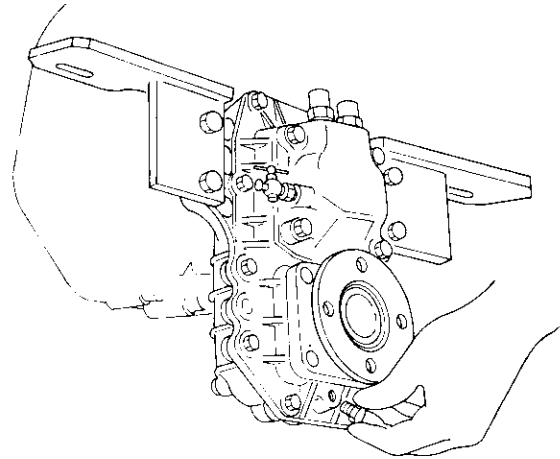
Tightning torque	18 ~ 22 kgf-m (130.2 ~ 159.1 ft-lb)
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NOTE: Check that the output shaft coupling turns smoothly at the neutral position of the shift lever.

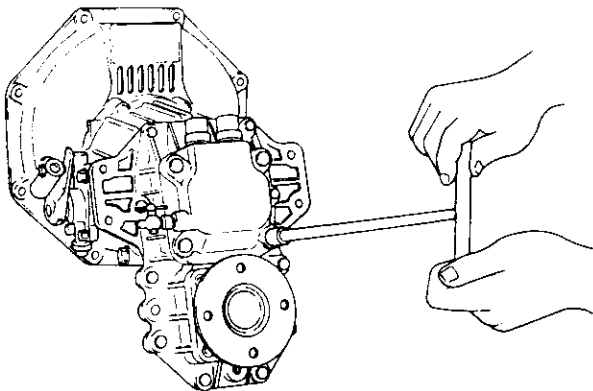
9-11 Caulk the lock nut



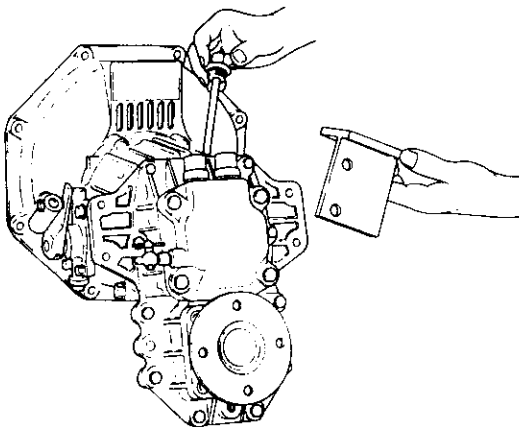
9-14 Fit the lube oil drain plug



9-12 Fit the oil cooler



9-13 Fit the engine feet, lube oil dipstick and O-ring.



CHAPTER 11 REMOTE CONTROL SYSTEM

1. Construction	11-1
2. Clutch and Speed Regulator Remote Control	11-3
3. Engine Stop Remote Control	11-7

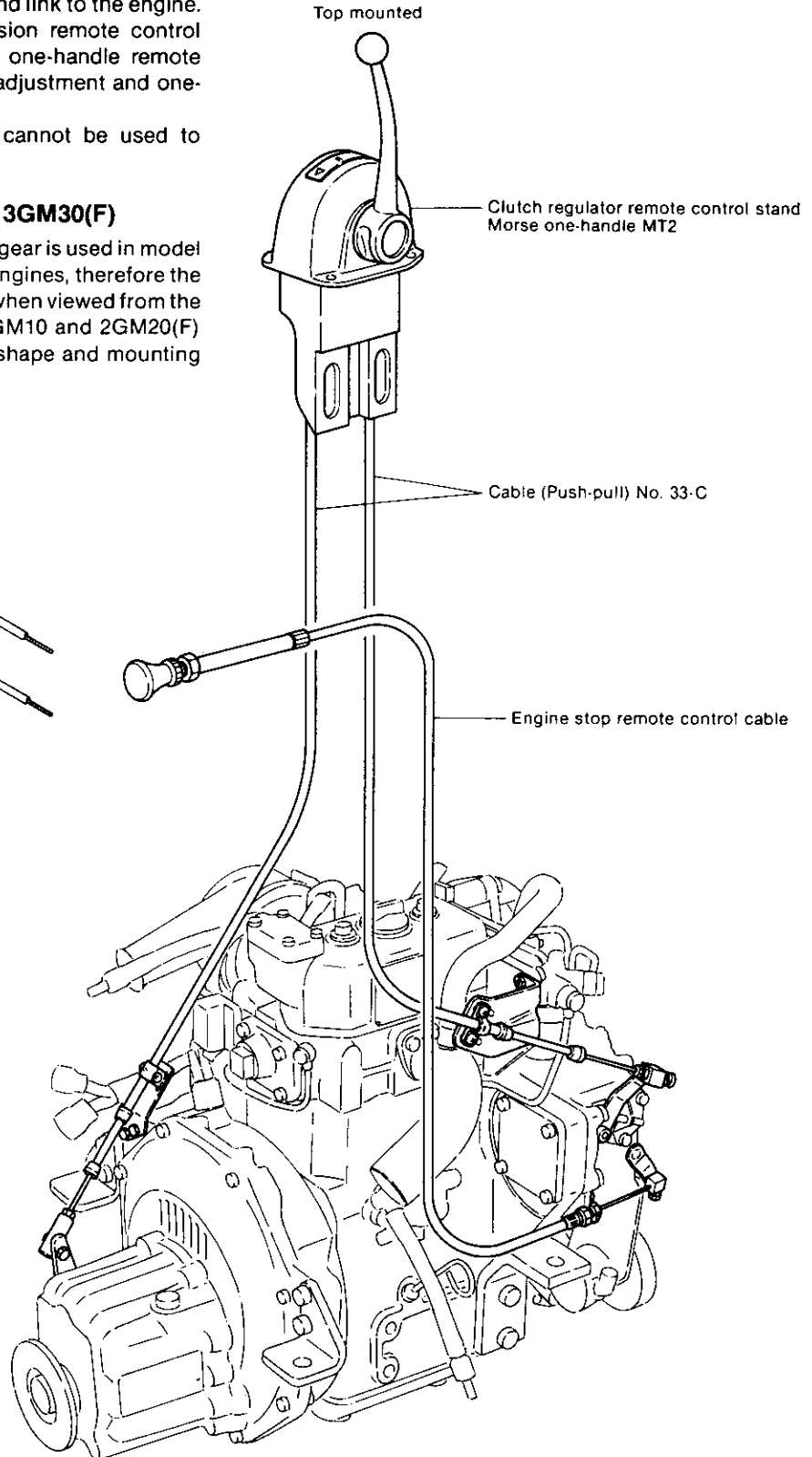
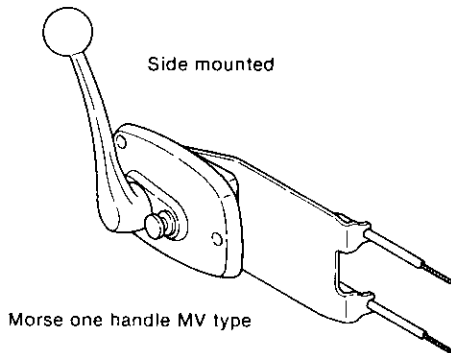
1. Construction

This engine is designed primarily for remote control operation. A remote control cable bracket can be installed by merely adding a remote control lever and link to the engine. Engine stop control and decompression remote control may also be installed, in addition to one-handle remote control, which permits engine speed adjustment and one-handle forward-astern switching.

For this engine, two-handle control cannot be used to replace one-handle control.

1-1 Model 1GM10, 2GM20(F) and 3GM30(F)

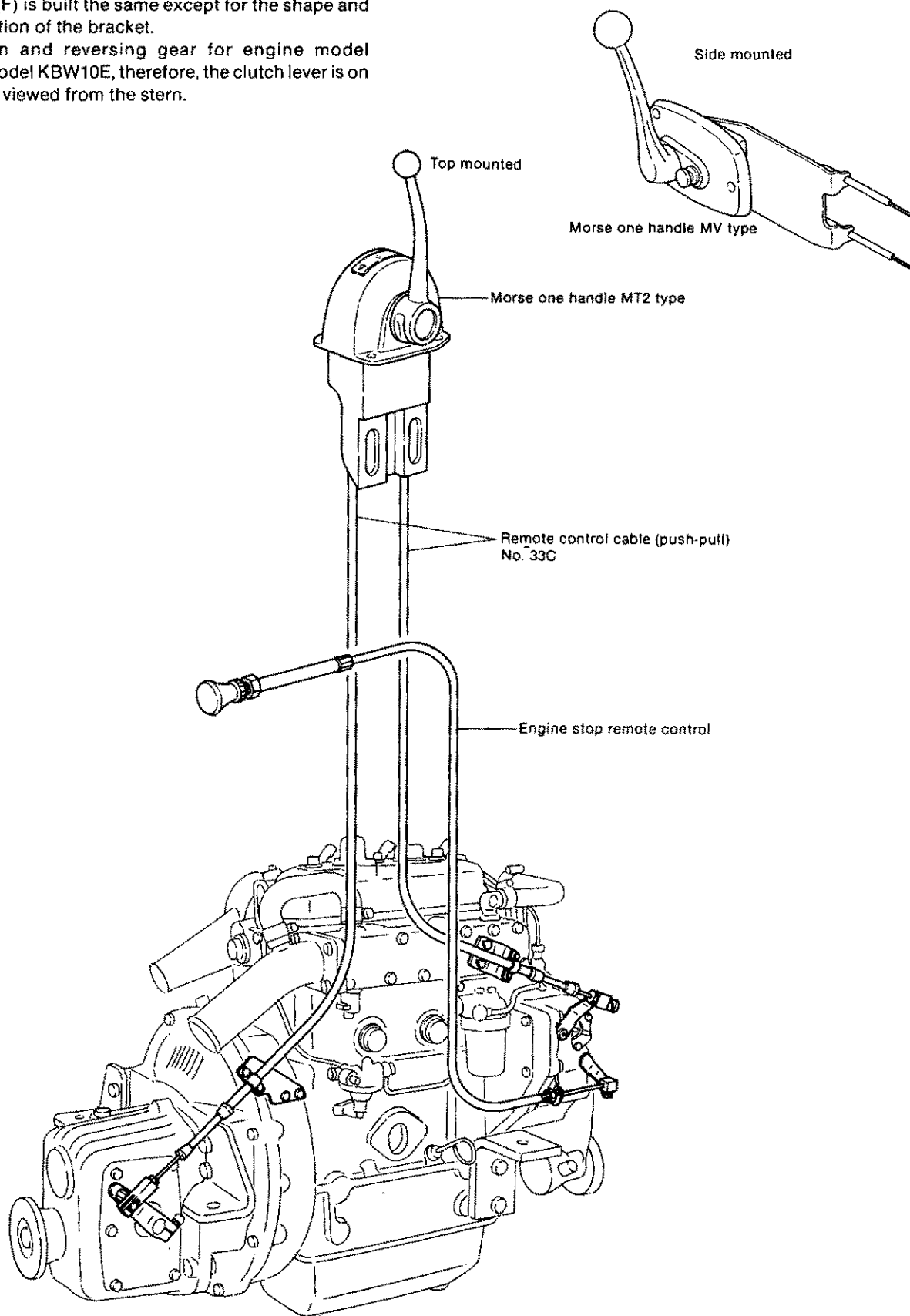
Model KM2-C reduction and reversing gear is used in model 1GM10 and 2GM20(F), 3GM30(F)(C) engines, therefore the forward and reverse lever is on the left when viewed from the stern. The construction for models 1GM10 and 2GM20(F) 3GM30(F) is the same except for the shape and mounting position of the bracket.



1-2 Model 3HM35(F)

Model 3HM35(F) is built the same except for the shape and mounting position of the bracket.

The reduction and reversing gear for engine model 3HM35(F) is model KBW10E, therefore, the clutch lever is on the right when viewed from the stern.

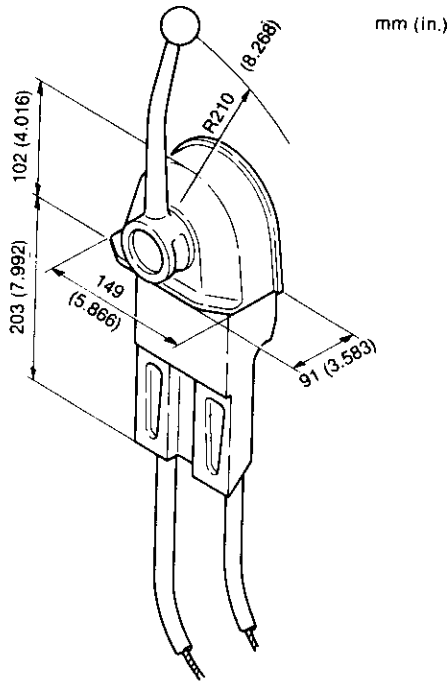


2. Clutch And Speed Regulator Remote Control

2-1 Construction

Both models of MT2 and MV morse one handle remote control can be used. They are optionally available.

2-1. 1 MT2 type

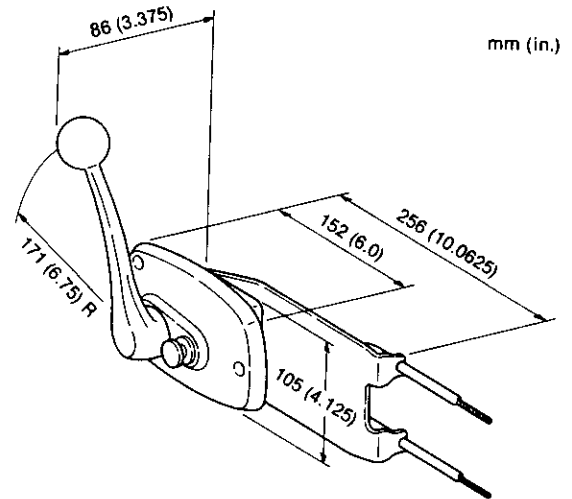


2-2. 2 MV type

Newly expanded MV series controls include right and left hand models designed for easier installation and servicing. The MV control can be preassembled and installed without removing side panels.

Pull-out button disengages clutch for full throttle range in neutral for safe starting and warm-up.

MV controls have forward, neutral and reverse detents; built-in friction to prevent throttle creep.

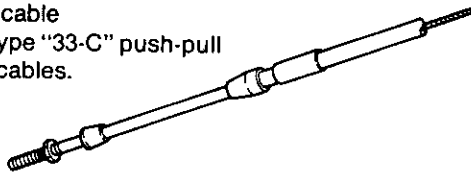


2-2 One-handle remote control composition

		1GM10, 2GM20(F), 3GM30(F)	3HM35(F)
Speed control	Remote control cable	33-C	
	Clamp	YANMAR made	
Clutch control	Remote control cable	33-C	
	Clamp	YANMAR made	
	Spring joint	YANMAR made	—
	Clevis	—	YANMAR made

(1) Control cable

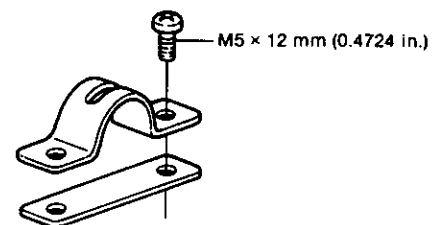
Morse Type "33-C" push-pull control cables.



Use only Super-Responsive Morse Control Cables. They are designed specifically for use with Morse control heads. This engineered system of Morse cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash. The thread size on cable ends is 10-32. Travel is up to 3". The core is a solid wire, with a 3/32" diameter.

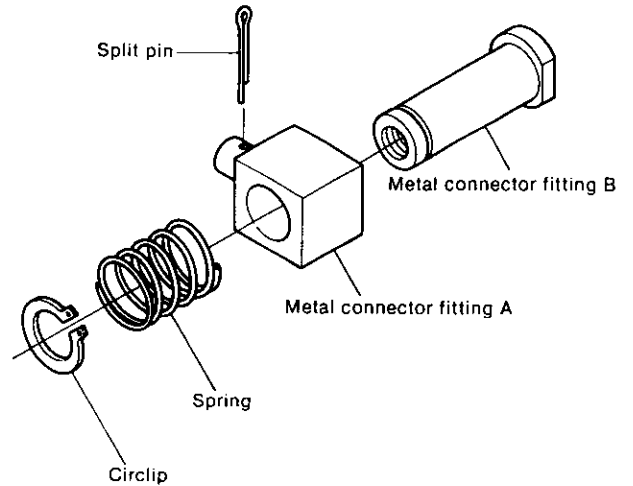
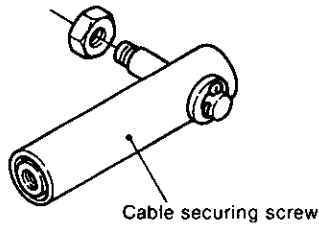
(2) Clamp

YANMAR cable clamps are standard parts, and are fitted to the brackets on the engine and clutch.



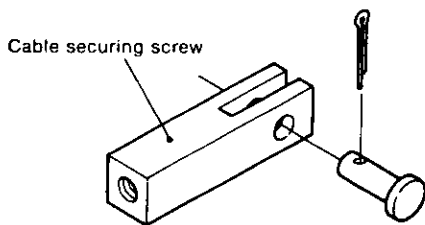
(3) Spring joint

The cone clutch is fitted to engine models 1GM10, 2GM20(F) and 3GM30(F). The spring joint is fitted to the clutch lever, and is also connected to the control cable.



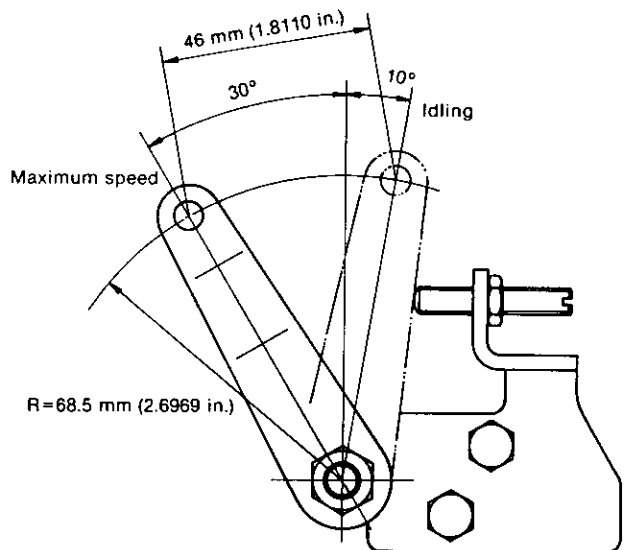
(4) Clevis

The YANMAR clevis is attached to the clutch lever on model 3HM35(F). Cable securing screw.



NOTE: When the push-pull cable is fitted, it must be fitted at the spring side.

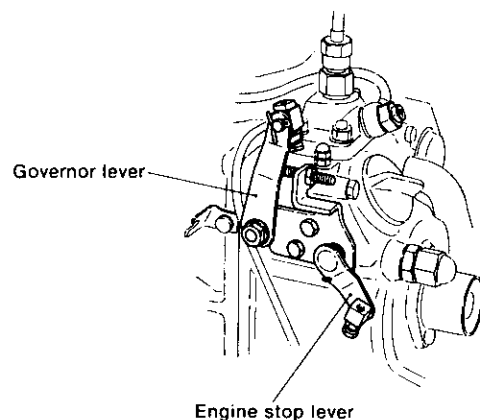
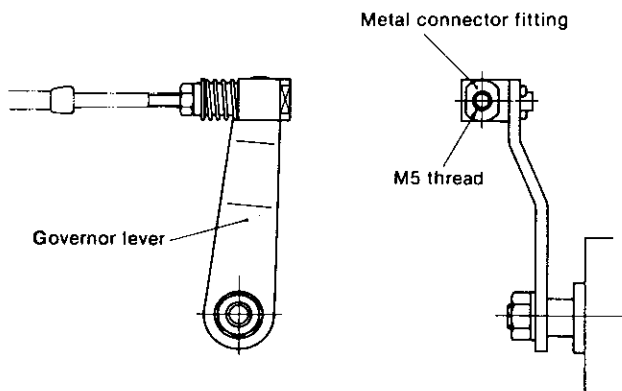
2-3.1 Movement of lever for model 1GM10(C)



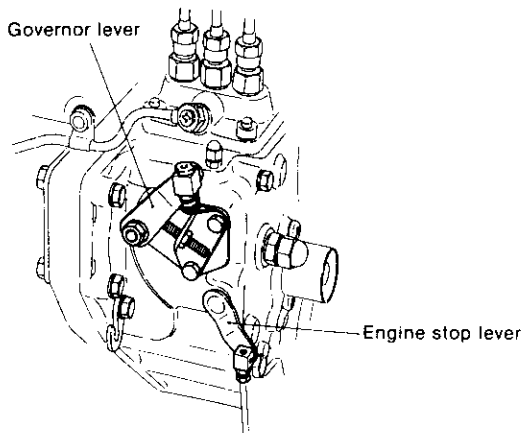
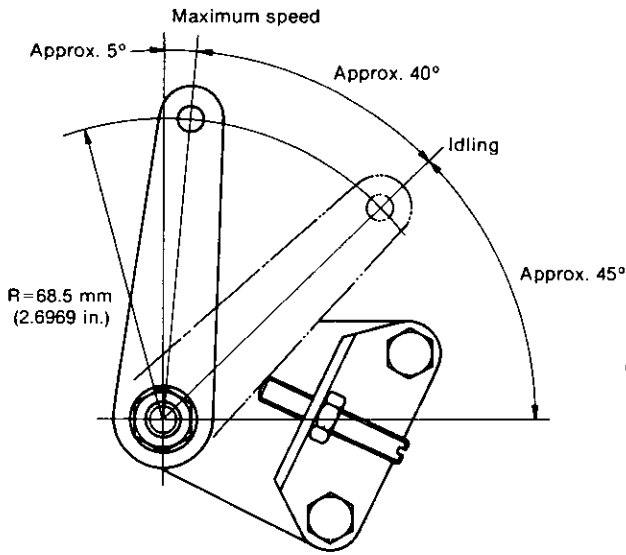
2-3 Engine side installation

The same governor lever is used in all 4 engine models, however, its operation angle is different depending on the model.

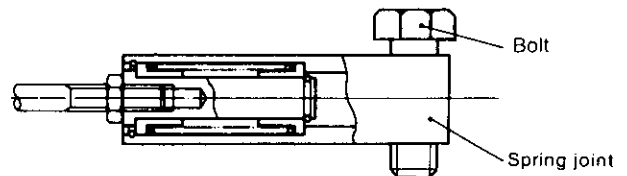
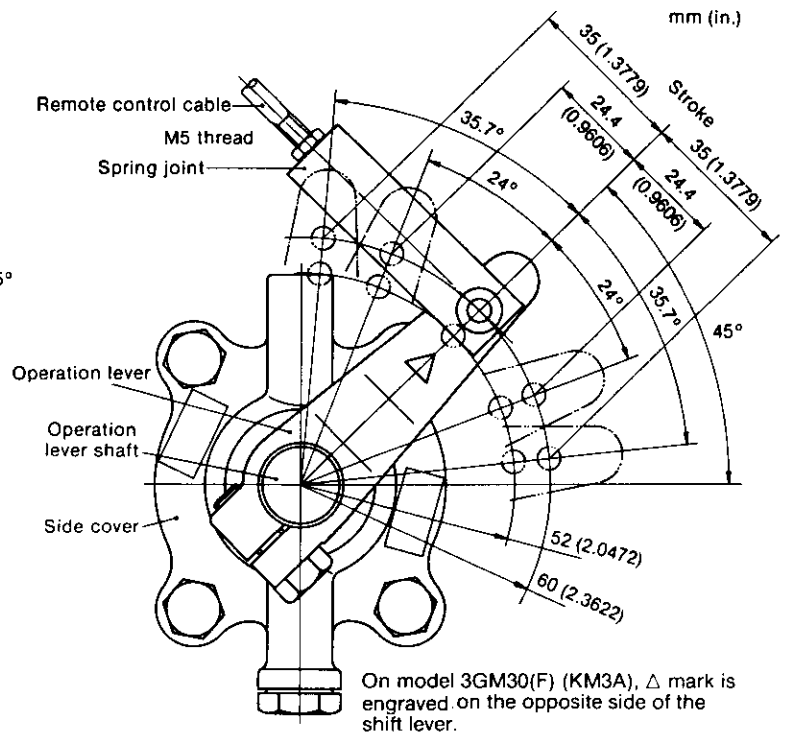
The connecting metal which fits with the damping spring is at the tip of the governor lever, and the cable has only to be screwed into this fitting.



2-3.2 Movement of lever for models 2GM20(F)(C), 3GM30(F)(C), and 3HM35(F)(C)



2-4.1 For models 1GM10, 2GM20(F) and 3GM30(F)

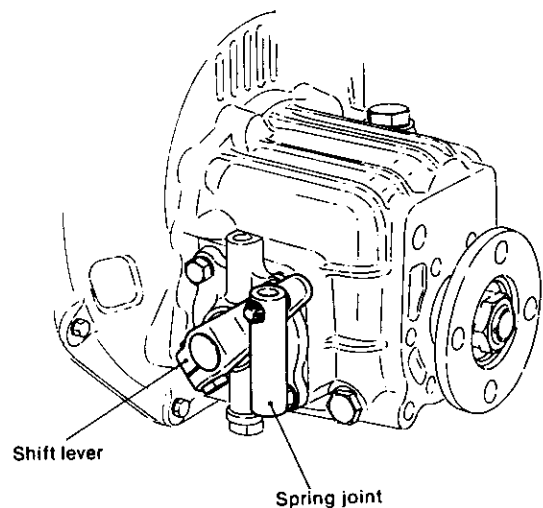


2-4 Setting the reduction and reversing gear side

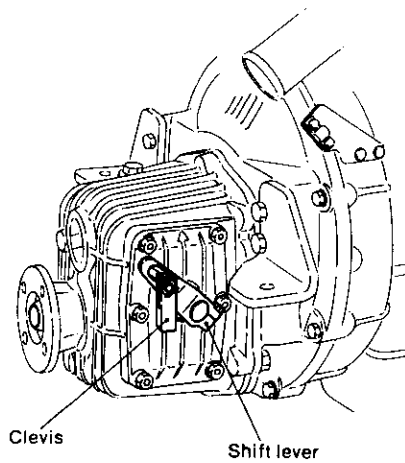
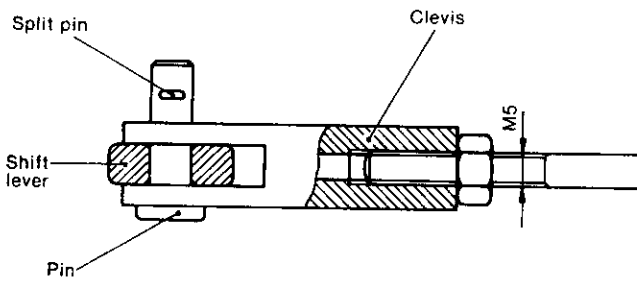
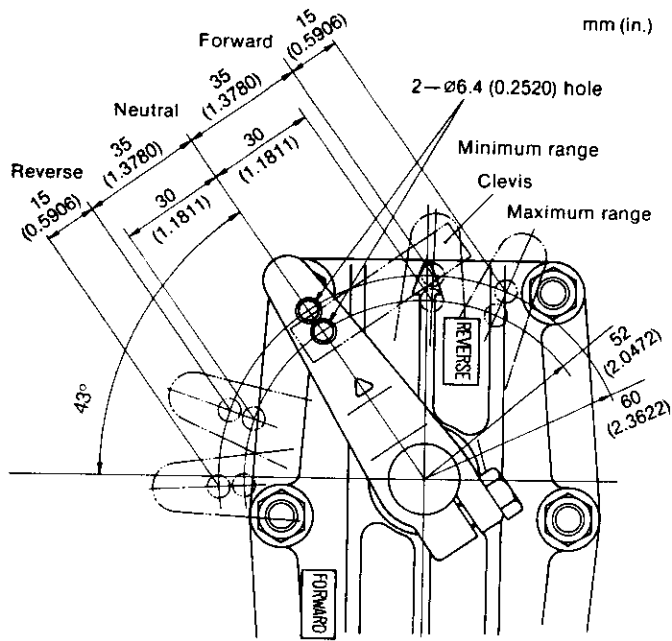
Model KM2C reduction and reversing gear is used for engine models 1GM10 and 2GM20(F), and model KM3A for engine model 3GM30(F).

On these reduction and reversing gears, the spring joint is fitted to the control lever, and the remote control cable is connected to this joint.

Reduction and reversing gear model KBW10E is used on engine model 3HM35(F). On these reduction and reversing gears, the clevis is attached to the clutch operating lever, and the remote control cable is connected to the clevis.

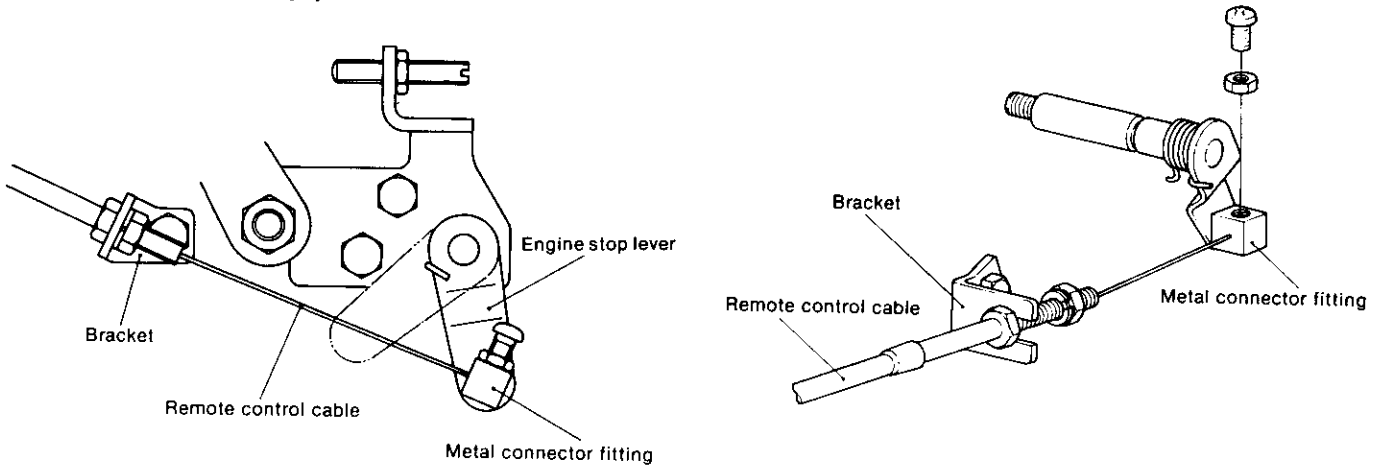


2-4.2 For model 3HM35(F)

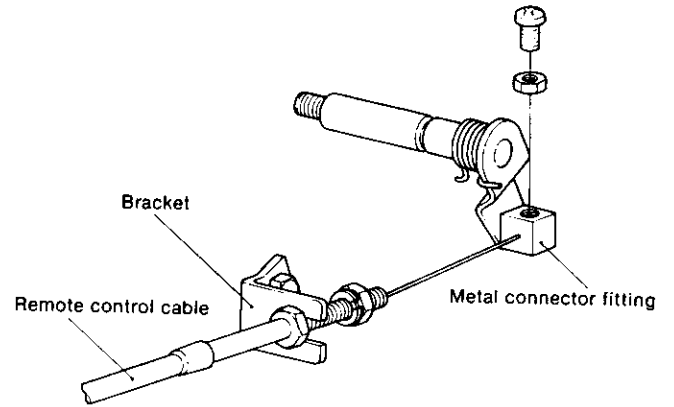


3. Engine Stop Remote Control

4-1 For model 1GM10(C)

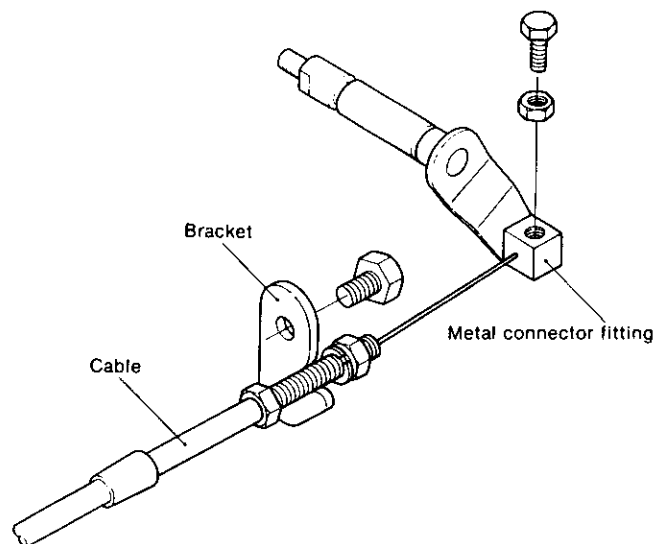
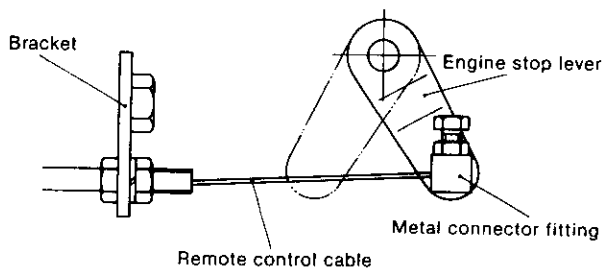


YANMAR made $\phi 1.5\text{mm}$ (0.05906 in.) option
Cable dia. $\phi 1.5 \sim \phi 2.5\text{mm}$ (0.05906 \sim 0.0984 in.)



The metal connector fitting has a hole of 2.5mm (0.0984 in.) dia. to accommodate the cable, and cable of 1.5 \sim 2.5mm (0.05906 \sim 0.0984 in.) dia. can be used in the connector.

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



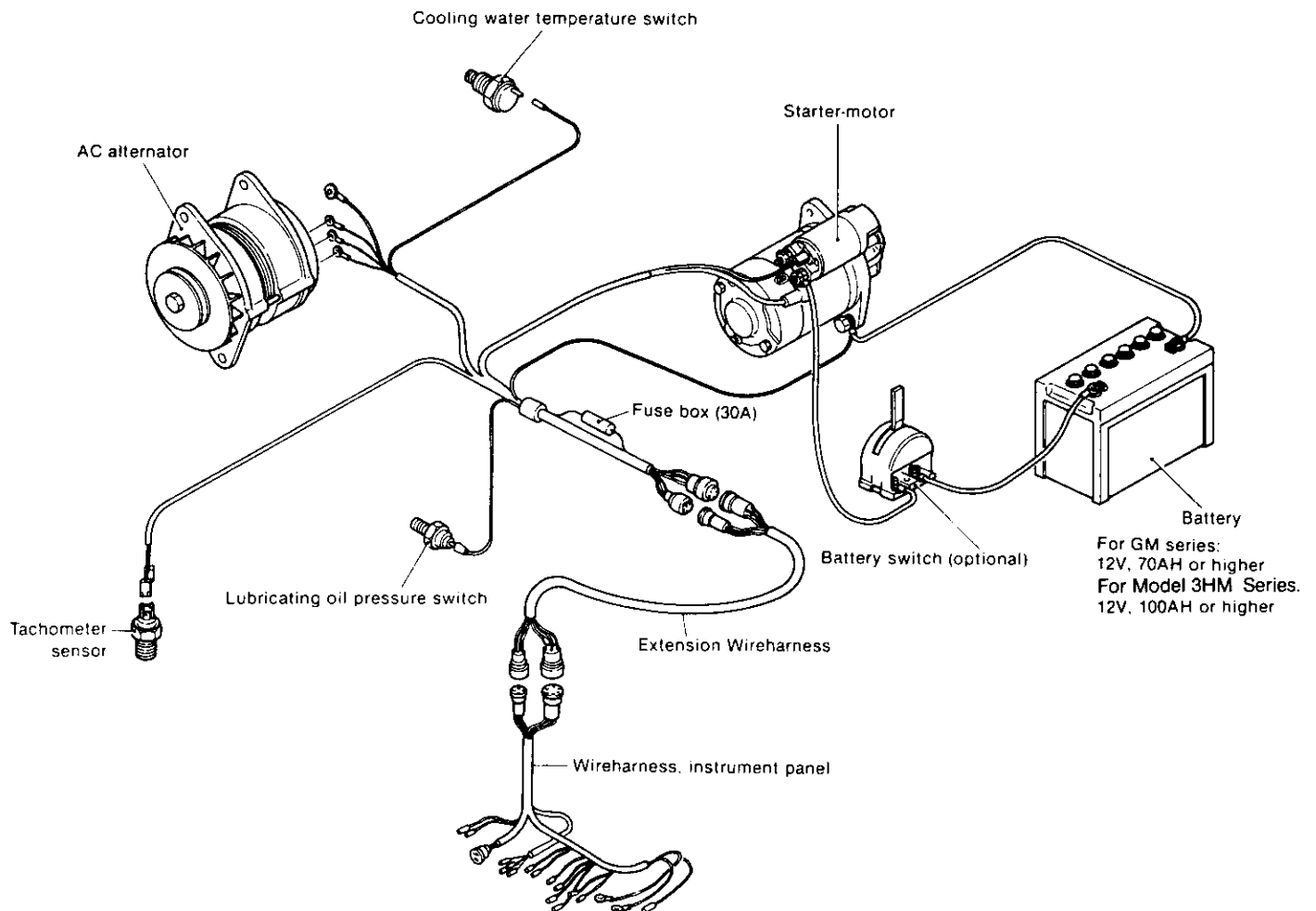
CHAPTER 12

ELECTRICAL SYSTEM

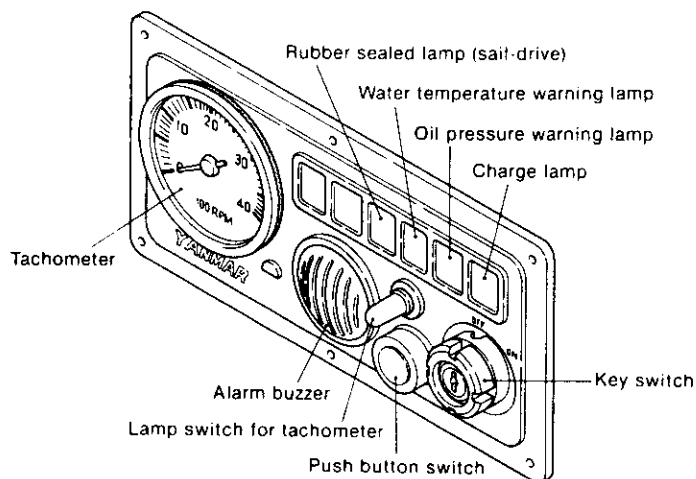
1. Electrical System	12-1
2. Battery	12-4
3. Starter Motor	12-7
4. Alternator Standard, 12V/55A	12-18
4A. Alternator Option, 12V/35A	12-28
5. Instrument Panel	12-37
6. Tachometer	12-43

1. Electrical System

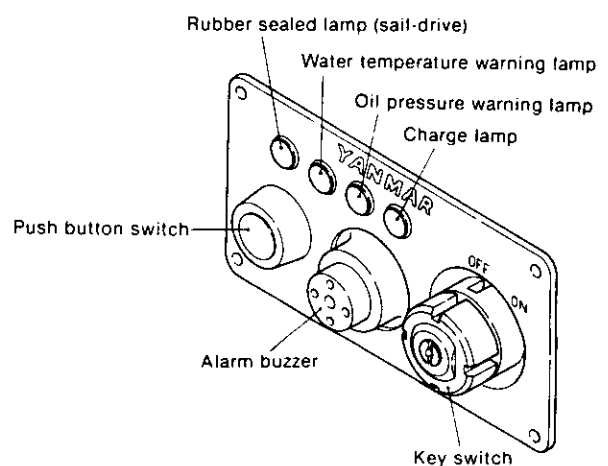
1-1 System diagram of electric parts



B-type instrument panel (large)

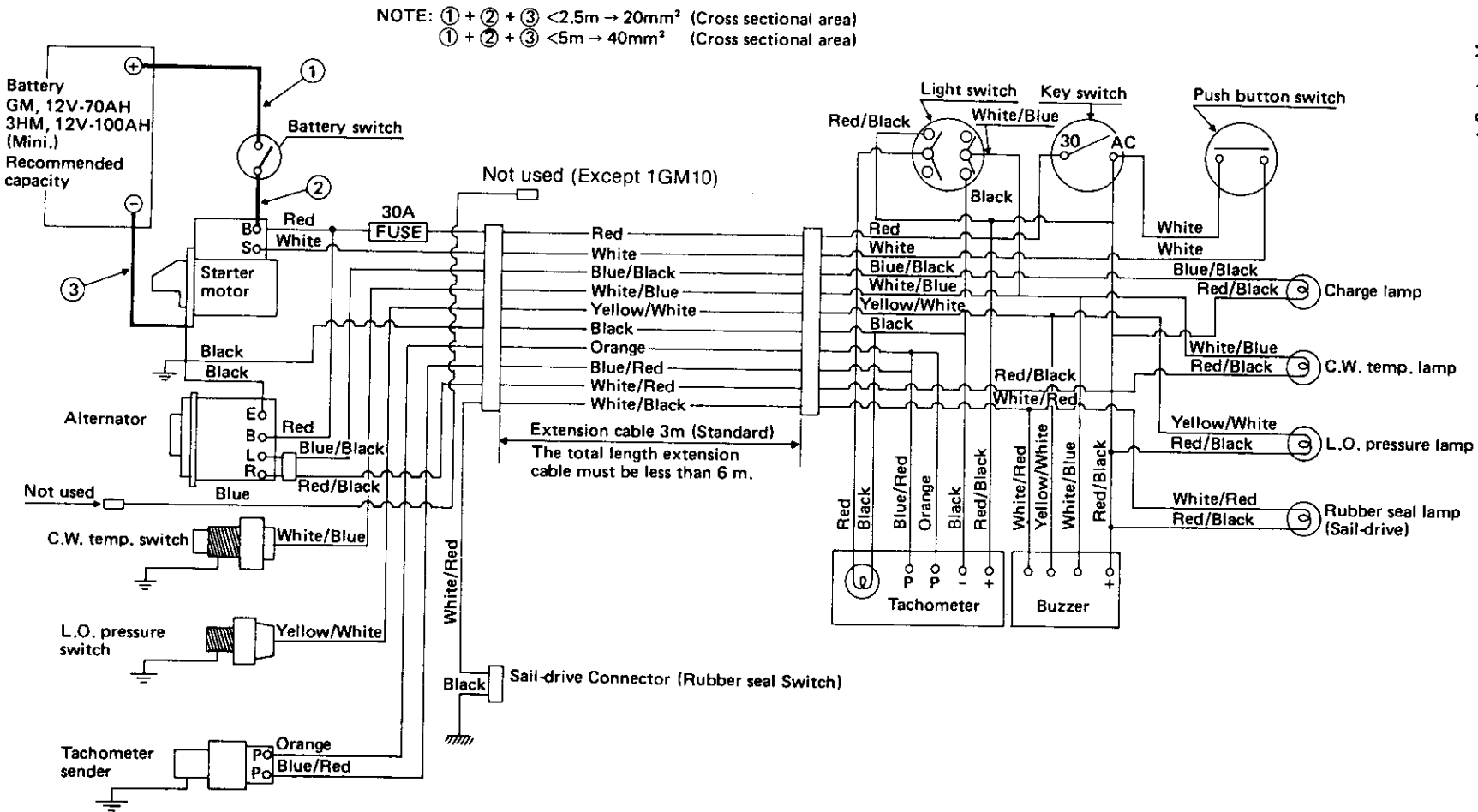


A-type instrument panel (small)



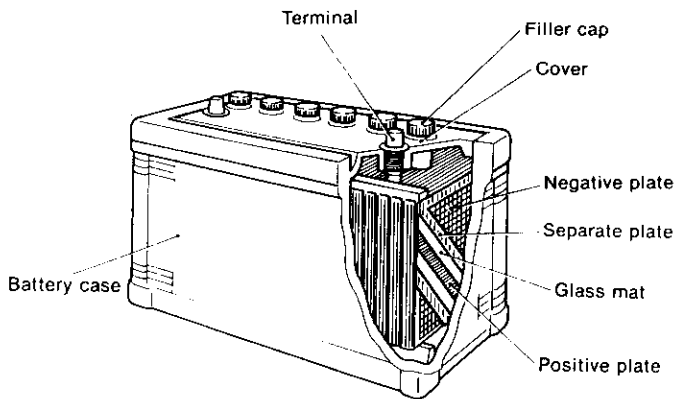
1-2. Wiring diagram

1-2-1 For the B-type (large) instrument board



2. Battery

2-1 Construction



The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.

As shown in the figure, a nonconductive container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive plates and lead dioxide negative plates separated by glass mats are stacked alternately in the electrolyte. The positive and negative plates are connected to their respective terminals.

Power is removed from the battery by connecting the load across these two terminals.

When the battery is discharging, an electric current flows from the positive plates to the negative plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

2-2 Battery capacity and battery cables

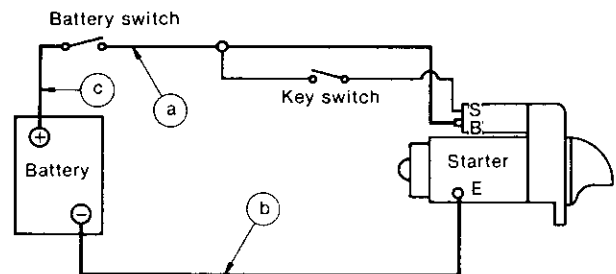
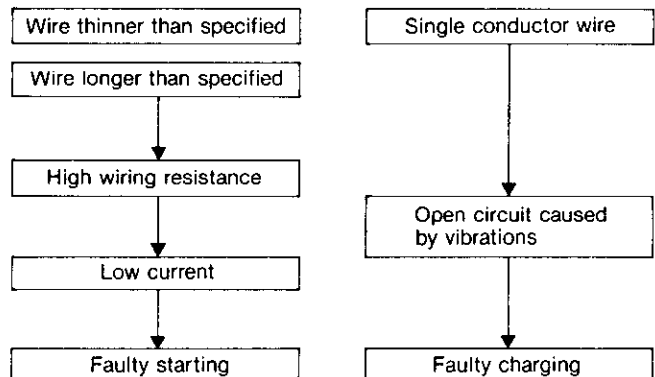
2-2.1 Battery capacity

Since the battery has a minimum capacity of 12V, 70AH, it can be used for 100 ~ 150AH.

	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Minimum battery capacity	12V 70AH	12V 100AH
Fully charged specific gravity	1.26	1.26

2-2.2 Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter, (soft automotive low-voltage wire [AV wire]). Using wire other than that specified may cause the following troubles:



The overall lengths of the wiring between the battery (+) terminal and the starter (B) terminal, and between the battery (-) terminal and the starter (E) terminal should be based on the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a + b + c allowable length
12V	0.2V or less/100A	20mm ² (0.0311 in. ²)	Up to 2.5m (98.43 in.)
		40mm ² (0.062 in. ²)	Up to 5m (196.87 in.)

NOTE: Excessive resistance in the key switch circuit (between battery and start (S) terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram exactly.

2-3 Inspection

The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to assure that it functions perfectly at all times.

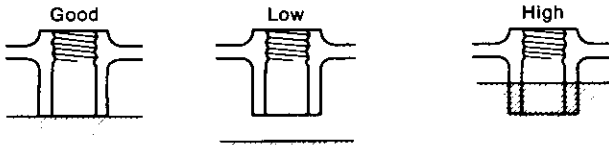
2-3.1 Visual inspection

- (1) Inspect the case for cracks, damage and electrolyte leakage.
- (2) Inspect the battery holder for tightness, corrosion, and damage.
- (3) Inspect the terminals for rusting and corrosion, and check the cables for damage.
- (4) Inspect the caps for cracking, electrolyte leakage and clogged vent holes.

Correct any abnormal conditions found. Clean off rusted terminals with a wire brush before reconnecting the battery cable.

2-3.2 Checking the electrolyte

(1) Electrolyte level



Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 ~ 20mm over the tops of the plates.

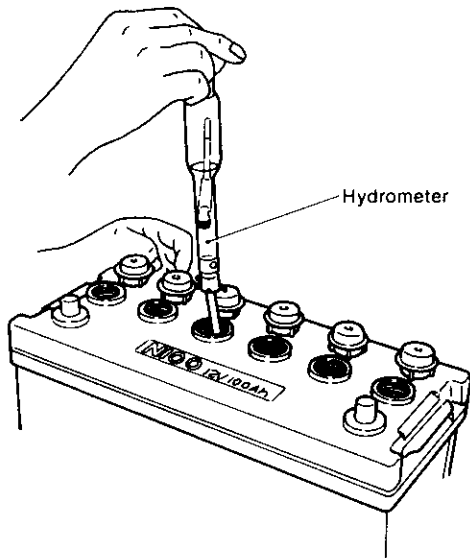
NOTES: 1) The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.

2) Always use distilled water to bring up the electrolyte level.

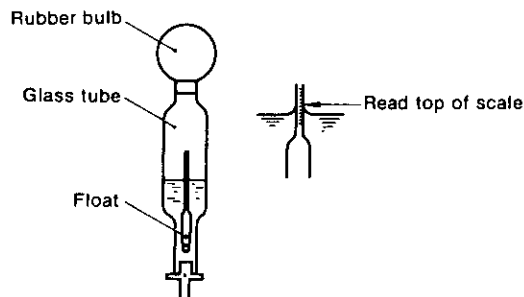
3) When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

(2) Measuring the specific gravity of the electrolyte

1) Draw some of the electrolyte up into a hydrometer.



2) Take the specific gravity reading at the top of the scale of the hydrometer.



3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200

(50%). If the specific gravity is below 1.200, recharge the battery.

4) If the difference in the specific gravity among the cells of the battery is ±0.01, the battery is OK.

5) Measure the temperature of the electrolyte. Since the specific gravity changes with the temperature, 20°C is used as the reference temperature.

Reading the specific gravity at 20°C

$$S_{20} = S_t + 0.0007 (t - 20)$$

S₂₀: Specific gravity at the standard temperature of 20°C

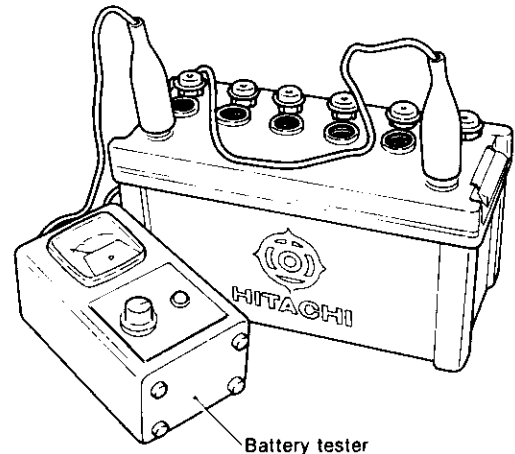
S_t: Specific gravity of the electrolyte at t°C

0.0007: Specific gravity change per 1°C

t: Temperature of electrolyte

2-3.3 Voltage test

Using a battery tester, the amount of discharge can be determined by measuring the voltage drop which occurs while the battery is being discharged with a large current.



(1) Connect the tester to the battery.

12V battery tester

Adjust the current (A).

(2) Connect the (+) lead of the tester to the (+) battery terminal, and the (-) tester lead to the (-) battery terminal.

(3) Push the TEST button, wait 5 seconds, and then read the meter.

• Repeat the test twice to make sure that the meter indication remains the same.

2-3.4 Washing the battery

(1) Wash the outside of the battery with a brush while running cold or warm water over the battery. (Make sure that no water gets into the battery.)

(2) When the terminals or other metal parts are corroded due to exposure to electrolyte leakage, wash off all the acid.

(3) Check the vent holes of the caps and clean if clogged.

(4) After washing the battery, dry it with compressed air, connect the battery cable, and coat the terminals with grease. Since the grease acts as an insulator, do not coat the terminals before connecting the cables.

2-4 Charging

2-4.1 Charging methods

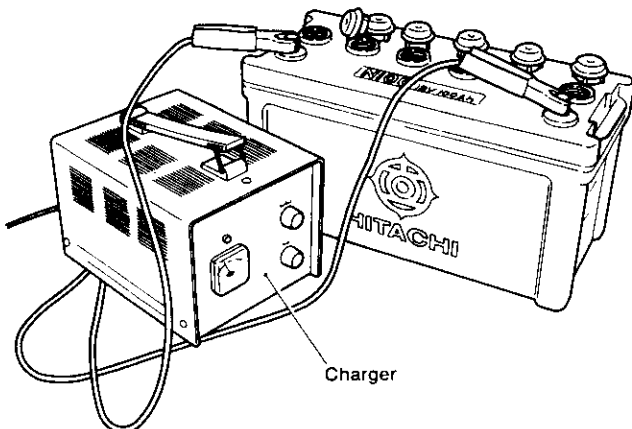
There are two methods of charging a battery: normal and rapid.

Rapid charging should only be used in emergencies.

- Normal charging... Should be conducted at a current of 1/10 or less of the indicated battery capacity (10A or less for a 100AH battery).
- Rapid charging... Rapid charging is done over a short period of time at a current of 1/5 ~ 1/2 the indicated battery capacity (20A ~ 50A for a 100AH battery). However, since rapid charging causes the electrolyte temperature to rise too high, special care must be exercised.

2-4.2 Charging procedure

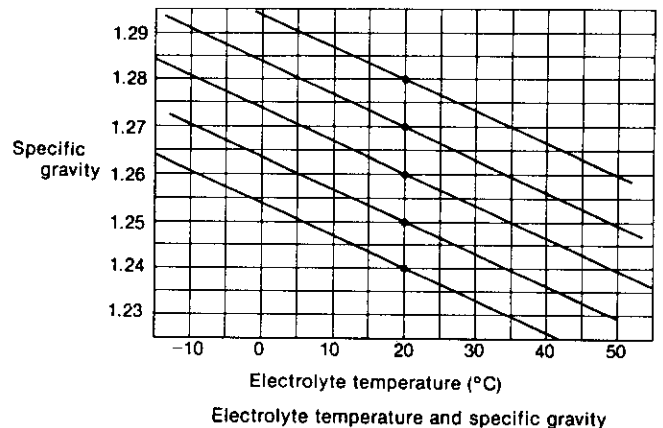
- (1) Check the specific gravity and adjust the electrolyte level.
- (2) Disconnect the battery cables.
- (3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (-) terminal.



- (4) Set the current to 1/10 ~ 1/5 of the capacity indicated on the outside of the battery.
- (5) Periodically measure the specific gravity during charging to make sure that the specific gravity remains at a high fixed value. Also check whether gas is being generated.

2-4.3 Charging precautions

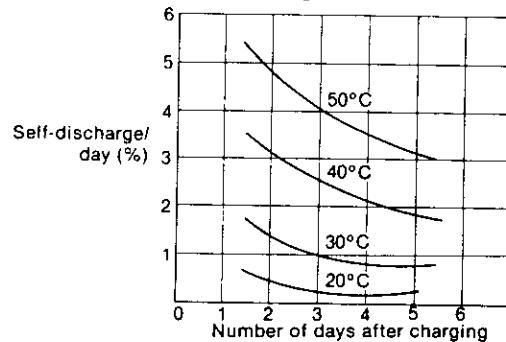
- (1) Remove the battery caps to vent the gas during charging.
- (2) While charging, ventilate the room and prohibit smoking, welding, etc.
- (3) The electrolyte temperature should not exceed 45°C during charging.
- (4) Since an alternator is used on this engine, when charging with a charger, always disconnect the battery (+) cable to prevent destruction of the diodes. (Before disconnecting the (+) battery cable, disconnect the (-) battery cable [ground side].)



2-5 Battery storage precautions

The life of a battery depends considerably on how it is handled. Generally speaking, however, after about two years its performance will deteriorate, starting will become difficult, and the battery will not fully recover its original charge even after recharging. Then it must be replaced.

- (1) Since the battery will self-discharge about 0.5%/day even when not in use, it must be charged 1 or 2 times a month when it is being stored.



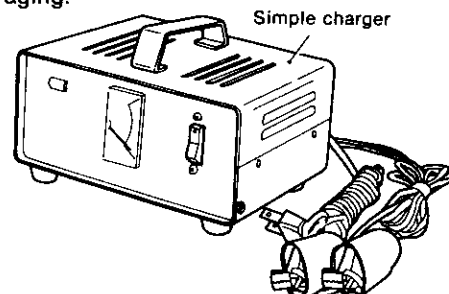
- (2) If charging by the engine alternator is insufficient because of frequent starts and stops, the battery will rapidly lose power.

Charge the battery as soon as possible after it is used under these conditions.

- (3) An easy-to-use battery charger that permits home charging is available from Yanmar. Take proper care of the battery by using the charger as a set with a hydrometer.

When the specific gravity has dropped to about 1.16 and the engine will not start, charge the battery up to a specific gravity of 1.26 (24 hours).

- (4) Before putting the battery in storage for long periods, charge it for about 8 hours to prevent rapid aging.



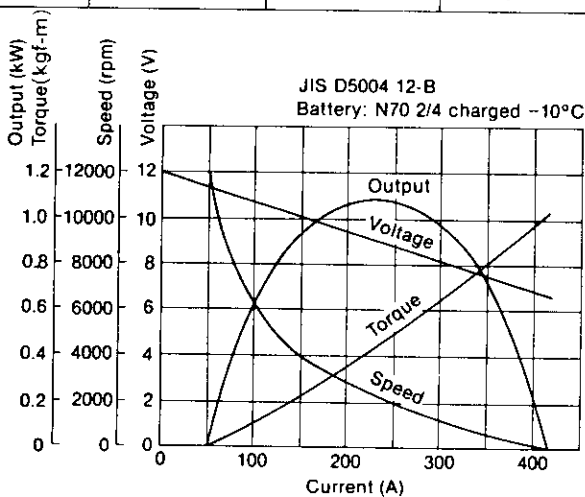
3. Starter Motor

The starter motor is installed on the flywheel housing. When the starting button is pushed, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.

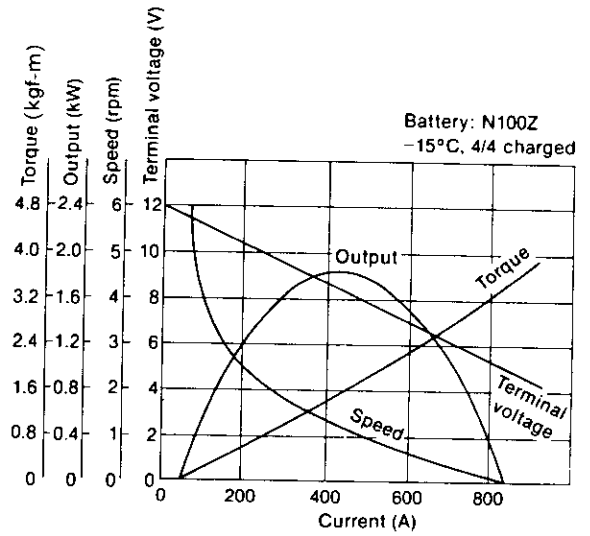
After the engine starts, the pinion automatically returns to its initial position when the starting button is released. Once the engine starts, the starting button should be released immediately. Otherwise, the starter motor may be damaged or burned out.

3-1 Specifications and Performance.

Engine Model	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)	
Model	S114-303	S12-77A	
Rating (sec)	30	30	
Output (kW)	1.0	1.8	
Direction of rotation (viewed from pinion side)	Clockwise	Clockwise	
Weight kg (lb)	4.4 (9.7)	9.3 (20.5)	
Clutch system	Overrunning	Overrunning	
Engagement system	Magnetic shift	Magnetic shift	
No. of pinion teeth	9	15	
Pinion flyout voltage (V)	8 or less	8 or less	
No-load	Terminal voltage (V)	12	12
	Current (A)	60 or less	90 or less
	Speed (rpm)	7000 or greater	4000 or greater
Loaded characteristics	Terminal voltage (V)	6.3	8.5
	Current (A)	460 or less	420
	Torque kgf-m (ft-lb)	0.9 (6.51) or greater	1.35 (9.76) or greater



S114-303 Performance curves



S12-77A Performance curves

3-2 Construction

The starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.

The starter motor is composed of three major parts, as follows:

(1) Magnetic switch

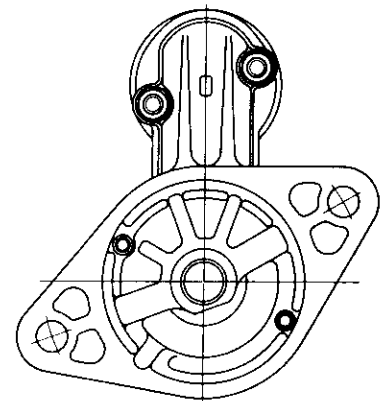
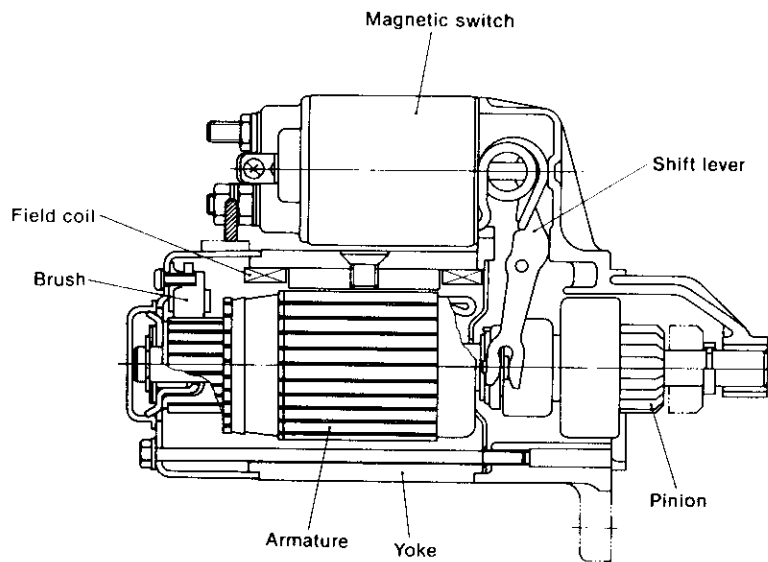
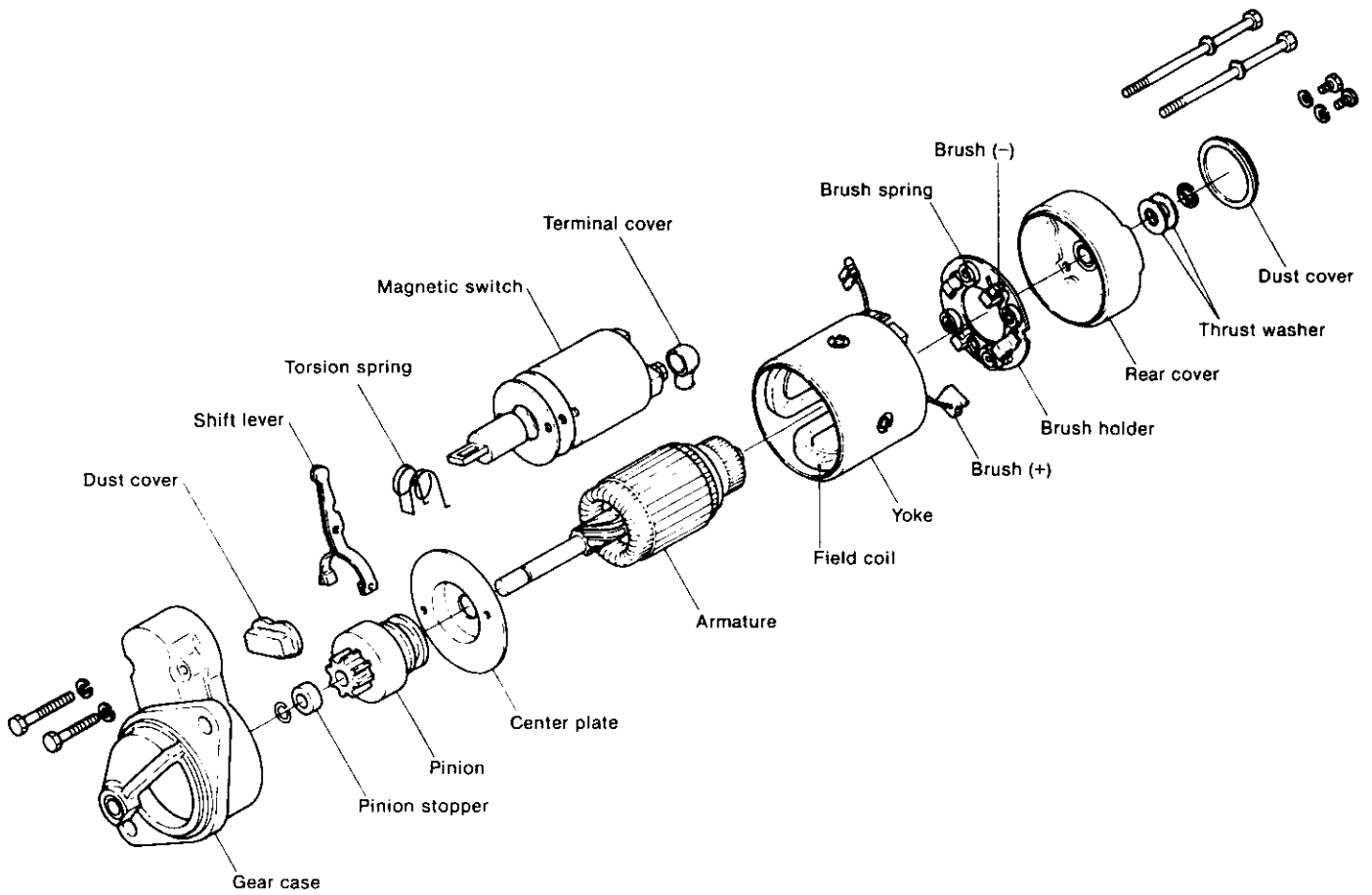
Moves plunger to engage and disengage pinion, and through the engagement lever, opens and closes main contact (moving contact) to stop the starter motor.

(2) Motor

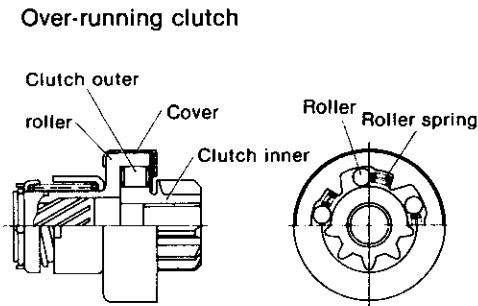
A continuous current series motor which generates rotational drive power.

(3) Pinion

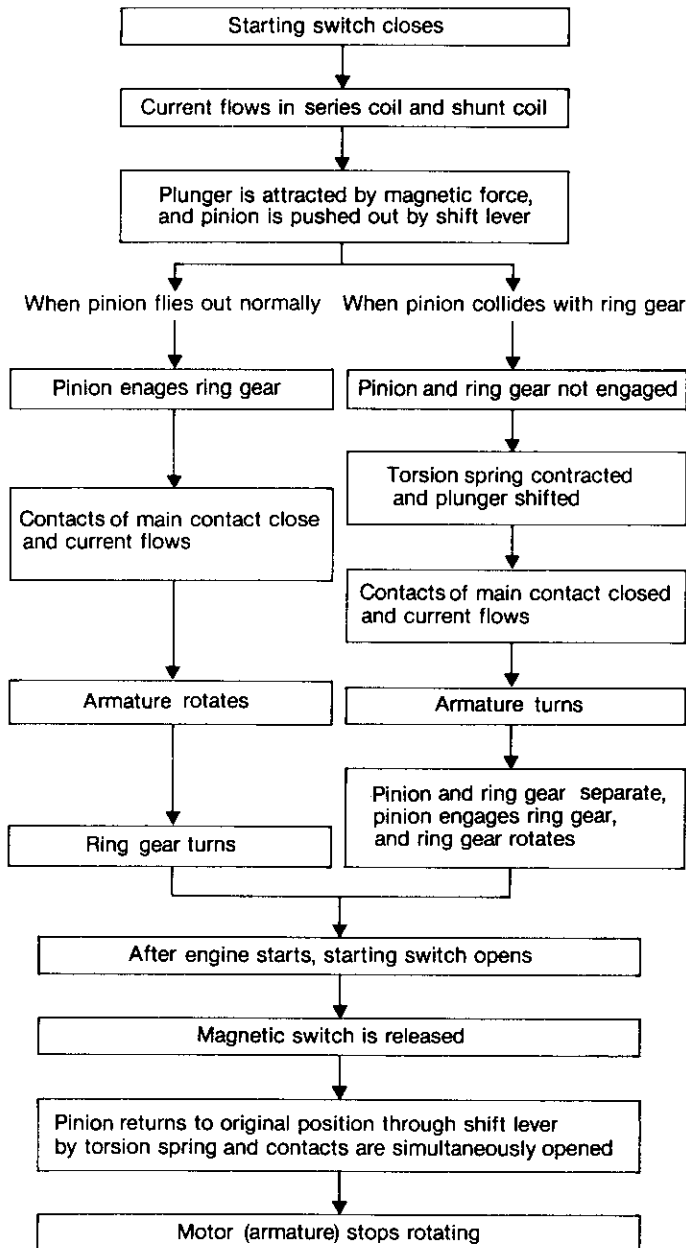
Transfers driving power from motor to ring gear. An over-speed clutch is employed to prevent damage if the engine should run too fast.



To prevent the motor receiving a shock which will occur as the engine starts and over-runs, this starter motor is installed with an over-running clutch.



3-3 Operation



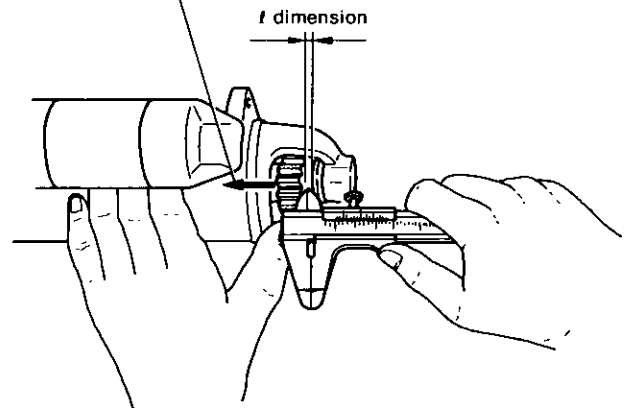
3-4 Adjustment and performance test

3-4.1 L-size measurement (gap between pinion and pinion stopper)

When the pinion is at the projected position, measure between pinion and pinion stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

Starter motor	<i>l</i> dimension mm (in.)
S114-303	0.3 ~ 2.5 (0.0118 ~ 0.0984)
S12-77A	0.2 ~ 1.5 (0.0079 ~ 0.0591)

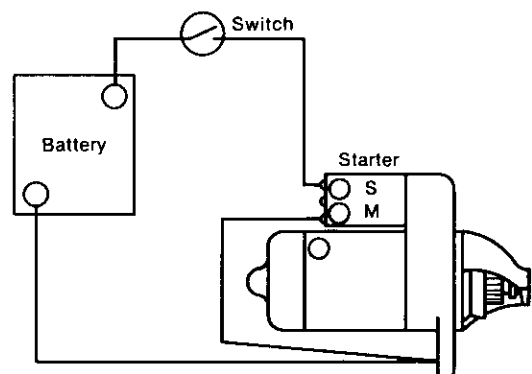
Pressing the pinion



Measuring of *l* dimension

3-4.2 Pinion movement

After complete assembly of the starter motor, connect up the motor as in Fig.



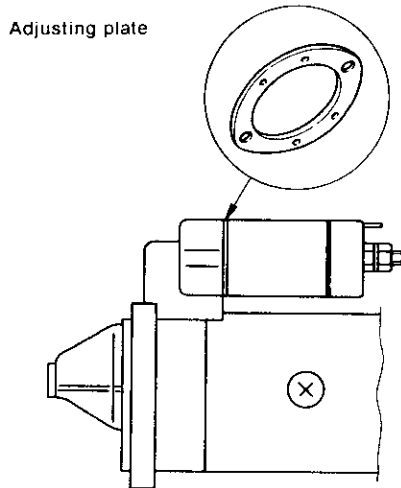
3-4.3 Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.

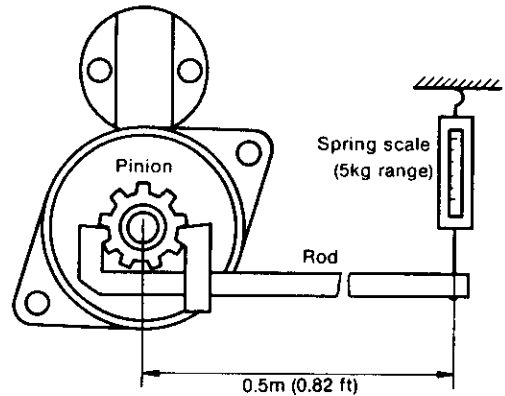
(1) Shim adjusting type (S114-303)

Adjust the *l*-dimension installing shim (Adjusting plate) at the magnetic switch attach section.

There are two kind of shim [Thickness 0.5mm (0.0197in.), 0.8mm (0.0315in.)]

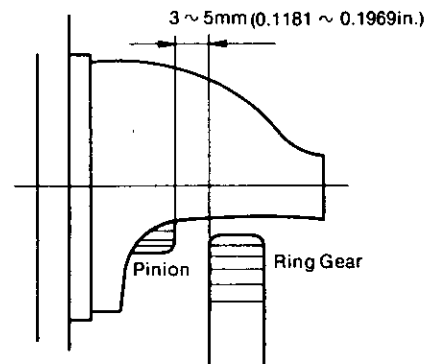


3-4.4 Pinion lock torque measurement



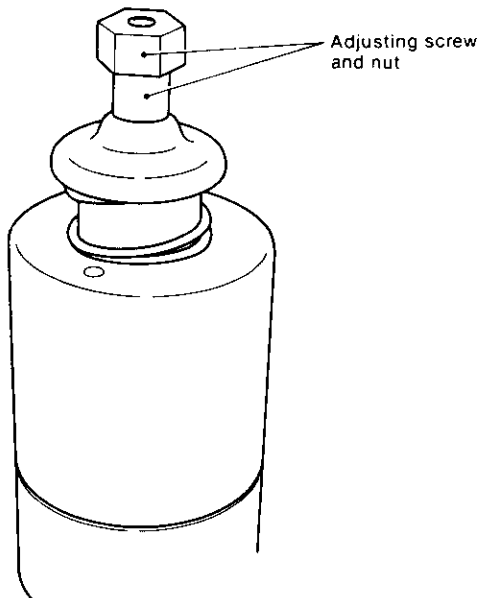
3-4.5 Mesh clearance

Mesh clearance is the distance between the flywheel ring gear and starter motor pinion in the rest position. This clearance should be between 3mm (0.1181in.) to 5mm (0.1969in.).



(2) Adjusting screw type (S12-77A)

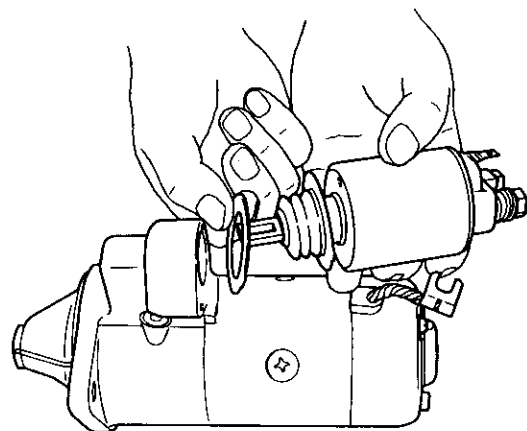
Adjust the *l*-dimension by adjusting screw and nut.



3-5 Disassembly

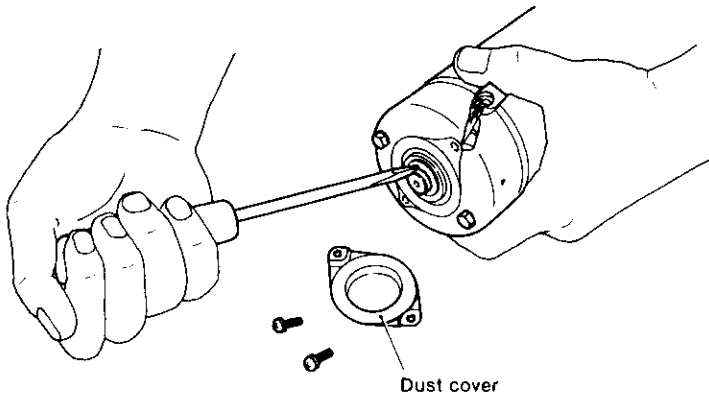
3-5.1 Magnetic switch

- (1) Disconnect magnetic switch wiring.
- (2) Remove through bolt mounting magnetic switch.
- (3) Remove magnetic switch.

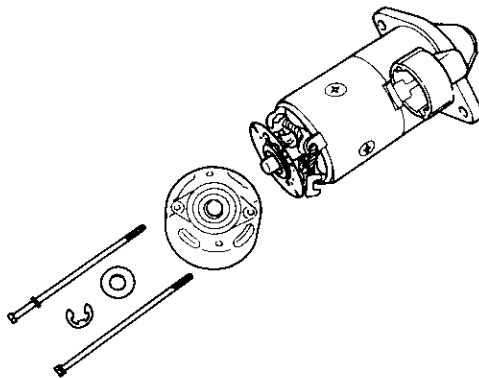


3-5.2 Rear cover

- (1) Remove dust cover.

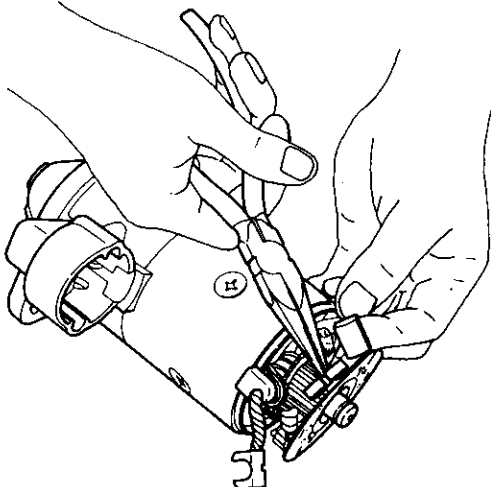


- (2) Remove E-ring, and remove thrust washer (be careful not to lose the washer and shim).
(3) Remove the two through bolts holding the rear cover and the two screws holding the brush holder.
(4) Remove rear cover.



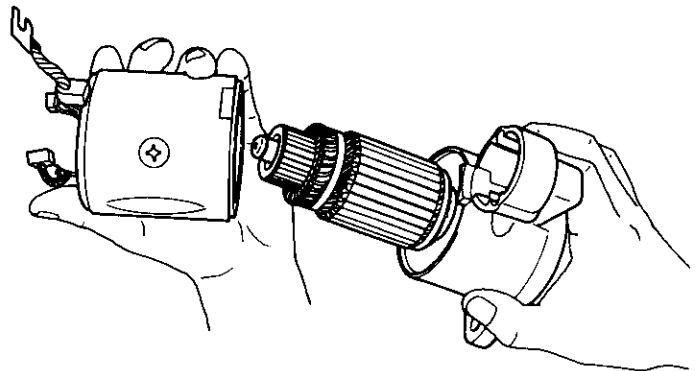
3-5.3 Brush holder

- (1) Float (-)brush from the commutator.
(2) Remove (+)brush from the brush holder.
(3) Remove brush holder.



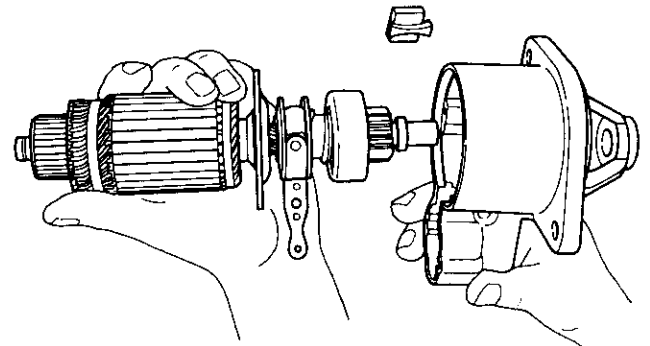
3-5.4 Yoke

- (1) Remove yoke. Pull it out slowly so that it does not strike against other parts.



3-5.5 Armature

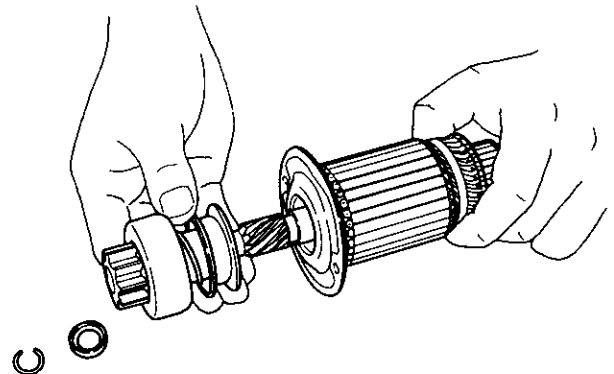
- (1) Slide pinion stopper to pinion side.



- (2) Remove the pinion stopper clip.

3-5.6 Pinion

- (1) Slide the pinion stopper to the pinion side.
(2) Remove the pinion stopper clip.
(3) Remove the pinion from the armature.

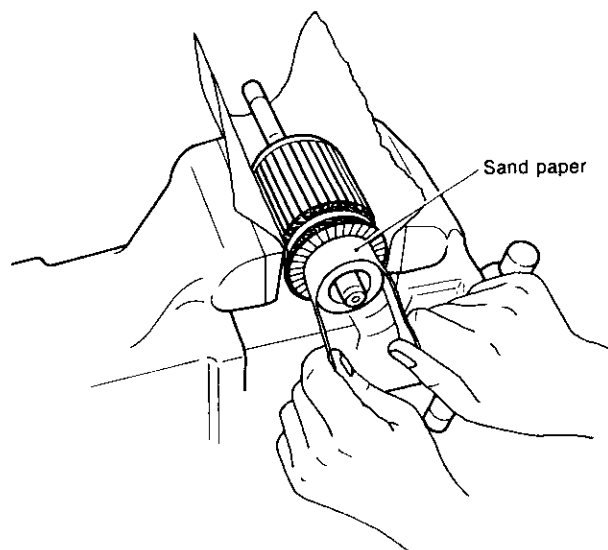


3-6 Inspection

3-6.1 Armature

(1) Commutator

Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.4 by turning it on a lathe. Replace the commutator if damage is irreparable.

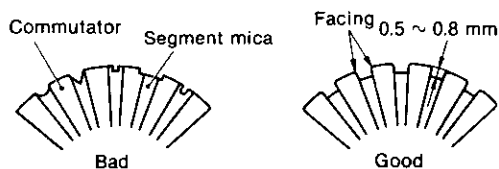
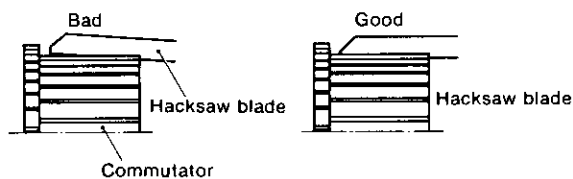


mm (in.)

	S114-303		S12-77A	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Commutator outside diameter	ø33 (1.299)	ø32 (1.260)	ø43 (1.693)	ø40 (1.575)
Commutator run-out	Within 0.03 (0.0012)	0.2 (0.0079)	Within 0.03 (0.0012)	0.2 (0.0079)
Difference between maximum diameter and minimum diameter	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)

(2) Mica undercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.



mm (in.)

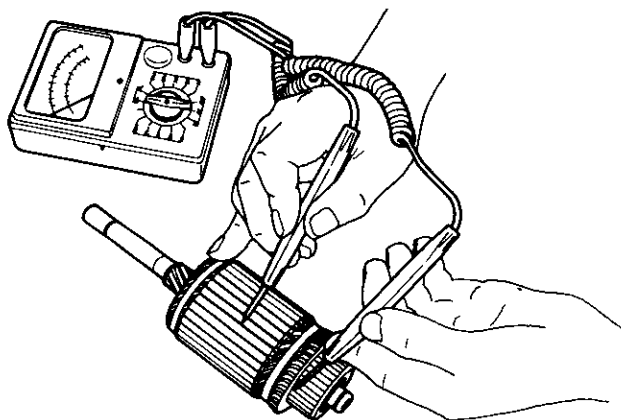
	Maintenance standard	Repair limit
Mica undercut	0.2 (0.0079)	0.5 ~ 0.8 (0.0197 ~ 0.0315)

(3) Armature coil ground test

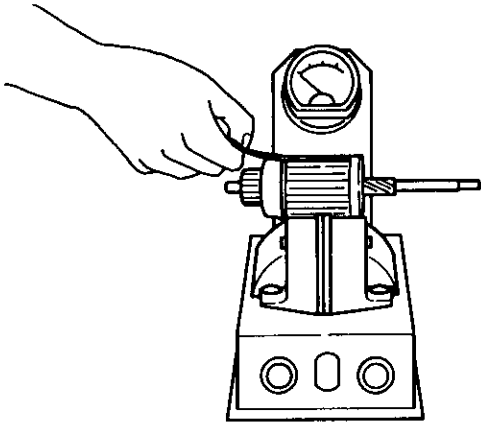
Using a tester, check for continuity between the commutator and the shaft (or armature core). Continuity indicates that these points are grounded and that the armature must be replaced.

- 1) Short test...existence of broken or disconnected coil.
- 2) Insulation test...between commutator and armature core or distortion shaft.

Checking commutator for insulation defects.

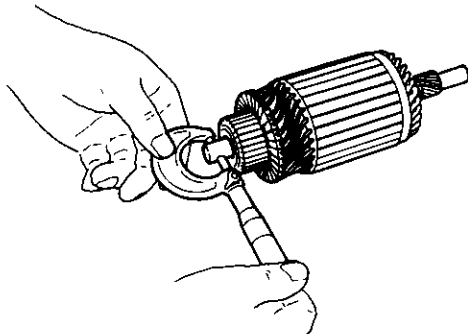


Checking armature windings for insulation faults.



(4) Armature shaft outside diameter

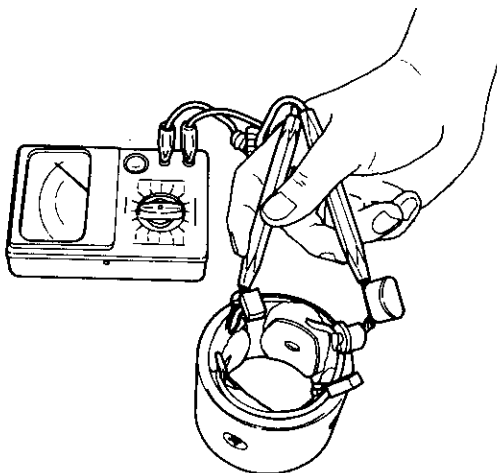
Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn. Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



3-6.2 Field coil

(1) Open test

Check for continuity between the terminals connecting the field coil brushes. Continuity indicates that the coil is open and that the coil must be replaced.



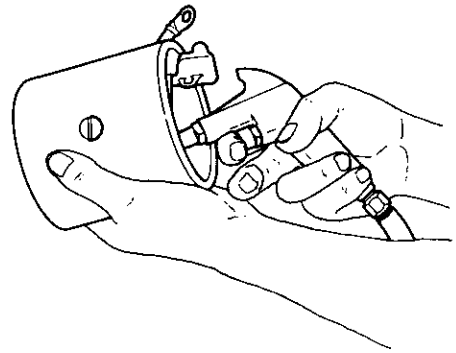
(2) Short test

Check for continuity between the yoke and any field coil terminal. Continuity indicates that the coil is shorted and that it must be replaced.

(3) Cleaning the inside of the yoke

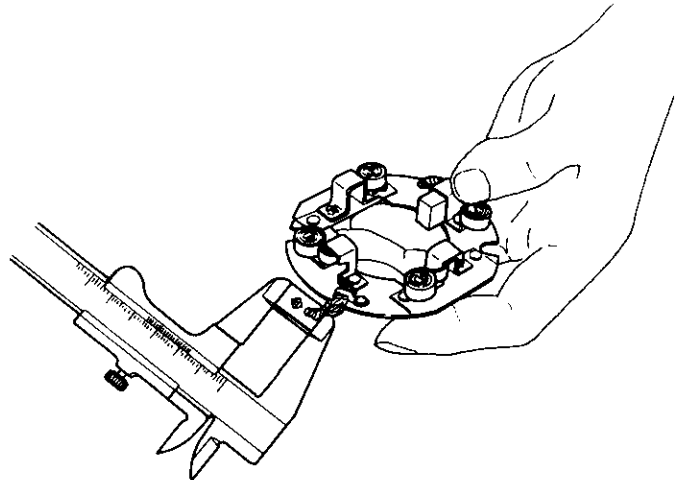
If any carbon powder or rust has collected on the inside of the yoke, blow the yoke out with dry compressed air.

*Do not remove the field coil from the yoke.



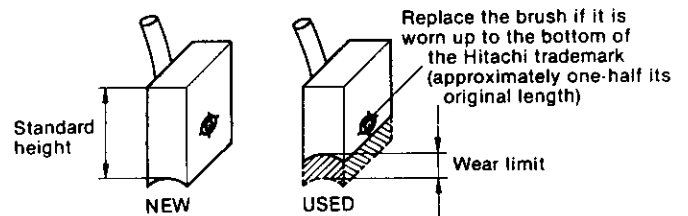
3-6.3 Brush

The brushes are quickly worn down by the motor. When the brushes are defective, the output of the motor will drop.



(1) Brush dimensions

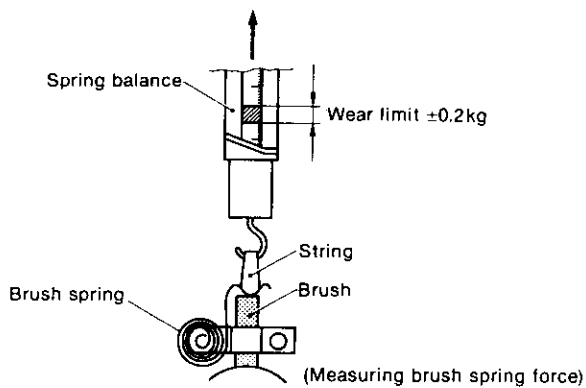
Replace brushes which have been worn beyond the specified wear limit.



	mm (in.)	
	S114-303	S12-77A
Brush standard height	16 (0.6299)	22 (0.8661)
Wear limit	4 (0.1575)	8 (0.3150)

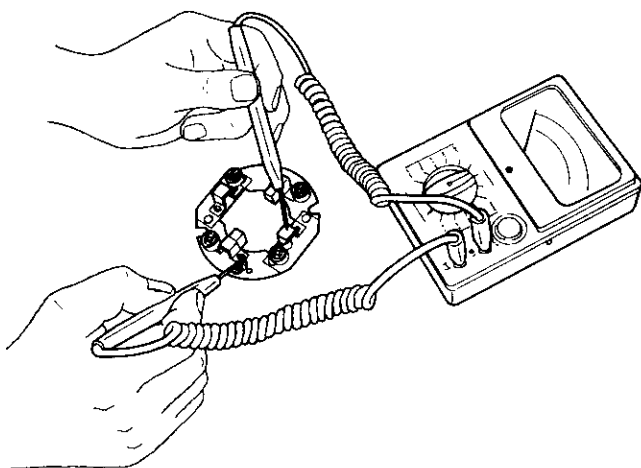
- (2) Brush appearance and movement in brush holder
If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

- (3) Brush spring
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds $\pm 0.2\text{kg}$.



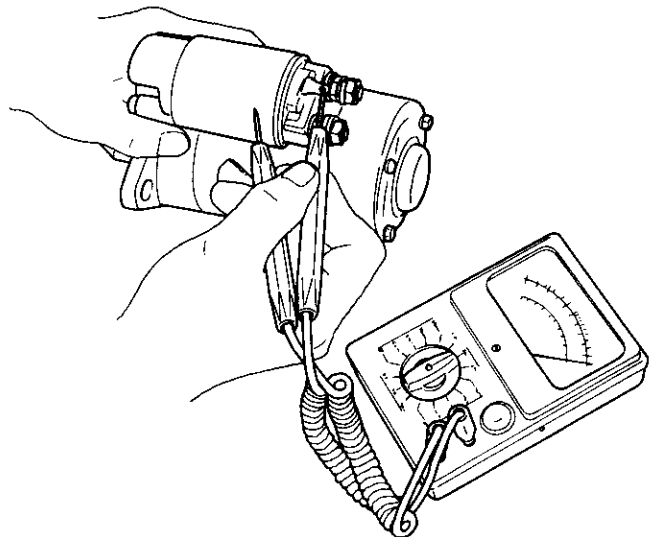
	S114-303	S12-77A
Standard spring load	1.6kg (3.527 lb)	0.85kg (1.8737 lb)

- (4) Brush holder ground test
Check for continuity between the insulated brush holder and the base of the brush holder assembly. Continuity indicates that these two points are grounded and that the holder must be replaced.



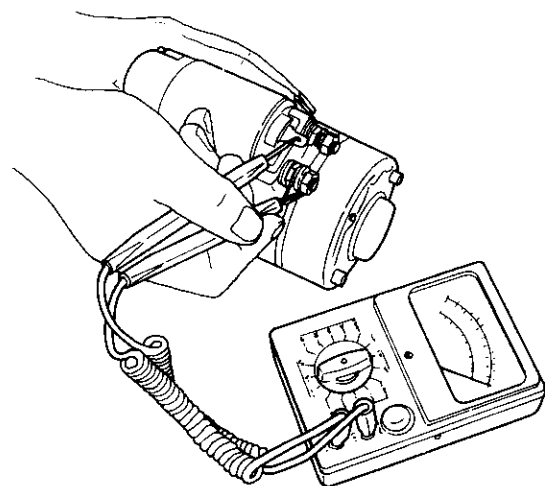
3-6.4 Magnetic switch

- (1) Shunt coil continuity test
Check for continuity between the S terminal and the magnetic switch body (metal part). Continuity indicates that the coil is open and that the switch must be replaced.



	S114-303	S12-77A
Coil resistance (at 20°C)	0.694Ω	0.590Ω

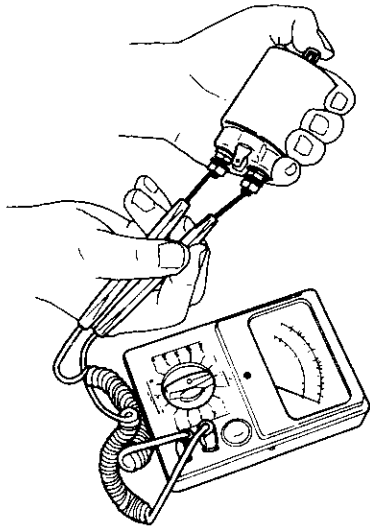
- (2) Series coil continuity test
Check for continuity between the S terminal and M terminal. Continuity indicates that the coil is open and that it must be replaced.



	S114-303	S12-77A
Resistance value (at 20°C)	0.324Ω	0.267Ω

(3) Contactor contact test

Push the plunger with your finger and check for continuity between the M terminal and B terminal. Continuity indicates that the contact is faulty and that the contactor must be replaced.

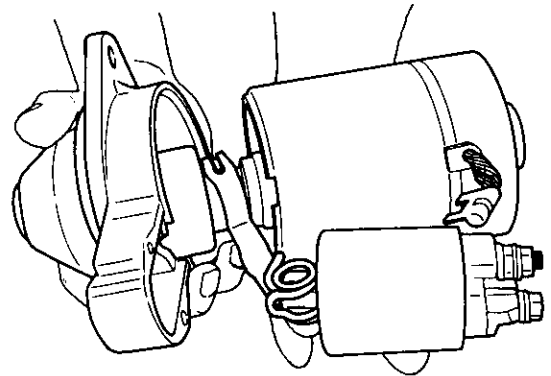


(2) Mounting the magnetic switch

Attach the shift lever to the pinion; assemble the gear case as shown below.

Do not forget to install the dust cover before assembling the gear case.

After reassembly, check by conducting no-load operation.



3-6.5 Pinion

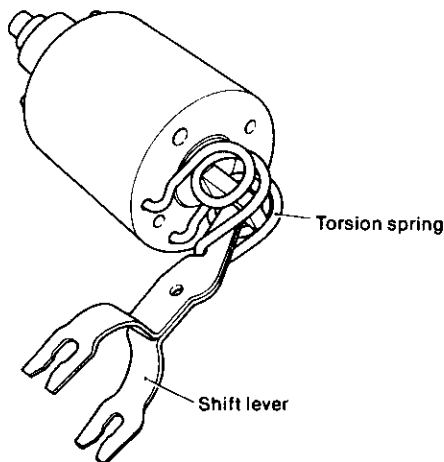
- (1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
- (2) Check if the pinion slides smoothly; replace the pinion if faulty.
- (3) Inspect the springs and replace if faulty.
- (4) Replace the clutch if it slips or seizes.

3-7 Reassembly precautions

Reassemble the starter motor in the reverse order of disassembly, paying particular attention to the following:

(1) Torsion spring and shift lever

Hook the torsion spring into the hole in the magnetic switch and insert the shift lever into the notch in the plunger of the magnetic switch through the torsion spring.



(3) Lubrication

Lubricate each bearing and spline (points indicated in the figure below) with high quality "Hitachi Electrical Equipment Grease A".

The following lubricants may be used in place of Hitachi Electrical Equipment Grease A.

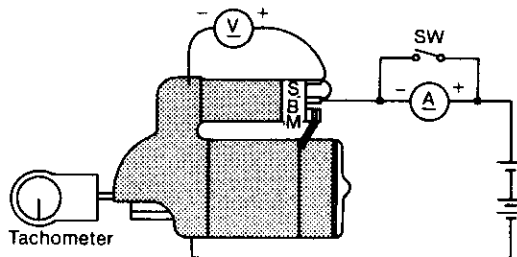
Magnetic switch plunger	Shell	Aeroshell No. 7
Bearing and spline	Shell	Albania Grease No. 2

3-8 Testing

3-8.1 No load test

Test procedure

- (1) Connect the positive side of the ammeter (A) to the positive terminal of the battery, and connect the negative side of the ammeter to the B terminal of the starter.



- (2) Connect the negative terminal of the battery to the body of the starter.
 - (3) Connect the positive side of the voltmeter (V) to the B terminal of the starter, and connect the negative side of the voltmeter to the body of the starter.
 - (4) Attach the tachometer.
 - (5) Connect the B terminal of the starter to the S terminal of the magnetic switch.
- The magnetic switch should begin operating, and the speed, current, and voltage should be the prescribed values.
 - A fully charged battery must be used.
 - Since a large current flows when the starter is operated, close the protection circuit switch before initial operation, then open the switch and measure the current after the starter reaches a constant speed.

3-9 Maintenance standard

			S114-303	S12-77A	
Brush	Standard spring load		kg (lb)	1.6 (3.527)	0.85 (1.8737)
	Standard height		mm (in.)	16 (0.6299)	22 (0.8661)
	Wear limit		mm (in.)	12 (0.472)	8 (0.3150)
Magnetic switch	Series coil resistance		Ω	0.324	0.267
	Shunt coil resistance		Ω	0.694	0.590
Commutator	Outside diameter	Maintenance standard	mm (in.)	∅33 (1.299)	∅43 (1.193)
		Wear limit	mm (in.)	∅32 (1.260)	∅40 (1.575)
	Difference between maximum diameter and maximum diameter	Repair limit	mm (in.)	0.4 (0.0157)	
		Repair accuracy	mm (in.)	0.05 (0.002)	
	Mica undercut	Maintenance standard	mm (in.)	0.2 (0.0079)	
Repair limit		mm (in.)	0.5 ~ 0.8 (0.0197 ~ 0.0315)		
Standard dimension	Rear side bearing	Shaft diameter	mm (in.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	14.950 ~ 14.968 (0.5886 ~ 0.5893)
		Bearing inside diameter	mm (in.)	12.500 ~ 12.527 (0.4921 ~ 0.4932)	15.000 ~ 15.018 (0.5906 ~ 0.5913)
	Intermediate bearing	Shaft diameter	mm (in.)	—	20.250 ~ 20.268 (0.7972 ~ 0.7980)
		Bearing inside diameter	mm (in.)	—	20.500 ~ 20.518 (0.8071 ~ 0.8080)
	Pinion sliding section	Shaft diameter	mm (in.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Pinion inside diameter	mm (in.)	12.530 ~ 12.550 (0.4933 ~ 0.4941)	14.030 ~ 14.050 (0.5524 ~ 0.5531)
	Pinion side bearing	Shaft diameter	mm (in.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Bearing inside diameter	mm (in.)	12.500 ~ 12.527 (0.4921 ~ 0.4932)	14.000 ~ 14.018 (0.5512 ~ 0.5519)

3-10 Various problems and their remedies**(1) Pinion fails to advance when the starting switch is closed**

Problem	Cause	Corrective action
Wiring	Open or loose battery or switch terminal	Repair or retighten
Starting switch	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Repair contacts, or replace switch
Starter motor	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Replace
Magnetic switch	Plunger of magnetic switch malfunctioning or coil shorted	Repair or replace

(2) Pinion is engaged and motor rotates, but rotation is not transmitted to the engine

Problem	Cause	Corrective action
Starting motor	Overrunning clutch faulty	Replace

(3) Motor rotates at full power before pinion engages ring gear

Problem	Cause	Corrective action
Starter motor	Torsion spring permanently strained	Replace

(4) Pinion engages ring gear, but starter motor fails to rotate

Problem	Cause	Corrective action
Wiring	Wires connecting battery and magnetic switch open or wire connecting ground, magnetic switch and motor terminals loose	Repair, retighten, or replace wire
Starter motor	Pinion and ring gear engagement faulty Motor mounting faulty Brush worn or contacting brush spring faulty Commutator dirty Armature, field coil faulty Field coil and brush connection loose	Replace Remount Replace Repair Repair or replace Retighten
Magnetic switch	Contactors contact faulty Contactors contacts pitted	Replace Replace

(5) Motor fails to stop when starting switch is opened after engine starts

Problem	Cause	Corrective action
Starting switch	Switch faulty	Replace
Magnetic switch	Switch faulty	Replace

4. Alternator Standard, 12V/55A

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V-belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keeps the generated voltage constant even when the engine speed changes.

4-1 Features

The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator is self-contained, and has no moving parts (mechanical contact point). It therefore has superior features such as freedom from vibration, no fluctuation of voltage during use, and no need for readjustment.

Also, it is of the over-heating compensation type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.

(2) The regulator is integrated within the alternator to simplify external wiring.

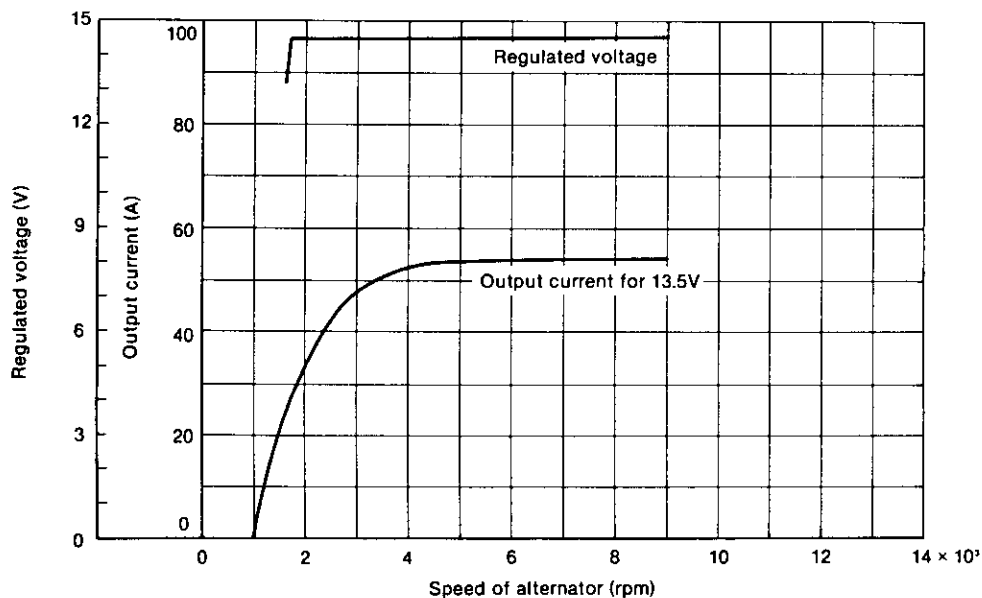
(3) The alternator is designed for compactness, lightness of weight, and high output.

(4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.

(5) As the alternator is to be installed on board, the following measures are taken to provide salt-proofing.

- 1) The front and rear covers are salt-proofed.
- 2) Salt-proof paint is applied to the diode.
- 3) The terminal, where the inboard harness is connected to the alternator, is nickel plated.

4-3 Characteristics

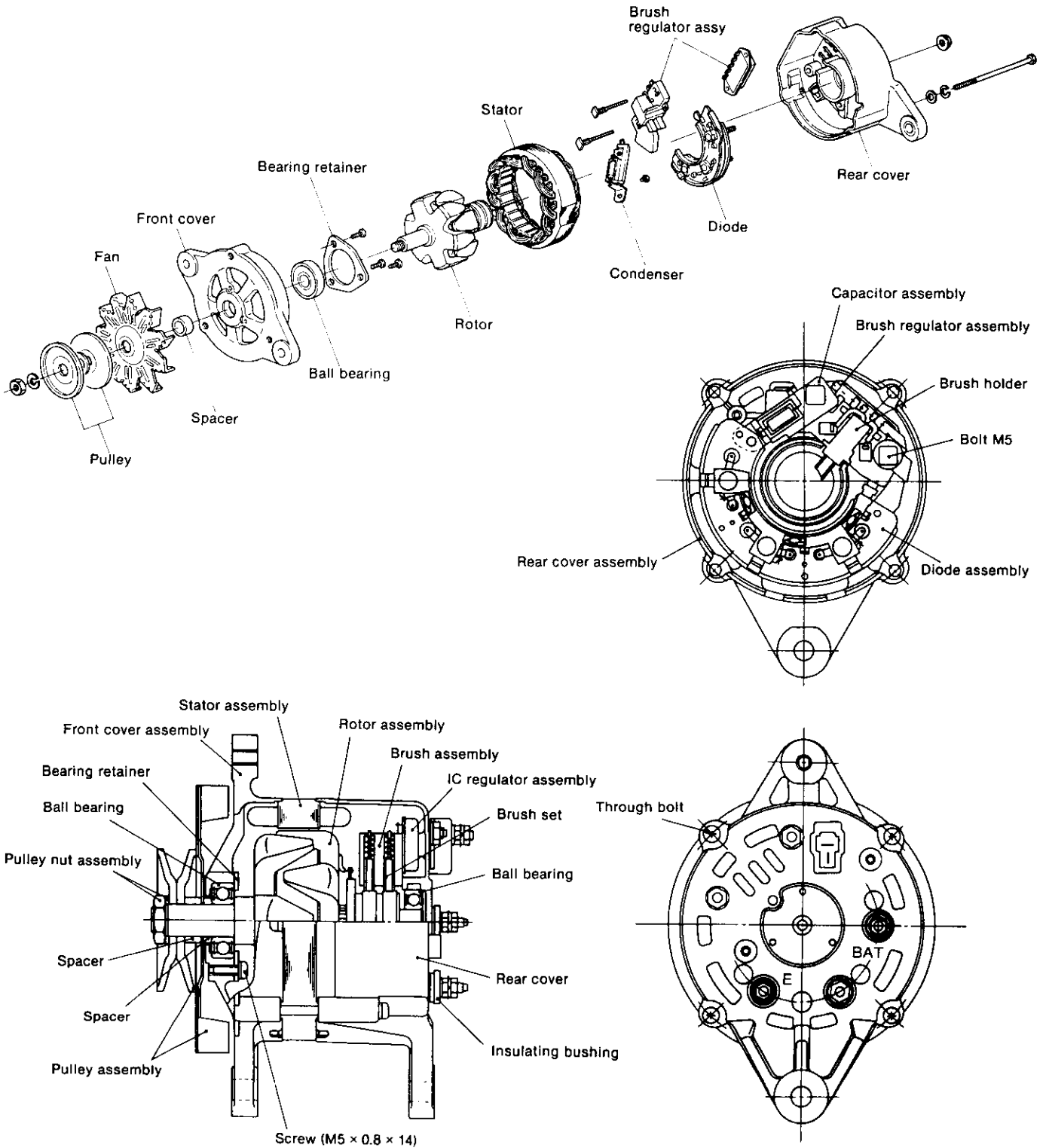


4-2 Specifications

Model of alternator	LR155-20 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/55A
Earth polarity	Negative earth (θ)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	4.3kg (9.5lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 53A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, -0.01/°C)

4-4 Construction

This is a standard rotating field type three-phase alternator. It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.



4-5 Alternator functioning

(1) IC regulator

The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.

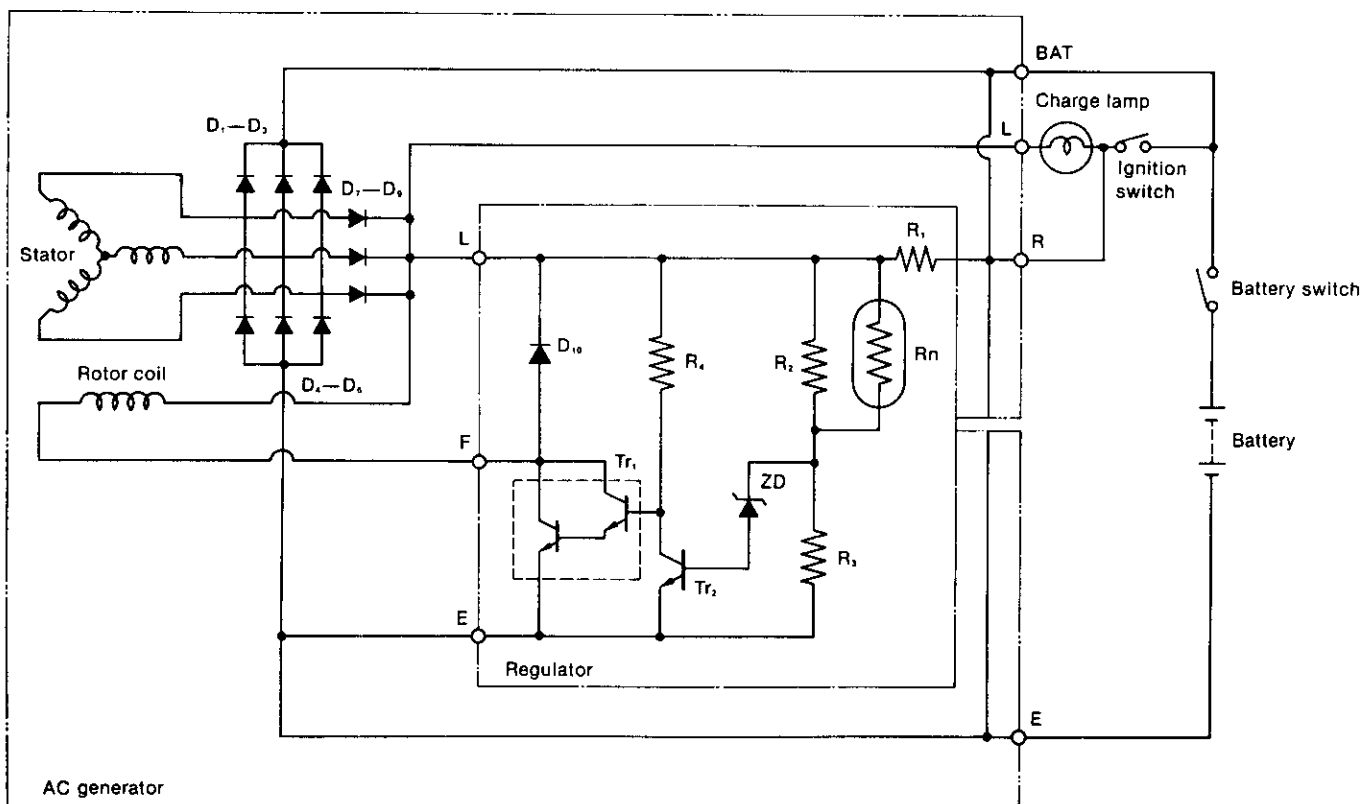
When the output voltage of the generator is within the standard value, the transistor (Tr_1) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor (Tr_1) turns off.

With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

(2) Charge lamp

When the transistor (Tr_1) is on, the charge lamp key switch is turned to ON, and current flows to R_1 , R_2 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

(3) Circuit diagram



BAT:	Generator output terminal	D_1-D_2 :	Output commutation diode
D_{10} :	IC protecting diode	R_1-R_2 :	Resistor
L:	Charge lamp terminal	D_7-D_8 :	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	R_n :	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2 :	Transistor		

4-6 Handling precautions

(1) Be careful of the battery's polarity (+, - terminals), and do not connect the wrong terminals to the wrong cables or the battery will be short-circuited by the generator diode.

In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

(2) Make sure of the correct connection of each terminal.

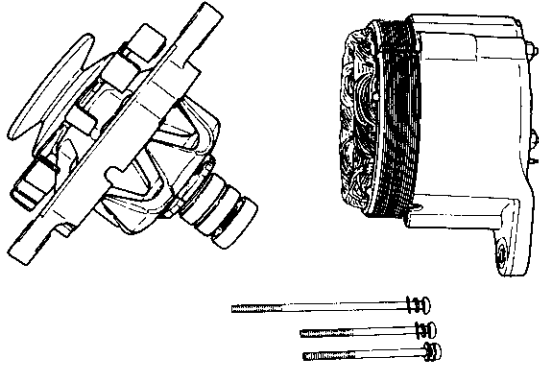
(3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.

(4) Do not short-circuit the terminals.

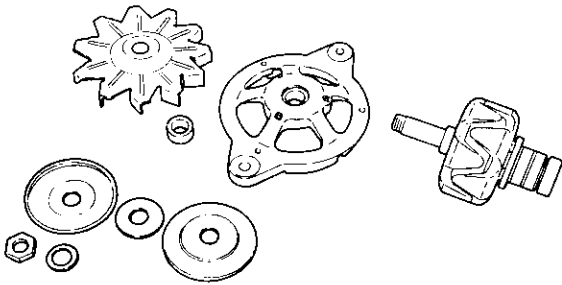
(5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)

4-7 Disassembling the alternator

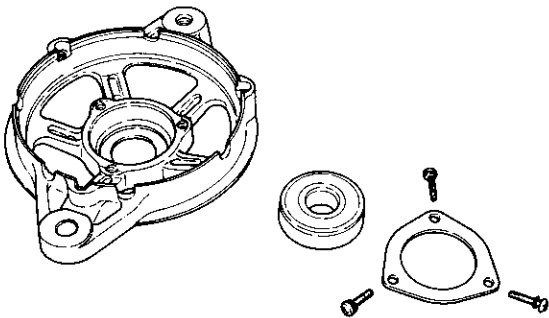
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



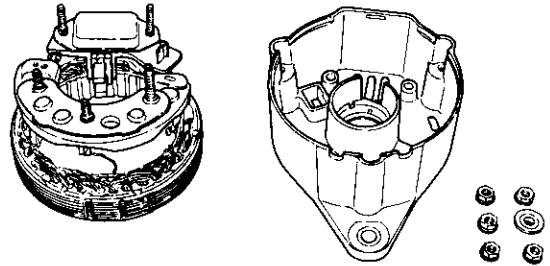
(2) Remove the pulley nut, and pull out the rotor from the front cover.



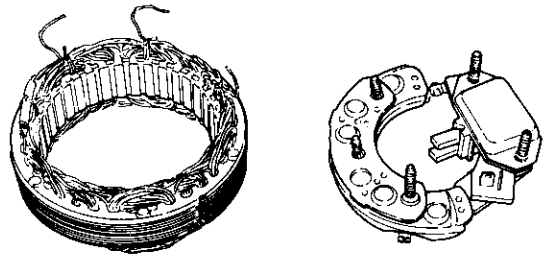
(3) Remove the $\varnothing 5\text{mm}$ screw from the front cover, and then remove the ball bearing.



(4) Remove the nut, the brush-holder, and diode fixing nut at the BAT, and the terminal screws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).

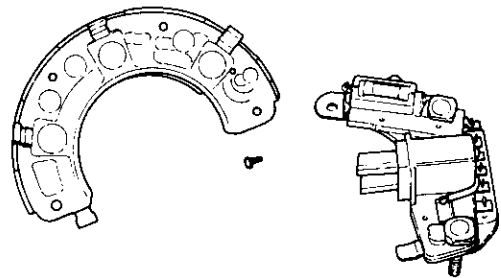


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

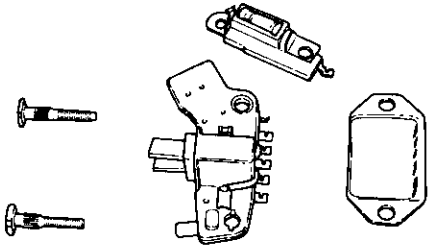


(6) Separating the regulator

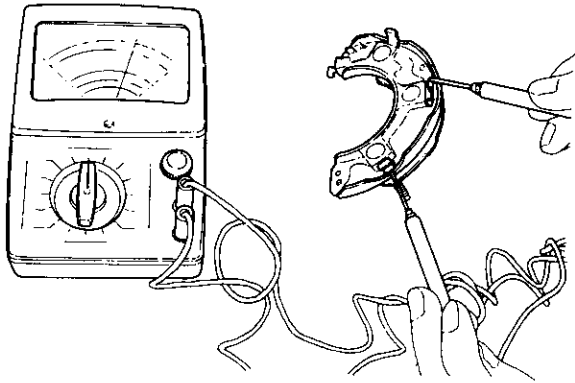
1) To separate the regulator, remove the $\varnothing 3.0\text{mm}$ rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.



After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



4-8 Inspection and adjustment

(1) Diode

Between terminals		BAT (+ side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	No continuity	Continuity
	- side		

Between terminals		E (- side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	Continuity	No continuity
	- side		

CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. Otherwise, the diode may burn out.

(2) Rotor

Inspect the slip ring surface, rotor coil continuity and insulation.

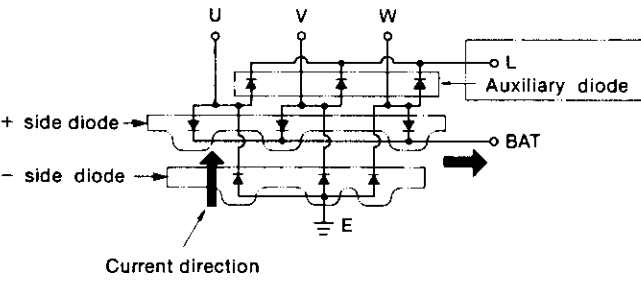
1) Inspecting the slip ring surface

Check if the surface of the slip ring is sufficiently smooth. If the surface is rough, grind the surface with No. 500—600 sand paper. If it is contaminated with oil, etc., wipe the surface clean with alcohol.

Slip ring outer dia.	Standard	Wear limit
	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

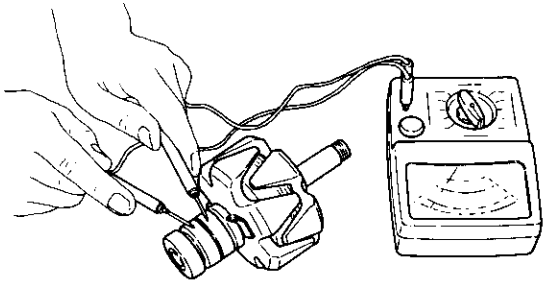
2) Rotor coil continuity test

Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.



U.V.W.: terminal from the stator coil

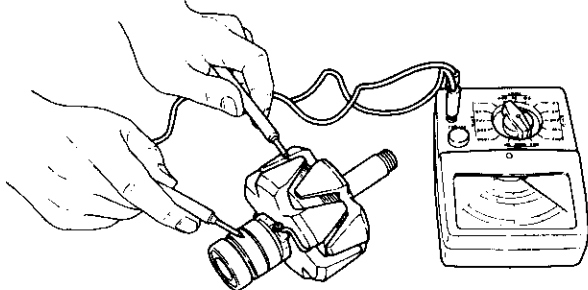
Current flows only in one direction in the diode as shown in Fig. 181. Accordingly, when there is continuity between each terminal (e.g. BAT and U), the diode is in normal condition (photo). When there is no continuity, the diode is defective. When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.



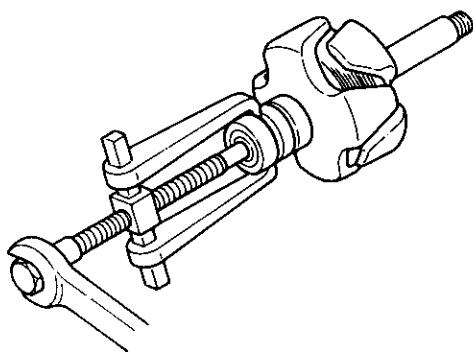
Resistance value	Approx. 3.34Ω at 20°C
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3) Rotor coil insulation test

Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short-circuit with the earth circuit. Replace the rotor coil.



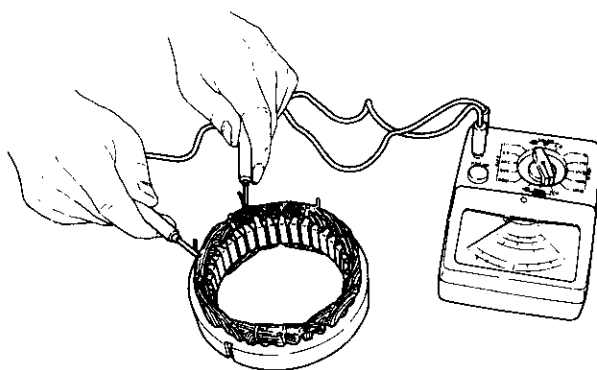
4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



(3) Stator

1) Stator coil continuity test

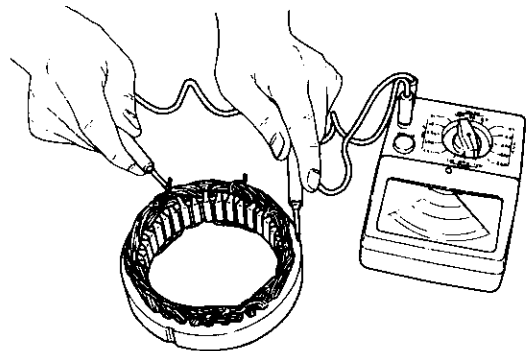
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.



Resistance value	Approx. 0.077Ω at 20°C 1-phase resistance
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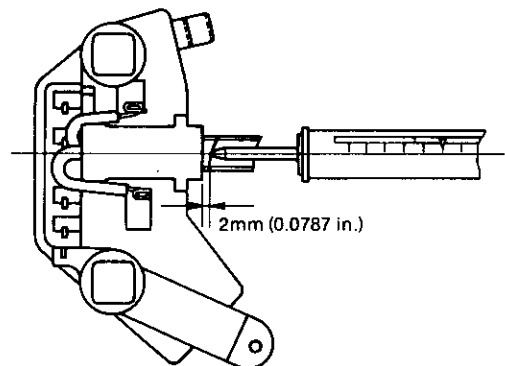
2) Stator coil insulation test

Check the continuity between the terminals and the stator core. If there is continuity, insulation of the stator coil is defective. This will cause a short-circuit with the earth core. Replace the stator coil.



(4) Brush

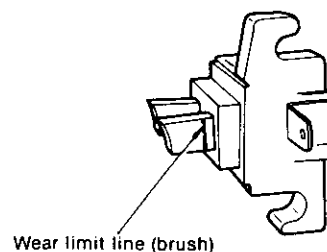
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush also check the strength of the brush spring. To check, push the spring down to 2mm from the end surface of the brush holder, and read the gauge.



Brush spring strength	255—345g (0.56 ~ 0.76lb.)
-----------------------	---------------------------

(5) Brush wear

Check the brush length. The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



	mm (in.)	
	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

(6) IC regulator

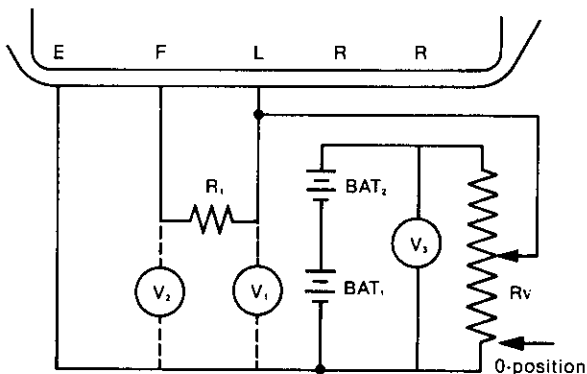
Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

- Resistor (R₁) 100Ω, 2W, 1pc.
- Variable resistor (R_v) 0—300Ω, 12W, 1pc.
- Battery (BAT₁, BAT₂) 12V, 2pcs.
- DC voltmeter 0—30V, 0.5 class 1pc.
(to measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.

- a) Check V₃ (BAT₁ + BAT₂ voltage). If the voltage is 20—26V, both BAT₁ and BAT₂ are normal.
- b) While measuring V₂ (F-E terminal voltage), move R_v gradually from the 0-position. Check if there is a point where the V₂ voltage rises sharply from below 2.0V to over 2.0V. If there is no such point, the regulator is defective. Replace the regulator. If there is a sharp voltage rise when testing, return the R_v to the 0-position, and connect the voltmeter to the V₁ position.
- c) While measuring V₁ (voltage between L-E terminals), move R_v gradually from the 0-position. There should be a point where the voltage of V₁ rises sharply by 2—6V. Measure the voltage of V₁ just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V₁ is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.



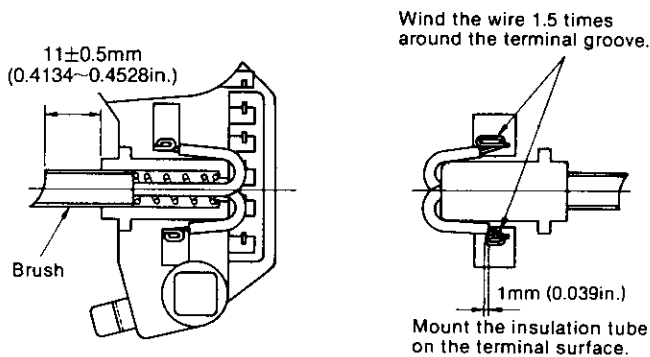
4-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4—7 disassembling alternator).

(1) Assembling the brush regulator

1) Solder the brushes.

Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).

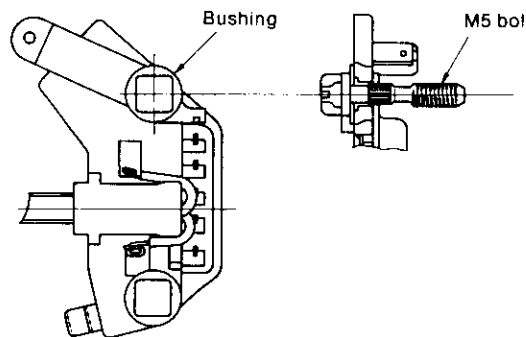


NOTES: 1. Use non-acid type paste.

2. The soldering iron temperature is 300 ~ 350°C.

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.

(If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)

2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

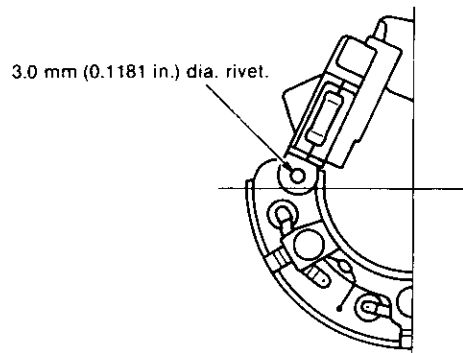
1) Check the rivets

Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500kg (1102 lbs.)
----------------	-------------------

2) Connect the brush to the diode.

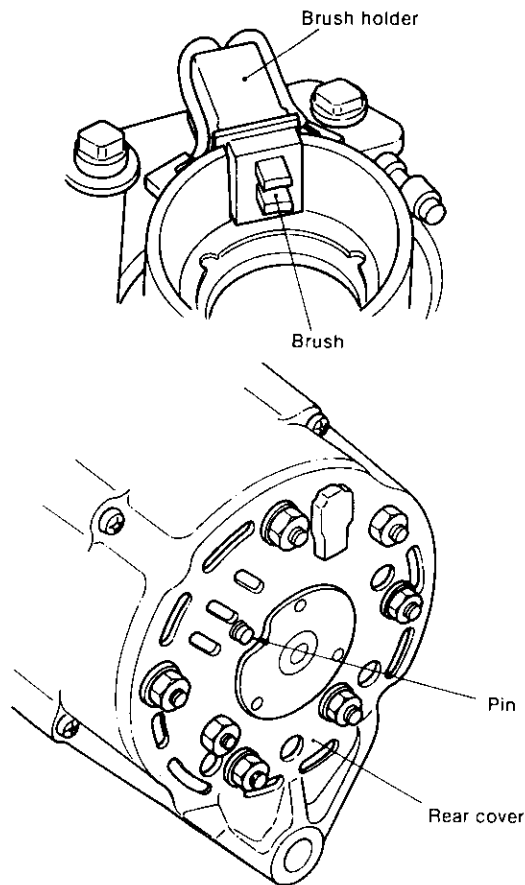
Insert the brush side terminal into the diode terminal, calk it, and then solder into place.



Rivetting pressure	500kg (1102 lbs.)
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(3) Assembling the rear cover

Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.

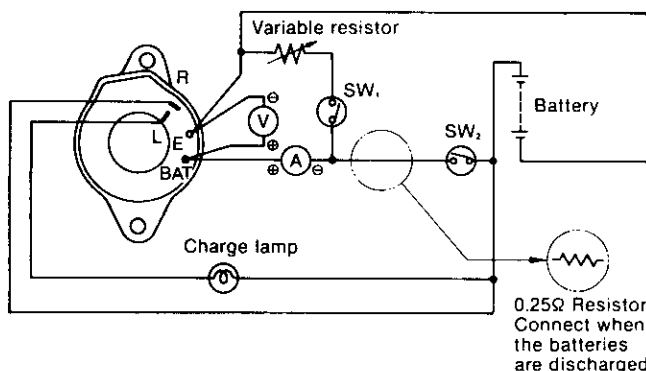


(4) Tightening torques

Positions	Tightening torque kgf-cm(ft-lb)
Brush holder fixing	32—40 (2.31 ~ 2.89)
Diode fixing	32—40 (2.31 ~ 2.89)
Bearing retainer fixing	32—40 (2.31 ~ 2.89)
Pulley nut tightening	400—600 (28.93 ~ 43.40)
Through-bolt tightening	32—40 (2.31 ~ 2.89)

4-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.



(1) Measuring devices

DC voltmeter	0—15V or 0—30V, 0.5 Class, 1pc.
DC ammeter	0—100A, 1.0 Class, 1pc.
Variable resistor	0—0.25Ω, 1kW, 1pc.
Lamp	12V, 3W
100Ω resistor	3W
0.25Ω resistor	25W

(2) Measuring the regulating voltage

- 1) When measuring devices are connected in the performance test circuit as shown above, the charge lamp lights.
- 2) Close SW₂, while keeping SW₁ open and run the AC generator. When the revolutions of the generator are gradually raised, the charge lamp goes off.
- 3) Raise the revolutions of the AC generator, and read the voltmeter gauge when the revolutions reach about 5,000 rpms.

NOTES: 1. Make sure that the ammeter indication at this time is less than 5A. If the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.

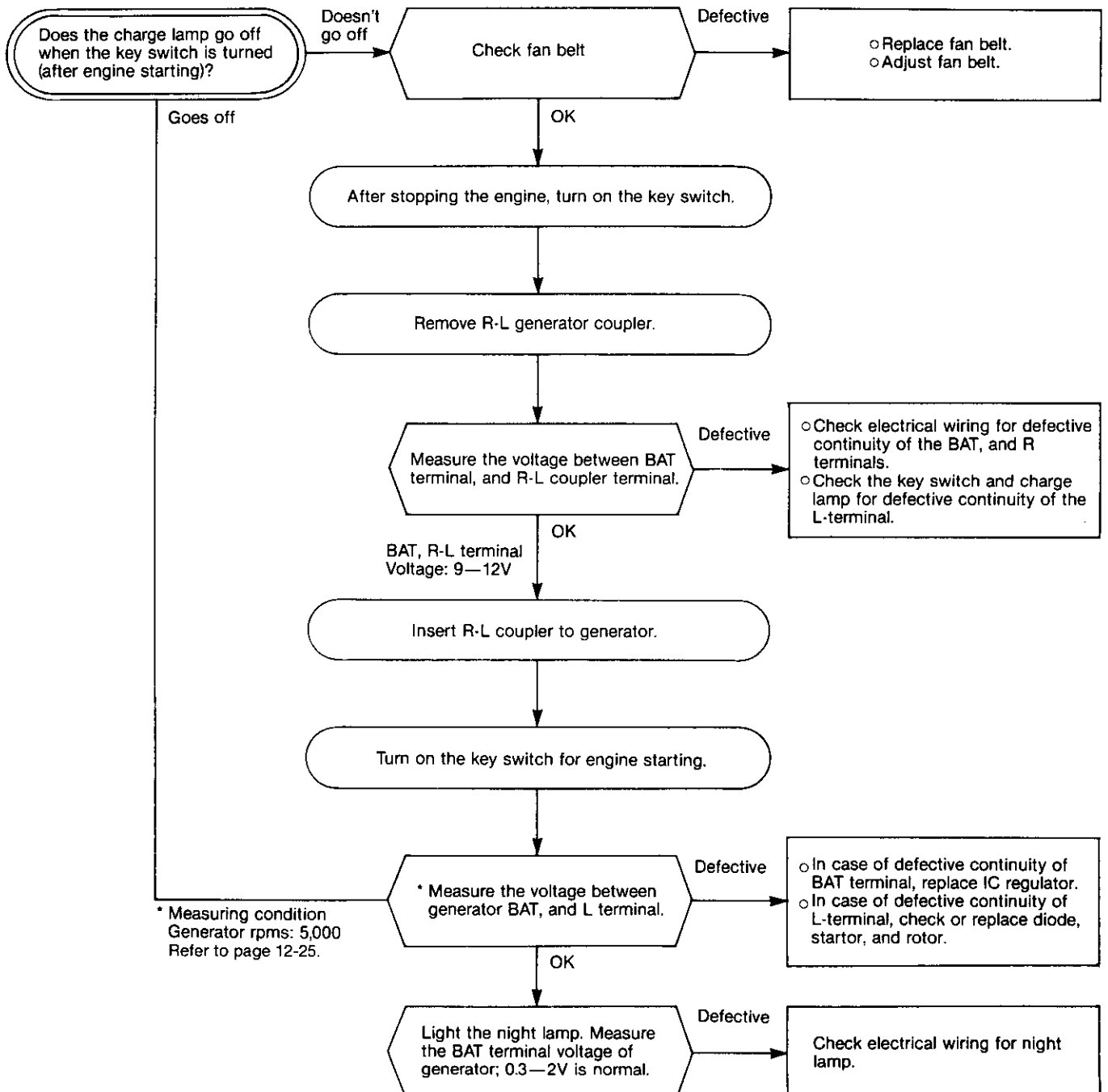
2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

(3) Precautions for measuring the regulating voltage

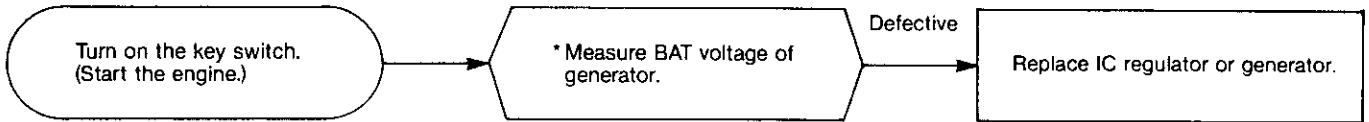
- 1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
- 2) Use a fully charged battery.
- 3) Measure the voltage quickly.
- 4) Keep SW₁ open for measurement.

4-11 Troubleshooting

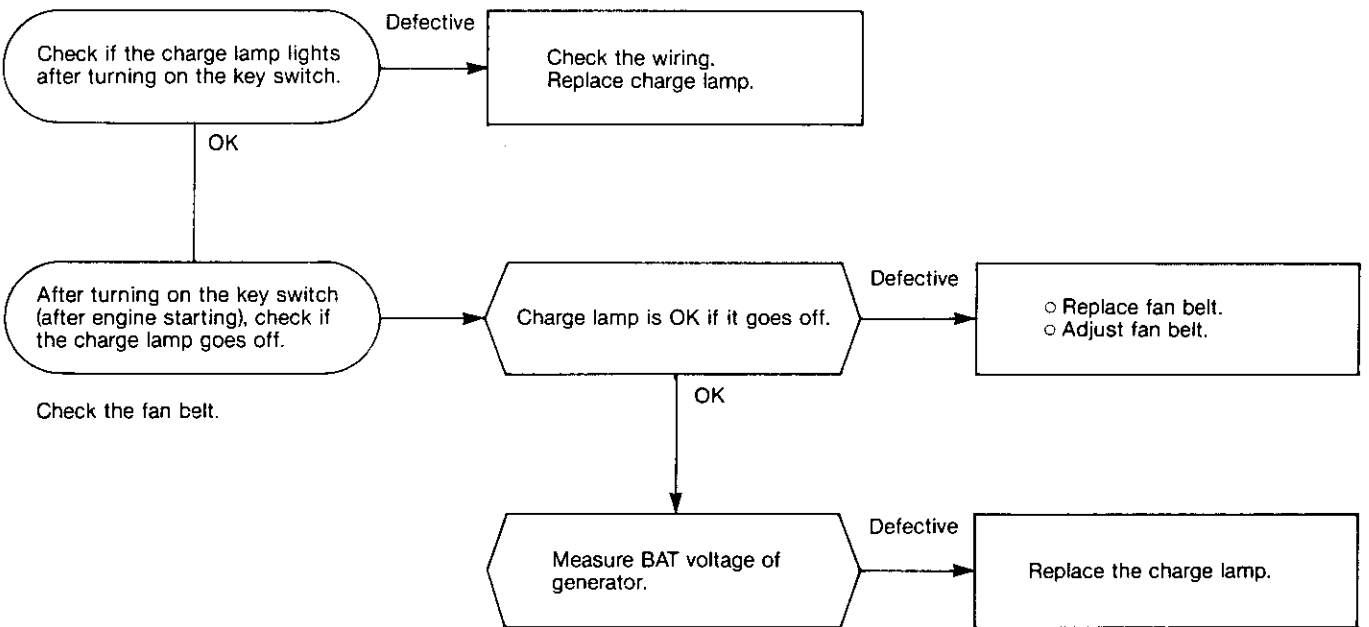
(1) Charging failure



(2) Overcharging



(3) Charge lamp failure



4A. Alternator, Option, 12V/35A [Except 1GM10(C)]

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V-belt.

The type of alternator used in this engine is ideal for high speed engines having a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keep the generated voltage constant even when the engine speed changes.

4A-1. Features

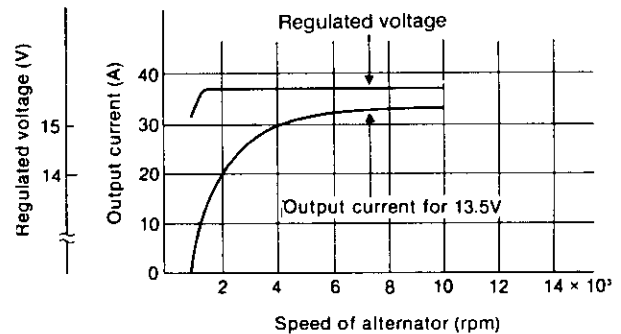
The alternator contains a regulator using an IC, and has the following features.

- (1) The IC regulator, which is self-contained, has no moving part (mechanical contact point), therefore it has superior features such as, freedom from vibration, no fluctuation of voltage during use, and no need for readjustment. Also, it is of the over-heating compensating type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.
- (2) The regulator is integrated within the alternator to simplify external wiring.
- (3) It is an alternator designed for compactness, light weight, and high output.
- (4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.
- (5) As the alternator is to be installed on board, the following countermeasures are taken to provide salt-proofing.
 - 1) The front and rear covers are salt-proofed.
 - 2) Salt-proof paint is applied to the diode.
 - 3) The terminal, where the harness inboard is connected to the alternator, is nickel plated.

4A-2. Specifications

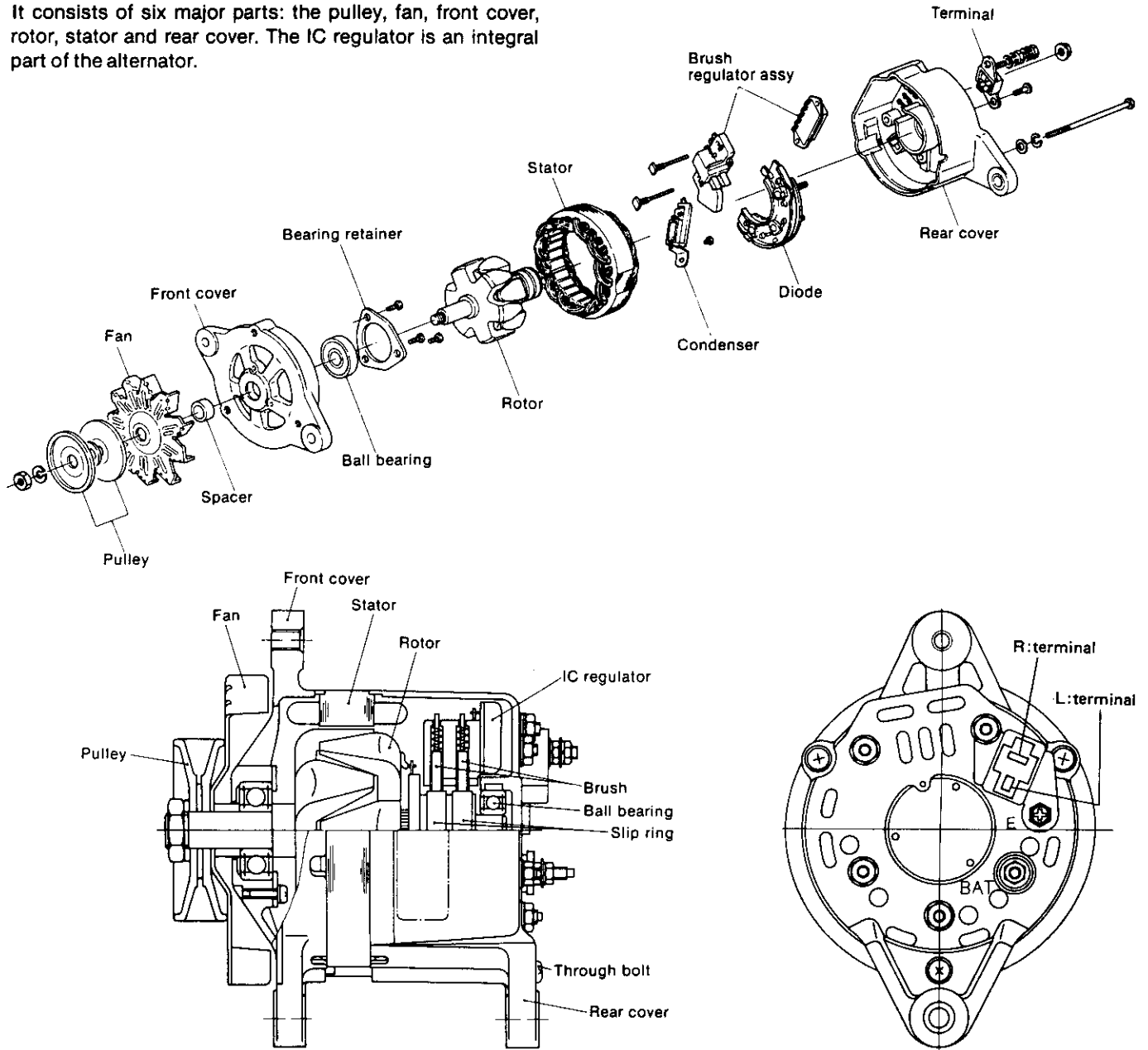
Model of alternator	LR135-105 (HITACHI)
Model of IC regulator	TR1Z-63 (HITACHI)
Battery voltage	12V
Nominal output	12V, 35A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	3.5 kg (7.7 lb)
Rated speed	5000 rpm
Operating speed	900 ~ 8000 rpm
Speed for 13.5V	900 rpm or less
Output current (when heated)	5000 rpm 32±2A
Regulated voltage	14.5±0.3V (at 20°C, Full battery)
Standard temperature/voltage gradient	-0.01V/°C

4A-3. Characteristics



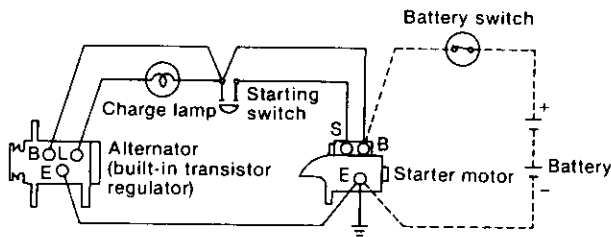
4A-4. Construction

This is a standard rotating field type three-phase alternator. It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.



4A-5. Wiring

(1) Wiring diagram



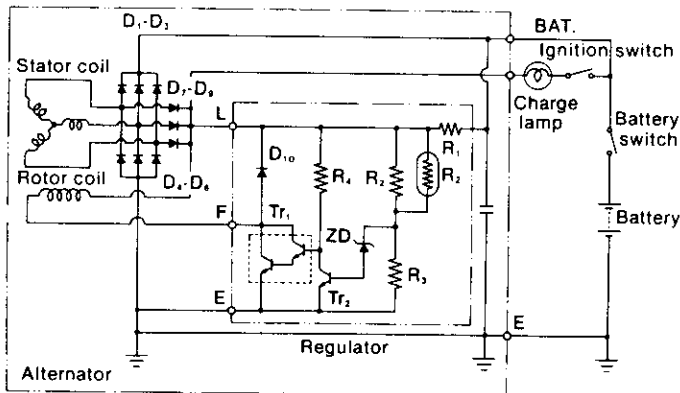
(2) Terminal connections

The alternator has the following terminals. Connect these terminals as indicated below.

Symbol	Terminal name	Connection to external wiring
B	Battery terminal	To battery (+) side
E	Ground terminal	To battery (-) side
L	Lamp (charge) terminal	To charge lamp terminal

4A-6. Circuit diagram

4A-6.1 Circuit diagram



- BAT: Battery output terminal
- L: Charge lamp terminal
- E: Earth
- $D_1 \sim D_6$: Diodes for rectifying the output current
- $D_7 \sim D_8$: Diodes for switching the charge lamp
- D_9 : Diode for protecting the IC
- ZD: Zener diode
- Tr_1, Tr_2 : Transistors
- $R_1 \sim R_3$: Resistors
- F: Rotor current
- R_n : Thermistor (resistors with current/temperature gradient)

4A-6.2 Principle of IC regulator function

The IC regulator controls the output voltage of the alternator by switching the rotor current (exciting current) on or off by means of the transistor Tr_1 , which is connected in series with the rotor coil.

When the output voltage of the alternator is within the regulated values, transistor Tr_1 is "ON" but when the voltage is outside the regulated value, the Zener diode ZD comes "ON", and regulates the output voltage rise by turning transistor Tr_1 "OFF".

The output voltage is kept within the regulated values by repeating the "ON"—"OFF" operation.

4A-7. Alternator handling precautions

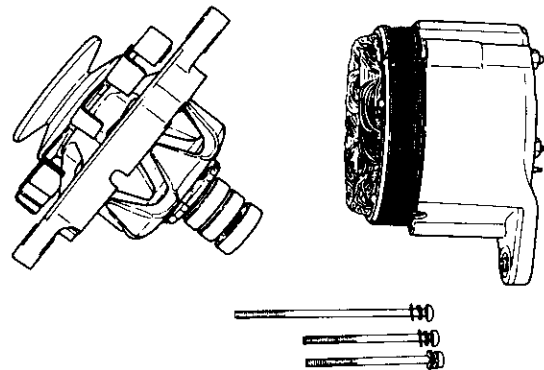
- (1) Pay attention to the polarity of the battery; be careful not to connect it in reverse polarity. If the battery is connected in reverse polarity, the battery will be shorted by the diode of the alternator, an overcurrent will result, the diodes and transistor regulator will be destroyed, and the wiring harness will be burned.
- (2) Connect the terminals correctly.
- (3) When charging the battery from outside, such as during rapid charging, disconnect the alternator B terminal or the battery terminals.
- (4) Do not short the terminals.
- (5) Never test the alternator with a high voltage meter.

4A-8. Alternator disassembly

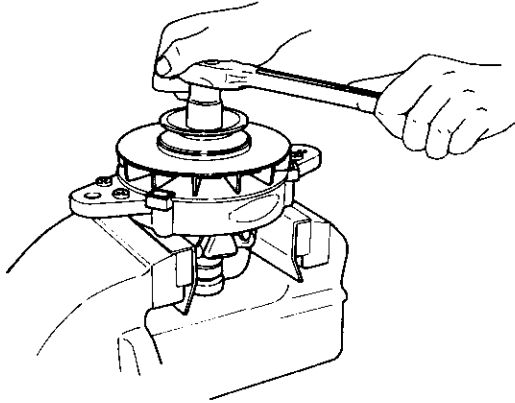
Disassemble the alternator as follows.

The major points of disassembly are the removal of the cover, the separation of the front and rear sides, and detailed disassembly.

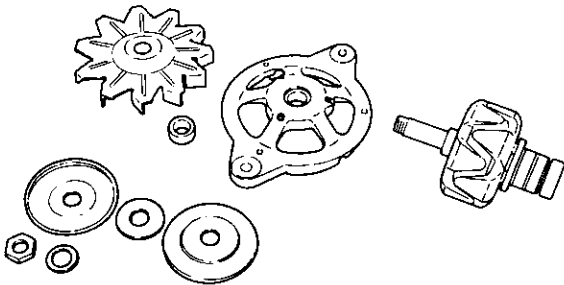
- (1) Remove the cover attached to the rear cover, remove the through bolts, and disassemble into front and rear sides.



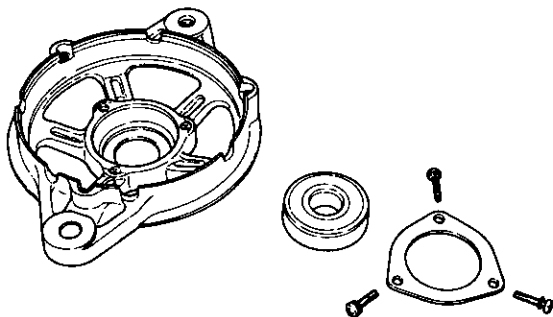
(2) When disassembling the front side pulley and fan, front cover and rotor, clamp the rotor in a vice within copper plates and loosen the pulley nut, as shown in the figure.



(3) When the fan and pulley have been removed, the rotor can be pulled from the front cover by hand.

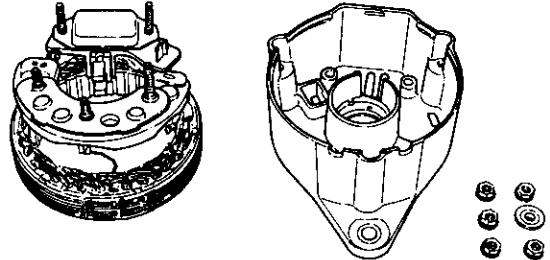


(4) Next, remove the bearing attached to the front cover. Loosen the bearing protector mounting bolts (M4) and pull the bearing by applying pressure to the bearing from the front cover.

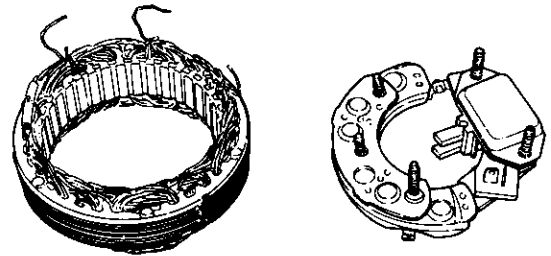


(5) Remove the nut at the threaded part of the BAT terminal on the rear cover, the fixing nut of the diode, and the bolt of E terminal.

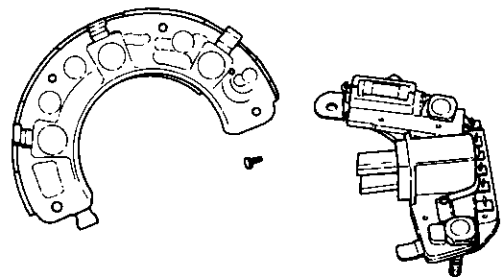
After removing the L terminal assembly, separate the alternator into rear cover and stator (with attached diode and brush holder).



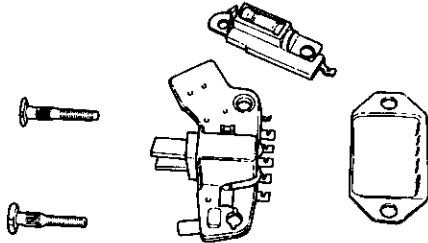
(6) Unsolder the lead wire connection and remove the diode assembly together with the regulator assembly.



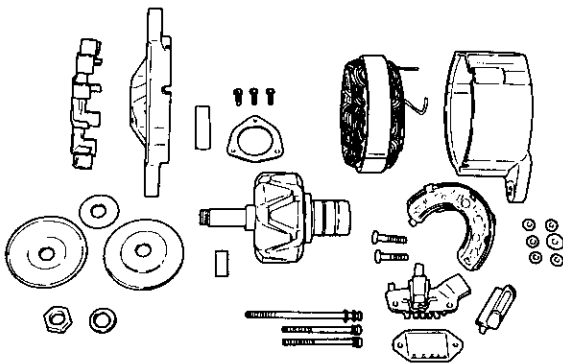
(7) Separate the diode assembly and the brush regulator assembly by removing the 3mm dia rivet which connects these two parts and then unsolder the L terminal connection.



(8) When replacing the IC regulator, it can be removed by unsoldering the regulator's terminals and removing two bolts. Never remove these two bolts except when the regulator is replaced.



(9) When (1)—(8) above are completed, the alternator is completely disassembled.

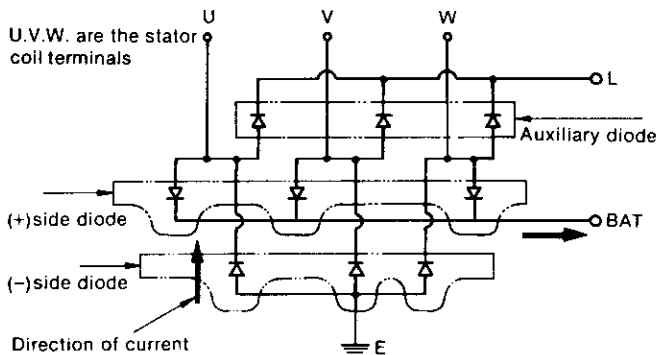


4A-9. Inspection and adjustment

4A-9.1 Diodes

	Between terminal		BAT (+ side diode)	
	Tester pin	(+) side	(-) side	
U.V.W	(+) side	—	Continuity No	
	(-) side	Continuity Yes	—	

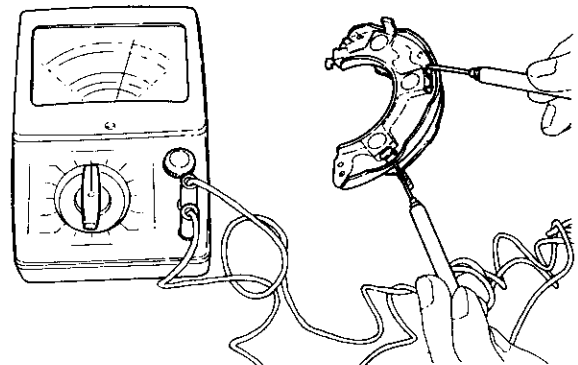
	Between terminal		E (- side diode)	
	Tester pin	(+) side	(-) side	
U.V.W	(+) side	—	Continuity Yes	
	(-) side	Continuity No	—	



Electric current flows only in one direction in the diode as shown on the previous page. By testing the continuity between terminals (e.g. BAT and U) with the continuity tester, (as shown in the picture), the diode is determined as usable when the continuity is "Yes", but is faulty when it "No".

Connect the tester in the reverse way, and then the diode is usable when continuity is "No", but faulty when "Yes". If a faulty diode is found in this test, replace it with a complete new diode assembly.

As the auxiliary diode does not have a terminal, check the continuity between its ends.



Diode short test

CAUTION: If a high voltage meter is used, a high voltage will be applied to the diode and the diode will be destroyed. Therefore, never test the diodes with a high voltage meter, etc.

4A-9.2 Rotor

(1) Slip ring wear

Because the slip rings wear very little, the diameter of the rings must be measured with a micrometer. Replace the rings (rotor assembly) when wear exceeds the maintenance standard by 1mm. (0.0393in.)

	Maintenance standard	Wear limit
Slip ring outside diameter	∅31.6 (1.2441)	∅30.6 (1.2047)

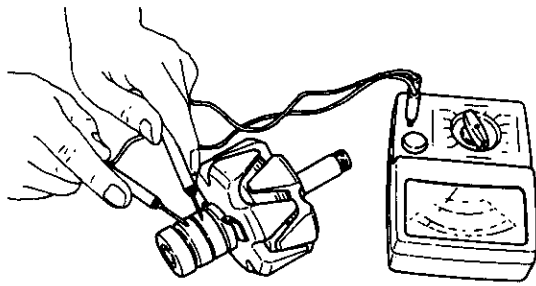
(2) Slip ring roughness

The slip ring should be smooth with no surface oil, etc. If the surface of the rings is rough, polish with #500 ~ #600 sandpaper, and if the surface is soiled, clean with a cloth dipped in alcohol.

(3) Rotor coil short test

Check the continuity between the rotor coil and slip ring with a tester. The resistance should be near the prescribed value.

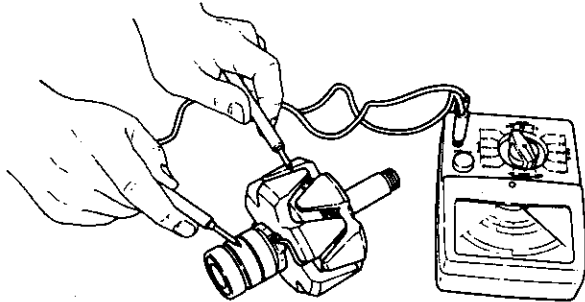
If the resistance is extremely low, there is a layer short at the rotor coil; if the resistance is infinite, the coil is open. In either case, replace the rotor.



Resistance value	Approx. 3.1 Ω (at 20°C)	LR135-105
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(4) Rotor coil ground test

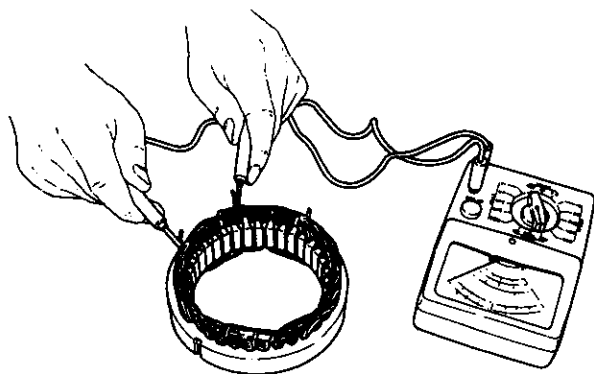
Check the rotor coil for grounding with a tester, or by checking the continuity between one slip ring and the rotor core or shaft.
Usable if the continuity is "No".
If "Yes", replace it as the rotor coil is grounded.



4A-9.3 Stator coil

(1) Stator coil short test

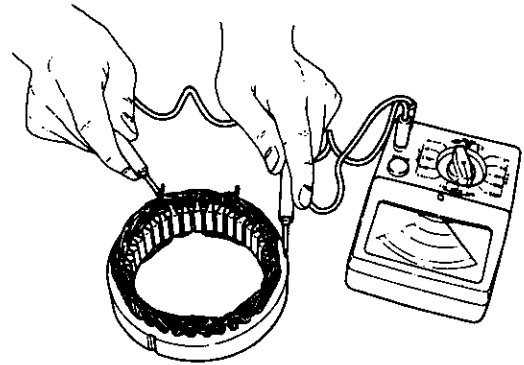
Check the continuity between the terminals of the stator coil. Measure the resistance between the output terminals with a tester. The resistance should be near the prescribed value.
If the stator coil is open, indicated by infinite resistance, it must be replaced.



Resistance value	Approx. 0.16 Ω (at 20°C) 1-phase resistance	LR135-105
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(2) Stator coil ground test

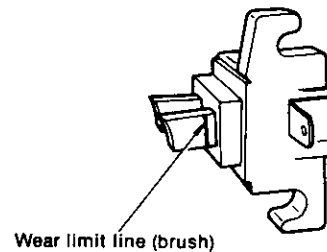
Check the continuity between one of the stator coil leads and the stator core.
The stator coil is good if the resistance is infinite. If the stator core is grounded, indicated by continuity, it must be replaced.



4A-9.4 Brush

(1) Brush wear

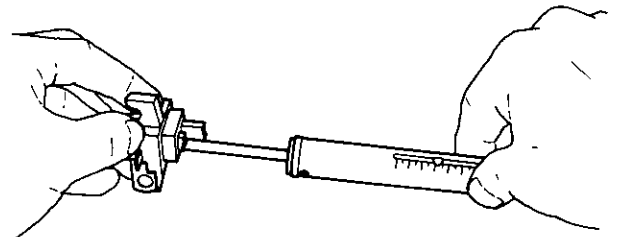
Check the brush length.
The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.

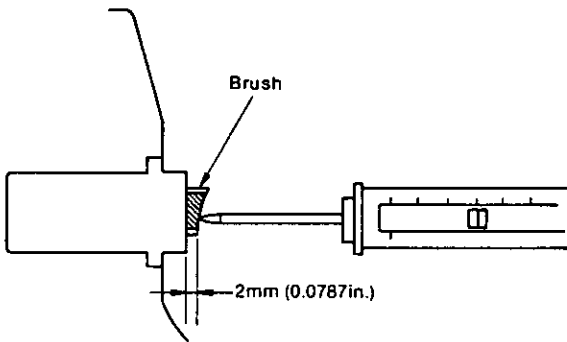


	mm (in.)	
	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

(2) Brush spring pressure measurement.

Measure the pressure with the brush protruding 2mm from the brush holder, as shown in the figure. The spring is normal if the measured value is over 150 gr.
Confirm that the brush moves smoothly in the holder.





Brush spring strength	300 ±45g (0.562 ~ 0.761 lb) (New brush)
-----------------------	--

4A-9.5 Checking IC regulator unit

Connect the wiring as shown in the diagram below using a variable register, two 12V batteries, register and ammeter.

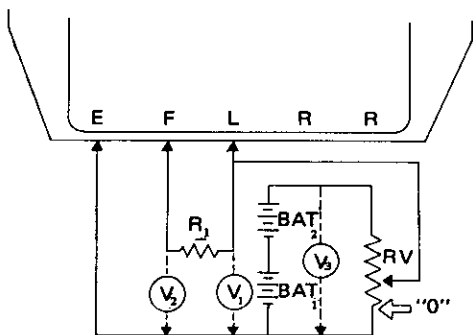
(1) Prepare the following measuring devices

- 1) Resistor (R_1) 100Ω 2W - 1
- 2) Variable resistor (R_v) 0-300Ω 12W - 1
- 3) Battery (BAT_1 , BAT_2) 12V - 2
- 4) DC voltmeter 0 ~ 30V 0.5 class - 1
(to measure at 3 points)

(2) Check the regulator in the following sequence.

- 1) Check V_3 (total voltage of BAT_1 plus BAT_2).
When the value is between 20V and 26V, BAT_1 and BAT_2 are normal.
- 2) When measuring V_2 (Voltage between F - E terminals), shift the variable resistor gradually from the "0" position. Check if the V_2 voltage changes sharply from below 2.0V to over 2.0V.
If there is no sharp voltage change, the regulator is faulty and must be replaced.
When there is sharp voltage change, stop the variable resistor at that point.
- 3) Measure V_1 (voltage between L - E terminals).
The V_1 voltage is the regulated voltage of the regulator ... Confirm that the value is within the standard range.

Adjusted voltage	14.3 ± 0.3V (at 20°C, with 2 batteries)
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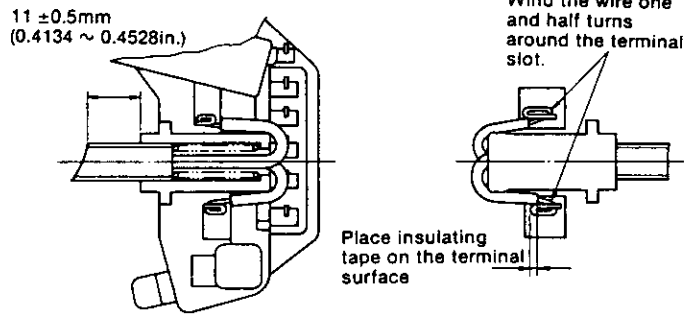
4A-10 Reassembly precautions

After inspection and servicing, reassemble the parts in the reverse order of disassembly, paying careful attention to the following items:

(1) Brush regulator assembly

1) Soldering the brush

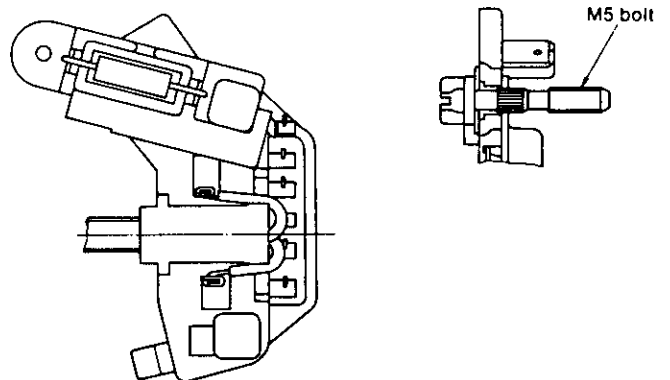
Solder the brush after setting it as shown in the figure. Take care that solder does not flow into the pig-tail (lead wire).



- NOTES: 1) Use non-acid flux for soldering.
2) The temperature of the soldering bit is to be 300 to 350°C.

2) Assembly of IC regulator

Place the IC regulator on the brush holder as shown in the figure, and insert the M5 bolt. After inserting the bolt, solder the brush holder to the IC regulator.

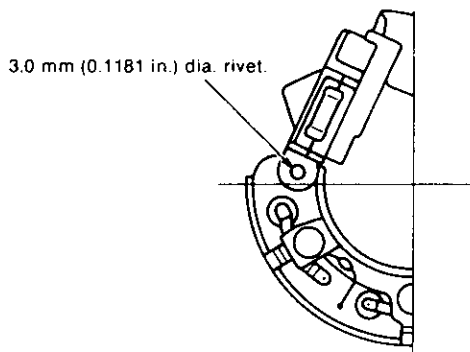


- NOTES: 1) Insertion pressure is 100 kg (220.5 lbs)
2) Insert vertically.

(2) Connecting the brush regulator assembly to the diode.

1) Fixing with rivet

Insert a 3mm dia. rivet as shown in the figure, and fix it by using the appropriate tool



Rivetting pressure	500 kg (1102 lbs)
--------------------	-------------------

- (3) Assembling rear cover
Assemble the rear cover after inserting the pin from outside and fitting the brush into the brush holder.
- (4) Tightening torque of each part

	kgf-cm(ft-lb)
Fixing flange holder	32 ~ 40 (2.31 ~ 2.89)
Fixing diode	32 ~ 40 (2.31 ~ 2.89)
Fixing bearing retainer	16 ~ 20 (1.16 ~ 1.45)
Tightening pulley nut	350 ~ 400 (25.32 ~ 28.93)
Tightening through bolt	32 ~ 40 (2.31 ~ 2.89)

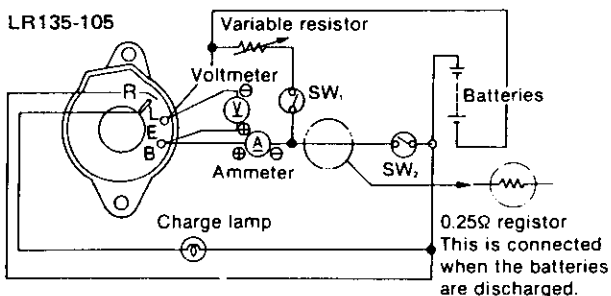
4A-11 Alternator performance test

4A-11.1 Test equipment

Test equipment	Quantity	Specifications
Battery	1	12V
DC voltmeter	1	0 ~ 30V Range 0.5
DC ammeter	1	0 ~ 50A Range 1.0
Variable resistor	1	0 ~ 0.25Ω capacity: 1 kW
Switch	2	Switch capacity: 40A
Tachometer	1	
0.25Ω resistor	1	25W

4A-11.2 Performance test circuit

When the circuit is connected the charge lamp will light.



4A-11.3 Performance test

- (1) Speed measurement at 13.5V.
 - 1) Run the alternator up to a speed of approx. 1500 rpm with SW, and SW, open. Then reduce speed gradually and measure the rpm when the voltage reaches 13.5V.
 - 2) This value is called the "rpm at 13V" and is acceptable if 1000 rpm or below. (The alternator speed at which the lamp goes on or off is 1500 rpm, or 1000 rpm or below, respectively, and there are different conditions for each of the two cases.)
- (2) Voltage measurement. Acceptable within the range of $14.3 \pm 1.3V$ and when the generator rpm is 5000, SW, is open and SW, is closed, the temperature is 20°C and using two batteries. (Confirm that the ammeter is 5A or below. If over 5A, connect the 0.25Ω resistor.)
- (3) Measurement of output current
 - 1) In the circuit shown in figure, set the variable resistor at the minimum value, close SW, and SW., and run the alternator.
 - 2) While keeping the voltage at 13.5V by adjusting the variable resistor, increase the alternator speed, and measure the current at 2500 rpm and 5000 rpm.

Acceptable current values	32A at 5000 rpm	LR135-105
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- (4) Remarks on performance test
 - a) For the test leads, use cable with a cross-sectional area of 8mm² or more and with a length not exceeding 2.5m between the alternator B terminal and the positive terminal of the battery, and between the S terminal and the negative terminal of the battery.
 - b) Switches with low contact resistance are to be used in the circuit.

4A-12. Standards of adjustment

	LR135-105
Standard height of brush	16mm (0.6299in.)
Limit of reduced height	9mm (0.3543in.)
Strength of brush spring	255 ~ 345g (0.56 ~ 0.76 lb)
Standard dimension of shaft at front end	15mm (0.5906in.)
Part No. of ball bearing	6302 BM
Standard dimension of shaft at rear end	12mm (0.4724in.)
Part No. of ball bearing	6201 SD
Resistance of rotor coil (at 20°C)	3.1Ω
Resistance of stator coil single phase (at 20°C)	1.6Ω
Standard O.D. of slip ring	31.6mm (1.244in.)
Limit of reduced size (diameter)	1mm (0.0394in.)
Limit of swing correction	0.3mm (0.0118in.)
Accuracy of swing correction	0.05mm (0.0070in.)

4A-13. Alternator troubleshooting and repair

(1) Failure to charge

Problem	Cause	Corrective action
Wiring, current	Open, shorted, or disconnected	Repair or replace
Alternator	Open, grounded, or shorted coil Terminal insulator missing Diode faulty	Replace Repair Replace
Transistor regulator	Transistor regulator faulty	Replace regulator

(2) Battery charge insufficient and discharge occurs easily

Problem	Cause	Corrective action
Wiring	Wiring shorted or loose, wiring thickness or length unsuitable	Repair or replace Replace
Generator	Rotor coil layer short Stator coil layer short; One phase of stator coil open Slip ring dirty V-belt loose Brush contact faulty Diode faulty	Replace Replace Clean or polish Retighten Repair Replace

(3) Battery overcharged

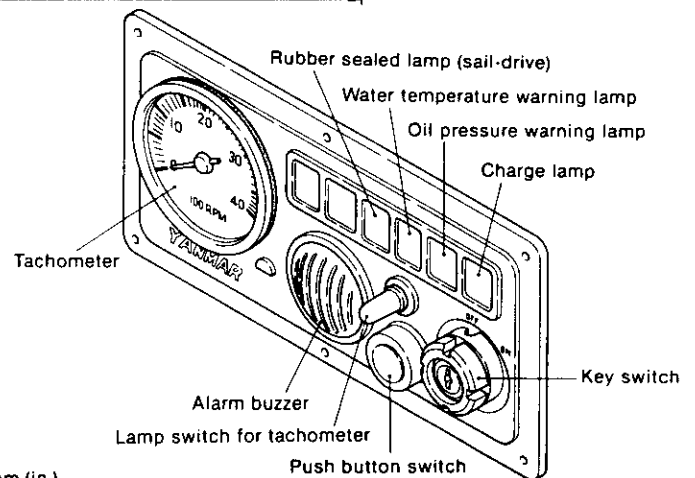
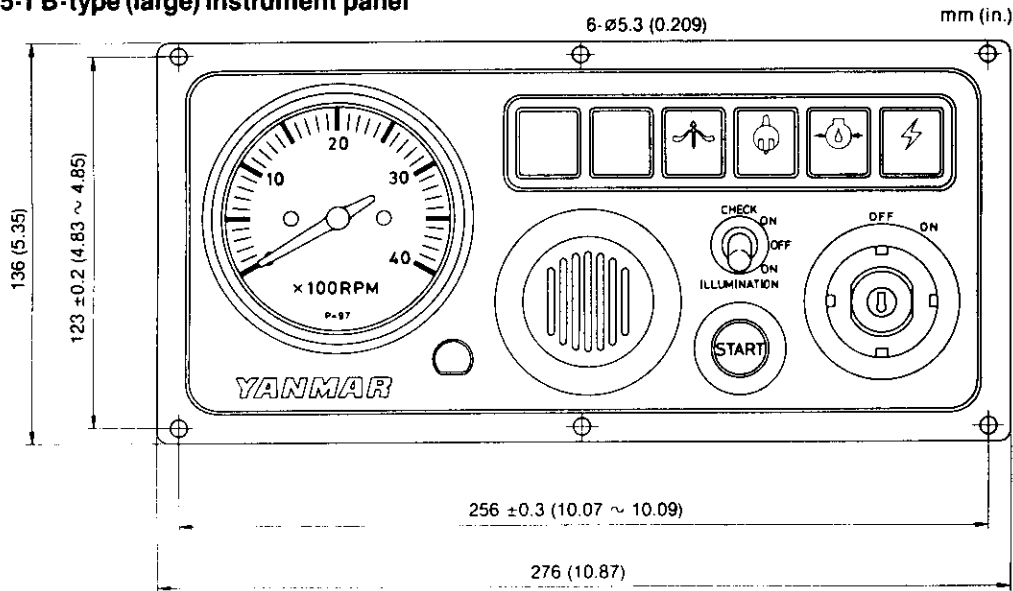
Problem	Cause	Corrective action
Battery	Electrolyte low or unsuitable	Add distilled water Adjust specific weight Replace
Transistor regulator	Regulator transistor shorted	Replace regulator

(4) Current charge unstable

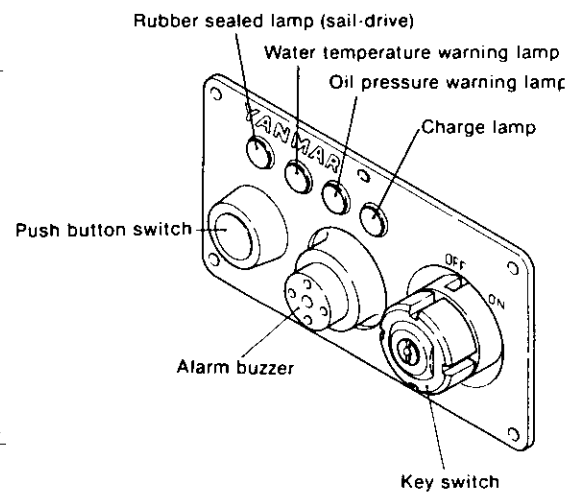
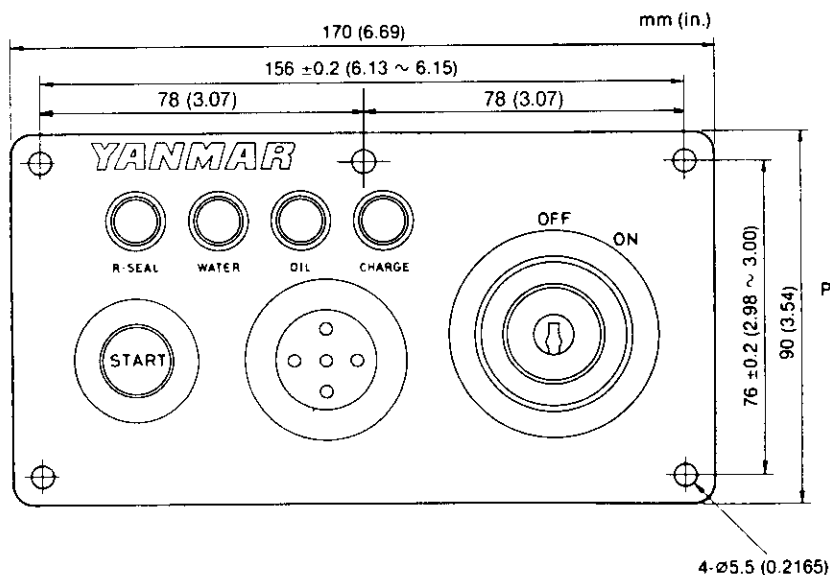
Problem	Cause	Corrective action
Wiring	Wiring shorted at a break in the covering due to hull vibration or intermittent contact at break	Repair or replace
Alternator	Layer short Balance spring damaged Slip ring dirty Coil open	Replace Replace Replace Repair or replace

5. Instrument Panel

5-1 B-type (large) instrument panel

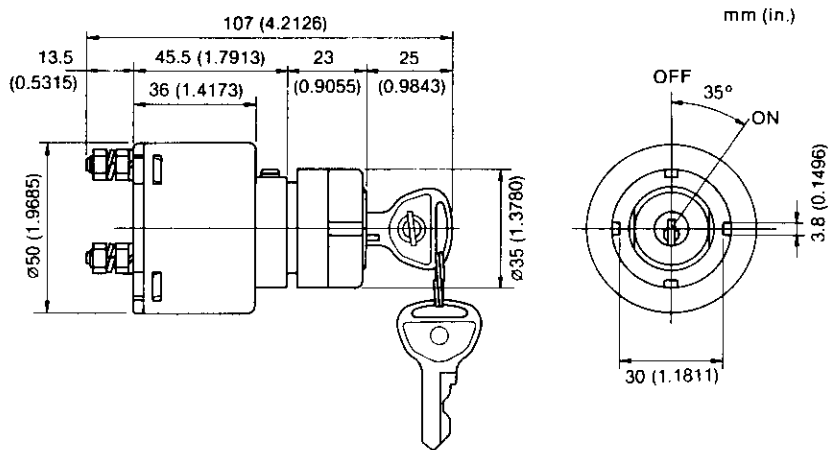


5-2 A-type (small) instrument panel



5-3 Key switch

(1) Construction and dimensions of key switch.

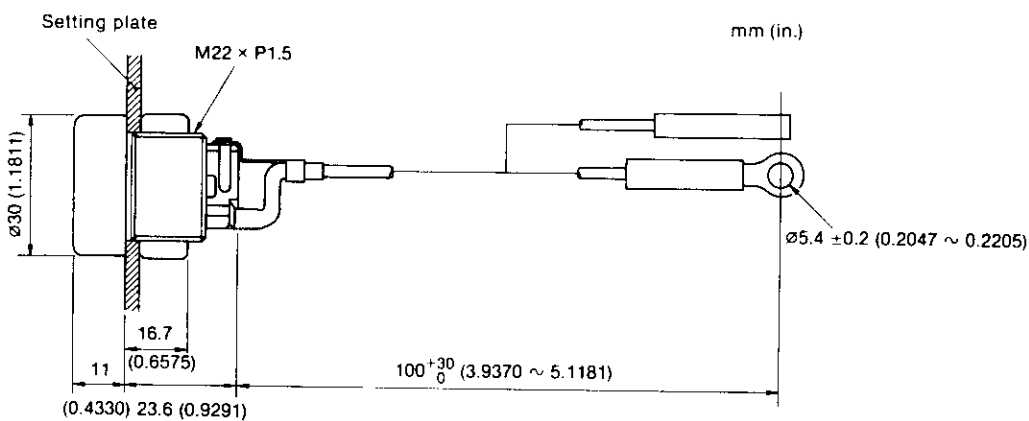


(2) Specifications of key switch

	All models
Rated voltage	DC 12V
Rated current	25A
Range of operating voltage	DC 10 ~ 30V
Part No.	124070-91250

5-4 Push button switch

(1) Construction and dimensions of key switch.



(2) Specifications of push button switch

	All models
Rated voltage	DC 12V
Rated load	20A (within 30 seconds)
Part No.	124070-91300

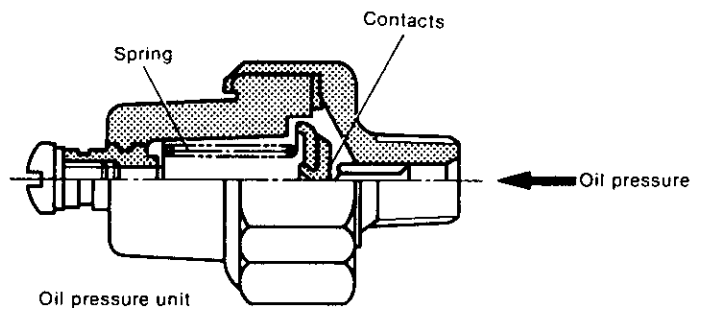
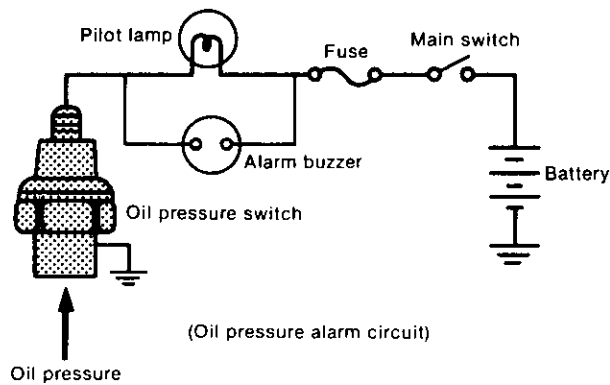
5-5 Warning devices

5-5.1 Oil pressure alarm

If the engine oil pressure is below $0.2 \pm 0.1 \text{ kgf/cm}^2$ ($1.422 \sim 4.266 \text{ lb/in}^2$), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring, and the lamp is illuminated through the lamp – oil pressure switch – ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.

Oil pressure unit specifications

	All models
Part No.	124060-39451
Rated voltage	12V
Operating pressure	$0.2 \pm 0.1 \text{ kgf/cm}^2$ ($1.422 \sim 4.266 \text{ lb/in.}^2$)
Lamp capacity	5W

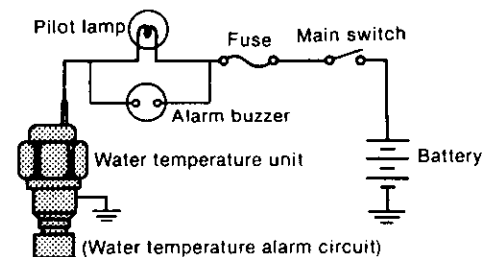


Inspection

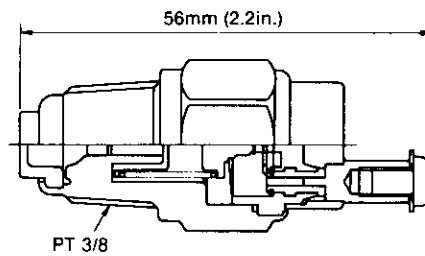
Problem	Inspection item	Inspection method	Corrective action
Lamp not illuminated when main switch set to ON	1. Oil pressure lamp blown out	(1) Visual inspection (2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded	Replace lamp
	2. Operation of oil pressure switch	Lamp illuminated when checked as described in (2) above	Replace oil pressure switch
Lamp not extinguished while engine running	1. Oil level low	Stop engine and check oil level with dipstick	Add oil
	2. Oil pressure low	Measure oil pressure	Repair bearing wear and adjust regulator valve
	3. Oil pressure faulty	Switch faulty if abnormal at (1) and (2) above	Replace oil pressure switch
	4. Wiring between lamp and oil pressure switch faulty	Cut the wiring between the lamp and switch and wire with separate wire	Repair wiring harness

5-5.2 Cooling water temperature alarm

A water temperature lamp and water temperature gauge, backed up by an alarm in the instrument panel, are used to monitor the temperature of the engine cooling water. A high thermal expansion material is set on the end of the water temperature unit. When the cooling water temperature reaches a specified high temperature, the contacts are closed, and an alarm lamp and buzzer are activated at the instrument panel.



Water temperature switch



Direct Sea Water Cooling Type

Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
65±2°C (154 ~ 148°F)	58°C (140°F) or more	DC12V 1A	Within 60 sec.	White	128275-91340

Fresh Water Cooling Type

Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
95°C (202~193°F)	88°C (187°F) or higher	DC 12V 1A	Within 60 sec.	Green	127610-91350

Pilot lamp: 12V, 3.4W

The parts of the alarm circuit which must be checked are the open pilot bulb, fuse, and wiring. To check, disconnect the wiring at the water temperature unit side and ground

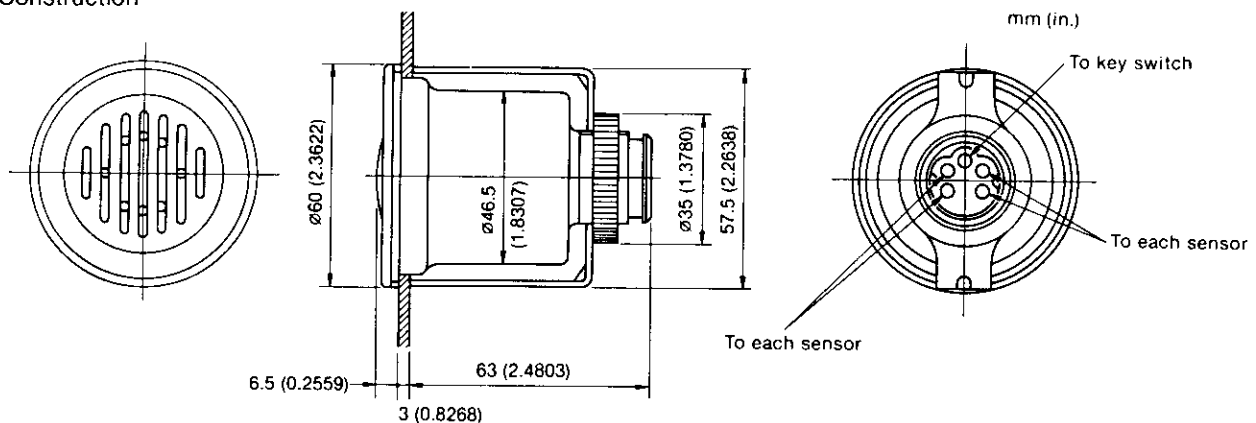
the cord—the pilot lamp is normal if the pilot lamp illuminates. Moreover, be sure to check the color of the code after replacing.

5-6 Alarm buzzer

The alarm buzzer sounds when the engine oil pressure, cooling water temperature, or charging becomes abnormal. The trouble source is indicated by illumination of the appropriate alarm lamp simultaneously with the sounding of the buzzer.

5-6.1 Buzzer for B-type instrument board

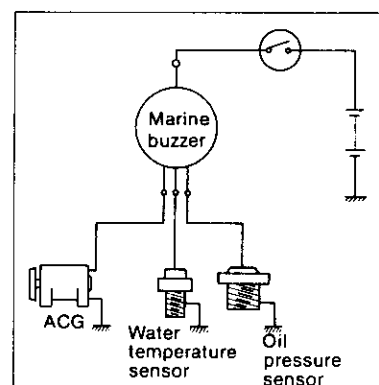
(1) Construction



(2) Specifications

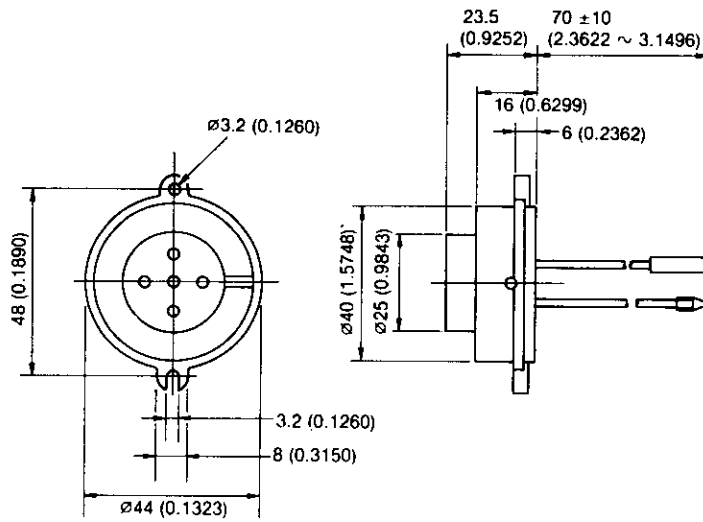
Model	WI1-05
Voltage	12V
Current consumption	100mA or below [at 12V, 15 ~ 30°C (59 ~ 86°F)]
Range of operating voltage	10 ~ 15V
Sound output	75dB (A) [at 1m, 12V, 15 ~ 30°C (59 ~ 86°F)]
Frequency	3 ±0.5kHz [at 12V, 15 ~ 30°C (59 ~ 86°F)]
Weight	0.2kg (0.44 lb)
Part No.	104271-91351

(3) Wiring diagram



5-6.2 Buzzer for A-type instrument panel

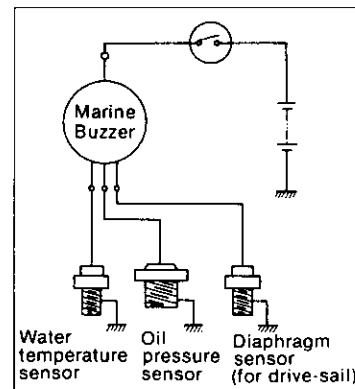
(1) Construction



(2) Specifications

Operating voltage	DC 10 ~ 15V
Rated voltage	DC 12V
Current	50 mA or below
Lead wire	49N (5kgf) or more, 15 seconds
Voltage for starting action	1V or more
Basic frequency of sound	$3.0^{+1.0}_{-0.5}$ kHz
Sound output	$\theta = 0 \sim 45^\circ$ 70dB or below
Current consumption	50 mA or below
Part No.	128270-91350

(3) Wiring diagram




5-6.3

Normal operation is as follows:

	Alarm buzzer	Charge lamp	Oil pressure lamp	Water temperature lamp
Main switch ON, engine stopped	Alarm	Illuminated	Illuminated	Extinguished
Main switch ON, engine running	No alarm	Extinguished	Extinguished	Extinguished
Key switch OFF, engine stopped	No alarm	Extinguished	Extinguished	Extinguished

* The condition of the lamp can be checked by using the check switch.

5-7

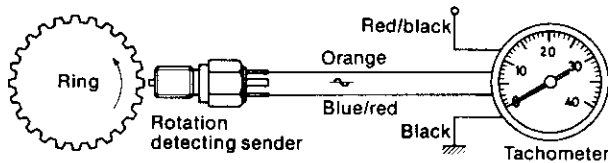
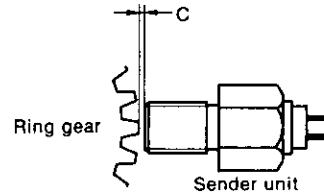
Fault	Diagnosis	Remedy
Warning lamp does not light.	<p>Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.</p> <p style="text-align: center;">↓ No</p> <p>Take out the lamp from P box case and check if it is unserviceable.</p> <p style="text-align: center;">↓ No</p> <p>It must be an open-circuit connection in the harness.</p>	<p>Yes Make good the connection.</p> <p>Yes Replace the lamp. (G-1 amp 12V 3.4W)</p> <p>Replace the harness.</p>
Buzzer does not sound.	<p>Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.</p> <p style="text-align: center;">↓ No</p> <p>Check if the buzzer is serviceable.</p> <p>(Fig.) </p> <p style="text-align: center;">↓ Yes</p> <p>It must be an open-circuit connection in the harness.</p>	<p>Yes Make good the connection.</p> <p>Replace the buzzer.</p> <p>Replace the harness.</p>
Other switches and items do not operate.	<p>Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.</p> <p style="text-align: center;">↓ No</p> <p>Check the continuity of the individual switch when the switch is closed by the tester.</p> <p style="text-align: center;">↓ OK</p> <p>It must be an open-circuit connection in the harness.</p>	<p>Make good the connection.</p> <p>Replace the defective item.</p> <p>Replace the harness.</p>

6. Tachometer

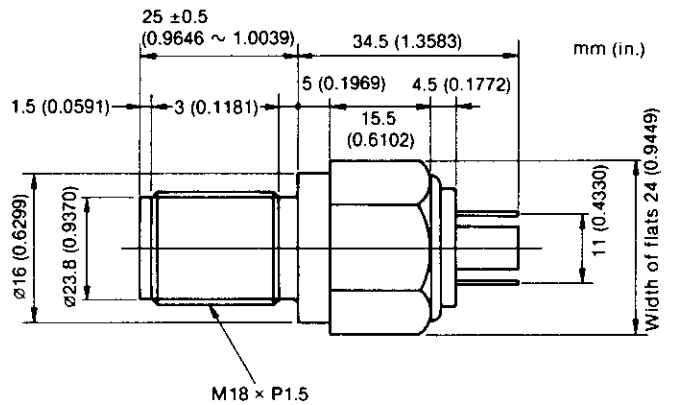
6-1 Construction of tachometer

The tachometer indicates the number of revolutions per minute by means of an electrical input signal which is generated as a pulse signal from the magnetic pickup sender (MPU sender).

The function of the sender is to convert the rotary motion into an electrical signal by means of counting by the number of teeth of the ring gear fitted to the flywheel housing.



(3) Dimensions of sender unit

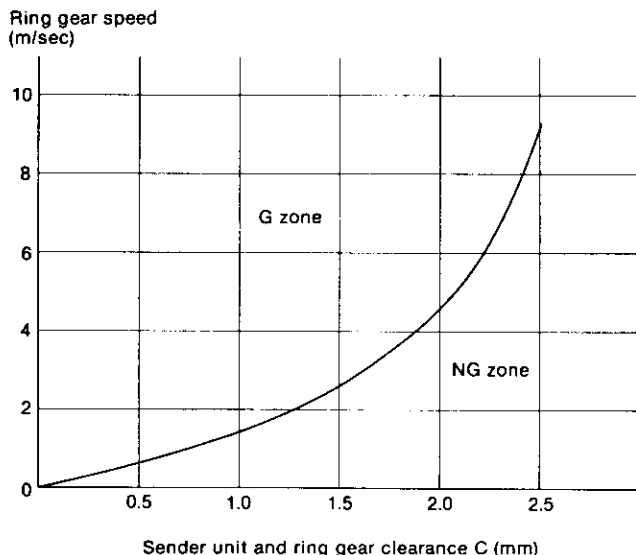


6-2 Specifications and dimensions of tachometer

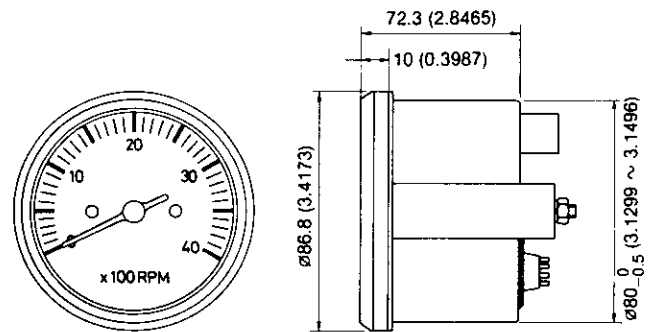
(1) Specifications

	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Rated voltage	DC 12V	
Range of operating voltage	10 ~ 15V	
Illumination	3.4W/12V	
Ring gear	No. of teeth	97 114
	Module	2.54 2.54
Part No. of tachometer	128170-91100	128670-91100
Part No. of sender unit	128170-91160	128170-91160

(2) Sensitivity limit of sender unit

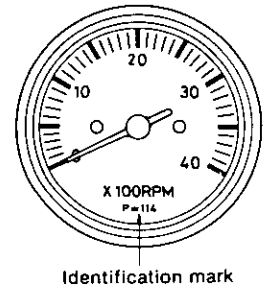
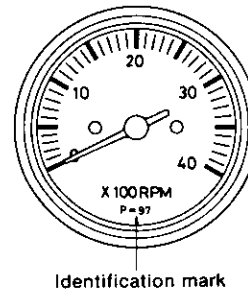


(4) Dimensions and shape of tachometer



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

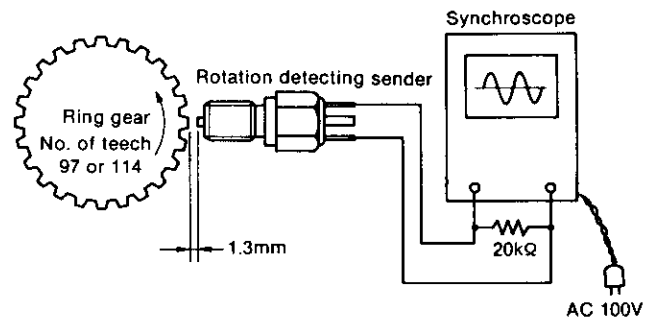
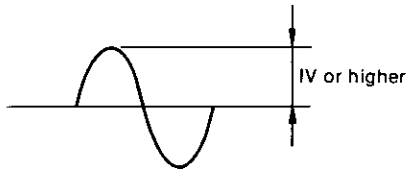
For model 3HM35(F)(C)



6-3 Measurement of sensor unit characteristics

(1) Measurement of output voltage

Output voltage	1.0V or higher
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* Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

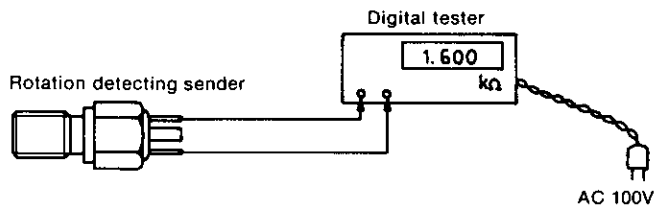
Measuring conditions

- Number of teeth of ring gear: 97,114
- Gap between the ring gear and sender: 1.3mm (0.0511in.)
- Resistance: 20kΩ
- Speed of ring gear: 500 rpm (approx. 800Hz)
- Measuring temperature: 20°C
- Measuring instrument: Synchroscope

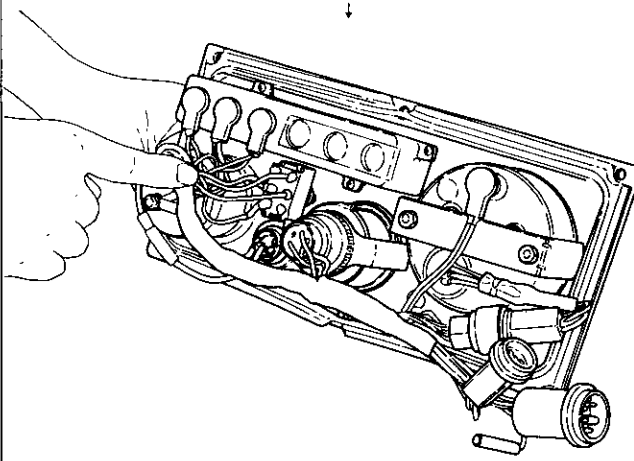
(2) Measurement of internal resistance

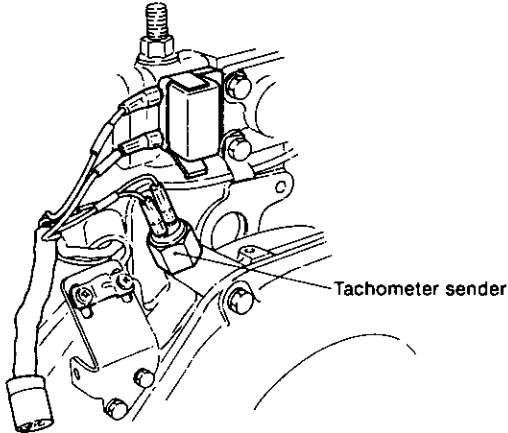
Measuring conditions

- Measuring temperature: 20°C
- Measuring instrument: Digital tester



6-4

Fault	Diagnosis	Remedy
Does not function well. 1) Pointer does not move. 2) Functions intermittently.	Check if there is an open-circuit cable connection at the rear of the meter, a loose or disconnected terminal, or bad continuity due to corrosion. 	Yes Make good the connection.
	Disconnect at the instrument terminals, and measure the voltage between the cable terminals. (To be 10 ~ 16V) ↓ Satisfactory	No If the input voltage is abnormal, check the cause. (e.g. short-circuit, disconnection, or blown fuse, etc.)

	<p>Check if the sender is loosely fitted.</p> <p style="text-align: center;">↓ No</p>  <p style="text-align: right;">Tachometer sender</p>	<p>Yes Fix the sender securely.</p>
	<p>Measure the internal resistance of the sender. (To be $1.6 \pm 0.1k\Omega$ at $20^{\circ}C$)</p> <p style="text-align: center;">↓</p>	<p>No Replace the sender.</p>
	<p>Measure the output voltage of the sender. (To be 1V or higher at $20^{\circ}C$)</p>	<p>No Replace the sender.</p>

CHAPTER 13 OPERATING INSTRUCTIONS

1. Fuel Oil and Lubricating Oil	13-1
2. Engine Operating Instructions	13-8
3. Troubleshooting and Repair	13-13

1. Fuel Oil and Lubricating Oil

Selection of and proper attention to fuel and lubricating oils has a substantial effect on engine performance, and these are vital factors governing engine life.

The use of low quality fuel and lubricating oils will lead to various engine troubles. Yanmar diesel engines will display satisfactory performance and ample reliability if the fuel and lubricating oil recommended by Yanmar are used correctly. For the engine to have long-term high performance, sufficient knowledge of the properties of the fuel and lubricating oils and their selection, management and usage are necessary.

1-1 Fuel

1-1.1 Properties of fuel

Numerous kinds of fuels are used with diesel engines, and the properties and composition of each differ somewhat according to the manufacturer.

Moreover, the various national standards are introduced here for reference purposes.

1-1.2 Recommended fuels

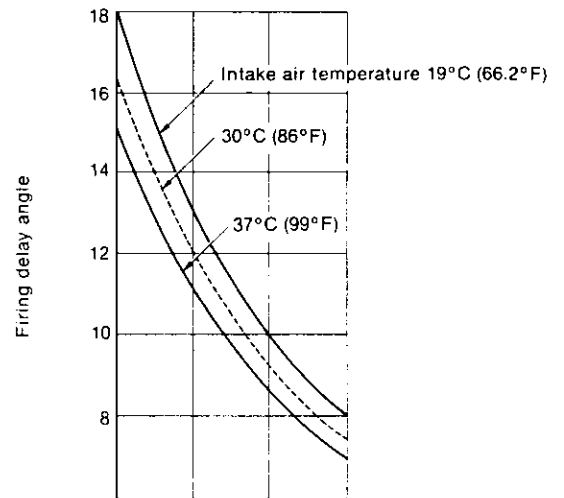
Manufacturer	Brand name
Caltex	Caltex Diesel Oil
Shell	Shell Diesoline or local equivalent
Mobil	Mobil Diesel Oil
Esso	Esso Diesel Oil
British Petroleum	BP Diesel Oil

1-1.3 Fuel selection precautions

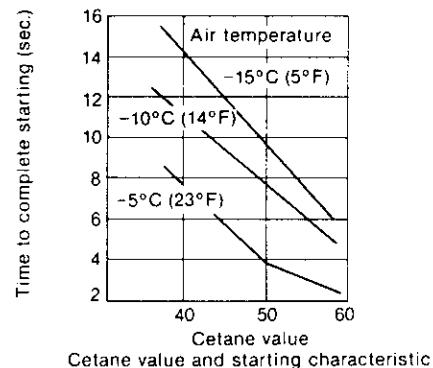
Pay careful attention to the following when selecting the fuel.

- (1) Must have a suitable specific gravity
Fuel having a specific gravity of 0.88 ~ 0.94 at 15°C is suitable as diesel engine fuel. Specific gravity has no relation to spontaneous combustibility, but does give an idea of viscosity and combustibility or mixing of impurities.
Generally, the higher the specific gravity, the higher the viscosity and the poorer the combustibility.
- (2) Must have a suitable viscosity
When the viscosity is too high, the fuel flow will be poor, operation of the pump and nozzle will be inferior, atomization will be faulty and fuel combustion will be incomplete.
If the viscosity is too low, the plunger, nozzle, etc. will wear rapidly because of insufficient lubrication. Generally, however, the higher the viscosity, the lower the quality of the fuel.
- (3) Cetane value must be high.
The most important indicator of fuel's combustibility is its cetane value (also represented by cetane index or diesel index). The cetane value is particularly important for fuels used in high-speed engines. The relationship among the cetane value, startability and firing

delay is shown in the figure below. Firing delay becomes smaller and starting characteristics better as the cetane value becomes higher.



Relationship between cetane value and firing delay



Cetane value and starting characteristic

The use of a fuel with an unsuitable cetane value will cause the following troubles:

- 1) Difficult starting.
 - 2) Poor operation.
 - 3) High combustion pressure and diesel knock.
 - 4) Lower output and engine damage because of overheating caused by knocking.
 - 5) Sticking of nozzles and exhaust valves.
 - 6) Severe smoking, carbon build-up inside the engine, and oil contamination.
 - 7) Deterioration of the oil and excessive wear in the piston rings, ring grooves, and cylinder liner.
- (4) The level of impurities must be low
- 1) Sulfur
With proper combustion sulfur in the fuel turns to nitrous acid gas (SO₂) and sulfuric anhydride (SO₃). When combustion is imperfect, it becomes sulfuric acid containing water that corrodes and wears the cylinder liners, pistons, exhaust valve and exhaust pipe.

Properties and compositions of fuel of various national standards

National standard		Japan JIS-K-2204-1965		U.S.A. ASTM-D975-74	U.K. BS-2689-70	
		Class No.1 light oil	Class No.2 light oil	No. 2D Diesel oil	Class A1	Class A2
Specific gravity	15/4°C	—	—	—	—	—
Kinetic viscosity	30°C cst (86°F cst)	2.7 or more	2.5 or more	(~ 5.2)	(~ 7.5)	(~ 7.5)
	37.8°C (100°F) cst	(2.3 or more)	(2.2 or more)	2.0~4.3	1.6 ~ 6.0	1.6 ~ 6.0
Reaction		Neutral	Neutral	—	—	—
Flash point	°C (°F)	50 or more (122 or more)	50 or more (122 or more)	51.7 or more (125 or more)	55 or more (131 or more)	55 or more (131 or more)
Flow point	°C (°F)	-5 or less (23 or less)	-10 or less (14 or less)	-12 or less (10.4 or less)	—	—
Residual carbon	Weight %	(10% residual oil) 0.15 or less	(10% residual oil) 0.15 or less	0.35 or less	0.2 or less	0.2 or less
Moisture	Volume %	—	—	—	0.05 or less	0.05 or less
Ash	Weight %	—	—	0.01 or less	0.01 or less	0.01 or less
Sulfur	Weight %	1.2 or less	1.2 or less	0.5 or less	0.5 or less	1.0 or less
Cetane value		50 or more	45 or more	40 or more	50 or more	45 or more
Sludge or sedimentation	%	—	—	0.05 or less	0.01 or less	0.01 or less
Distillation properties, temperatures at 90% distillation	°C (°F)	350 or below (662 or below)	350 or below (662 or below)	282.21 ~ 338 (540 ~ 640)	357 or below (675 or below)	357 or below (675 or below)

- 2) Water content
A high water content causes sludge, resulting in lower output, imperfect combustion and trouble in the fuel injection system.
- 3) Carbon content
If the carbon content is high, carbon will remain inside the combustion chamber, causing accelerated cylinder liner and piston wear and corrosion of the pistons and exhaust valves.
- 4) Residual carbon (coke content)
Coke becomes a carbide that sticks to the end of the nozzle, causing faulty injection. In addition, unburned carbon will build up on the pistons and liners, causing piston ring wear and sticking.

1-1.4 Simple methods of identifying fuel properties

- (1) Fuel that is extremely odorous and smoky contains a large amount of volatile components and impurities.
- (2) Fuel that emits little smoke when used in a lamp is of good quality.
- (3) Fuel that emits a crackling sound when soaked into paper and ignited contains a high water content.
- (4) If a transparent film of diesel oil is squeezed between two pieces of glass, the water content and impurities can be determined.

- (5) If cracked by mixing with an equal amount of sulfuric acid in a glass tube, numerous black particles and impurities will appear. These are mainly carbon and resin.
- (6) Discoloration of litmus test paper indicates the presence of acids.

1-1.5 Troubles caused by bad fuel

- (1) Clogging of exhaust valve
In addition to faulty compression, incomplete combustion, and high fuel consumption, a clogged exhaust valve will cause fuel to be mixed in the exhaust, leading to corrosion of the exhaust valve seat.
- (2) Clogging of piston ring grooves
Clogged piston ring grooves will cause accelerated cylinder liner and piston wear due to sticking rings, fuel gas blowback, faulty lubrication, incomplete combustion, high fuel consumption, contaminated lubricating oil, and combustion gas blowback.
- (3) Clogged or corroded injection valve hole
This will cause incomplete combustion and piston and liner wear, fuel injection mechanism wear, corrosion, and groove wear and corrosion.
- (4) Sediment inside crankcase
Since sediment in the crankcase is often mistakenly judged as coming from the lubricating oil, care must be taken in determining its true origin.

1-1.6 Relationship between fuel properties and engine performance

Fuel property	Starting characteristic	Lubrication characteristic	Smoke generation	Exhaust odor	Output	Fuel consumption	Clogging of combustion chamber
Firing Cetane value	Directly related—Starting characteristic improves as cetane value increases	Directly related—Lubrication improves as cetane value rises	Closely related—Smoke increases as cetane value decreases	Directly related—Decreased by increasing cetane value	Irrelevant	Related	Related—Decreased by reducing cetane value
Volatility 90% end point	No clear relationship	Related—Becomes poor when volatility is poor	Directly related—Increases as volatility decreases	No direct relationship	Irrelevant	Irrelevant	Related—Increases as volatility decreases
Viscosity	No clear relationship	Some relationship—Becomes poor when viscosity increases	Related—Increases as viscosity increases	No independent relationship	Irrelevant	Irrelevant	Related—Increases with viscosity
Specific gravity	Irrelevant	Irrelevant	Related—Increases as specific gravity increases	No independent relationship	Directly related—Associated with calorific value	Related—Associated with calorific value	Related—Depends on properties of engine
10% residual carbon	Irrelevant	Irrelevant	Related—Improves as residual carbon decreases	No independent relationship	Irrelevant	Irrelevant	Related—Decreases as residual carbon decreases
Sulfur				No independent relationship			
Flash point				No independent relationship			

1-1.7 Fuel handling precautions

- (1) Fill the fuel tank after work to prevent condensation of water in the tank.
- (2) Always use a tank inlet strainer. Water mixed in the fuel can be removed by removing the strainer quickly.
- (3) Remove the plug at the bottom of the fuel tank and drain out the water and sediment after every 100 hours of operation, and when servicing the pump and nozzle.
- (4) Do not use fuel in the bottom of the fuel tank because it contains large amounts of dirt and water.

1-2 Lubricating oil

Selection of the lubricating oil is extremely important with a diesel engine. The use of unsuitable lubricating oil will cause sticking of the piston rings, accelerated wear and seizing of the piston and cylinder liner, rapid wear of the bearings and other moving parts, and reduced engine durability. Since this engine is a high-speed engine, always follow the lubricating oil replacement interval.

1-2.1 Action of the lubricating oil

- (1) Lubricating action: Builds a film of oil on each moving part reduces wear and its accompanying damage.
- (2) Cooling action: Removes heat generated at moving parts by carrying it away with the lubricating oil flow.
- (3) Sealing action: Maintains the air tightness of the pistons and cylinders by the oil film on the piston rings.
- (4) Cleaning action: Carries away carbon produced at the cylinders as well as dust that has entered from the outside.
- (5) Rustproofing action: Prevents corrosion by coating metal surfaces with a thin film of oil.

Various additives are added to the lubricating oil to ensure that adequate performance is assured under the high-speed, high-load and other severe operating conditions met by modern diesel engines. While these additives differ with each manufacturer, commonly used additives include:

- 1) Flow point reduction additive
- 2) Viscosity index improvement additive
- 3) Oxidation prevention additive
- 4) Cleaning dispersent
- 5) Lubrication additive
- 6) Anticorrosion additive
- 7) Bubble elimination additive
- 8) Alkali neutralizer

1-2.2 Required lubricating oil conditions

- (1) Must be of suitable viscosity
If the viscosity is too low, the oil film will be too thin and the lubricating action insufficient. If the viscosity is too high, the friction resistance will be increased and starting will become especially difficult.
- (2) Viscosity change with temperature must be small.
While the lube oil temperature goes from low at starting to high during operation, the viscosity index should be high at all temperatures.
- (3) Must have good lubricating capability
That is, it must coat metal surfaces as a thin film. In other words, the lubricating oil must coat the metal surfaces so that metal-to-metal contact caused by breaking of the oil film at the top dead center and bottom dead center piston position does not occur, and that the oil film is not broken by collision, even at the bearings.
- (4) Mixability with water must be low
Since water can mix with the oil because of the presence of cooling water in the engine, emulsification of water and oil, which causes the oil to lose its lubricating properties, must be prevented.
- (5) Must be neutral and difficult to oxidize
Since acids and alkalis corrode metal, the lubricating oil must be neutral. Moreover, since even a neutral oil will be oxidized easily by contact with the combustion gas, the oil must be stable with few oxidizing elements.
- (6) Must withstand high temperature and must evaporate or combust with difficulty
Oil must have a high flash point. If it is evaporated by heat or is not burned completely, carbon will be produced. This carbon is toxic.
- (7) Must not contain any water or dirt and must have a low sulfur and coke content

1-2.3 Classification by viscosity

SAE No.	-17.8°C (6°F)		98.9°C (210°F)		Applicable temperature range (outside temperature)
	Saybolt universal viscosity (sec)	Dynamic viscosity (cst)	Saybolt universal viscosity (sec)	Dynamic viscosity (cst)	
5W	Under 4,000	Under 869	—	—	20°C or less (68°F or less)
10W	6,000 ~ 12,000	1,303 ~ 2,606	—	—	
20W	12,000 ~ 48,000	2,606 ~ 10,423	—	—	
20	—	—	45 ~ 58	5.73 ~ 9.62	20°C ~ 35°C (68°F ~ 95°F)
30	—	—	58 ~ 70	9.62 ~ 12.93	
40	—	—	70 ~ 85	12.93 ~ 16.77	35°C or greater (95°F or greater)
50	—	—	85 ~ 110	16.77 ~ 22.68	

Since only 98.9°C viscosity is stipulated for S.A.E. No. 20 ~ 50 oil in the table, and only -17.8°C viscosity is stipulated for S.A.E. No. 5W ~ 20W oil, they are not guaranteed at other temperatures. On the other hand, S.A.E. No.10W viscosity is stipulated. Oil having viscosity equal to that of S.A.E. No.30 even at 98.9°C is called S.A.E. No.10W-30, or multigrade oil. Multigrade oil comprises S.A.E. No.5W-20, 10W-30, and 20W-40. In arctic regions, oil from S.A.E. No.20W to 10W-30 can be used.

1-2.4 SAE service classification and API service classification

SAE new classification (1970)	API service classification (1960)
CA	DG
CB·CC	DM
CD	DS

- (1) DG grade: Used when deposits and engine wear must be controlled when the engine is normally operated at a light load using low sulfur fuel.
- (2) DM grade: Used when the generation of deposits and wear caused by sulfur in the fuel is possible under severe conditions.
- (3) DS grade: Used under extremely severe operating conditions or when excessive wear or deposits are caused by the fuel.

Classification	Engine service (API)
CA	Light duty diesel engine service: Mild, moderate operation diesel engine service with high-performance fuel, and mild gasoline engine service. The oil designed for this service was mainly used in the 1940s and 50s. This oil is for high performance fuel use and has bearing corrosion and high temperature deposit prevention characteristics.
CB	Moderate duty diesel engine service: Mild, moderate operation diesel engine service using low performance fuel requiring bearing corrosion and high temperature deposit prevention characteristics. Includes mild gasoline engine service. Oil designed for this service was introduced in 1949. The oil is used with high sulfur fuels and has bearing corrosion and high temperature deposit prevention characteristics.
CC	Moderate duty diesel engine service and gasoline engine service: Applicable to low supercharged diesel engines for moderate to severe duty. The oil designed for this service was introduced in 1961 and is widely used in trucks and agricultural equipment, construction machinery, farm tractors, etc. The oil features high deposit prevention characteristics in low supercharged diesel engines, and rust, corrosion and low temperature sludge prevention characteristics in gasoline engines.
CD	Severe duty diesel engine service: Applicable to high-speed, high-output high supercharged diesel engines which are subjected to considerable wear and deposits. This oil was introduced in 1955, and is used as a wide property-range fuel in high supercharged engines. It also has bearing corrosion and high temperature deposit prevention characteristics.

1-2.5 Lubricating oil

SAE new classification CB grade or CC grade fuel having suitable viscosity for the atmospheric temperature must be used in this engine.

1-2.6 Recommended lubricating oils

Supplier	Brand Name	SAE No.			
		Below 10°C (Below 50°F)	10~20°C (50~68°F)	20~35°C (68~95°F)	Over 35°C (Over 95°F)
SHELL	Shell Rotella Oil	10W, 20/20W	20/20W	30 40	50
	Shell Talona Oil	10W	20	30 40	50
	Shell Rimula Oil	20/20W	20/20W	30 40	—
CALTEX	RPM Delo Marine Oil	10W	20	30 40	50
	RPM Delo Multi-Service Oil	20/20W, 10W	20	30	50
MOBIL	Delvac Special	10W	20	30	—
	Delvac 20W—40	20W—40	20W—40	—	—
	Delvac 1100 Series	10W, 20/20W	20/20W	30 40	50
	Delvac 1200 Series	10W, 20/20W	20/20W	30 40	50
ESSO	Estor HD	10W	20	30 40	—
	Esso Lube HD	—	20	30 40	50
	Standard Diesel Oil	10W	20	30 40	50
B.P. (British Petroleum)	B.P. Energol ICMB B.P. Energol DS-3	20W	20W	40	50

1-2.7 Engine oil replacement and handling

(1) Necessity of replacement

Since the engine oil is exposed to high temperatures during use and is mixed with air at high temperatures, it will oxidize and its properties will gradually change. In addition, its lubricating capabilities will be lost through contamination and dilution by water, impurities, and the fuel. Emulsification and sludge are produced by heat and mixing when the lubricating oil contains water and impurities, causing its viscosity to increase. Moreover, if the carbon in the cylinders enters the crankcase, the oil will turn pure black and the change in its properties can be seen at a glance. The continued use of deteriorated oil will not only cause wear and corrosion of moving parts, but will ultimately cause the bearings and cylinders to seize. Therefore, deteriorated oil must be replaced.

(2) Replacement period

Although the engine oil change interval differs with the engine operating conditions and the quality of the lubricating oil and fuel used, the oil change interval should be as follows when CB grade oil is used in a new engine:

1st time After approximately 20 hours of use

2nd time After approximately 30 hours of use

From 3rd time . . . After every 100 hours of use

Drain the old oil completely and replace it with new oil while the engine is still warm.

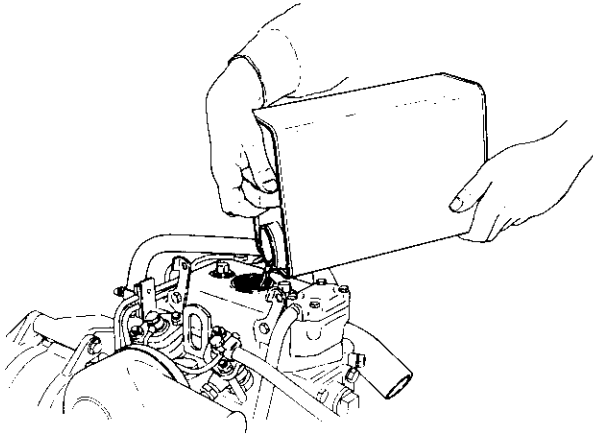
CAUTION: Never mix different brands of lubrication oil.

1-2.8 Adding oil

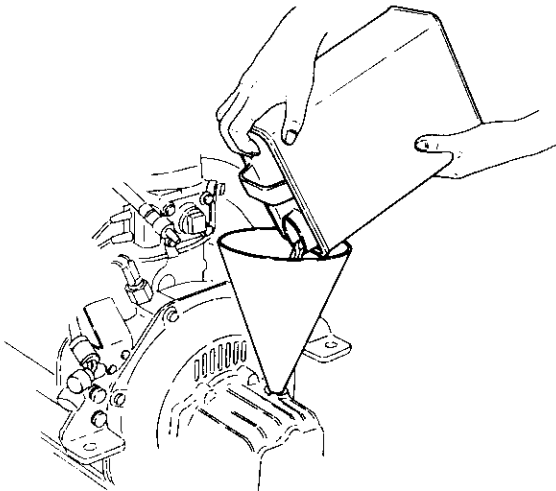
The crankcase and clutch case are not connected. For the crankcase, add one of the lubricating oils described in chapter 1.2.6. For the clutch case, add the lubrication oil described below. Be sure not to mix up the oils.

Supplier	1GM10	2GM20 (F)	3GM30 (F)	3HM35(F)
SHELL	Same lube oil as for crankcase			SHELL DEXRON
CALTEX				TEXAMATIC FLUID(DEXRON)
MOBIL				MOBILE ATF 220
ESSO				ESSO ATF
B.P.				B.P. AUTRAN DX

- (1) Remove the clutch case clutch and head cover filler plug (engine), and fill with specified lubricating oil up to the top marks on the respective dipsticks. (Oil levels must not drop below the lower marks on the dipsticks.)



Engine



Clutch

- (2) Since it takes sometime for the oil to flow completely into the clutch case and oil pan, wait for 2 ~ 3 minutes after filling before checking the oil levels. Moreover, check the oil while the boat is afloat.

1-2.9 Oil capacity

Lubricating oil capacity at an engine mounting angle (rake) of 8° is given below.

	Crankcase	Clutch case (except sail-drive)
1GM10(C)	1.3ℓ	0.25ℓ
2GM20(F)(C)	2.0ℓ	
3GM30(F)(C)	2.6ℓ	0.3ℓ
3HM35(F)(C)	5.4ℓ	0.7ℓ

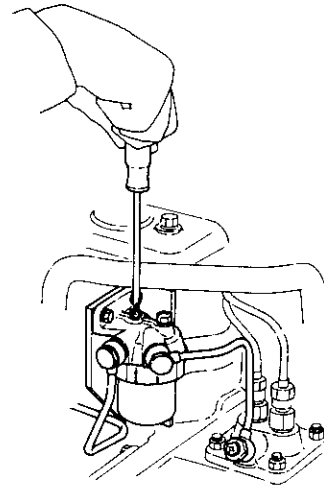
- Check the crankcase oil level by completely inserting the dipstick. Check the clutch case oil level without screwing in the cap.
The oil levels must be between the upper and lower limit marks on both dipsticks.

2. Engine Operating Instructions

2-1 Preparations before starting

2-1.1 Fueling up

- (1) Check the fuel level in the fuel tank and add fuel if necessary.
- (2) Remove water and dirt collected in the bottom of the tank using the fuel tank drain cock.
- (3) Add clean fuel to the tank.
Since dirt and water sink to the bottom of the fuel drum, do not turn the drum upside down and do not pump the fuel from the bottom of the drum.



2-1.2 Adding lubricating oil

- (1) Check the oil level with the dipstick, and add oil, if necessary, to bring the level up to the full mark of the dipstick.
The level must be neither too low nor too high.
- (2) The crankcase and clutch case require different oil. Check both and add oil separately, being careful not to mix the oils.
- (3) Since the crankcase oil flows into the crankcase through the camshaft and valve chambers, wait 2 ~ 3 minutes before checking its level.

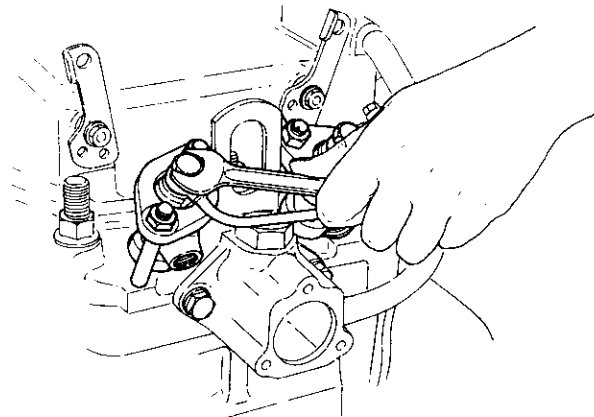
2-1.3 Lubricating each part

- (1) Lubricate each pin of the remote control lever.

2-1.4 Checking fuel priming and injection

- (1) Operate the priming lever of the fuel pump.
- (2) Set the regulator handle to the full speed position and check for injection sound by turning the engine over several times.
- (3) If there is no fuel injection sound, bleed the air from the fuel system.

- (3) Bleed the air from the fuel return pipe.
Loosen the connector bolt of the fuel return pipe installed on the fuel injection valve, and bleed the air by operating the manual handle of the fuel pump. Bleed the air in the No.1 cylinder (timing gear case side) and No.2 cylinder (clutch side), in that order.



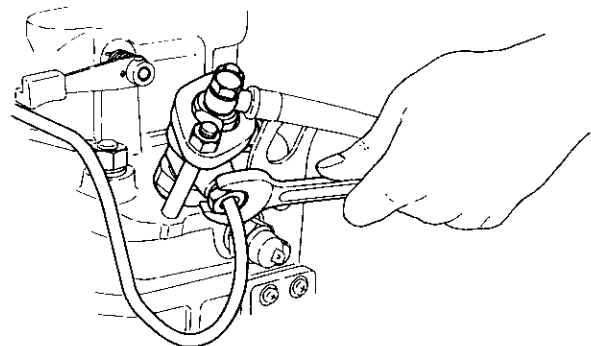
2-1.5 Bleeding the fuel system

Since the presence of air in the fuel system anywhere between the fuel tank and the injection valve will cause faulty fuel injection, always bleed the air from the system when the fuel system is disassembled and reassembled.

Bleeding the fuel system

- (1) Open the fuel tank cock.
- (2) Bleed the air from the fuel filter.
Loosen the air bleeding plug at the top of the fuel filter body and operate the manual handle of the fuel pump until no more bubbles appear in the fuel flowing from the filter.
Then install and tighten the air bleeding plug.

- (4) Bleed the air from the fuel injection pipe.



Loosen the nipple on the fuel injection valve side, set the regulator handle to the operating position and the decompression lever to the decompression position, and crank the engine. When no more bubbles appear in the fuel flowing from the end of the injection pipe, retighten the nipple.

(5) Check injection.

After bleeding the air, set the regulator handle to the operating position, set the decompression lever to the decompression position, and crank the engine. When fuel is being injected from the injection valve, an injection sound will be heard and you can feel resistance if you place your hand on the fuel injection pipe. This check must not be performed more than two or three times since overchecking will flood the combustion chamber with fuel, and faulty combustion will occur at starting.

2-1.6 Checking for abnormal sounds by cranking

- (1) Set the regulator handle to the STOP position, release the compression of the engine by setting the decompression lever, and crank the engine about 10 times to check for abnormal sounds.
- (2) Crank the engine with the starting handle (Always turn the engine in the proper direction of rotation.)

2-1.7 Checking the cooling system

- (1) Open the Kingston cock.
- (2) Check for bending and cross-sectional deformation of the cooling water inlet pipe.
- (3) Set all water drain cocks to the CLOSED position.

2-1.8 Checking the remote control system

- (1) Check that the remote control handle operates correctly.
- (2) Check that the engine stop remote control operates smoothly.

2-1.9 Checking the electrical system

- (1) Check the battery electrolyte level and add distilled water if low.
- (2) Check that the wiring is connected correctly. (Especially for polarity.)
- (3) Turn the battery switch on, set the main switch to the ON position, and check if the oil pressure lamp and charge lamp are illuminated and if the alarm buzzer sounds when the engine is stopped. (The charge lamp should be on while the engine is stopped and should be off while the engine is running.)

2-1.10 Checking appearance and exterior

- (1) Check for loose or missing bolts and nuts.
- (2) Check for loose or disconnected piping and hoses.
- (3) Check that there are no tools or other articles near rotating parts or on the engine.

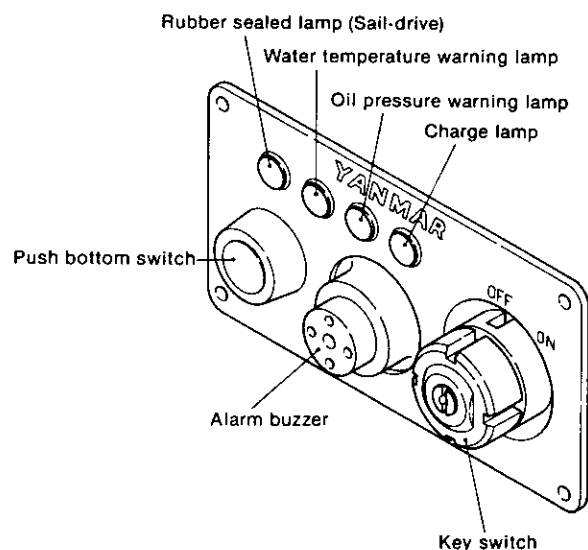
2-2 Starting and warm-up

2-2.1 Starting

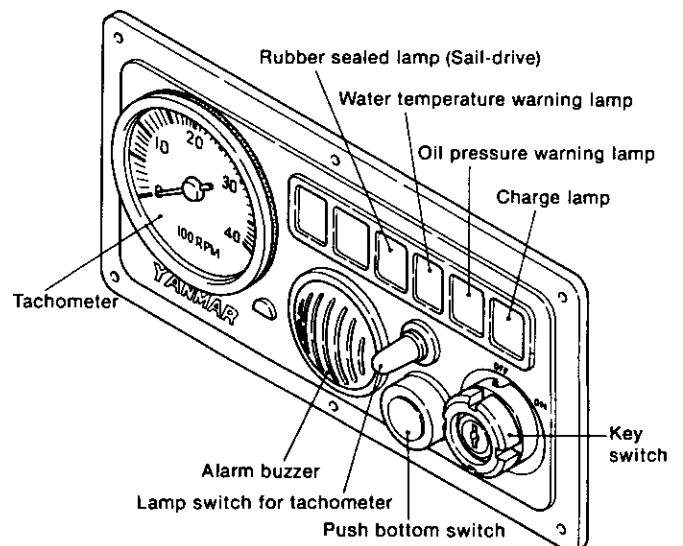
(1) Starting procedure

- 1) Set the clutch handle to the "NEUTRAL" position.
- 2) Set the governor lever to the "MEDIUM SPEED".
- 3) Keep the decompression lever in the "OPERATION" position.
- 4) Set the main switch to the ON position. The alarm buzzer will sound.
- 5) Push the starting button to start the engine. Release the start button after the engine has started.
- 6) When the engine has started, the alarm lamps and buzzer will go off. If the lamps or buzzer stay on, immediately stop the engine and check for trouble.

A type



B type



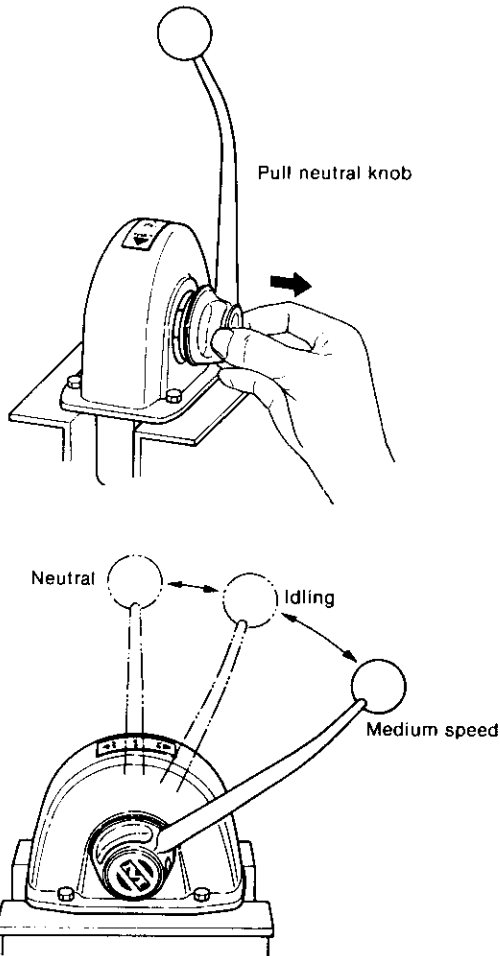
(2) Starting precautions

- 1) Don't continue to push the starting button over 15 seconds.
 If the engine doesn't start, wait 30 seconds or more.
- 2) When restarting the engine, always confirm the flywheel is stopped.
 If you re-start the engine while the flywheel is rotating, the pinion gear of the starter motor and the ring gear of the flywheel will be damaged.
- 3) When starting is difficult in cold weather lift the decompression lever to decompress the engine, and turn the starting motor. Once the engine has reached a certain speed, return the decompression lever to the "OPERATION" position. In this way, starting is made easier while current consumption is reduced.

2-2.2 Starting with one-handle remote control (option)

(1) Starting procedure

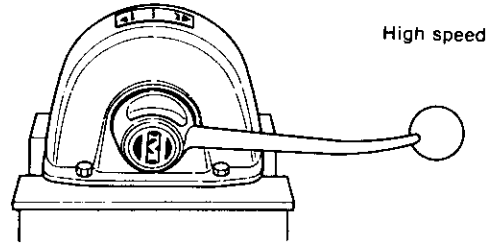
- 1) Pull the neutral knob and set the control lever to the "MEDIUM SPEED" position.



- 2) Set the main switch to the "ON" position, and push the starting button to start the engine.

(2) Starting in cold weather

- 1) Pull the neutral knob, and set the control lever to the HIGH SPEED position.



- 2) Set the decompression handle to the DECOMPRESSION position.
- 3) Set the main switch to the ON position and start the engine by pushing the starting button, at the same time putting the decompression lever to the COMPRESSION position. After the engine has started, return the control lever to the MEDIUM SPEED position.

*When the control lever is set in the HIGH SPEED position, injection timing is automatically delayed to facilitate starting.

CAUTION: When the engine is started with the control lever in the HIGH SPEED position, the starting button must be released immediately and the control lever must be returned to the idling position after the engine has started. If the starting button is not released, the starter motor will overrun, causing it to be damaged or burnt out.

2-2.3 After starting

(1) Warm-up operation

The engine must not be suddenly operated at full load immediately after starting. Warm up the engine for about 5 minutes after starting by running the engine at about half speed, and begin full load operation only after the temperature of each part has risen to a uniform value. Neglecting to warm up the engine will result in:

- 1) Seizing of the piston and liner due to sudden heat expansion of the piston.
- 2) Burning of piston rings and seizing of bearings/bushings because of insufficient lubrication.
- 3) Faulty intake and exhaust valve seat contact and shortening of the life of each part due to sudden heating.

Warm-up time (no-load operation)
 1,000 ~ 1,200 rpm 3 minutes
 1,600 ~ 1,800 rpm 2 minutes

CAUTION: Do not run the engine at full speed for 50 hours after installation to assure proper break-in.

- (2) Checking after starting
Check the following with the clutch in the NEUTRAL position:
- 1) Meters and lamps on the instrument panel
 - Check that all alarm lamps are off (1,000 rpm or higher).
 - Alarm buzzer must be off.
 - 2) Cooling water discharge
(Check that the cooling water temperature reaches 45 ~ 55°C before beginning operation.)
 - 3) Check for abnormal sounds and heating.
 - 4) Check for oil and water leakage from piping.
 - 5) Check the state of lubrication of the valve arms.

2-3 Operation

If warm-up operation is normal, engage the clutch and begin normal operation. Check the following during operation and stop the engine and take suitable corrective action if there are any abnormalities.

2-3.1 Checks during operation

- (1) Oil pressure
Check that the lubricating oil pressure and operating oil pressure lamps are off.
Lubrication oil pressure during operation: 2.5 ~ 3.5 kgf/cm²
- (2) Cooling water
Periodically check whether water is being discharged from the cooling water outlet pipe.
If the cooling water is being discharged intermittently or if only a small amount of water is being discharged during high speed operation, immediately stop the engine and check if air is being sucked into the cooling system, the impeller of the water pump is abnormal, or the water pipes and Kingston cock are clogged.
Cooling water temperature during operation: 45 ~ 55°C.
Check that the water temperature alarm lamp is off.
- (3) Fuel
Check the fuel level in the fuel tank and add fuel before the tank becomes too low. If the fuel level is low, air will enter the fuel injection system and the engine will stop.
- (4) Charging
Check that the charge lamp is off.
If the charge lamp is still on even when the engine is run at 1,000 rpm or above, the charging system is faulty and the battery is not being charged.
- (5) Temperature of each part
At full power operation, the surface temperature of each engine part is about 50 ~ 60°C and hot to the touch. If engine temperature is too high, the oil will be used up, the propeller shaft will not be centered, or other troubles may occur.
- (6) Leakage and abnormalities
Check for water leakage, oil leakage, gas leakage, loose bolts, abnormal sounds, abnormal heating, and vibration.
- (7) Exhaust color
Black exhaust smoke indicates that the engine is being overloaded and that the lives of the intake and ex-

haust valves, piston rings, cylinder liners, and injection nozzle will be shortened. Do not run the engine for long periods when exhaust is this colour.

- (8) Abnormal sounds, abnormal heating
When abnormal sounds or abnormal heating occur during operation, immediately stop the engine and check for trouble.

2-3.2 Operating precautions

- (1) Always set the battery switch and main switch to the ON position during operation.
Since the diodes of the alternator will be damaged, don't set the switches OFF position.
- (2) Do not touch the starting button during operation. Operation of the starter motor pinion will damage the gears.
- (3) Since the boat will resonate and vibrate at a certain speed, depending on the structure of the hull, do not operate it at that speed.
- (4) Always set the clutch in the neutral position and wait for the propeller to stop rotating before raising the propeller shaft (if hoisting type stern gears are installed).
- (5) Do not suddenly apply a full load to the engine or operate it at full load for long periods.

2-4 Stopping

2-4.1 Stopping procedure

- (1) Before stopping, put the clutch in NEUTRAL and run the engine at approximately 1,000 rpm for about 5 minutes.
- (2) Before stopping, temporarily raise the speed to the rated speed to blow out residue in the cylinders. Then stop the engine by pulling the engine stop lever to cut the fuel.

2-4.2 Stopping precautions

- (1) Do not stop the engine with the decompression lever.
If the engine is stopped with the decompression lever, fuel will remain in the combustion chamber and abnormal combustion will occur when the engine is started again, perhaps damaging the engine.
- (2) If the engine is stopped immediately after full-load operation, the temperature of each part will rise suddenly, leading to trouble.

2-4.3 Inspection and procedures after stopping

- (1) Always close the Kingston cock after the engine is stopped.
Water may enter because of a faulty water pump, etc.
- (2) In cold weather, the cooling water should always be drained after engine use to prevent freezing. There are water drain cocks on the cylinders and the exhaust manifold. (Drain the water after the engine has cooled.)
- (3) Check for oil leakage and water leakage, and repair as required.
- (4) Check for loose bolts and nuts, and repair as required.

2-5 Storage when moored for an extended period

- (1) Securely close engine room windows and doors so that rain and snow cannot enter.
Also plug the exhaust outlet since water that enters the cylinder from the exhaust pipe will be compressed when the engine is started, causing serious trouble.
- (2) The boat may also sink because of water leakage at the stern tube stuffing box packing. This can be prevented by tightening the packing.
- (3) Change the lubricating oil before cranking the engine.
- (4) Wipe off each part and coat with oil to prevent rusting of the engine exterior.
- (5) Coat the regulator handle stand and each link with a thin film of lube oil or grease.
- (6) Run the engine once a week to lubricate each part. This will prevent rusting of the bearings, pistons, and cylinder liners.

2-6 Emergency stop

- (1) Loosen the fuel valve high-pressure pipe to release the fuel.
- (2) Pull the decompression lever (decompression mechanism) so that compression is not applied to the combustion chamber.
- (3) Block the air intake port so that air does not enter the combustion chamber.

3. Troubleshooting and Repair

If trouble occurs in the engine, the engine must be immediately stopped or run at low speed until the cause of the trouble is located.

If even extremely small troubles are not detected and corrected early, they can lead to serious trouble and even disaster. Detecting and correcting troubles quickly is extremely important.

3-1 Troubles and corrective action at starting

Trouble	Cause	Corrective action
Flywheel fails to rotate correctly	(1) Battery not charged (2) Starter motor faulty (3) Moving parts seized (4) Lubricating oil viscosity too high	1) Recharge battery 2) Disassemble and repair starter motor 3) Inspect and repair 4) Replace with lubricating oil of suitable viscosity
Starter motor rotates, but engine fails to start	(1) Fuel not injected, or injection faulty	1) Prime and bleed air from fuel lines 2) Inject fuel through injection valve and replace needle if required 3) Clean fuel filter 4) Check operation of fuel pump, plunger, plunger spring, and delivery valve, and replace if required 5) The remote control system or governor is faulty, so check if fuel is cut off, and adjust if required
	(2) Fuel injection timing incorrect	1) Correct the fuel injection timing 2) Check if alignment mark of timing gear is aligned
	(3) Compression pressure low	1) Lap valves when air tightness of intake and exhaust valve is poor 2) Replace cylinder head packing if gas is leaking 3) Clean or replace piston rings when sticking occurs 4) Readjust timing when intake and exhaust valve closing is very slow.
	(4) Drop in compression ratio	1) Replace piston pin bearing and crank pin bearing if worn 2) Replace piston rings if worn

3-2 Troubles and corrective action during operation

Trouble	Cause	Corrective action
Engine stops suddenly	(1) Fuel injection cut off due to trouble in the governor or governor system (2) Air in fuel tank (3) Air in fuel system (4) Piston, bearing, or other moving parts seized	1) Inspect, and repair or replace 2) Add fuel 3) Bleed air 4) Inspect and repair or replace the parts
Speed decreases unexpectedly	(1) Governor maladjusted (2) Overload (3) Piston seized (4) Bearing seized (5) Fuel filter clogged (6) Fuel injection pump or injection valve sticking Dirt in fuel pump delivery valve (7) Air in fuel system (8) Water in fuel	1) Adjust 2) Lighten the load (check propeller system and power take-off system) 3) Stop the engine, and repair or replace 4) Stop the engine, and repair or replace 5) Clean the fuel filter 6) Stop the engine, and repair or replace 7) Prime and bleed air 8) Drain the fuel tank and fuel filter Add fuel if insufficient
Exhaust color is bad	(1) Load unsuitable (2) Fuel injection timing off (3) Fuel unsuitable. (4) Injection valve faulty (5) Intake and exhaust valve adjustment faulty (6) Intake and exhaust valves leaking. (7) Output of cylinders uneven (8) Injection pressure too low (9) Precombustion chamber melted	1) Adjust the load (check propeller system and power take-off system) 2) Adjust injection timing 3) Change the fuel type 4) Test injection and replace valve if required 5) Adjust valve head clearance 6) Lap or grind valves 7) Check the fuel injection pump and injection valve and replace if necessary 8) Set injection pressure with shims 9) Replace the precombustion chamber...Perform item (1) above
Full load operation impossible	(1) Fuel filter clogged (2) Fuel pump plunger worn	1) Check and replace filter element 2) Replace plunger and barrel as a set
Output of cylinders uneven	(1) Air in fuel pump or fuel line (2) Water in fuel (3) Fuel injection volume uneven (4) Fuel injection timing uneven (5) Intake and exhaust valves sticking (6) Injection valve faulty	1) Prime and bleed air from the fuel pump and fuel lines 2) Drain the fuel tank and fuel filter and add fuel 3) Check and adjust injection volume 4) Check and adjust injection timing 5) Disassemble and clean 6) If nozzle is clogged, clean; replace nozzle if necessary If the needle is sticking, inspect and replace

Trouble	Cause	Corrective action
Engine knocks	(1) Bearing clearance too large (2) Connecting rod bolt loose (3) Flywheel bolt, coupling bolt loose (4) Injection timing faulty (5) Too much fuel injected because of faulty fuel pump or injection nozzle	1) Inspect, and repair or replace parts 2) Check and retighten 3) Check and retighten or replace bolt as required 4) Check and adjust 5) Check fuel injection pump and injection nozzle and replace if required
Engine oil pressure low	(1) Lubricating oil leakage (2) Bearing, crankpin bearing clearance too large (3) Oil filter clogged (4) Oil regulator valve loose. (5) Oil temperature high; cooling water flow insufficient (6) Lubricating oil viscosity low (7) Excessive gas leaking into crankcase	1) Check engine interior and exterior piping, replenish oil 2) Check clearance, and replace bearing if necessary 3) Check and replace filter element 4) Check and readjust oil pressure 5) Check oil pump, and replace if necessary 6) Replace with oil having a high viscosity index 7) Check pistons, piston ring, and cylinder liners and replace if necessary
Lubricating oil temperature too high	(1) Cooling water flow insufficient (2) Excessive gas leaking in to crankcase (3) Overload	1) Check water pump 2) Check piston rings and cylinder liners 3) Lighten the load
Cooling water temperature high	(1) Air sucked in with cooling water (2) Cooling water flow insufficient (3) Cooling system dirty (4) Thermostat faulty	1) Check water pump inlet side pipe connections 2) Check water pump 3) Flush cooling system with cleaner 4) Replace thermostat
Propeller shaft rotates even when clutch is in neutral position	(1) Neutral position adjustment faulty (2) Friction plate seized (3) Steel plate warped	1) Reset neutral position adjusting bolt 2) Check and repair 3) Repair or replace
Ahead, neutral, astern switching faulty	(1) Clutch face seized (2) Moving parts, lever system malfunctioning (3) Remote control system malfunctioning	1) Replace 2) Readjust 3) Repair or replace
Abnormal heating	(1) Clutch slipping because of overload operation (2) Bearing damaged (3) Excessive oil (4) Oil deteriorated	1) Reduce load 2) Replace 3) Check oil level and adjust to prescribed level 4) Replace oil
Abnormal sound	(1) Gear noise caused by torsional vibration (2) Gear backlash excessive	1) Avoid high speeds 2) Replace

CHAPTER 14

DISASSEMBLY AND REASSEMBLY (Direct Sea-Water Cooling Engine)

1. Disassembly and Reassembly Precautions	14-1
2. Disassembly and Reassembly Tools	14-2
3. Others	14-13
4. Disassembly	14-14
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DISASSEMBLY AND REASSEMBLY

This chapter covers the most efficient method of disassembling and reassembling the engine. Some parts may not have to be removed, depending on the maintenance and inspection objective. In this case, removal is unnecessary and disassembling in accordance with this section is not required.

However, if you follow the disassembly and reassembly procedures, adjustment methods, and precautions described in this chapter, you should be able to prevent subsequent troubles and a loss in engine performance after reassembly. The engine must be test-run to confirm that the engine is functioning properly and delivering full performance.

Since this chapter does not cover detailed disassembly and reassembly procedures for each part, refer to pertinent chapters for details.

1. Disassembly and Reassembly Precautions

- (1) Record the parts that require replacement, and replace them with new parts during reassembly.
Be careful not to reassemble with the old parts.
- (2) Do not forget adhesives and packing agents for sealing during reassembly.
Packing of the specified quality and packing agents matched to the packing material must be used.
- (3) Arrange the disassembled parts into groups, such as individual cylinders, intake and exhaust, etc.
Cylinder No. is indicated No. 1, No. 2 and/or No. 3 cylinder from Flywheel side.
- (4) The prescribed tightening torque must be observed when tightening bolts and nuts. Moreover, since the strength of the bolts and nuts depends on their material, be sure to use the correct bolts and nuts at their proper places.

Special bolts, nuts Head cover, rod bolts, flywheel, etc.

Strong bolts Bolts marked (7) (JIS.7T)

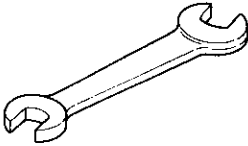
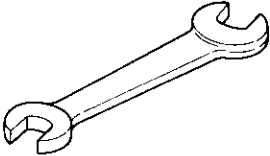
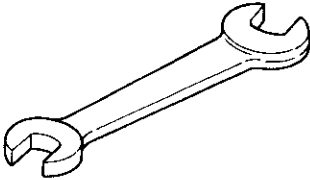
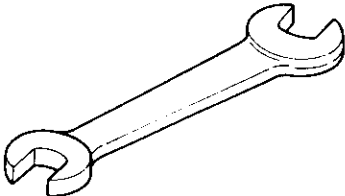
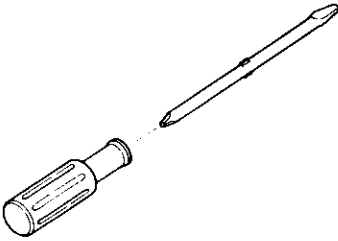
Common bolts, nuts . . . Unmarked (JIS.4T)

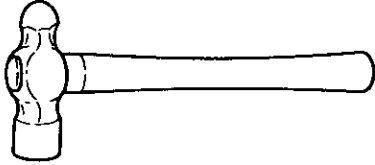
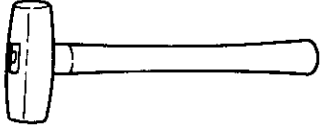
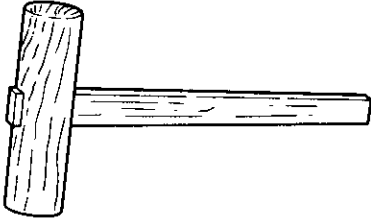
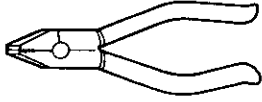

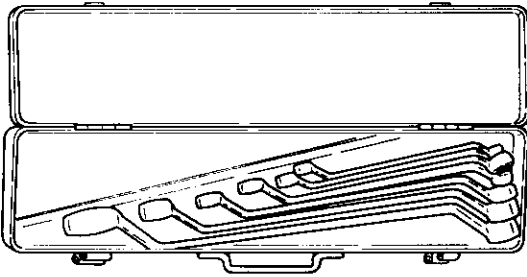
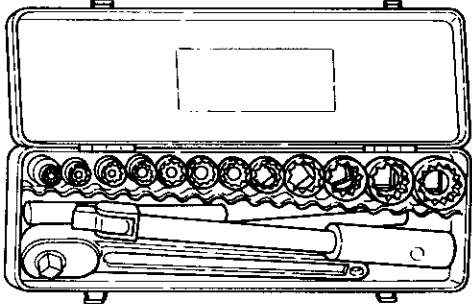
In addition, check the disassembly and reassembly precautions for each engine model.

2. Disassembly and Reassembly Tools

The following tools are necessary when disassembling and reassembling the engine. These tools must be used according to disassembly process and location.

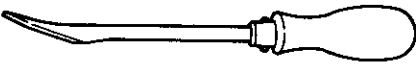

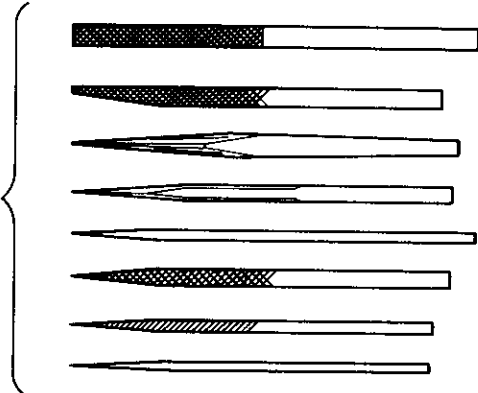

2-1. General handtools

Name of tool	Illustration	Remarks
Wrench		YANMAR standard Code no.; 28110-100130 Size; 10 x 13
Wrench		YANMAR standard Code no.; 28110-120140 Size; 12 x 14
Wrench		YANMAR standard Code no.; 28110-170190 Size; 17 x 19
Wrench		YANMAR standard Code no.; 28110-220240 Size; 22 x 24
Screwdriver		YANMAR standard Code no.; 104200-92350

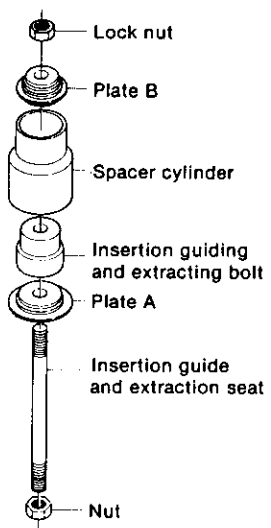
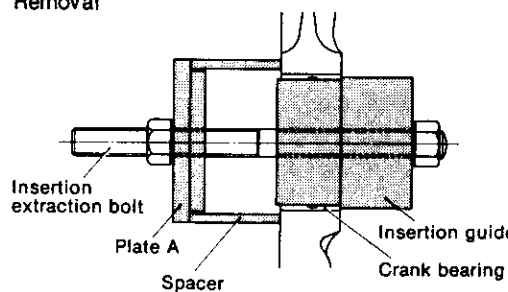
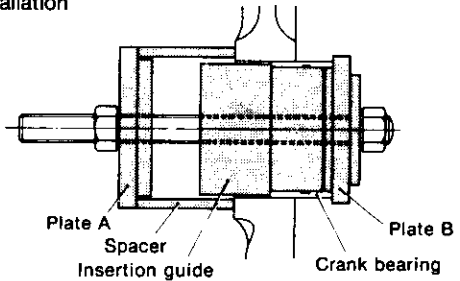
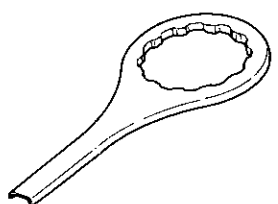
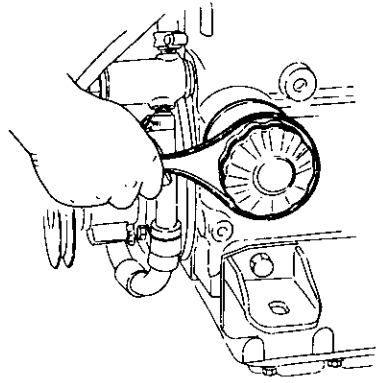
Name of tool	Illustration	Remarks
Steel hammer		Local supply
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set

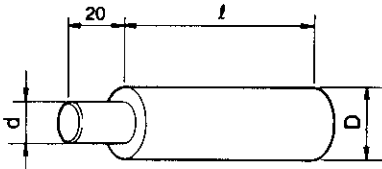
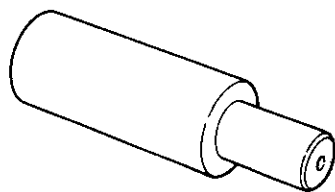
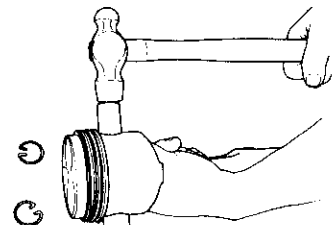
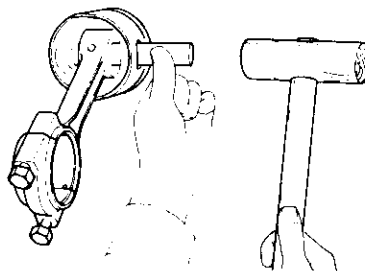
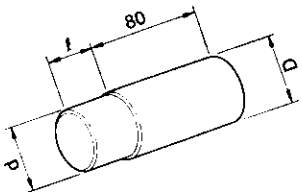
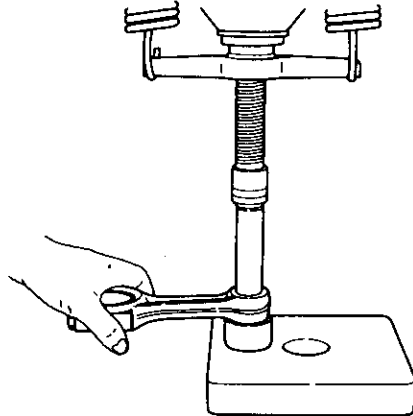
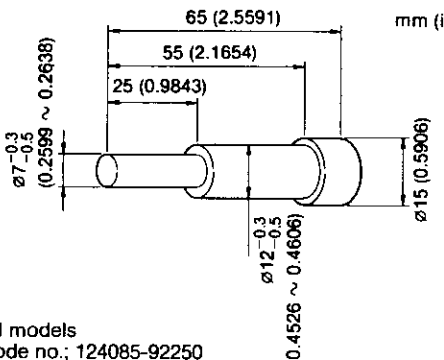
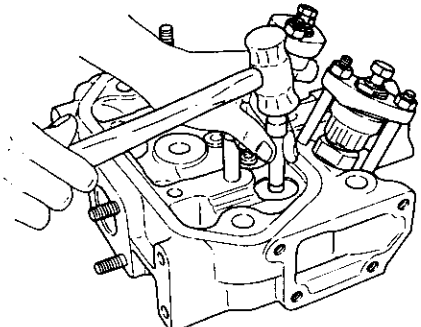
Chapter 14 Disassembly and Reassembly
 2. Disassembly and Reassembly Tools

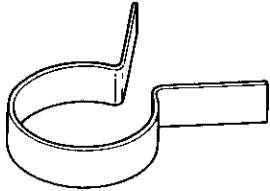
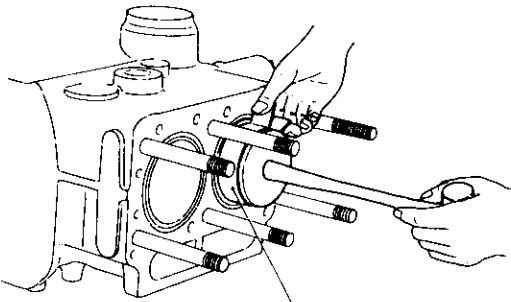
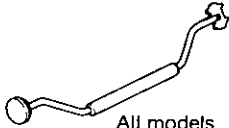


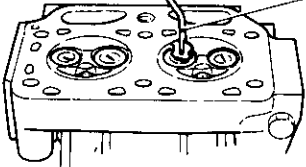

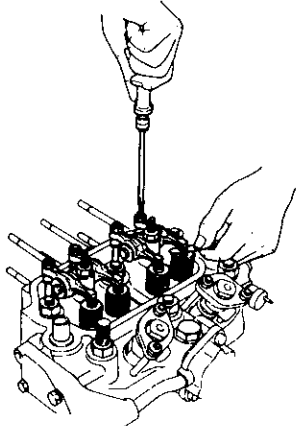
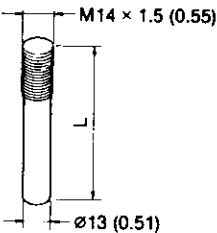
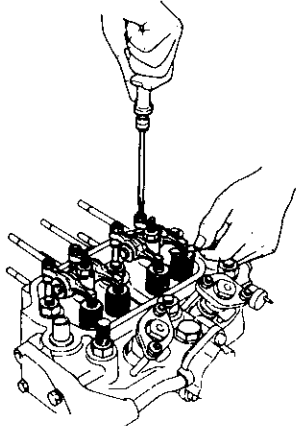
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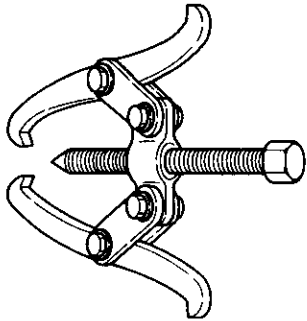
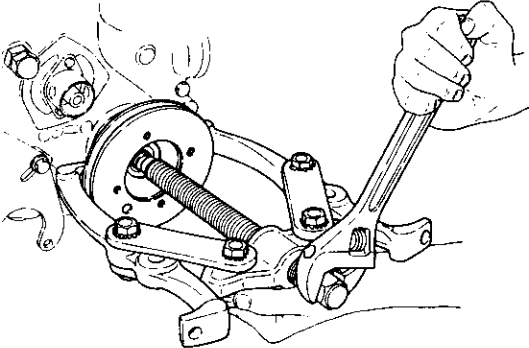
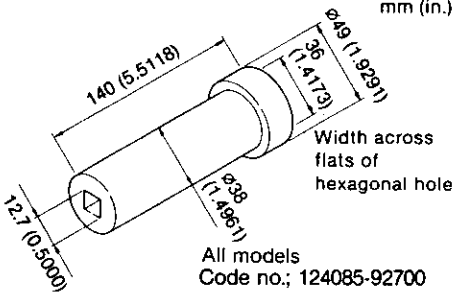
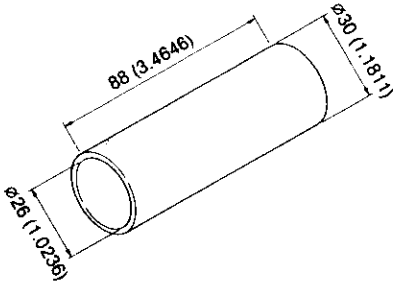
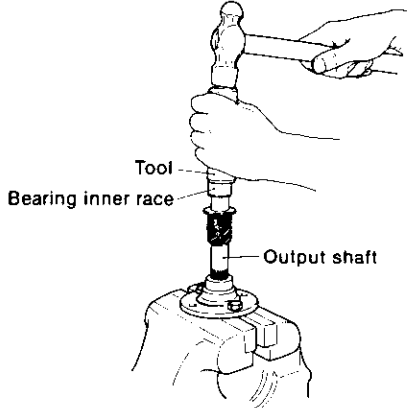
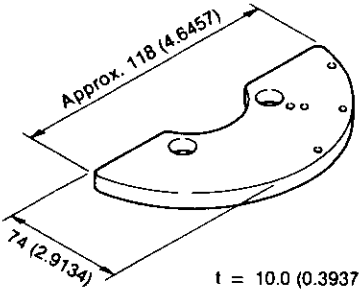
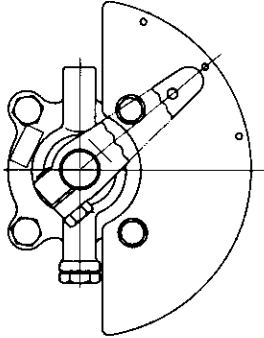
Name of tool	Illustration	Remarks
Scraper		Local supply
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size: 4mm (0.1575in.) 5mm (0.1969in.)

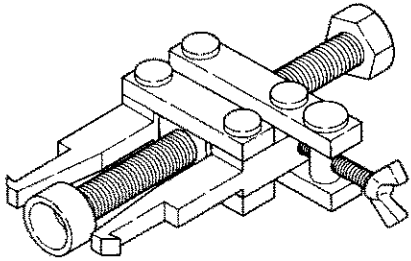
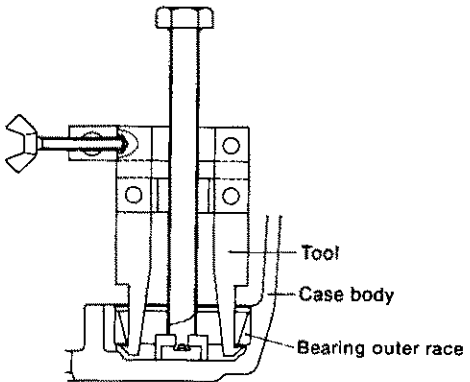
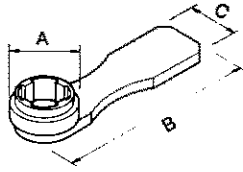
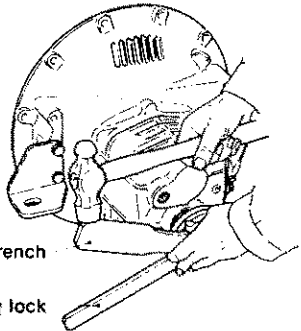
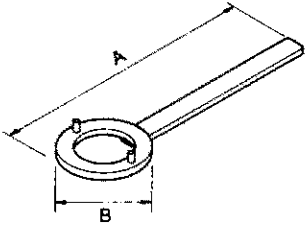
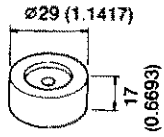
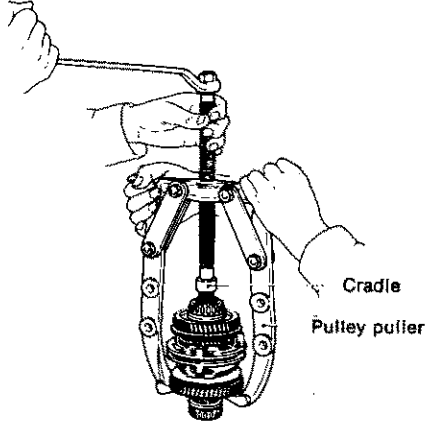
2-2 Special handtools

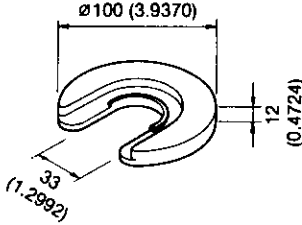
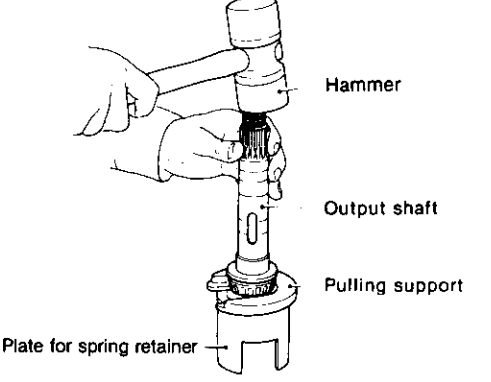
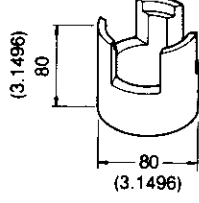
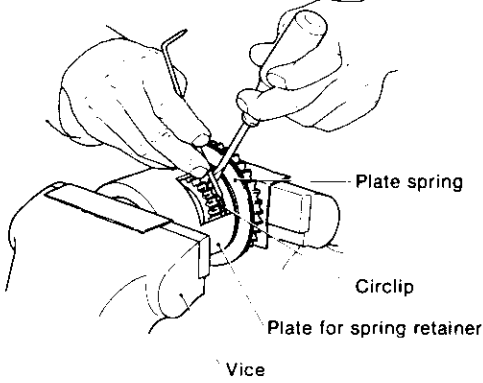
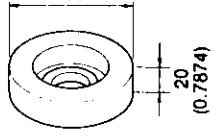
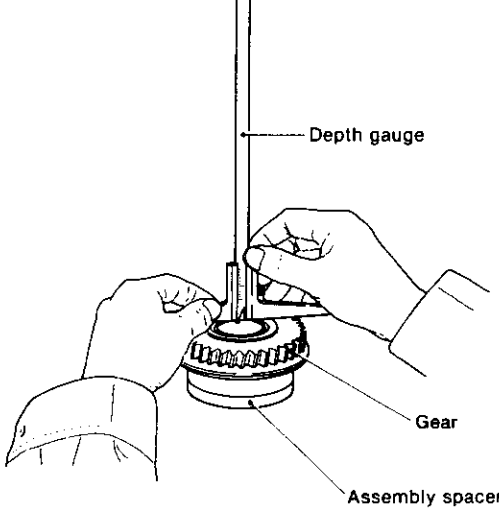
Name of tool	Shape and size	Application						
<p>Main bearing replacer</p>	 <table border="1" data-bbox="431 1198 917 1321"> <thead> <tr> <th>Model</th> <th>Assembly code no.</th> </tr> </thead> <tbody> <tr> <td>1GM10(C), 2GM20(F)(C), 3GM30(F)(C)</td> <td>124085-92400</td> </tr> <tr> <td>3HM35(F)(C)</td> <td>128670-92400</td> </tr> </tbody> </table>	Model	Assembly code no.	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	124085-92400	3HM35(F)(C)	128670-92400	<p>Removal</p>  <p>Installation</p> 
Model	Assembly code no.							
1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	124085-92400							
3HM35(F)(C)	128670-92400							
<p>Lubricating oil No. 2 filter case remover</p>								

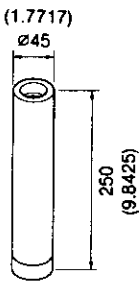
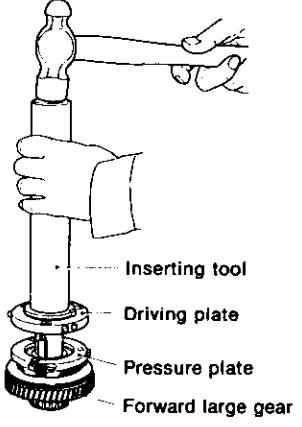
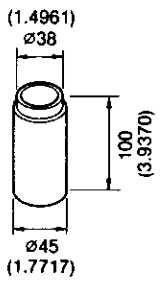
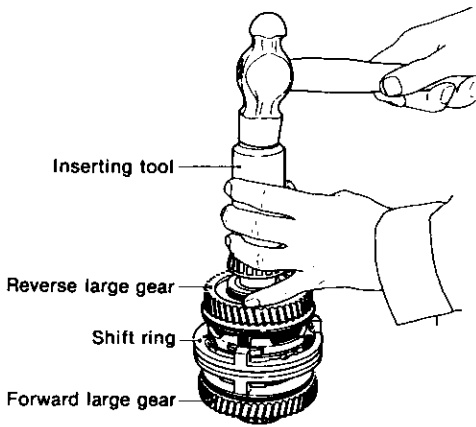
Name of tool	Shape and size	Application																			
<p>Piston pin insertion/ extraction tool</p>	<p style="text-align: right;">mm (in.)</p>  <table border="1" data-bbox="439 884 917 1108"> <thead> <tr> <th>Model</th> <th>d</th> <th>D</th> <th>l</th> <th>Code No.</th> </tr> </thead> <tbody> <tr> <td>1GM10 (C)</td> <td rowspan="3">$\phi 9.5 \pm 0.1$ (0.3700 ~ 0.3780)</td> <td>$\phi 20_{-0.15}$</td> <td rowspan="3">97 (3.8189)</td> <td rowspan="3">124085 -92260</td> </tr> <tr> <td>2GM20 (F)(C)</td> <td>$\phi 20_{-0.25}$ (0.7776 ~ 0.7815)</td> </tr> <tr> <td>3GM30 (F)(C)</td> <td></td> </tr> <tr> <td>3HM35 (F)(C)</td> <td>$\phi 12$ (0.4724)</td> <td>$\phi 22$ (0.8661)</td> <td>80 (3.1496)</td> <td>128670 -92260</td> </tr> </tbody> </table>	Model	d	D	l	Code No.	1GM10 (C)	$\phi 9.5 \pm 0.1$ (0.3700 ~ 0.3780)	$\phi 20_{-0.15}$	97 (3.8189)	124085 -92260	2GM20 (F)(C)	$\phi 20_{-0.25}$ (0.7776 ~ 0.7815)	3GM30 (F)(C)		3HM35 (F)(C)	$\phi 12$ (0.4724)	$\phi 22$ (0.8661)	80 (3.1496)	128670 -92260	 <p>Piston pin extractor</p>  <p>Extraction of piston pin</p>  <p>Insertion of piston pin</p>
Model	d	D	l	Code No.																	
1GM10 (C)	$\phi 9.5 \pm 0.1$ (0.3700 ~ 0.3780)	$\phi 20_{-0.15}$	97 (3.8189)	124085 -92260																	
2GM20 (F)(C)		$\phi 20_{-0.25}$ (0.7776 ~ 0.7815)																			
3GM30 (F)(C)																					
3HM35 (F)(C)	$\phi 12$ (0.4724)	$\phi 22$ (0.8661)	80 (3.1496)	128670 -92260																	
<p>Connecting rod small end bushing insertion/ extraction tool</p>	<p style="text-align: right;">mm (in.)</p>  <table border="1" data-bbox="439 1355 917 1624"> <thead> <tr> <th>Model</th> <th>d</th> <th>D</th> <th>l</th> <th>Code No.</th> </tr> </thead> <tbody> <tr> <td>1GM10 (C)</td> <td rowspan="3">$\phi 20_{-1.0}$ (0.7480 ~ 0.7756)</td> <td>$\phi 22_{-0.3}$</td> <td rowspan="3">20 (0.7874)</td> <td rowspan="3">124085 -92270</td> </tr> <tr> <td>2GM20 (F)(C)</td> <td>$\phi 22_{-0.0}$ (0.8268 ~ 0.8543)</td> </tr> <tr> <td>3GM30 (F)(C)</td> <td></td> </tr> <tr> <td>3HM35 (F)(C)</td> <td>$\phi 23_{-0.6}$ (0.8819 ~ 0.8937)</td> <td>$\phi 25_{-0.3}$ (0.9606 ~ 0.9724)</td> <td>3.0 (1.1811)</td> <td>128670 -92270</td> </tr> </tbody> </table>	Model	d	D	l	Code No.	1GM10 (C)	$\phi 20_{-1.0}$ (0.7480 ~ 0.7756)	$\phi 22_{-0.3}$	20 (0.7874)	124085 -92270	2GM20 (F)(C)	$\phi 22_{-0.0}$ (0.8268 ~ 0.8543)	3GM30 (F)(C)		3HM35 (F)(C)	$\phi 23_{-0.6}$ (0.8819 ~ 0.8937)	$\phi 25_{-0.3}$ (0.9606 ~ 0.9724)	3.0 (1.1811)	128670 -92270	 <p>Extraction</p>
Model	d	D	l	Code No.																	
1GM10 (C)	$\phi 20_{-1.0}$ (0.7480 ~ 0.7756)	$\phi 22_{-0.3}$	20 (0.7874)	124085 -92270																	
2GM20 (F)(C)		$\phi 22_{-0.0}$ (0.8268 ~ 0.8543)																			
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3HM35 (F)(C)	$\phi 23_{-0.6}$ (0.8819 ~ 0.8937)	$\phi 25_{-0.3}$ (0.9606 ~ 0.9724)	3.0 (1.1811)	128670 -92270																	
<p>Intake and exhaust valve insertion/ extraction tool</p>	<p style="text-align: right;">mm (in.)</p>  <p>All models Code no.; 124085-92250</p>																				

Name of tool	Shape and size	Application						
Piston ring compressor	 <table border="1" data-bbox="459 555 937 696"> <thead> <tr> <th>Model</th> <th>Code No.</th> </tr> </thead> <tbody> <tr> <td>3GM35(F)(C)</td> <td>102700-92140</td> </tr> <tr> <td>1GM10(C), 2GM20(F)(C), 3GM30(F)(C)</td> <td>101200-92140</td> </tr> </tbody> </table>	Model	Code No.	3GM35(F)(C)	102700-92140	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	101200-92140	 <p>Piston insertion guide</p>
Model	Code No.							
3GM35(F)(C)	102700-92140							
1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	101200-92140							
Valve lapping handle	 <p>All models Code no.; 28210-000031</p>	 <p>Lapping tool</p>						
Valve lapping powder	 <p>All models Code no.; 28210-000070</p>							
Feeler gauge 0.2mm (0.0079)	 <p>All models Code no.; 28312-200750</p>							
Fuel injection valve replacer	 <p>mm (in.)</p> <p>All models Code no.; 101104-92180</p>							


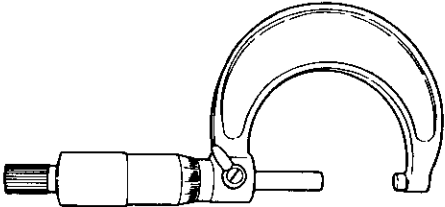
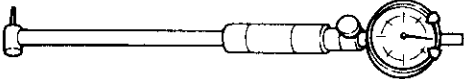
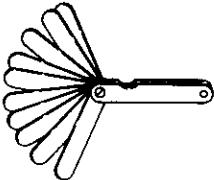
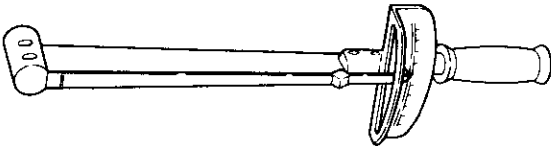
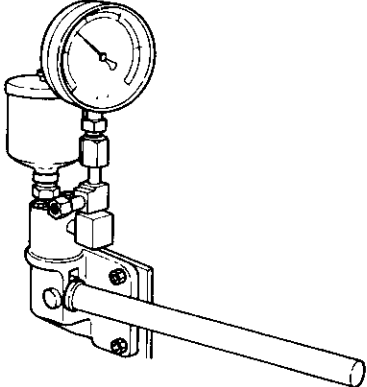
Name of tool	Shape and size	Application
<p>Pulley puller</p>	 <p>Rocal supply</p>	 <p>Removing the coupling</p>
<p>Tool for turning crankshaft gear nut Tightening the crankshaft gear nut</p>	 <p>mm (in.)</p> <p>Width across flats of hexagonal hole</p> <p>All models Code no.; 124085-92700</p>	
<p>Driving tool for bearing inner race (for models 1GM10, 2GM20(F), 3GM30(F))</p>	 <p>mm (in.)</p> <p>Code no.; 177088-09150</p>	 <p>Tool Bearing inner race Output shaft</p> <p>The bearing inner race of the drive output shaft.</p>
<p>Operation lever locating jig [for models 1GM10 2GM20(F) and 3GM30(F)]</p>	 <p>mm (in.)</p> <p>t = 10.0 (0.3937)</p> <p>Code no.; 177088-09160</p>	 <p>Adjusting the operation lever</p>

Name of tool	Shape and size	Application								
Extractor tool for the bearing outer race (for models 1GM10, 2GM20(F), 3GM30(F))	 <p style="text-align: right;">Code no.; 177088-09160</p>	 <p>Tool Case body Bearing outer race</p> <p>Extracting the bearing outer race from the housing.</p>								
Output shaft nut wrench for 3HM35(F)	 <p style="text-align: right;">mm (in.)</p> <table border="1" data-bbox="445 976 921 1061"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>Code No.</th> </tr> </thead> <tbody> <tr> <td>∅55 (2.1654)</td> <td>230 (9.0551)</td> <td>45 (1.7717)</td> <td>177099-09010</td> </tr> </tbody> </table>	A	B	C	Code No.	∅55 (2.1654)	230 (9.0551)	45 (1.7717)	177099-09010	 <p>Output shaft nut wrench Output shaft coupling lock</p>
A	B	C	Code No.							
∅55 (2.1654)	230 (9.0551)	45 (1.7717)	177099-09010							
Output shaft coupling lock for 3HM35(F)	 <p style="text-align: right;">mm (in.)</p> <table border="1" data-bbox="445 1373 921 1442"> <thead> <tr> <th>A</th> <th>B</th> <th>Code No.</th> </tr> </thead> <tbody> <tr> <td>290 (11.4173)</td> <td>∅100 (3.9370)</td> <td>177099-09020</td> </tr> </tbody> </table>	A	B	Code No.	290 (11.4173)	∅100 (3.9370)	177099-09020	<p>For removing and tightening the output shaft nut.</p>		
A	B	Code No.								
290 (11.4173)	∅100 (3.9370)	177099-09020								
Puller cradle for 3HM35(F)	 <p style="text-align: right;">mm (in.)</p> <p style="text-align: center;">Code no.; 177095-09170</p>	 <p>Cradle Pulley puller</p> <p>For removing the output shaft when using a pulley puller.</p>								

Name of tool	Shape and size	Application
<p>Pulling support for 3HM35(F)</p>	<p>mm (in.)</p>  <p>Code no.; 177099-09030</p>	 <p>Hammer Output shaft Pulling support Plate for spring retainer</p> <p>For removing the needle bearing inner race, thrust collar and thrust bearing of the output shaft (forward gear side).</p>
<p>Plate for spring retainer for 3HM35(F)</p>	<p>mm (in.)</p>  <p>Code no.; 177095-09070</p>	 <p>Plate spring Circlip Plate for spring retainer Vice</p> <p>For removing and installing the plate spring, retainer and circlip of the large gears (forward and reverse).</p>
<p>Assembly spacer for 3HM35(F)</p>	<p>mm (in.)</p>  <p>Code no.; 177090-09010</p>	 <p>Depth gauge Gear Assembly spacer</p> <p>For determining the thickness of the adjusting plate.</p>

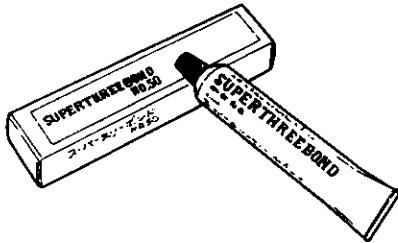
Name of tool	Shape and size	Application
<p>Inserting tool for 3HM35(F)</p>	<p style="text-align: right;">mm (in.)</p>  <p style="text-align: center;">Code no.; 177095-09020</p>	 <p>For installing the spacer and needle bearing inner race of the output shaft. (reverse small gear side).</p>
<p>Inserting tool for 3HM35(F)</p>	<p style="text-align: right;">mm (in.)</p>  <p style="text-align: center;">Code no.; 177099-09040</p>	 <p>For installing the thrust bearing and thrust collar (reverse large gear side).</p>

2-3 Measuring instruments

Nomenclature		Accuracy and range
Vernier calipers		1/20 mm, 0 ~ 150 mm.
Micrometer		1/100 mm, 0 ~ 25 mm, 25 ~ 50 mm, 50 ~ 75 mm, 75 ~ 100 mm,
Cylinder gauge		1/100 mm, 18 ~ 35 mm, 35 ~ 60 mm, 50 ~ 100 mm,
Thickness gauge		0.05 ~ 2mm (0.0020 ~ 0.0787 in.)
Torque wrench		0 ~ 13 kgf-m (0 ~ 94 ft-lb)
Nozzle tester		0 ~ 500 kgf-cm ² (0 ~ 7111.7 lb/in. ²)

3. Others

Supplementary packing agent

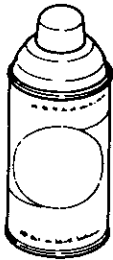


Type	Use
"Three Bond 3B8-005"	White. Since "Three Bond 3B8-005" is a nonorganic solvent, it does not penetrate asbestos sheets made principally or completely of asbestos. Always use it with grey asbestos sheet packing for complete oil tightness. When "Three Bond 3B8-005" is difficult to obtain, use silicone nonsolvent type "Three Bond No. 50."
"Three Bond No. 50"	Grey. Silicone nonsolvent type liquid packing. Semidry type packing agent coated on mating faces to prevent oil and gas leakage. Does not penetrate asbestos sheet and assures complete oil tightness.
"Three Bond No. 1"	Reddish brown. Paste type wet viscous liquid packing. Ideal for mating faces which are removed but reinstalled. Particularly used to prevent water leakage and to prevent seizing of bolts and nuts.

The surface to be coated must be thoroughly cleaned with thinner or benzene and completely dry. Moreover, coating must be thin and uniform.

Products of Three Bond Co., Ltd.

Paint



Color spray

Metallic Ecole Silver is used entirely on this engine.

Wipe off the surface to be painted with thinner or benzene, shake the spray can well, push the button at the top of the can and spray the paint onto the surface from a distance of 30 ~ 40 cm.

Paint

Type

White paint
(Mixed oil paint)

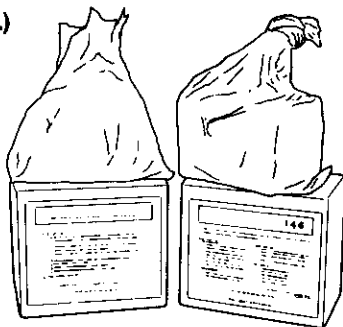
Usage point

Cylinder liner
insertion hole

Use

Paint parts that contact the cylinder body when inserting the cylinder liner to prevent rusting and water leakage.

Yanmar cleaner (Ref.)



Cooling passage cleaner is made by adding one part "Unicon 146" to about 16 parts water (specific gravity ratio). To use, drain the water from the cooling system, fill the system with cleaner, allowing it to stand overnight (10 ~ 15 hours). Then drain out the cleaner, fill the system with water, and operate the engine for at least one hour.

NEJI LOCK SUPER 203M: a locking agent for screws (Ref.)



For coating on screws and bolts to prevent loosening, rusting, and leaking. To use, wipe off all oil and water on the threads of studs, coat the threads with screw lock, tighten the stud bolt, and allow to stand until the screw lock hardens. Use screw lock on the oil intake pipe threads, oil pressure switch threads, fuel injection timing shim faces, and front axle bracket mounting bolts.

4. Disassembly

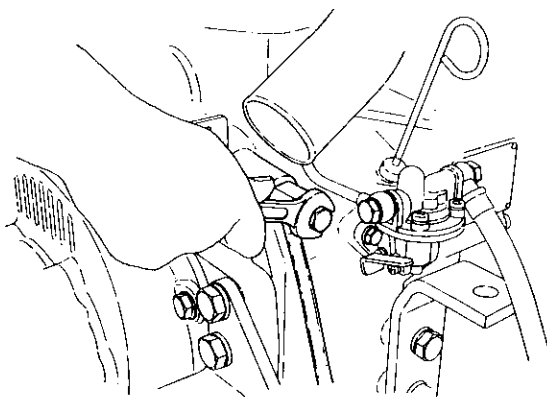
4-1. General Precautions

Maintenance and inspection should be done as effectively as possible, avoiding unnecessary disassembling except for general overhauls.

At the time of disassembly, record the presence of parts which require repair or replacement, and make arrangements beforehand for procurement of such parts so that problems will not occur during the reassembling operation.

4-2. Dismantling engine model 1GM10(C)

4-2.1 Open the cooling water drain cock and drain the cooling water

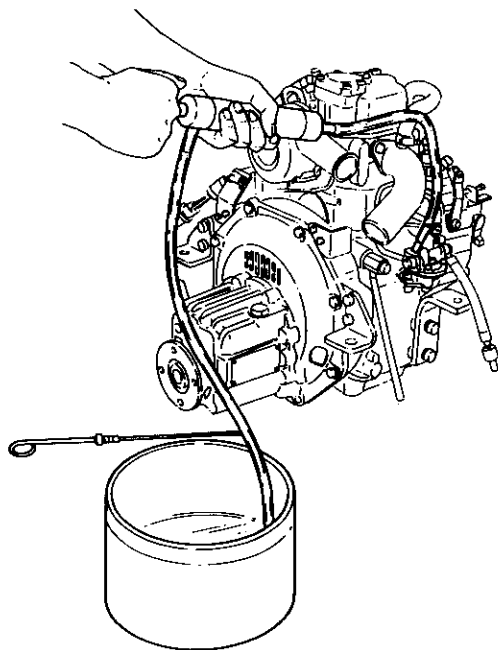


4-2.2 Drain the lubricating oil

(1) Engine side

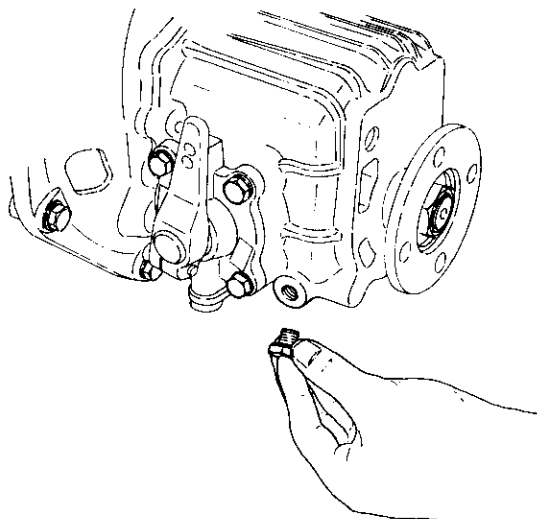
Insert a suction tube into the dipstick hole and pump out the oil with a waste oil pump (option).

Alternatively remove the plug of oil pan and oil intake pipe, and drain the oil.



(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 stern side of the clutch case and drain the oil.

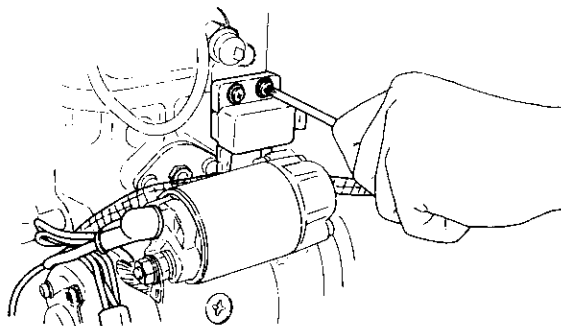


4-2.3 Disconnect the remote control cables

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

4-2.4 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

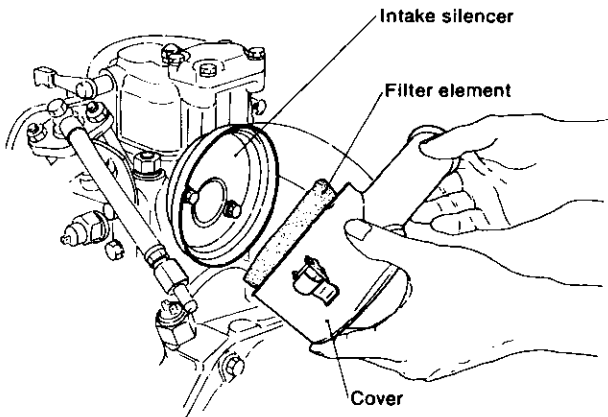


4-2.5 Disconnect the cooling water inlet pipe

NOTE: Always close the Kingston cock.

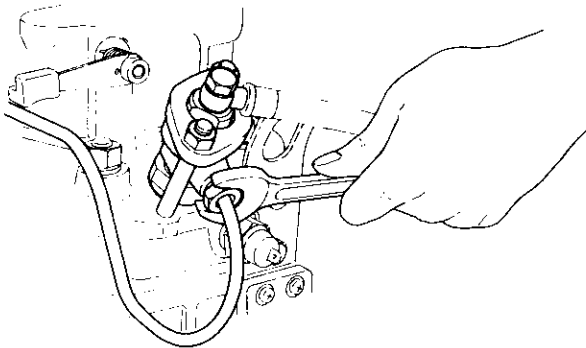
4-2.6 Remove the air intake silencer

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

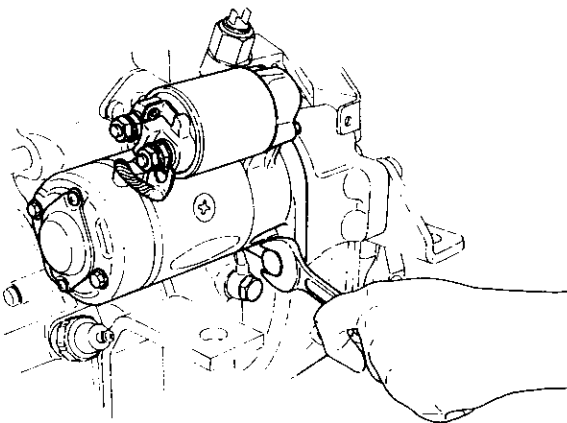


4-2.7 Disconnect the fuel piping

- (1) Fuel tank to feed pump
- (2) Feed pump to fuel filter
- (3) Fuel filter to fuel injection pump
- (4) Fuel high pressure pipe
- (5) Fuel return pipe

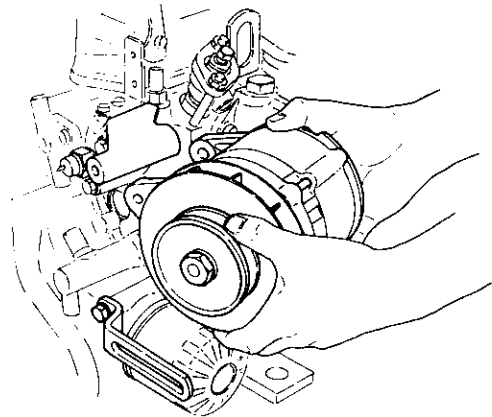


4-2.8 Remove the starter motor



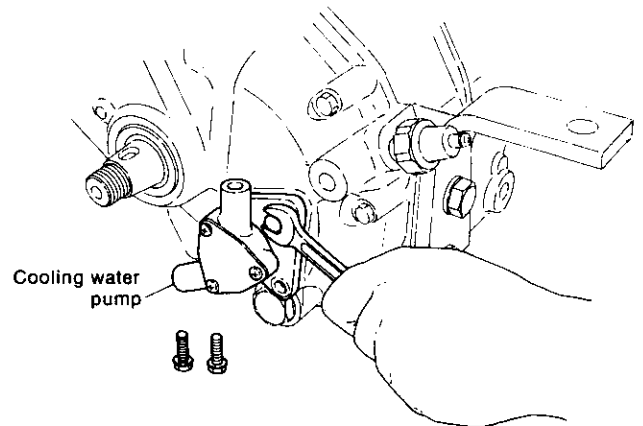
4-2.9 Remove the alternator

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



4-2.10 Remove the water pump

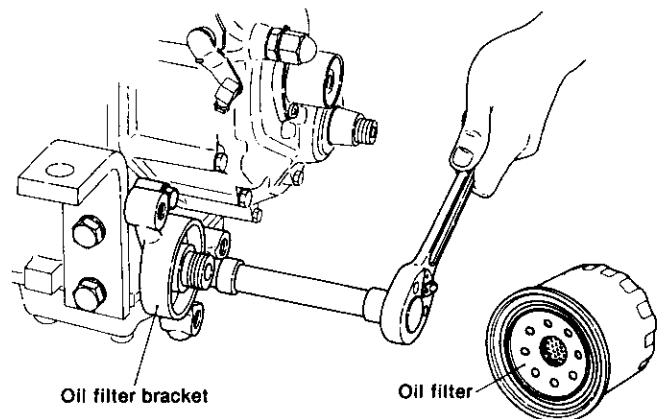
- (1) Disconnect the hose between the water pump and cooling water cylinder inlet joint.



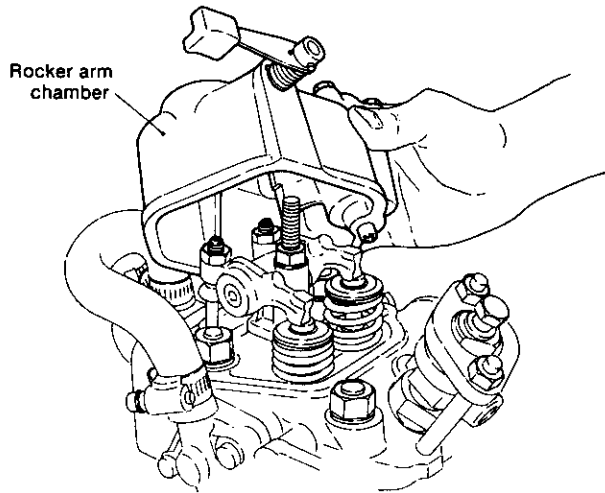
- (2) Loosen the water pump mounting bolts and remove the water pump.

4-2.11 Remove the oil filter and bracket.

- (1) Remove the oil filter using the remover.
- (2) Loosen the joint bolts and remove the oil pipes.
- (3) Remove the oil filter bracket.

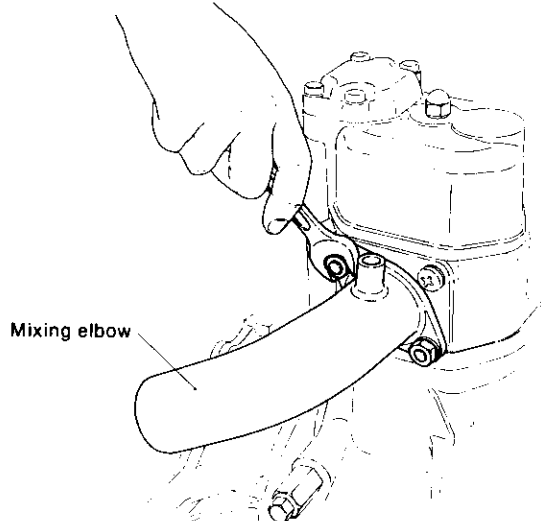


4-2.12 Remove the rocker arm chamber



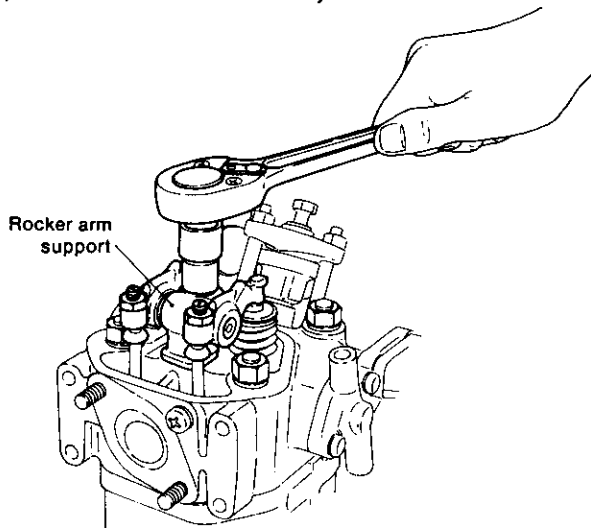
4-2.13 Remove the mixing elbow

- (1) Disconnect the cooling water bypass hose
- (2) Remove the mixing elbow



4-2.14 Remove the rocker arms

- (1) Remove the rocker arm ass'y

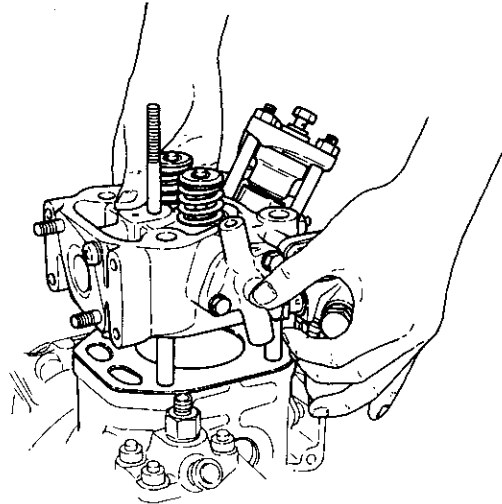


- (2) Pull the push rods
- (3) Remove the cotter pins of the intake and exhaust valve springs.

NOTE: Arrange parts by intake and exhaust.

4-2.15 Remove the cylinder head

- (1) Disconnect the lubricating oil pipe located at the cylinder block and the cylinder head.
- (2) Remove the cylinder head nuts in the prescribed order, and remove the cylinder head.

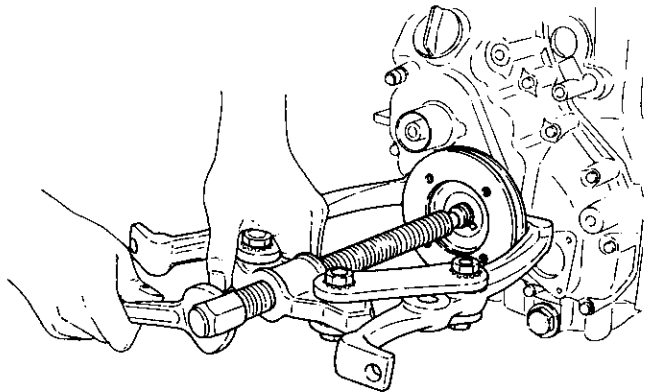


- (3) Remove the gasket packing

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

4-2.16 Remove the crankshaft pulley

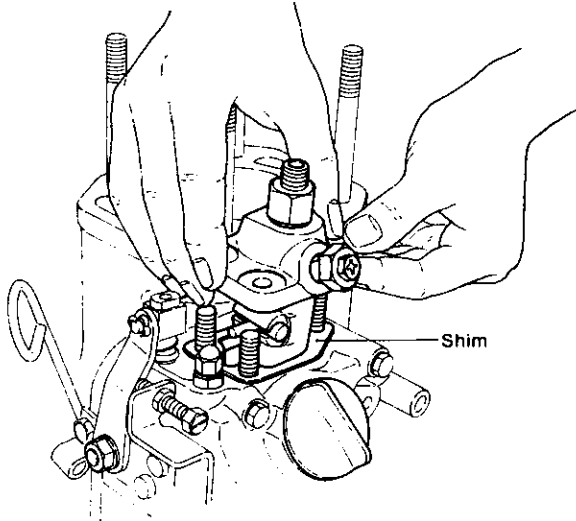
Remove the crankshaft pulley end nut and remove the V-pulley and key.



4-2.17 Remove the injection pump

- (1) Remove the fixing nut of the fuel injection pump
- (2) Open the oil supply hole, move the governor lever 2, and take out the fuel injection pump by matching the control rack with the cut-off part of the gear case.

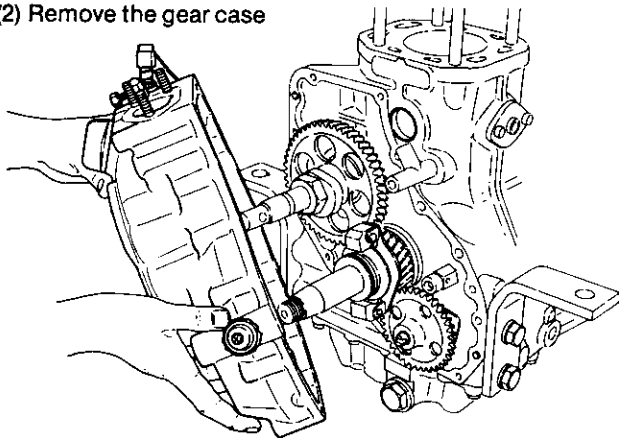
(3) Remove the injection timing adjustment shims



CAUTION: Note the number and total thickness of the timing adjustment shims.

4-2.18 Remove the timing gear case

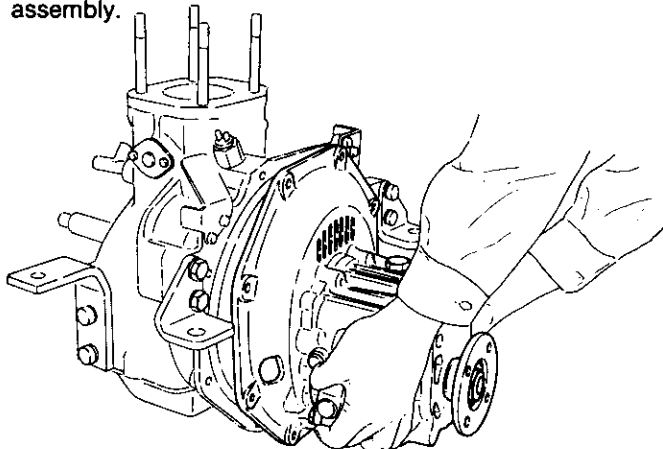
- (1) Remove the starting shaft cover, loosen the bolt with the hexagonal socket head, and withdraw the pin for handle fitting.
- (2) Remove the gear case



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

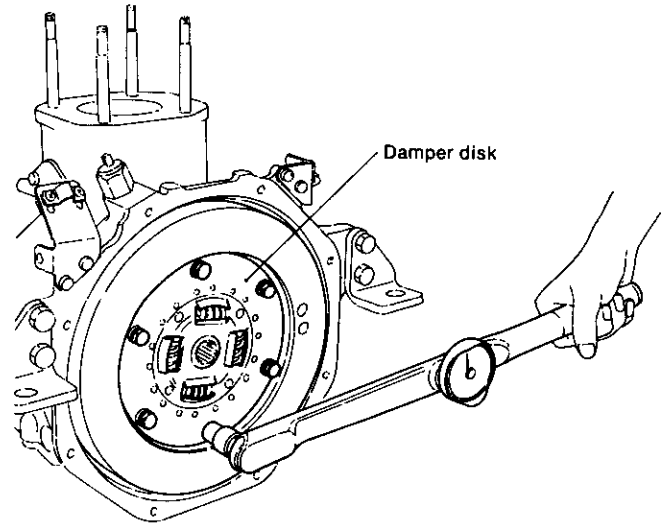
4-2.19 Remove the clutch assembly

Loosen the mounting flange bolts and remove the clutch assembly.



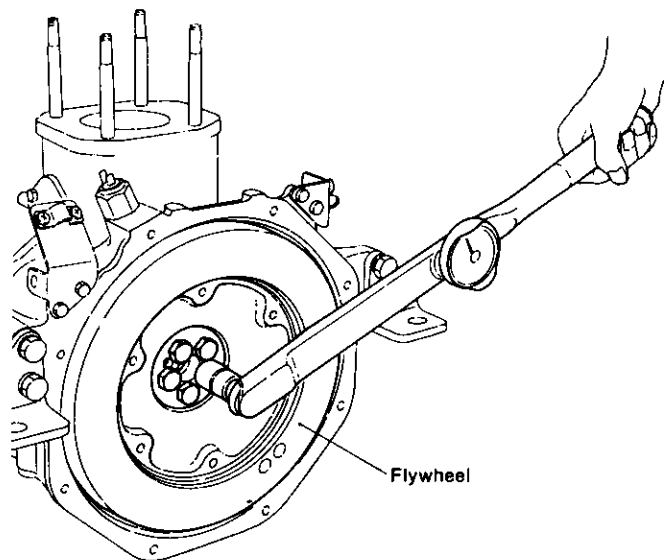
4-2.20 Remove the flywheel

(1) Remove the clutch disk

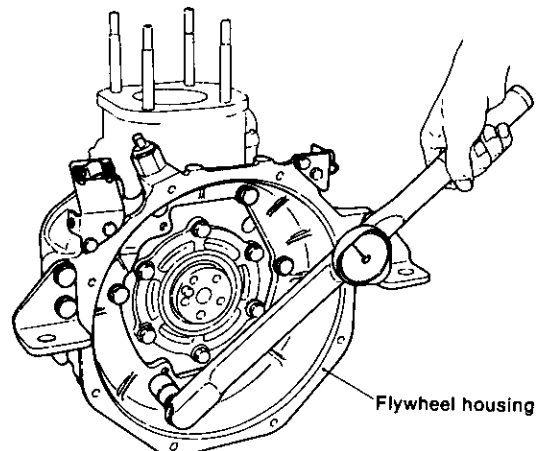


(2) Remove the flywheel

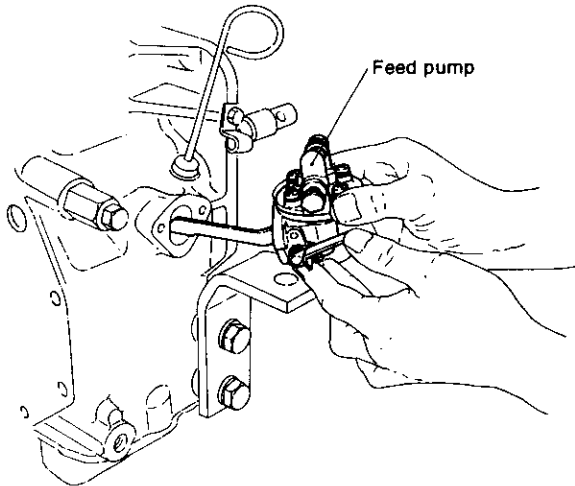
Screw-in the two bolts for securing the clutch disc (slightly to the left and right sides of the flywheel) and remove it by pulling on the bolts.



4-2.21 Remove the flywheel housing



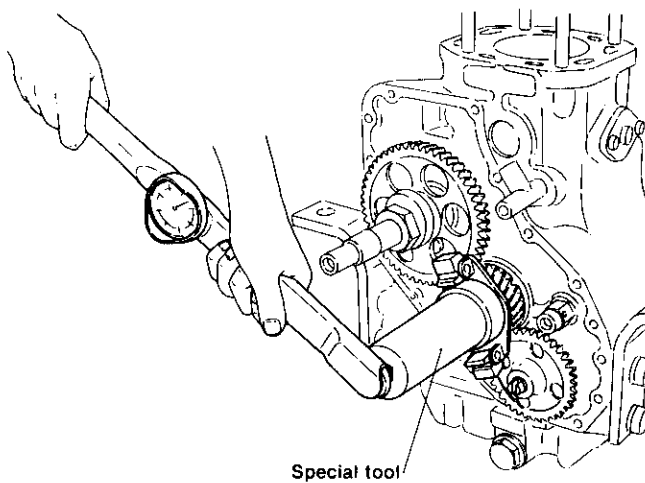
4-2.22 Remove the feed pump



4-2.23 Remove the lubricating oil dipstick

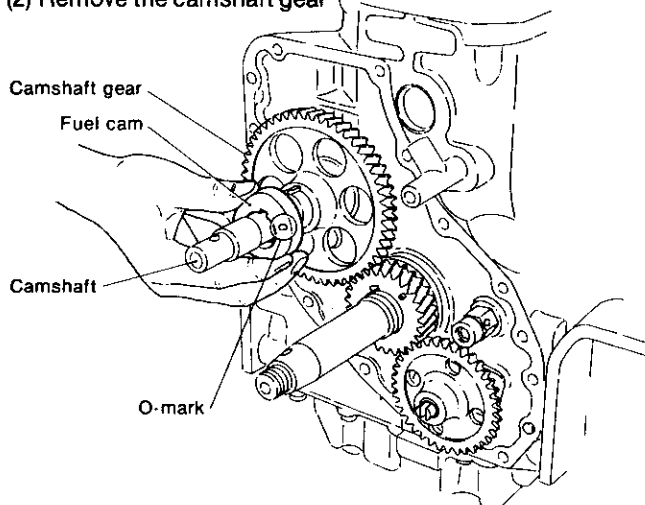
4-2.24 Remove the governor weight assembly

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



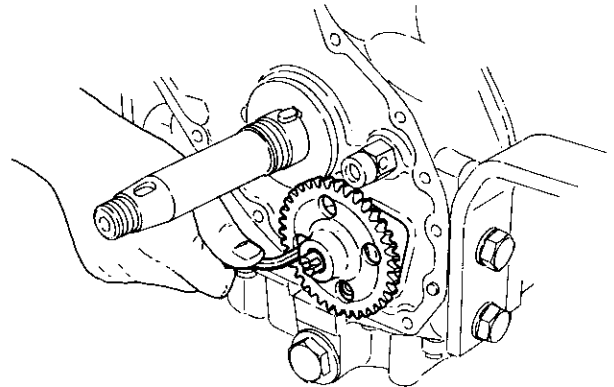
4-2.25 Remove the camshaft gear

- (1) Remove the camshaft end nut and remove the fuel cam
- (2) Remove the camshaft gear

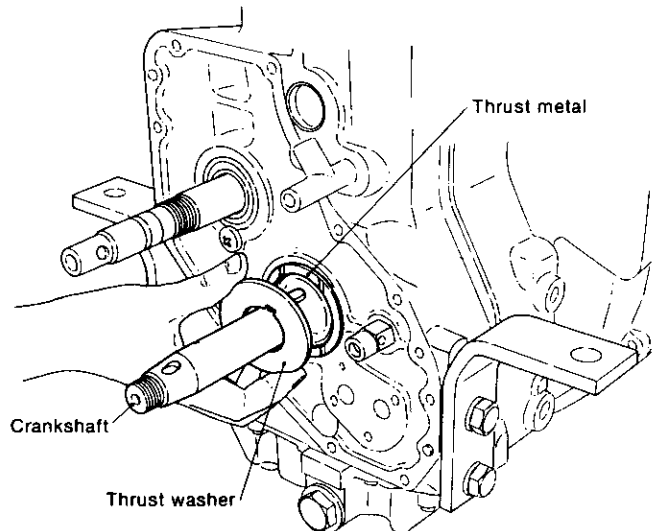


4-2.26 Remove the crankshaft gear and the lubricating oil pump

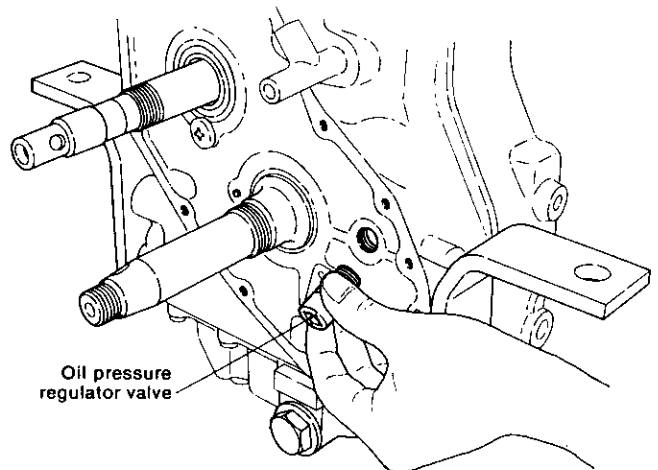
- (1) Remove the crankshaft gear
- (2) Remove the lubricating oil pump and gear assembly



- (3) Remove the thrust metal and the thrust washer from the crankshaft.

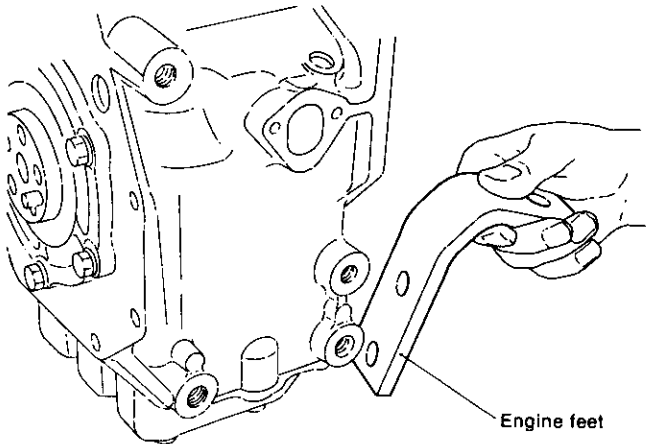


- (4) Remove the lubricating oil pressure control valve.

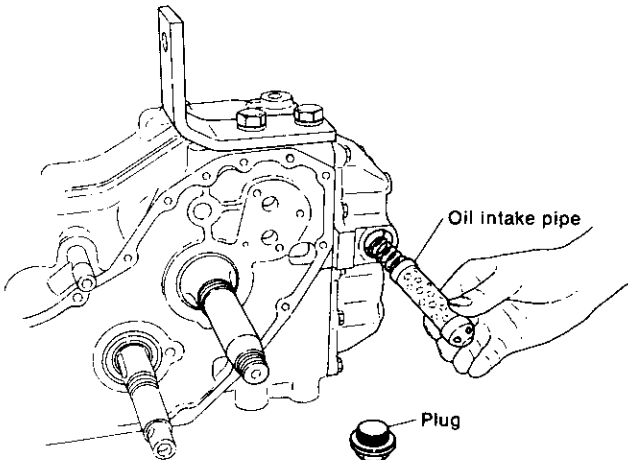


4-2.27 Turn the engine onto its side

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

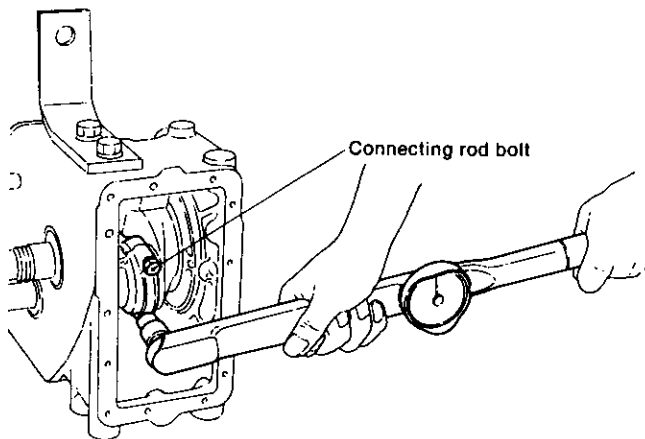


4-2.28 Remove the oil pan and the oil intake pipe

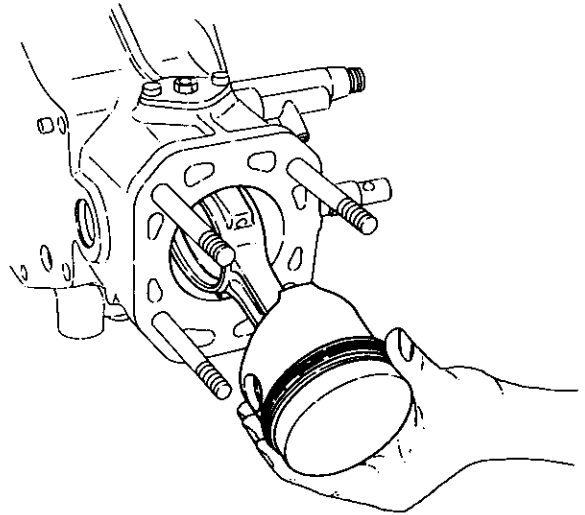


4-2.29 Remove the piston connecting rod assembly

- (1) Set the piston to bottom dead center and remove the connecting rod bolts.

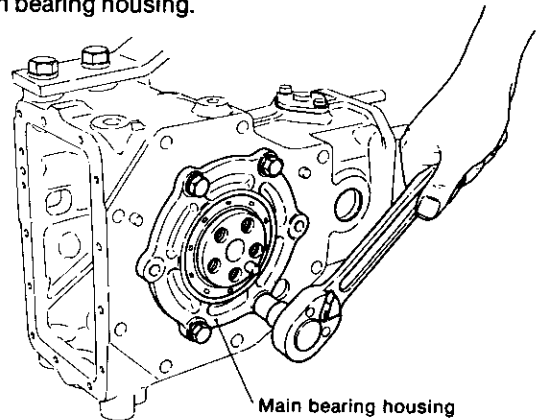


- (2) Set the piston to top dead center, turning the crankshaft so that the connecting rod does not separate from the crank pin. Pull out the piston connecting rod assembly by pushing the large end of the rod with a pusher.



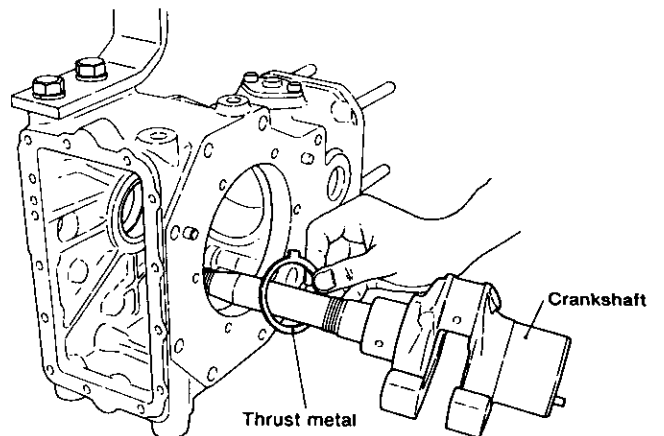
4-2.30 Remove the main bearing housing

- Remove the main bearing housing bolt and remove the main bearing housing.



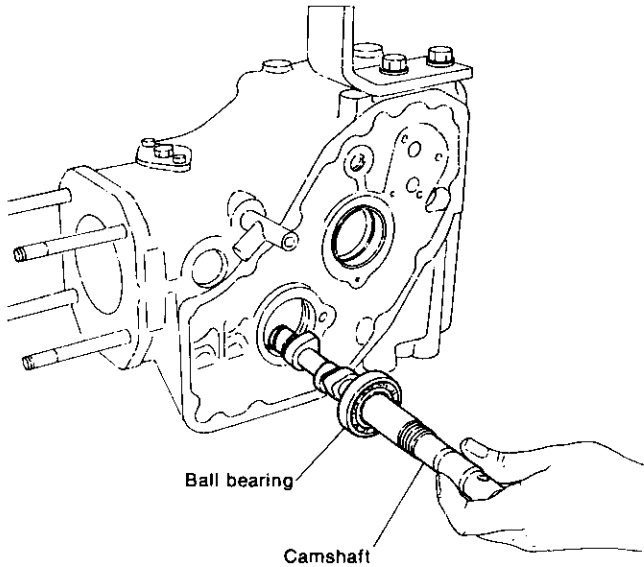
4-2.31 Pull the crankshaft

- (1) Pull the crankshaft
- (2) Remove the thrust metal



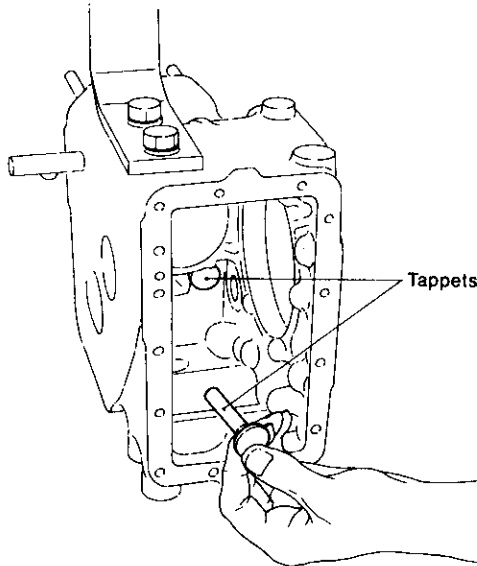
4-2.32 Remove the camshaft

- (1) Remove the camshaft bearing set screw
- (2) Check that all the tappets are separated from the cam, and pull the camshaft out.



4-2.33 Remove the tappets

NOTE: Arrange the removed tappets by intake and exhaust.

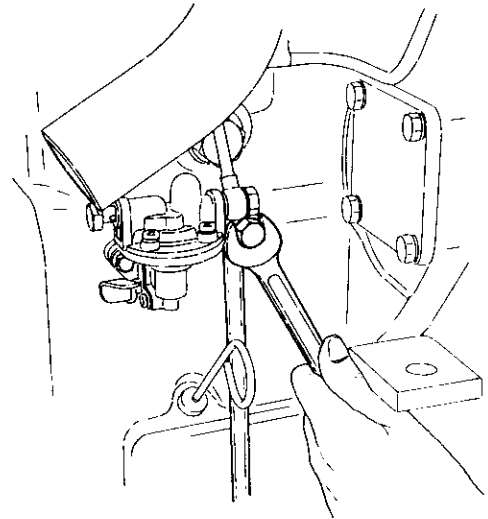


4.3 Dismantling engine models 2GM20(C) and 3GM30(C)

For the model 3HM35 engine, refer to the model 3GM30(C) instructions as the procedure is almost the same for both engine models.

4-3.1 Open the cooling water drain cocks and drain the cooling water

- (1) Cylinder body water drain cock

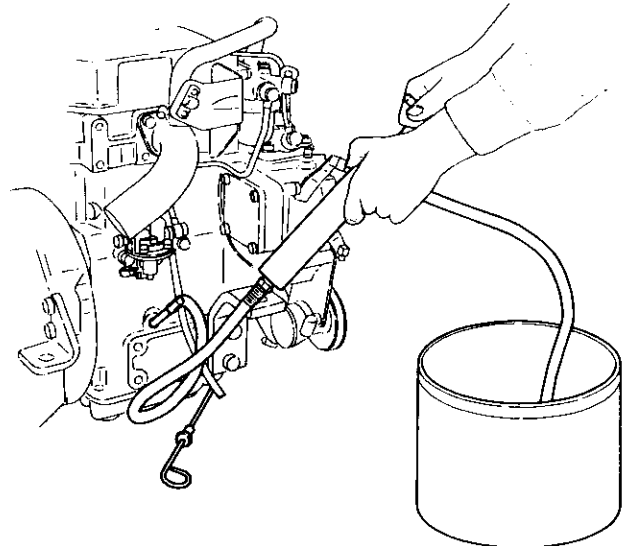


- (2) Exhaust pipe water drain cock [only for model 3GM30(C)]

4-3.2 Drain the lubricating oil

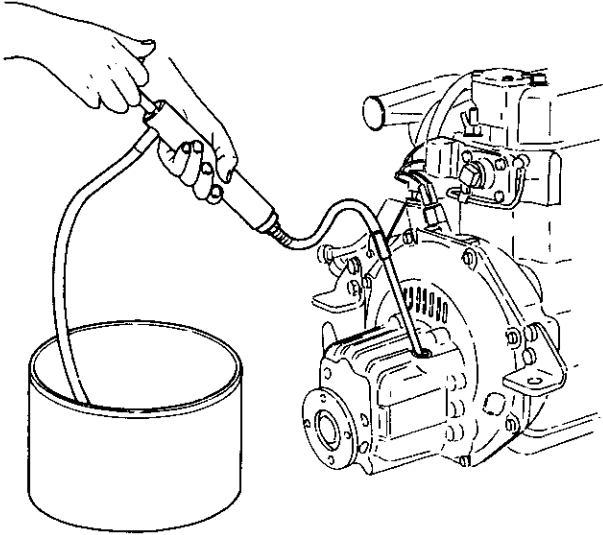
- (1) Engine side

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

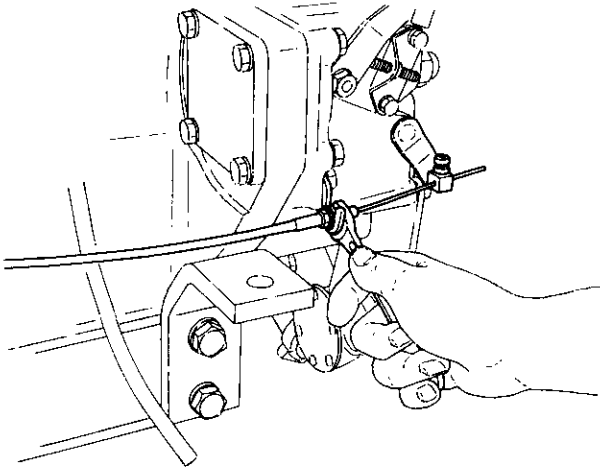


(2) Clutch side

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

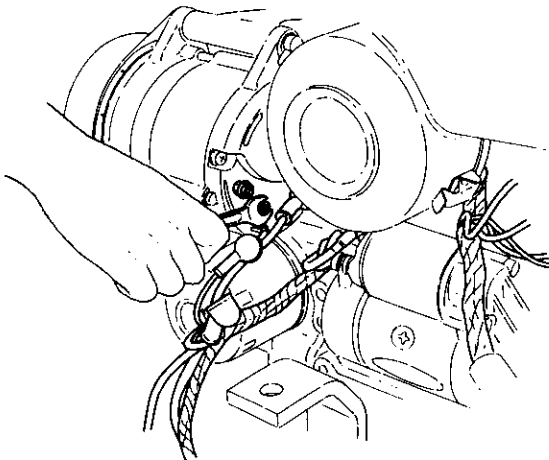


4-3.3 Disconnect the remote control cables



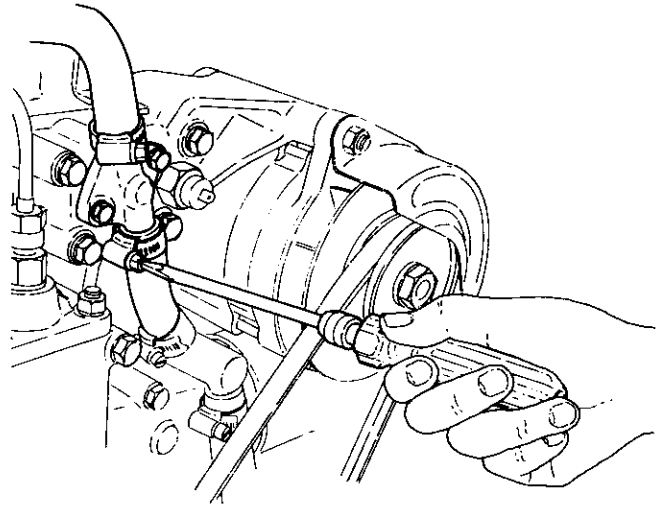
- (1) Clutch remote control cable and bracket
- (2) Speed remote control cable and bracket
- (3) Engine stop remote control cable and bracket
- (4) Decompression remote control cable

4-3.4 Disconnect the electrical wiring



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

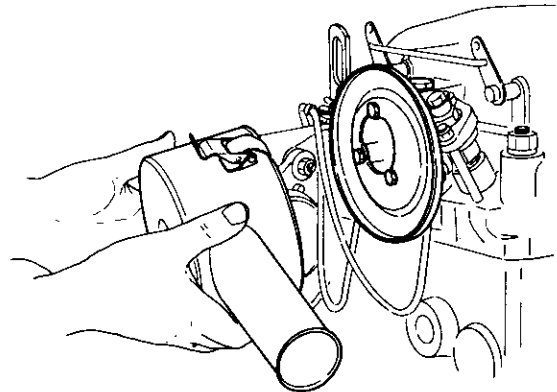
4-3.5 Disconnect the cooling water inlet pipe and bilge pipe



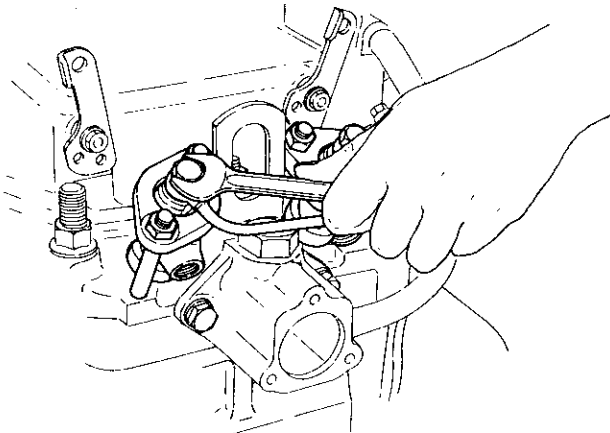
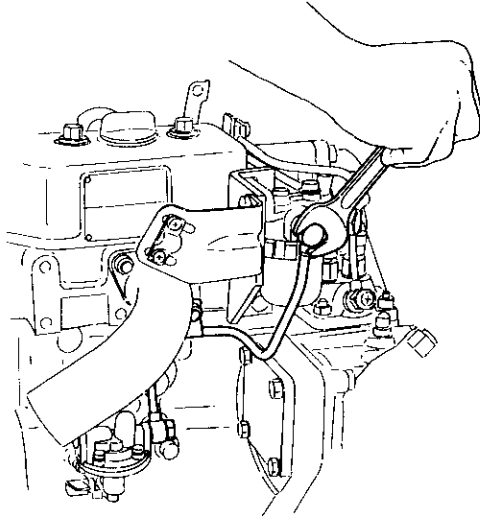
NOTE: Always close the Kingston cock

4-3.6 Remove the air intake silencer

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

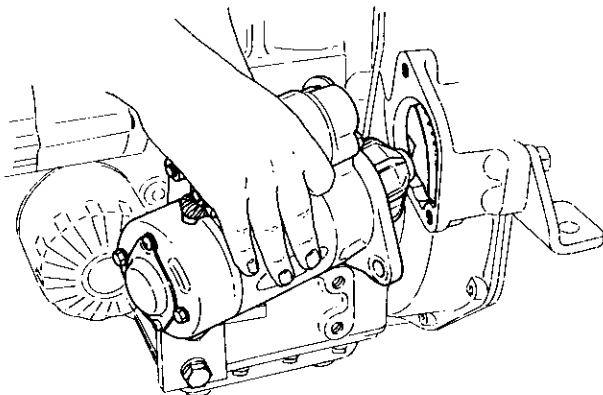


4-3.7 Disconnect the fuel piping



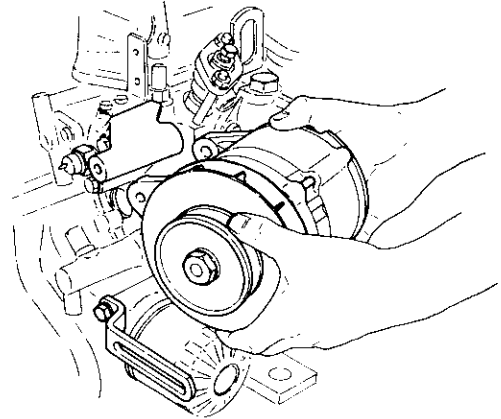
- (1) Fuel tank to feed pump
- (2) Feed pump to fuel filter
- (3) Fuel filter to fuel injection pump
- (4) Fuel high pressure pipe
- (5) Fuel return pipe

4-3.8 Remove the starter motor

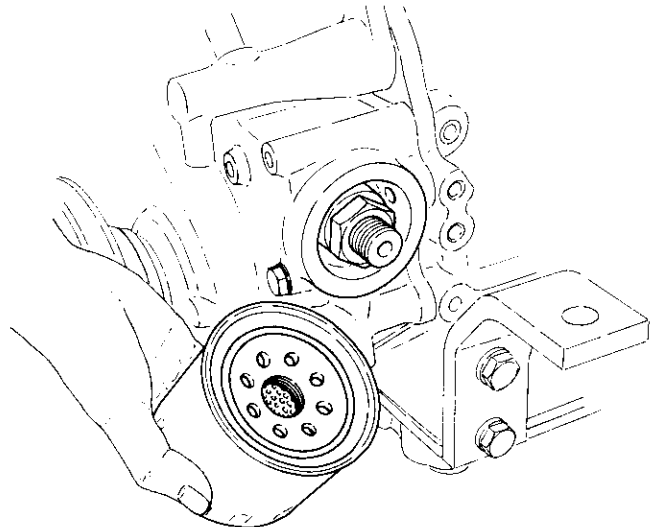


4-3.9 Remove the alternator

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

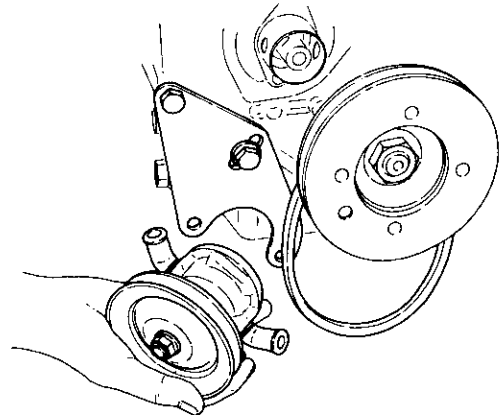


4-3.10 Remove the oil filter



4-3.11 Remove the water pump

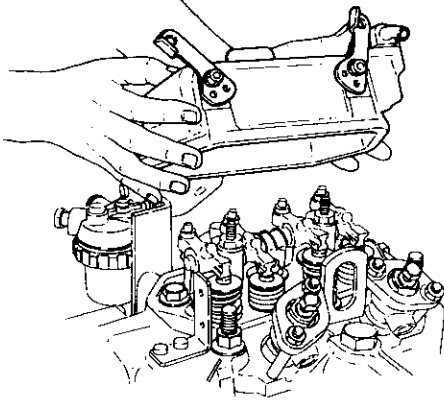
- (1) Disconnect the hose between the water pump and cooling water cylinder inlet joint.



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

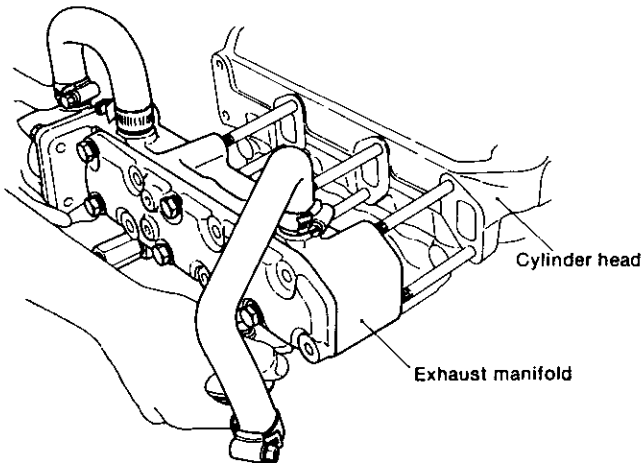
4-3.12 Remove the rocker arm chamber

- (1) Remove the breather pipe at the side of the intake pipe [intake manifold for model 3GM30(C)].
- (2) Remove the rocker arm chamber



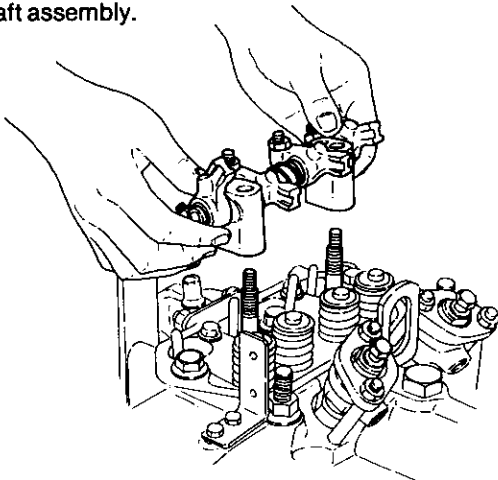
4-3.13 Remove the exhaust manifold [only for model 3GM30(C)] and the mixing elbow

- (1) Disconnect the cooling water bypass hose at the thermostat cover side.
- (2) Remove the mixing elbow [2GM20(C)].
- (3) Remove the exhaust manifold together with the fuel filter and mixing elbow [3GM30(C)].

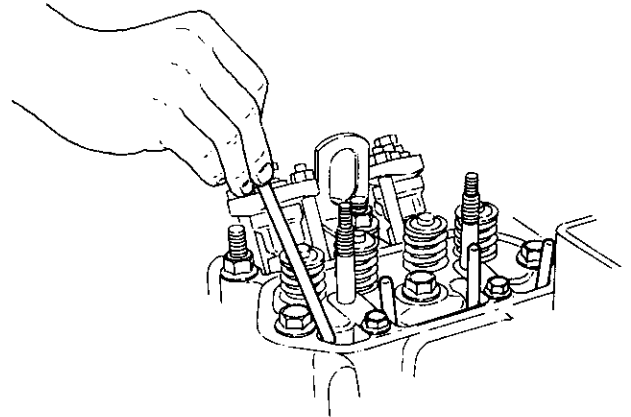


4-3.14 Remove the rocker arms

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



- (2) Pull the push rods.

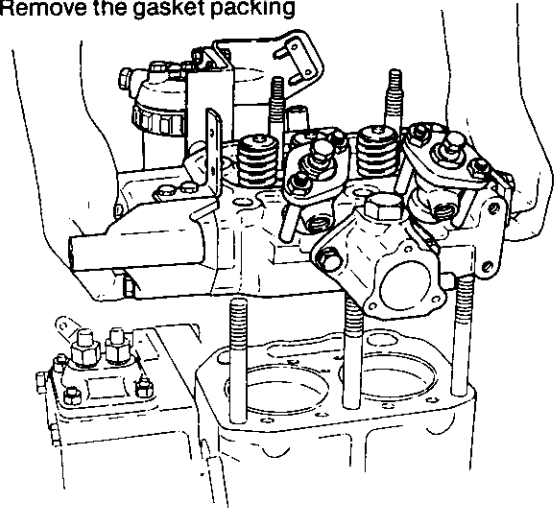


- (3) Remove the cotter pins of the intake and exhaust valve springs.

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

4-3.15 Remove the cylinder head

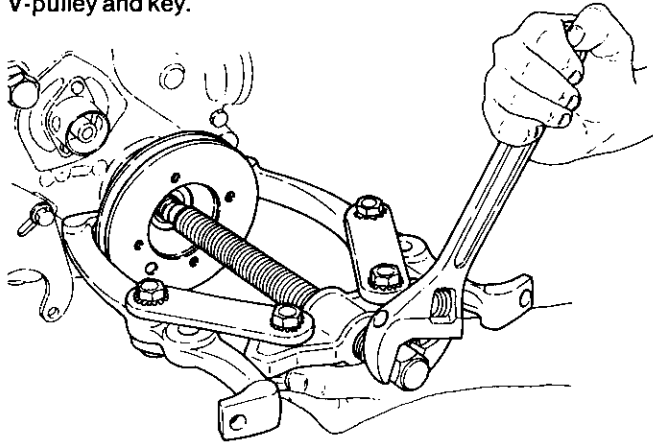
- (1) Disconnect the lubricating oil pipe.
- (2) Remove the cylinder head nuts in the prescribed order, and remove the cylinder head.
- (3) Remove the gasket packing



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

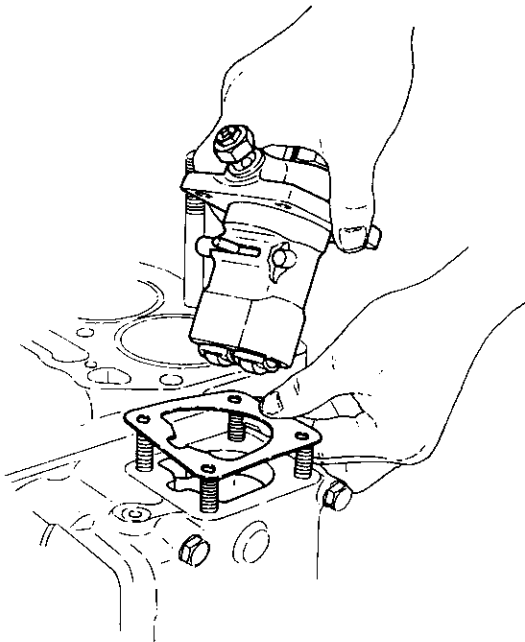
4-3.16 Remove the crankshaft pulley

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



4-3.17 Remove the injection pump

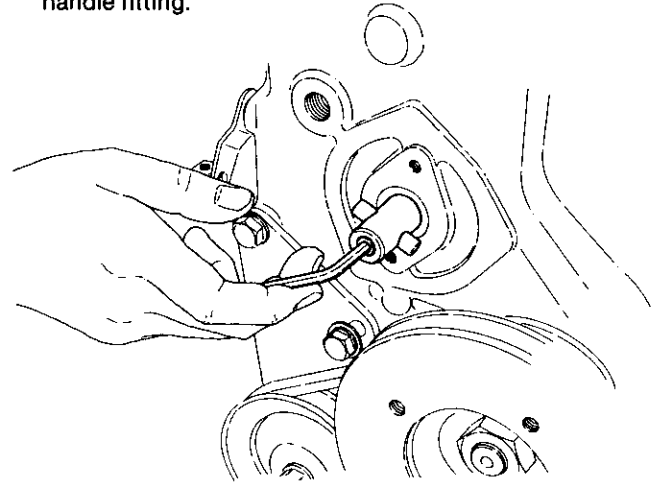
- (1) Remove the injection pump nut.
- (2) Remove the gear case side cover, move the governor lever 2, take out the fuel injection pump by matching the control rack with the cut-off part of the gear case.



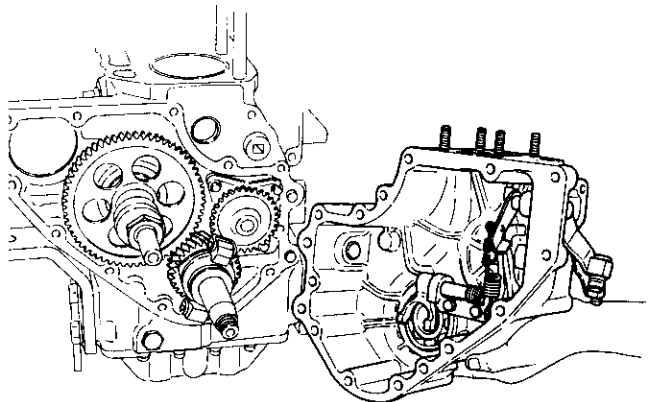
- (3) Remove the injection timing adjustment shims.
CAUTION: Note the number and total thickness to the timing adjustment shims.

4-3.18 Remove the timing gear case

- (1) Remove the starting shaft cover, loosen the bolt with the hexagonal socket head, and withdraw the pin for handle fitting.



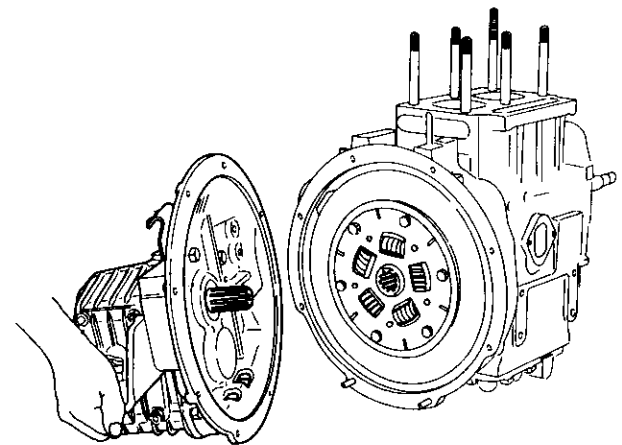
- (2) Remove the gear case



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

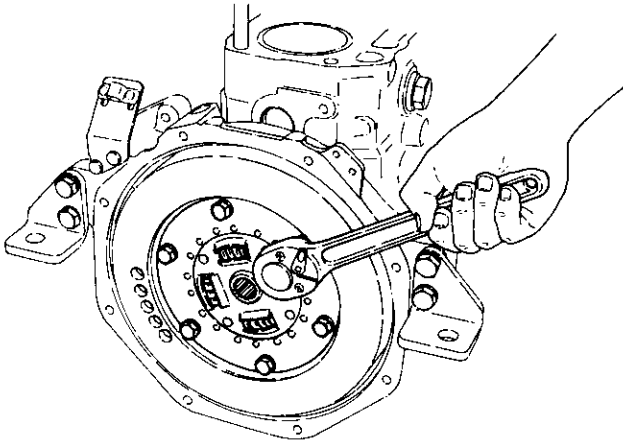
4-3.19 Remove the clutch assembly

Loosen the mounting flange bolts and remove the clutch assembly.



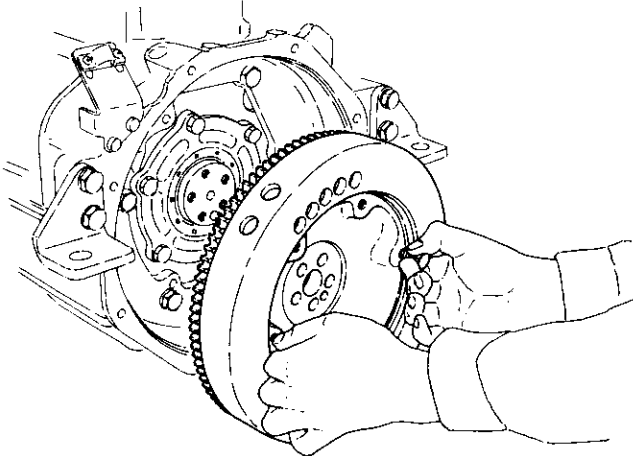
4-3.20 Remove the flywheel

(1) Remove the damper disk

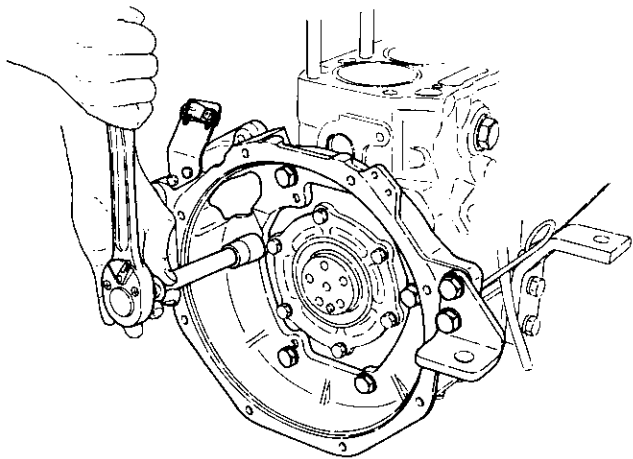


(2) Remove the flywheel

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.

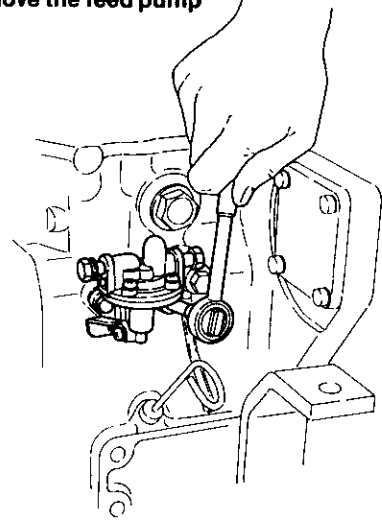


4-3.21 Remove the flywheel housing



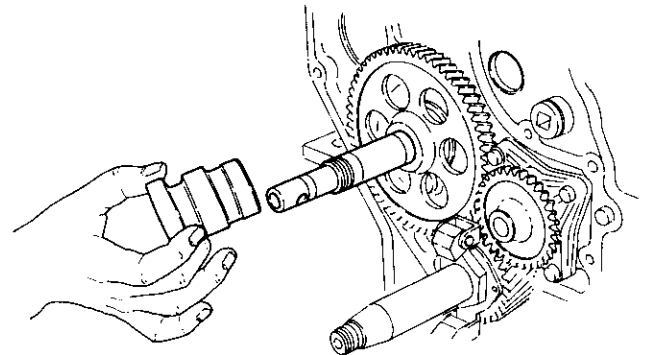
4-3.22 Remove the lubricating oil dipstick

4-3.23 Remove the feed pump

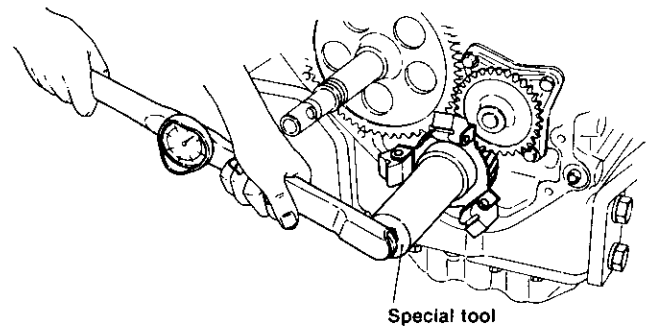


4-3.24 Remove the fuel cam

Remove the camshaft end nut and remove the fuel cam



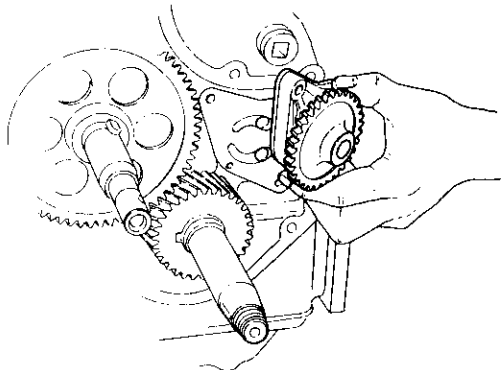
4-3.25 Remove the governor weight assembly



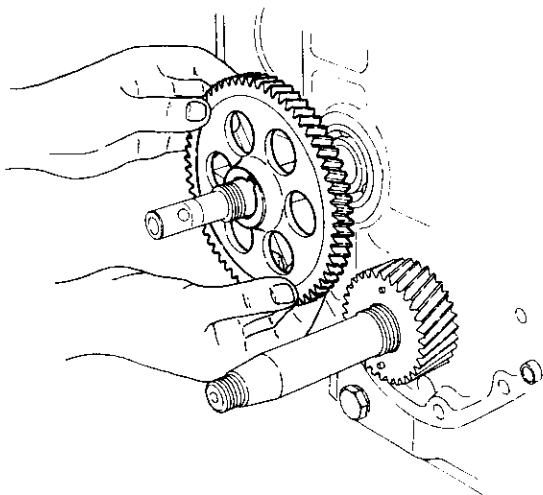
Special tool

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

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



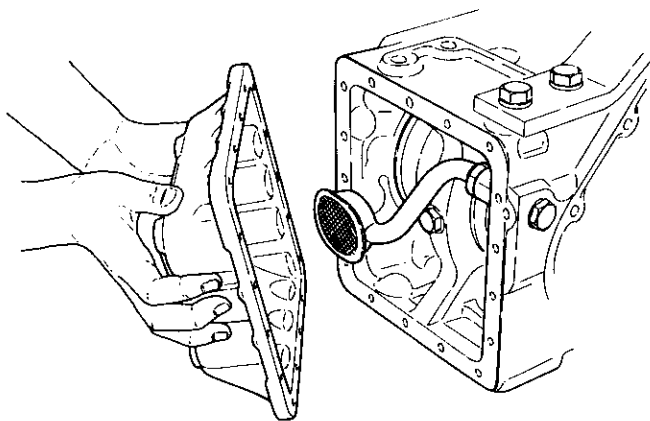
4-3.27 Remove the camshaft gear and the crankshaft gear



4-3.28 Turn the engine onto its side

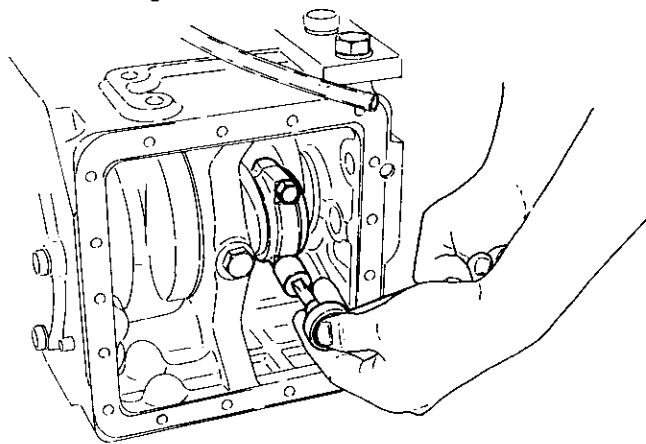
- (1) Remove the engine feet of the crankshaft side
- (2) Turn the cylinder block over so that the crankshaft side is on the bottom.

4-3.29 Remove the oil pan and the oil intake pipe

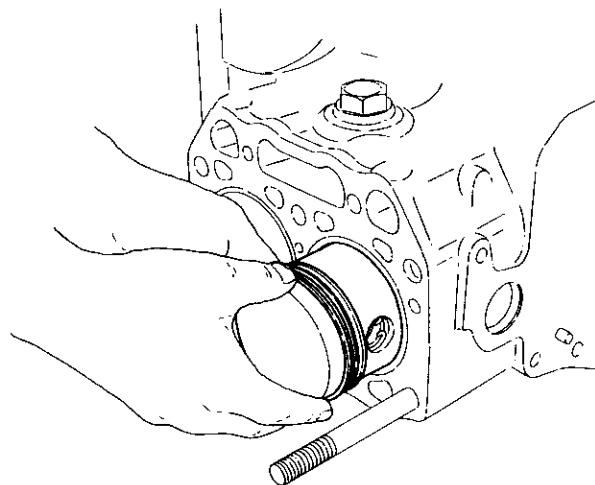


4-3.30 Remove the piston connecting rod assembly

- (1) Set the piston to bottom dead center and remove the connecting rod bolts.

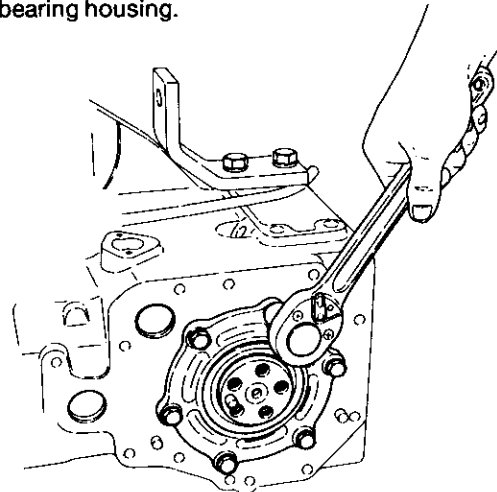


- (2) Set the piston to top dead center, turning the crankshaft so that the connecting rod does not separate from the crank pin. Pull out the piston connecting rod assembly by pushing the large end of the rod with a pusher.

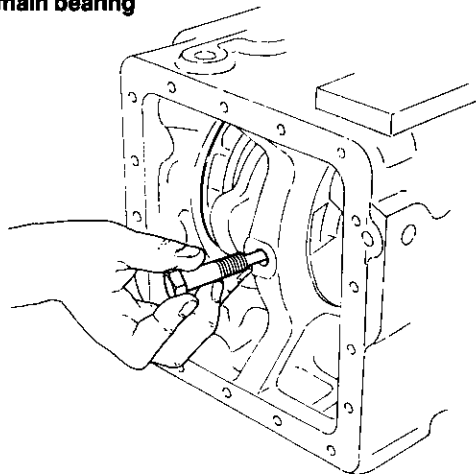


4-3.31 Remove the main bearing housing

- Remove the main bearing housing bolt and remove the main bearing housing.

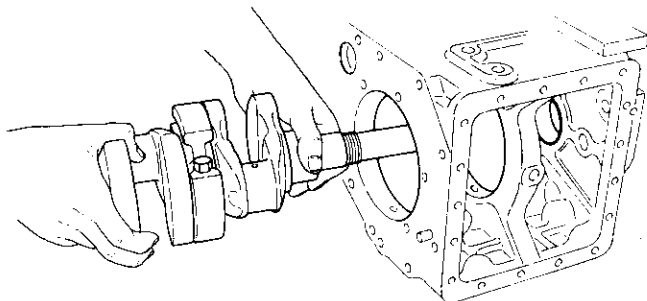


4-3.32 Remove the mounting bolt of the intermediate main bearing



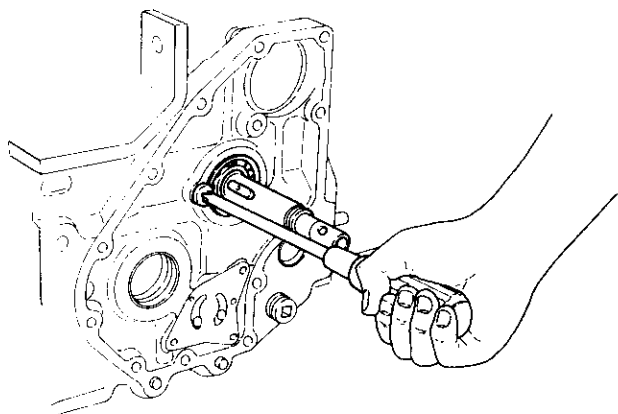
Two intermediate main bearings, viz. No.1 and No.2, for engine model 3GM30(C).

4-3.33 Pull the crankshaft

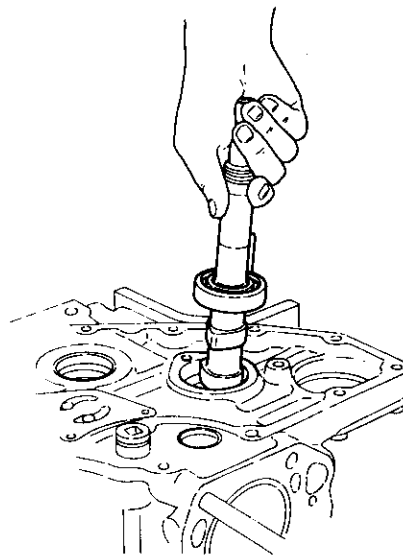


4-3.34 Remove the camshaft

(1) Remove the camshaft bearing set screw.

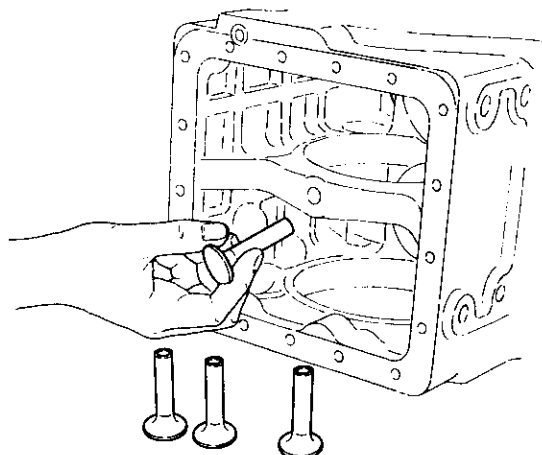


(2) Place the cylinder block upside down or raise the cylinder block by inserting a plate beneath it in order to prevent contact between the tappet and the cam.



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

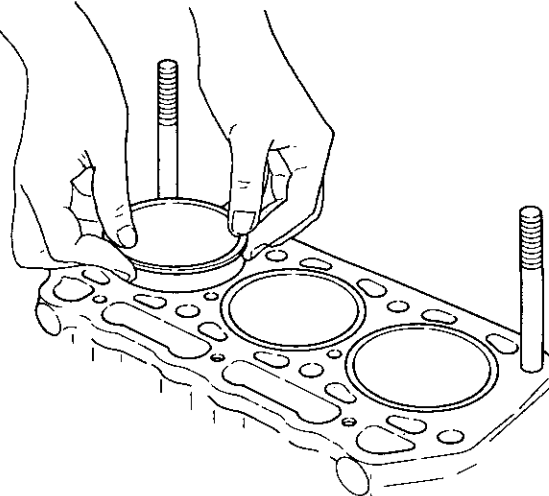
4-3.35 Remove the tappets



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.



5. Reassembly

5.1 General Precautions

Warped washers and packings must necessarily be replaced with new ones.

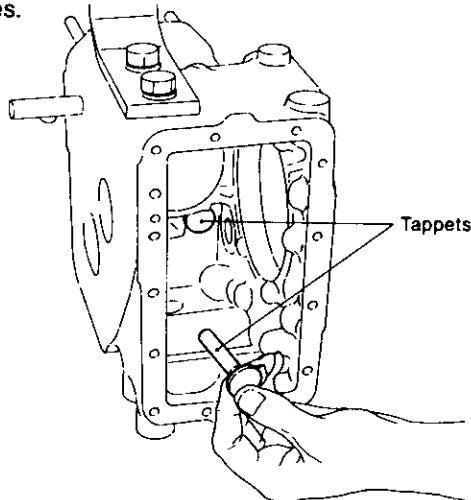
In assembling, sealing must be applied to all designated parts. Omission may cause serious trouble during a trial running of the engine after completion of reassembly. Adjustments should be performed in accordance with the instructions given.

After completion of engine reassembly, recheck any deficiencies which might have appeared during maintenance and inspection, conduct a trial running of the engine and then submit it to the user.

5.2 Reassembly of engine model 1GM10(C)

5-2.1 Insert the tappets

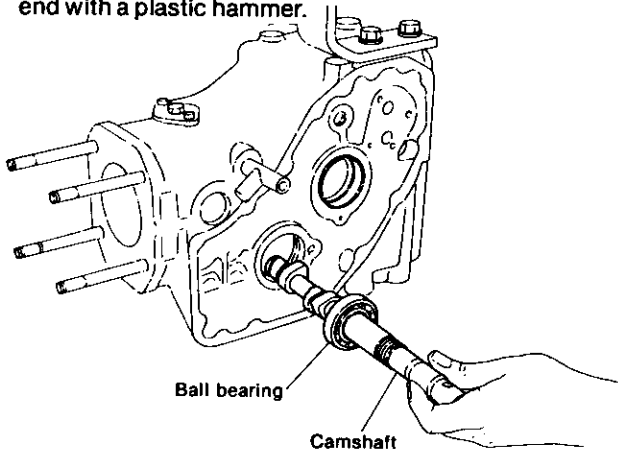
- (1) Turn the cylinder block over or turn it upside down.
- (2) Coat the tappets with oil and insert into the tappet holes.



NOTE: Assemble the tappets at their original positions, paying careful attention to intake and exhaust.

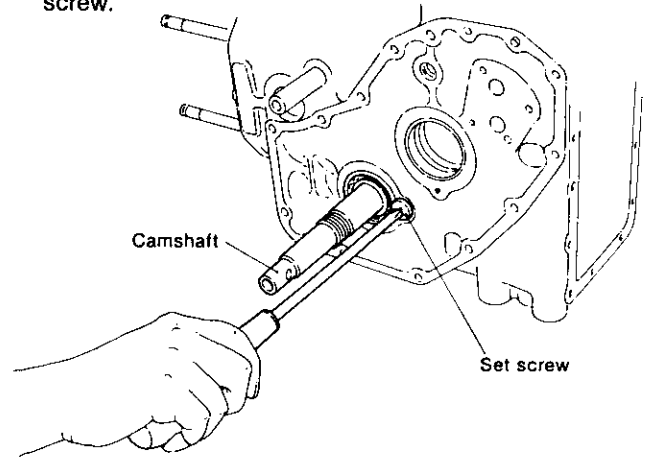
5-2.2 Insert the camshaft

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



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

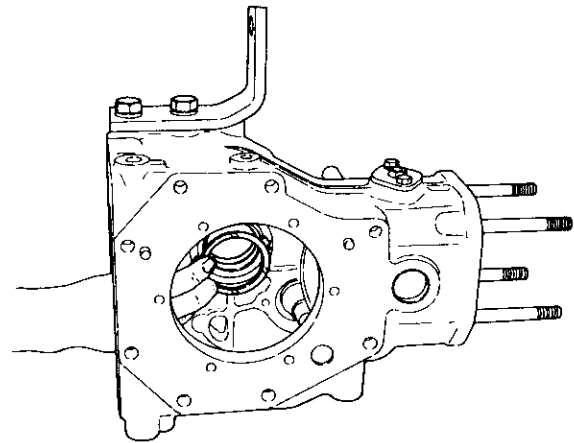
- (2) After inserting the camshaft, check that it rotates smoothly before tightening the camshaft bearing set screw.



Tightening torque	2 kgf-m (14.5 ft-lb)
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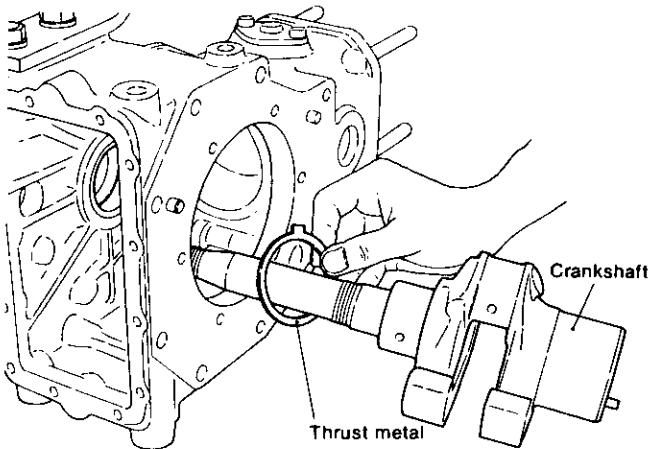
5-2.3 Install the crankshaft

- (1) Coat the cam gear side thrust metal with oil and install.



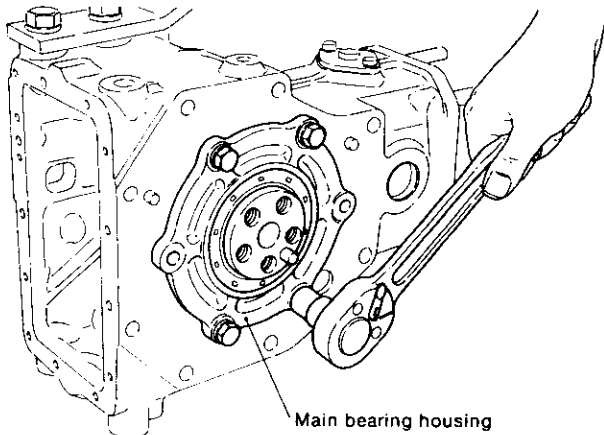
CAUTION: Install so that the thrust metal oil groove is at the crankcase side, being careful not to damage the tab.

(2) Insert the crankshaft



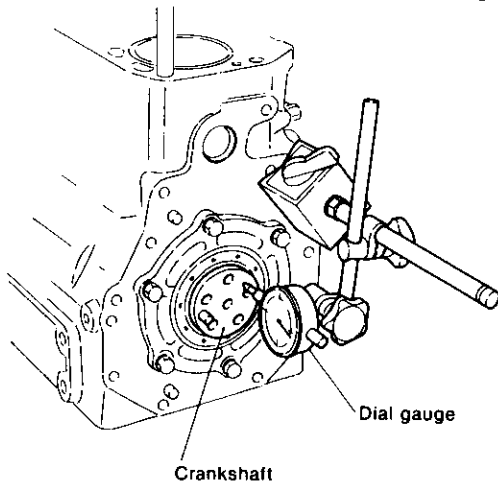
5-2.4 Install the main bearing housing

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



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

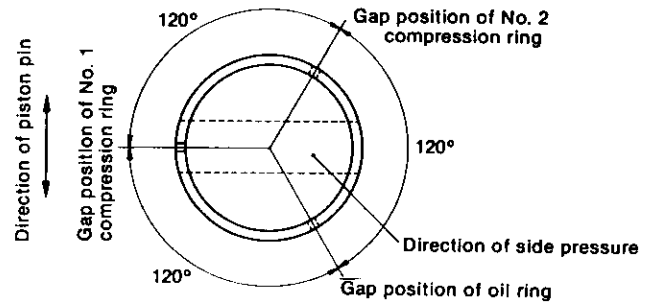
- (3) Check that the crankshaft rotates smoothly
- (4) Measure the crankshaft side gap, and adjust it to the prescribed value by the thickness of the packing.



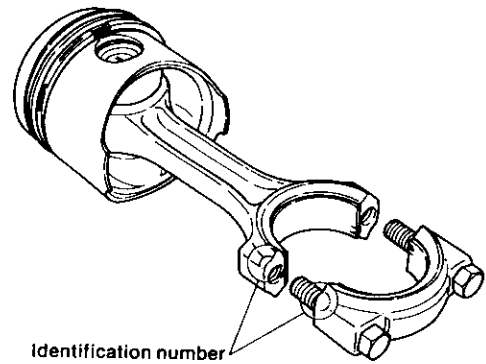
Crankshaft side gap	0.06 ~ 0.19mm (0.0024 ~ 0.0075in.)
---------------------	---------------------------------------

5-2.5 Assemble the piston and connecting rod assembly

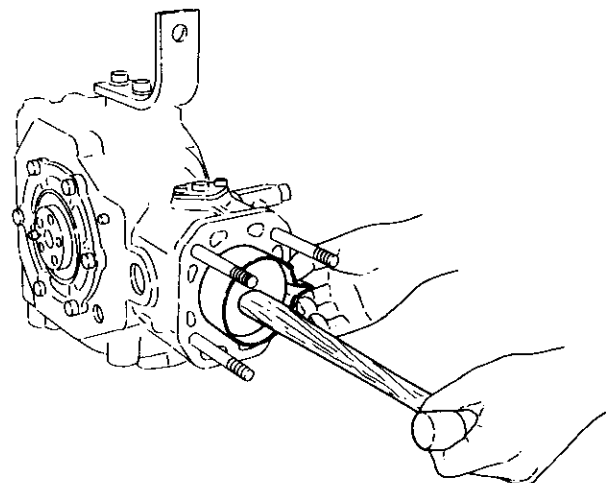
- (1) Coat the crankpin section with oil and position so that the crank is at the top.
- (2) Coat the piston and crankpin bearing with oil.
- (3) Position the piston rings so that the gaps are 120° apart, being sure that there is no gap at the side pressure section.



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

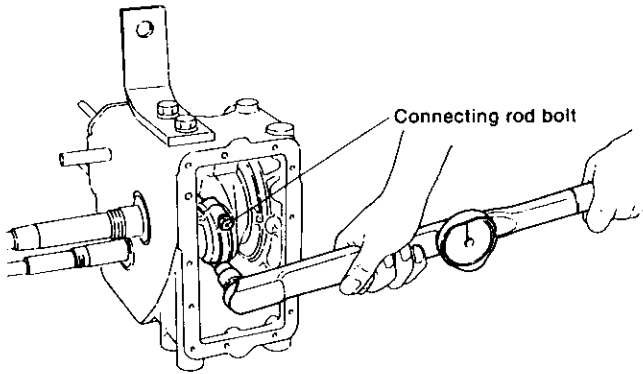


- (5) After the connecting rod large end contacts the crankpin, push the piston crown down slowly to turn the crankshaft to bottom dead center.



(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.



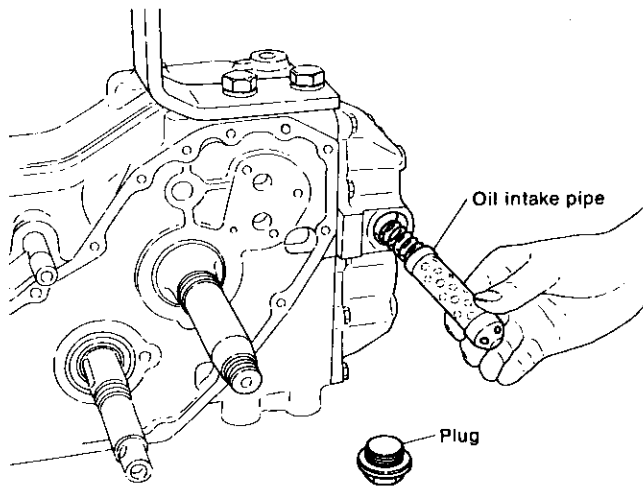
Tightening torque	2.5 kgf-m (18.1 ft-lb)
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(7) Measure the side clearance.

Side clearance	0.2 ~ 0.4mm (0.0079 ~ 0.0157in.)
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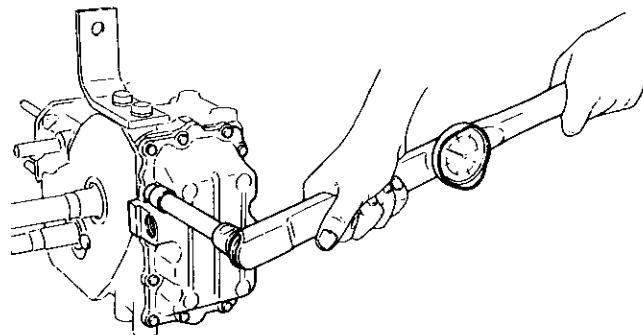
(8) Check that the crankshaft rotates smoothly.

5-2.6 Install the lubricating oil intake pipe to the oil pan



5-2.7 Install the engine bottom cover (oil pan)

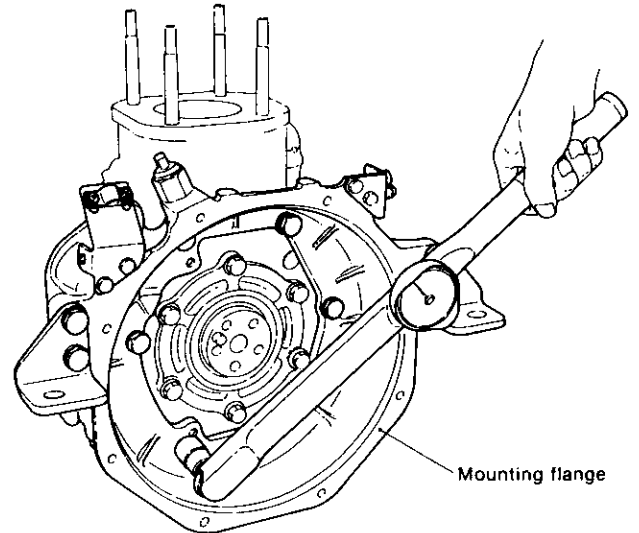
(1) Change the packing.
(2) Install the bottom cover.



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

5-2.8 Install the mounting flange

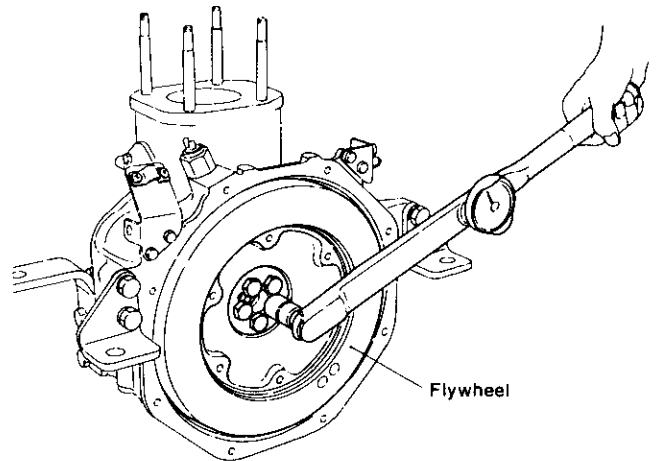
(1) Set the engine upright.
(2) Align the positioning pins and tighten the flange.



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

5-2.9 Install the flywheel

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



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

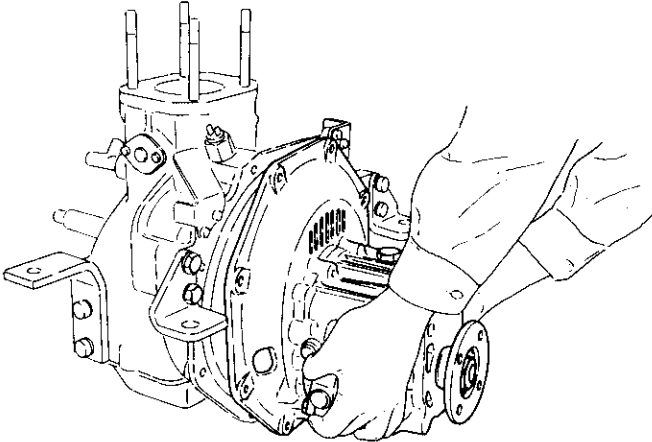
NOTE: After tightening, check the end run-out

5-2.10 Install the clutch assembly

(1) Install the clutch disc on the flywheel

Tightening torque	2.5 kgf-m (18 ft-lb)
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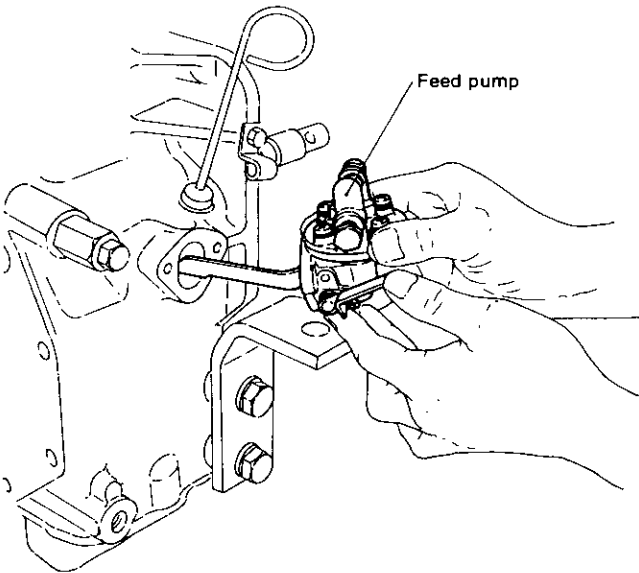
(2) Align the disk and input shaft spline, and install the clutch assembly on the mounting flange.



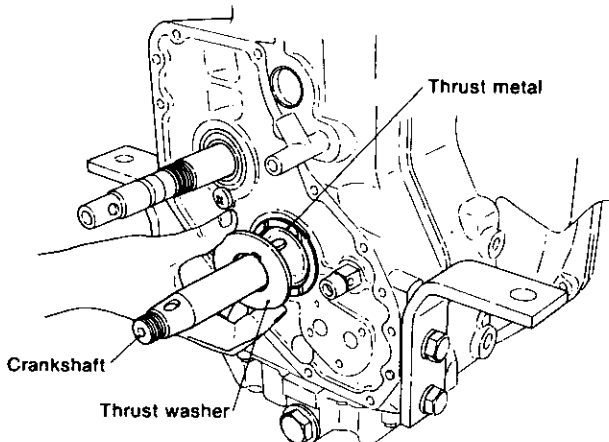
Tightening torque	2 ~ 2.5kgf-m (14.5 ~ 18 ft-lb)
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5-2.11 Install the engine feet and set the engine in position

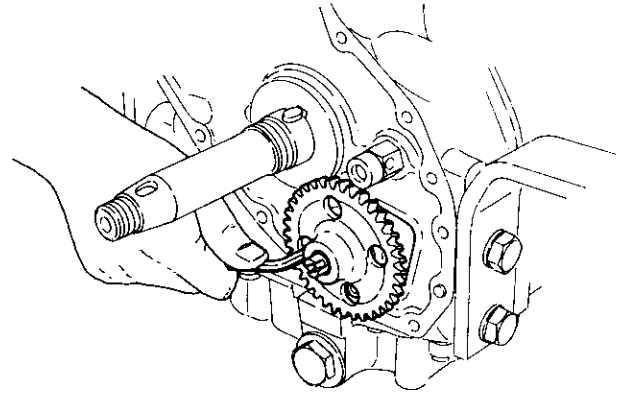
- (1) Dipstick
- (2) Fuel feed pump



5-2.12 Assemble the thrust metal and thrust washer



5-2.13 Install the lubricating oil pump and gear assembly

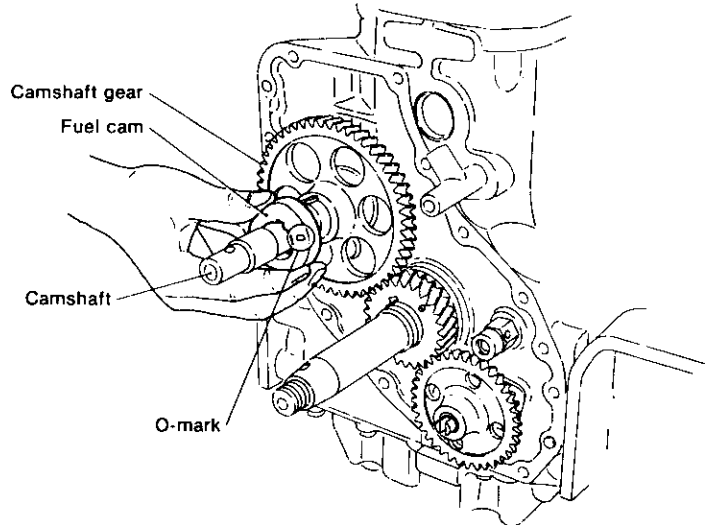


Lube pump body mounting bolt	0.9 kgf-m (6.5 ft-lb)
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5-2.14 Assemble the crankshaft gears

- (1) Coat the crankshaft section and the inside of the gear with oil.
- (2) Insert the crankshaft gear

5-2.15 Assemble the camshaft gear and fuel cam



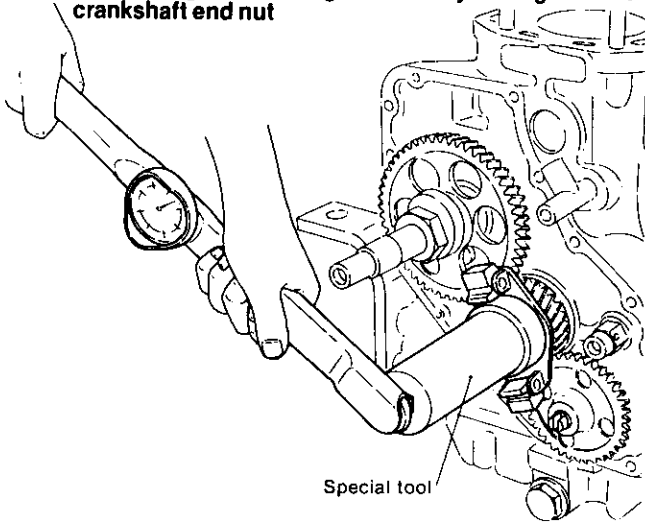
- (1) Coat the shaft hole of the camshaft gear with oil, and align the matching marks of the camshaft gear and the crankshaft gear and insert the camshaft gear.
- (2) Coat the fuel cam with oil and insert the cam by aligning the "0" mark opposite the camshaft gear.
- (3) Tighten the camshaft end nut

Tightening torque	7 ~ 8kgf-m (50.6 ~ 57.9 ft-lb)
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(4) Check the backlash

	mm (in.)	
	Maintenance standard	Wear limit
Crankshaft gear and camshaft gear backlash		
Crankshaft gear and lubrication oil pump driven gear backlash	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)
Camshaft gear and fuel feed pump driven gear backlash		

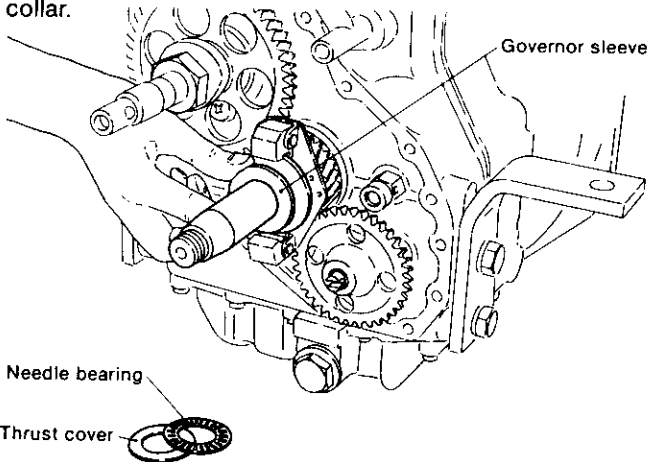
5-2.16 Install the governor weight assembly and tighten the crankshaft end nut



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

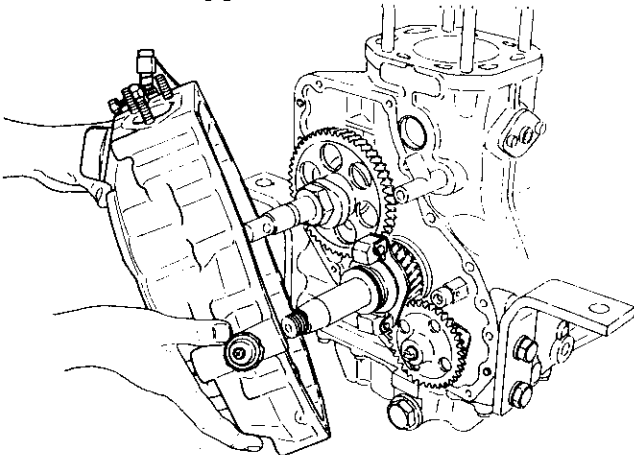
5-2.17 Install the governor sleeve

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



5-2.18 Install the timing gear case

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

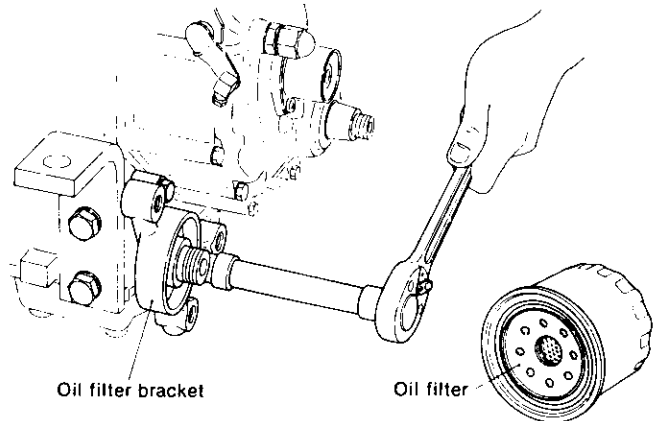


Tightening torque	0.9 kgf-m(6.5 ft-lb)
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- (3) Insert the pin for fitting the handle into the camshaft and fix it by means of the bolt with the hexagonal socket head, then fit the starting shaft cover.

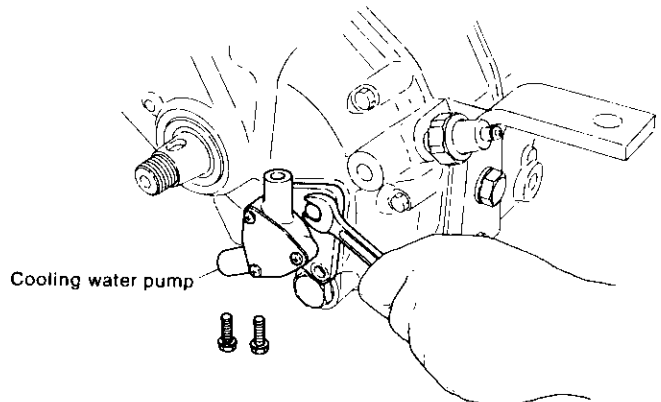
5-2.19 Install the oil filter and bracket

- (1) Install the oil filter bracket on the gear side of the cylinder block.
- (2) Install the oil pipes.
- (3) Install the oil filter.



5-2.20 Install the water pump

- (1) Install the water pump



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

- (2) Install the water pipe (pump to cylinder inlet joint)

5-2.21 Install the crankshaft V-pulley

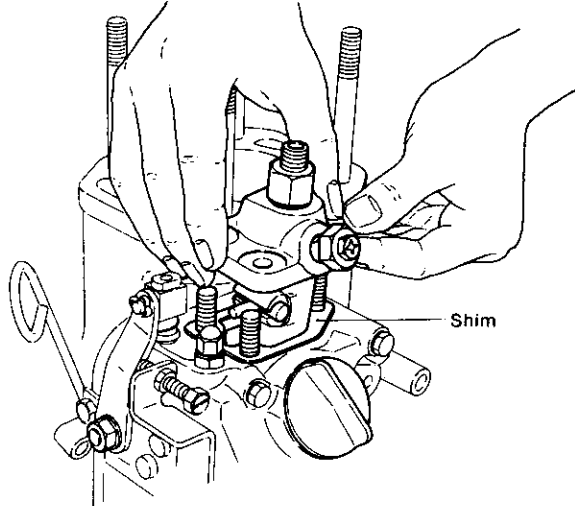
- (1) Install the crankshaft key
- (2) Coat the crankshaft V-pulley and the inside of the oil seal with oil.
- (3) Insert and tighten the V-pulley, making sure that the lip of the oil seal is not distorted.

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

5-2.22 Install the fuel injection pump

- (1) Remove grease from both sides of the fuel injection timing adjustment shims with thinner, and coat the shims with "Screw Lock Super 203M."

- (2) Insert the pump by looking through the oil filler and align the governor No.2 lever and rack connecting part.



- (3) Tighten the fuel pump

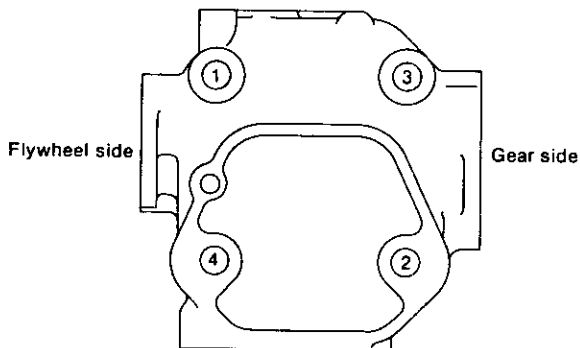
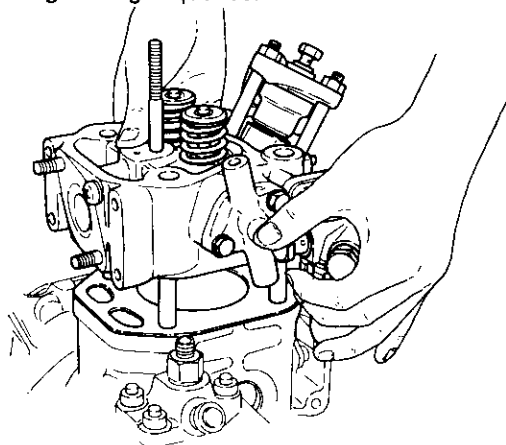
Tightening torque	2.5 kgf-m (18 ft-lb)
-------------------	----------------------

5-2.23 Install the cylinder head

- (1) Install the gasket packing

CAUTION: Take particular note of the fitting surfaces. Fit the side with the recessed part of the cooling water passage to the cylinder block 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.

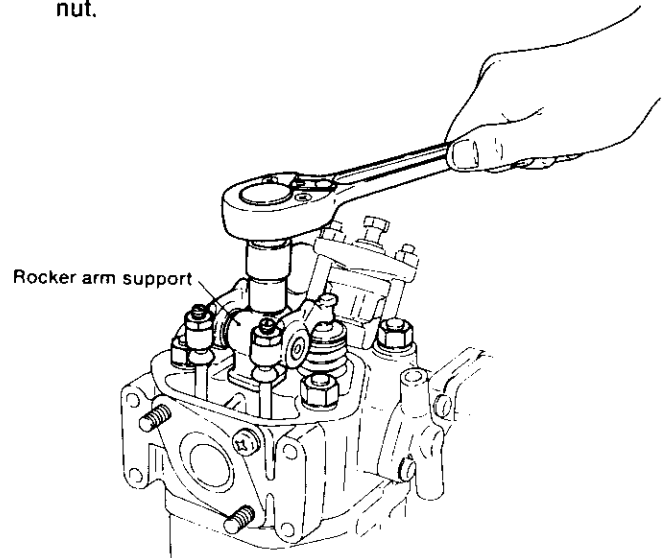


Tightening torque	7.5 kgf-m (54.2 ft-lb)
-------------------	------------------------

- (3) Install the water pipe (from the thermostat cover to the cylinder inlet joint)

5-2.24 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 kgf-m (27 ft-lb)
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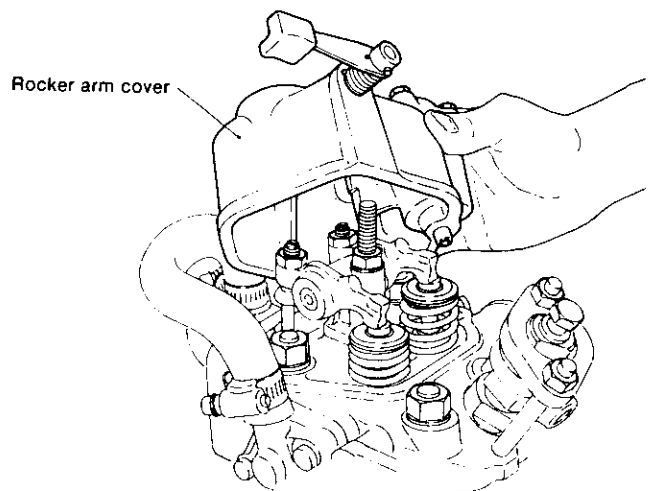
CAUTION: 1. Loosen the valve head clearance adjusting screw in advance.

2. Check that the arm moves smoothly.

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

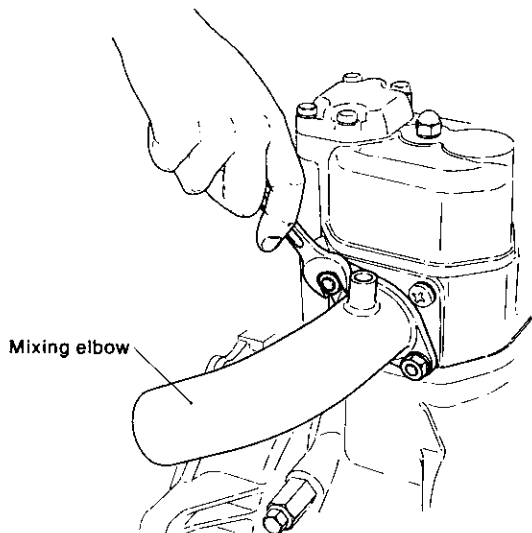
Intake and exhaust valve head clearance (engine cold):	0.2mm (0.008in.)
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5-2.25 Install the rocker arm cover



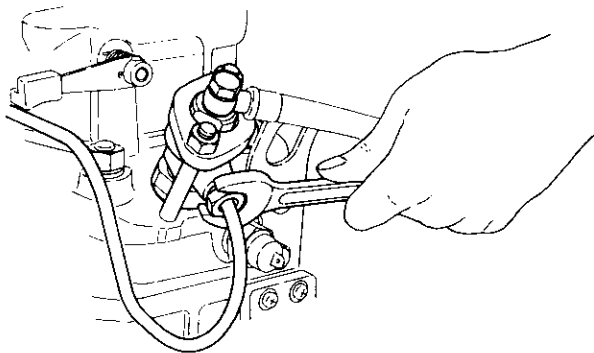
5-2.26 Install the mixing elbow

(1) Install the mixing elbow



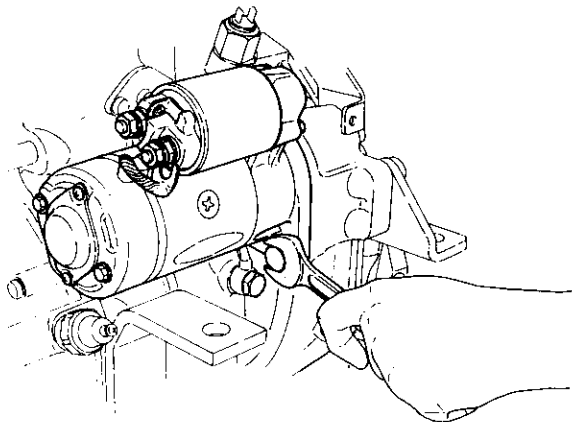
(2) Install the cooling water bypass hose
(from the mixing elbow to the thermostat cover)

5-2.27 Install the fuel pipe



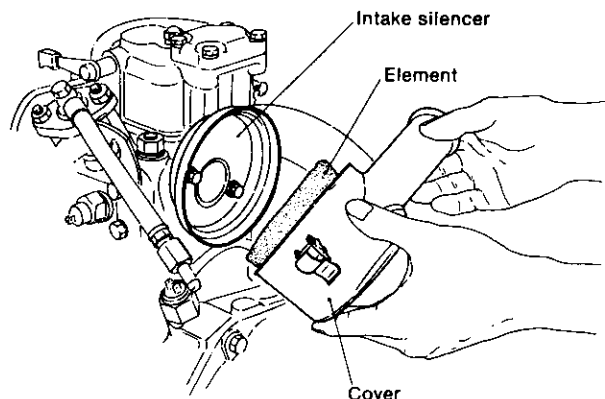
- (1) Install the feed pump to fuel filter pipe
- (2) Install the fuel filter to fuel injection pump pipe
- (3) Install the fuel high pressure pipe
- (4) Install the fuel return pipe

5-2.28 Install the starter motor



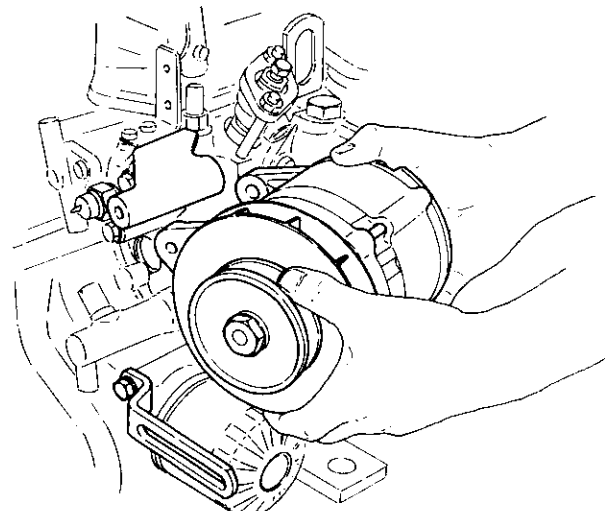
5-2.29 Install the intake silencer

- (1) Install the intake silencer cover to the intake port.
- (2) Install the intake silencer and tighten it with the clip.



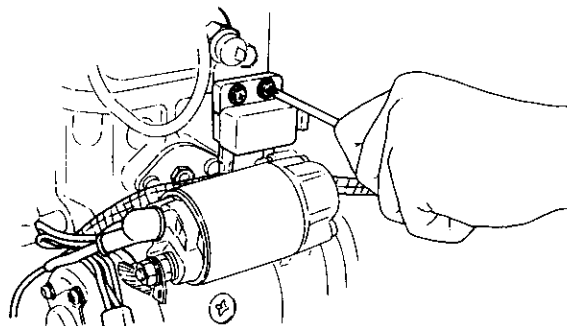
5-2.30 Install the alternator

(1) Install the alternator to the bracket.



(2) Install the V-belt and tighten the adjusting bolt while adjusting the V-belt tension.

5-2.31 Connect the electrical wiring



5-2.32 Install the remote control cables

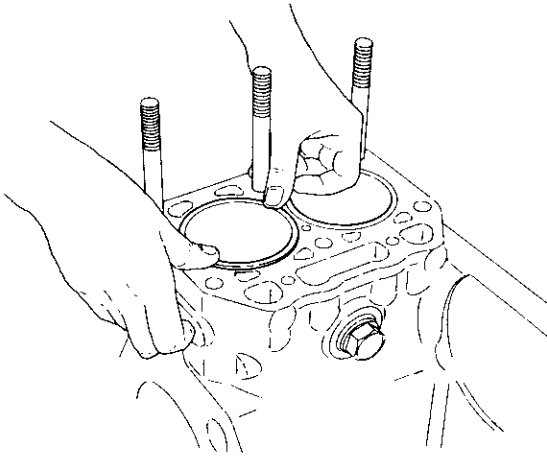
5-2.33 Connect the interior piping

5.3 Reassembly of engine models 2GM20(C) and 3GM30(C)

Refer to the model 3GM30(C) instructions, as the models 3HM35(C) and 3GM30(C) are almost the same.

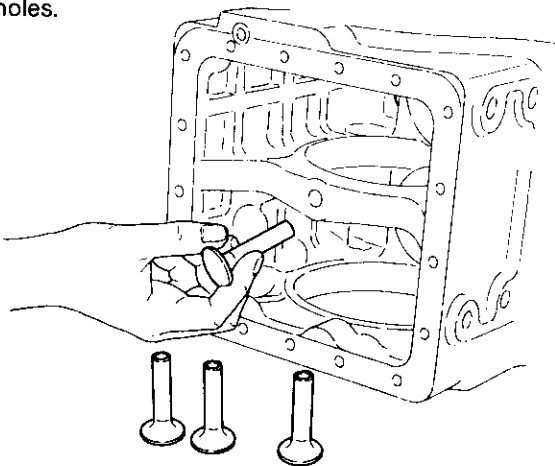
5-3.1 Assemble the cylinder liners

- (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 to check that the cylinder liner protrusion is correct.



5-3.2 Insert the tappets

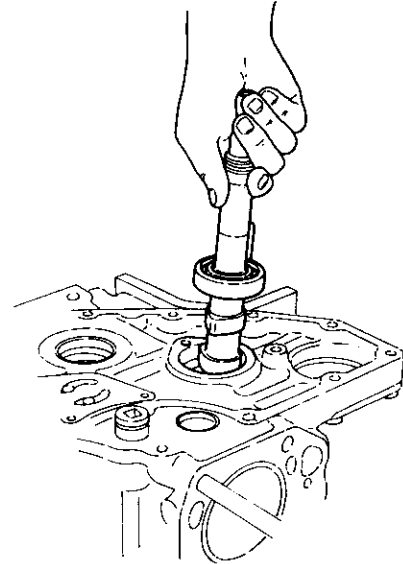
- (1) Turn the cylinder block over or turn it upside down.
- (2) Coat the tappets with oil and insert into the tappet holes.



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

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.

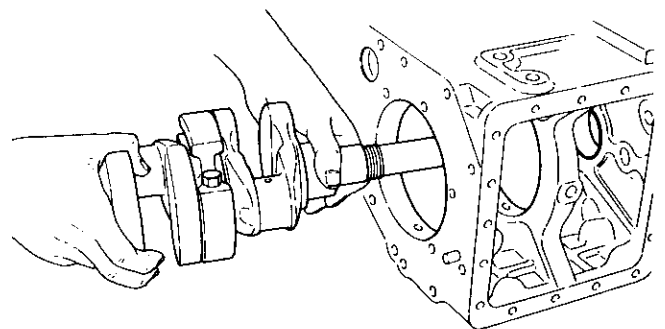


NOTE: Be careful not to damage the groove in the end of the shaft.

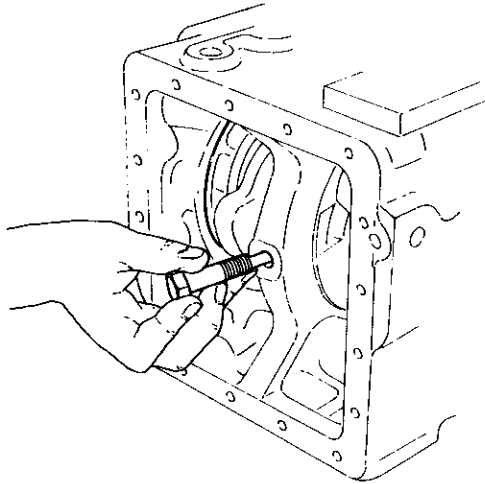
- (2) After inserting the camshaft, check that it rotates smoothly before tightening the camshaft bearing set screw.

Tightening torque	2 kgf-m (14.5 ft-lb)
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5-3.4 Install the crankshaft



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

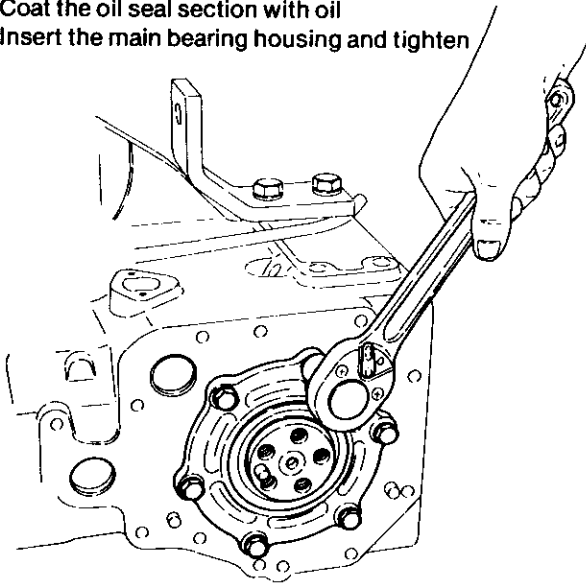


The two intermediate main bearings, viz No.1 and No.2, for model 3GM30(C).

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

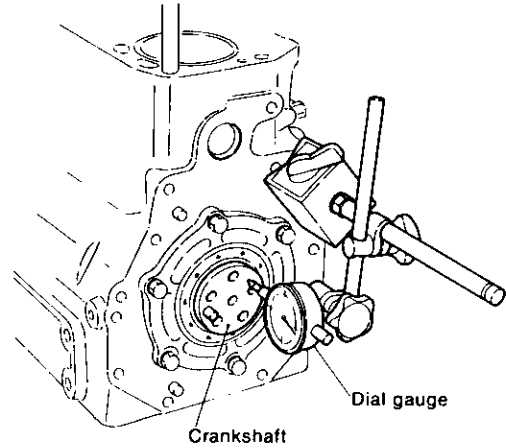
- (1) Coat the oil seal section with oil
- (2) Insert the main bearing housing and tighten



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

- (3) Check that the crankshaft rotates smoothly

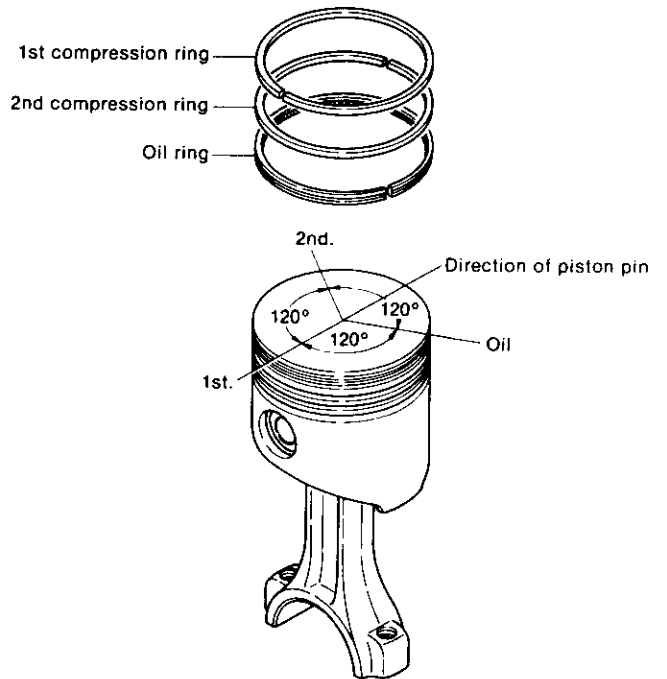
- (4) Measure the crankshaft side gap, and adjust it to the prescribed value by the thickness of the packing.



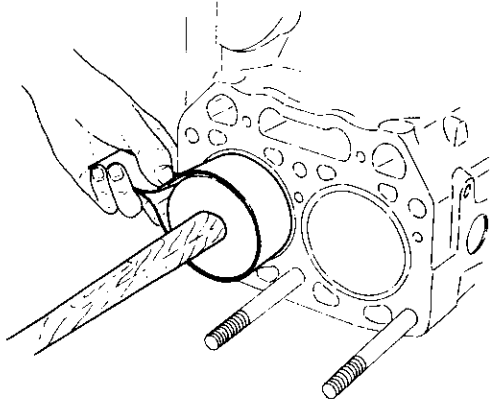
Crankshaft side gap	0.09 ~ 0.18mm (0.035 ~ 0.0071in.)
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5-3.7 Assemble the piston and connecting rod assembly

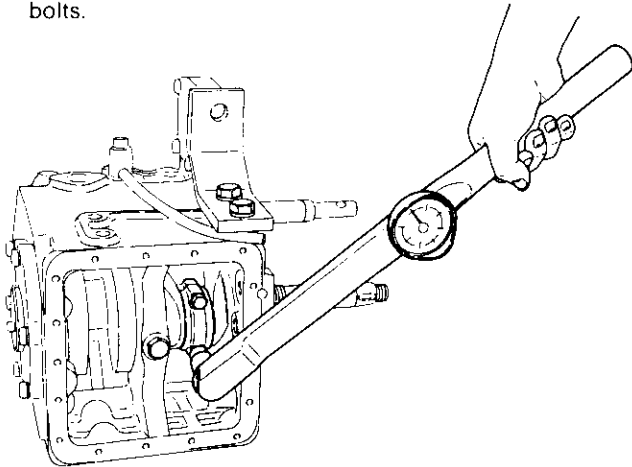
- (1) Coat the crankpin section with oil and position so that the insertion side crank is at the top.
- (2) Coat the piston and crankpin bearing with oil.
- (3) Position the piston rings so that the gaps are 120° apart, being sure that there is no gap at the side pressure section.



- (4) Insert the piston connecting rod assembly so that the side of the connecting rod big 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 with the crankpin, push the piston crown down slowly to turn the crankshaft to bottom dead center.
(6) Align the connecting rod cap and the 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.

	kgf-m (ft-lb)	
	2GM20(C), 3GM30(C)	3HM35(F)
Tightening torque	2.5(18.1)	4.5(32.5)

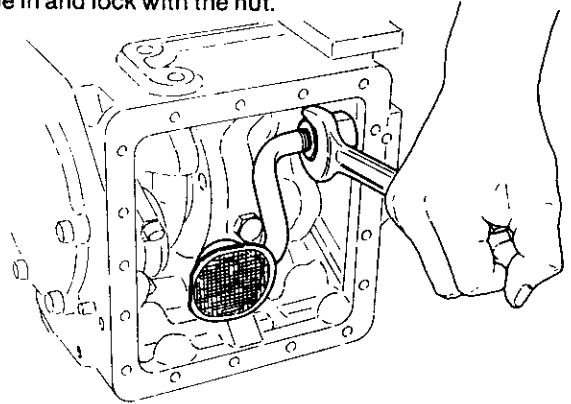
- (7) Measure the side clearance

Side clearance	0.2 ~ 0.4mm (0.0079 ~ 0.0157in.)
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- (8) Check that the crankshaft rotates smoothly

5-3.8 Install the lubricating oil intake pipe

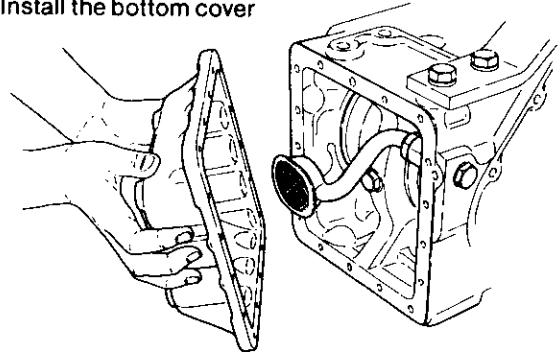
Coat the threads with "Screw Lock Super 203M", screw the pipe in and lock with the nut.



Screw-in distance	8 ~ 10mm (about 6 turns) (0.3149 ~ 0.3937in.)
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5-3.9 Install the engine bottom cover (oil pan)

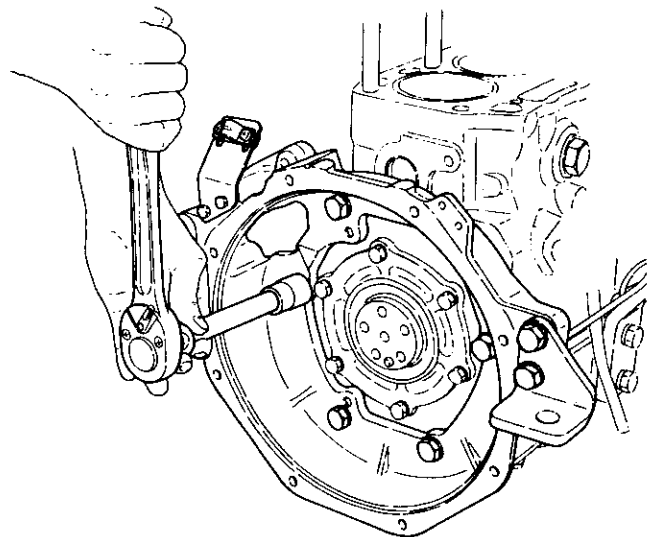
- (1) Change the packing
(2) Install the bottom cover



Tightening torque	0.9 kgf-m (8.5 ft-lb)
-------------------	-----------------------

5-3.10 Install the mounting flange

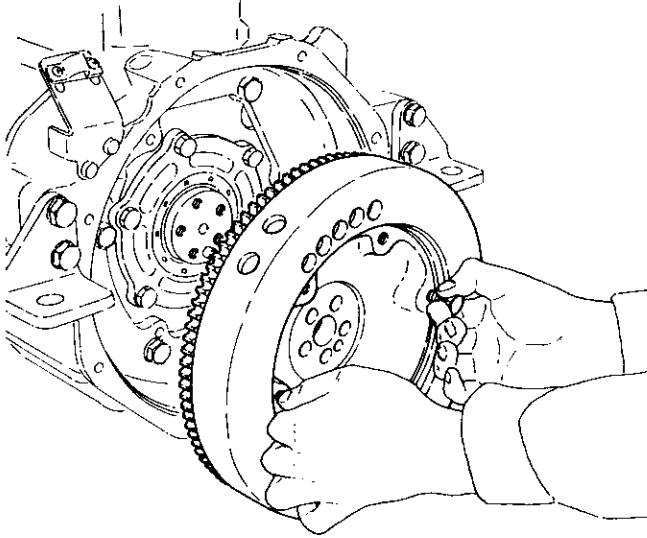
- (1) Set the engine upright
(2) Align the positioning pins and tighten the flange



Tightening torque	4.5 kgf-m (32.5 ft-lb)
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5-3.11 Install the flywheel

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

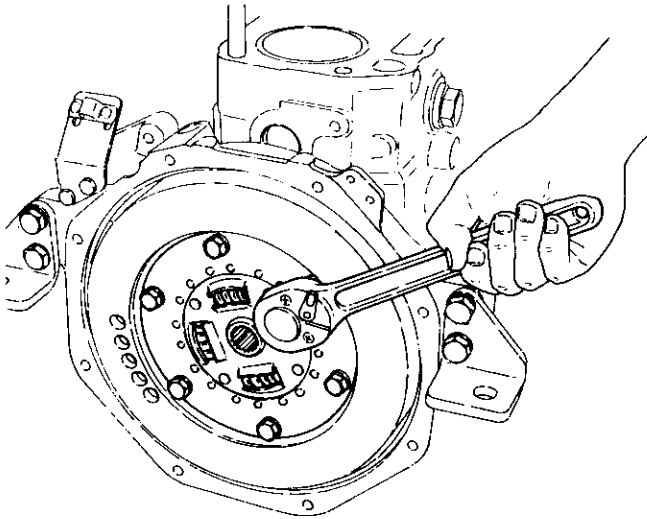


Tightening torque	6.5 ~ 7.0 kgf-m (47 ~ 50.6 ft-lb)
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NOTE: After tightening, check the end run-out

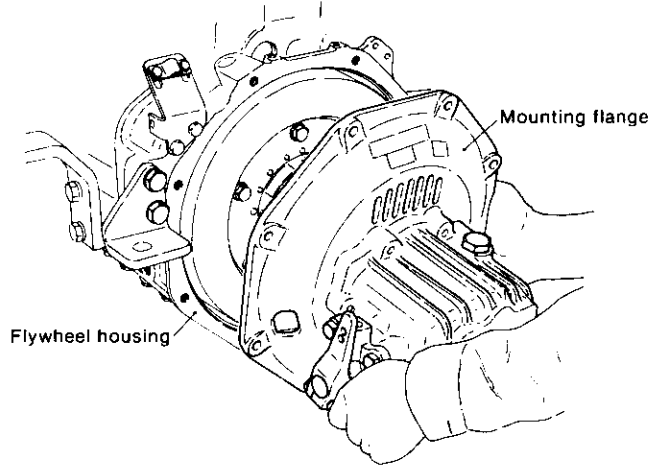
5-3.12 Install the clutch assembly

- (1) Install the clutch disc on the flywheel



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

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



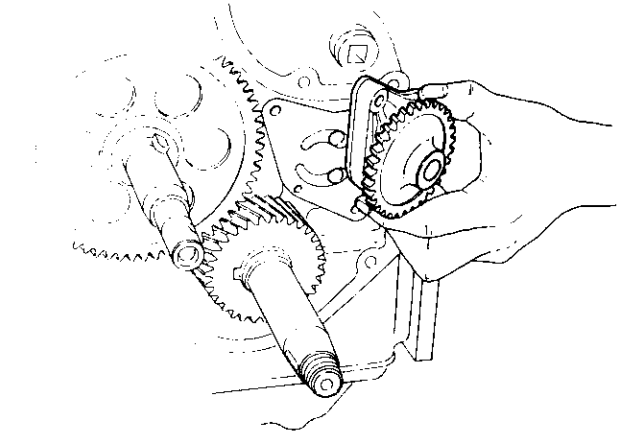
Tightening torque	2.0 ~ 2.5kgf-m(14.5 ~ 18.1 ft-lb)
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5-3.13 Install the engine feet and set the engine in position

- (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.

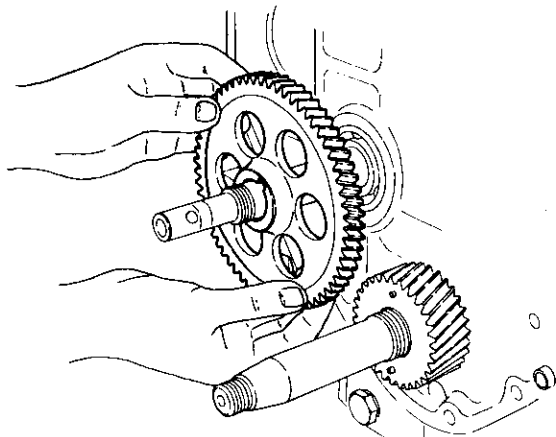


Lube pump body mounting bolt	0.9 kgf-m(6.5 ft-lb)
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5-3.15 Assemble the camshaft gear and fuel cam

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

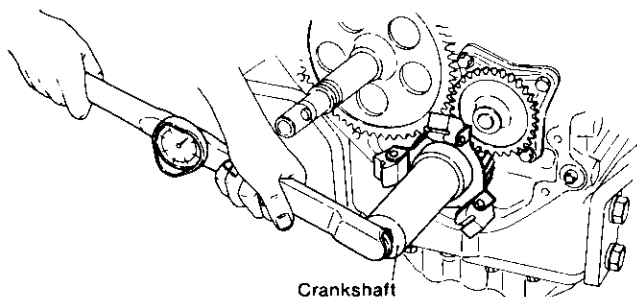
- (2) Coat the fuel cam with oil and insert the cam by aligning the "0" mark opposite the camshaft gear.



- (3) Tighten the camshaft end nut.

Tightening torque	7~8kgf-m(50.6~57.9ft-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.

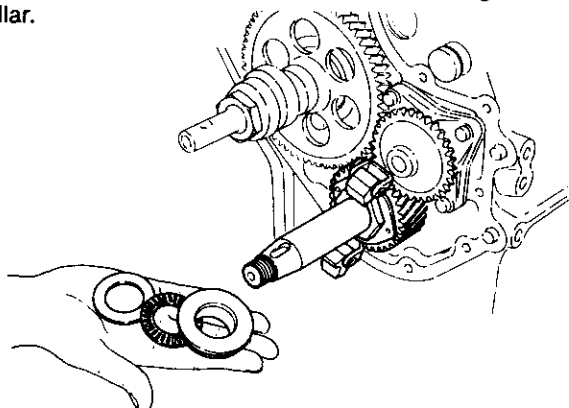
Backlash	0.05~0.13mm (0.0020~0.0051in.)
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- (4) Install the governor weight assembly and tighten the crankshaft end nut.

Tightening torque	8~10kgf-m(57.9~72.3ft-lb)
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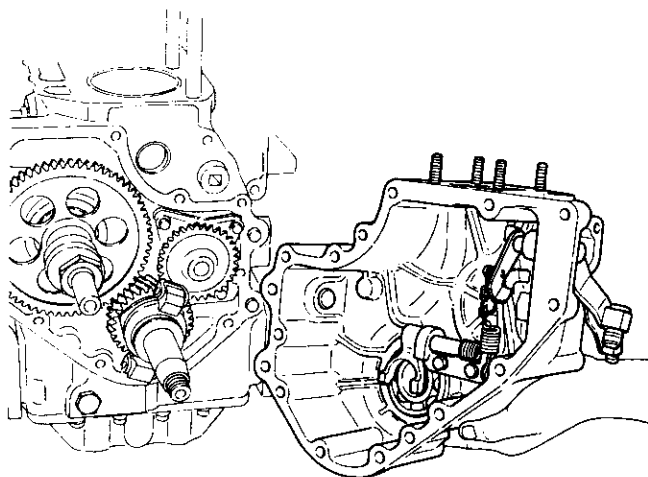
5-3.17 Install the governor sleeve

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



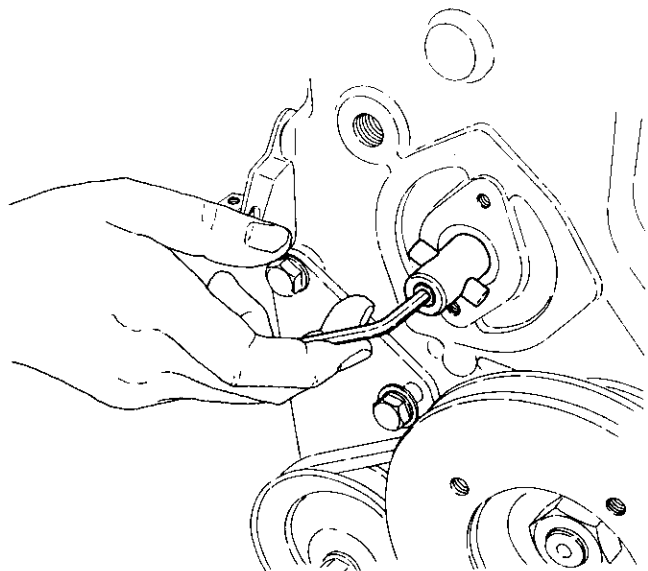
5-3.18 Install the timing gear case

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



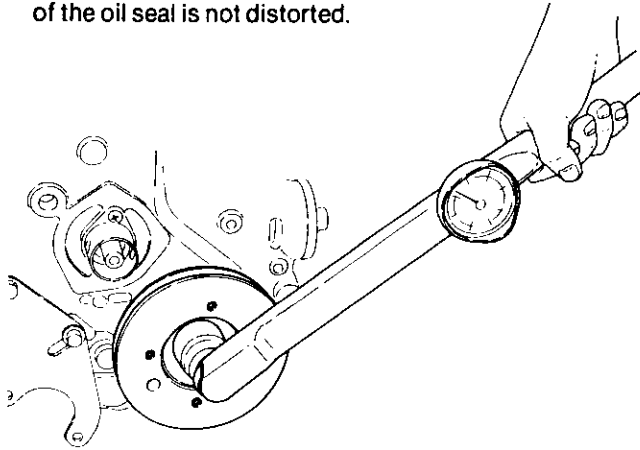
Tightening torque	2.5kgf-m(18ft-lb)
-------------------	-------------------

- (3) Insert the pin for fitting the handle into the camshaft and fix it by means of the bolt with the hexagonal socket head, then fit the starting shaft cover.



5-3.19 Install the crankshaft V-pulley

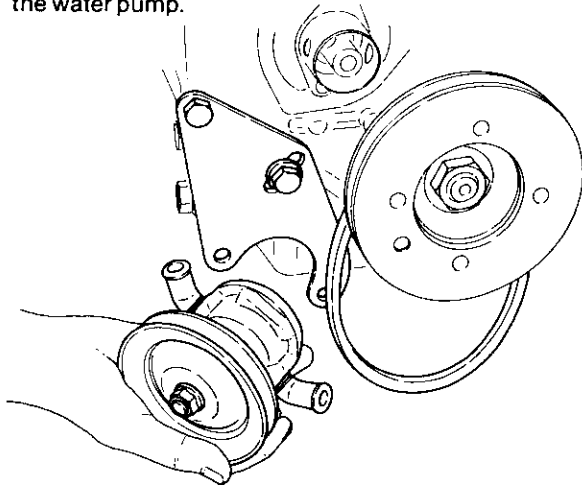
- (1) Install the crankshaft key
- (2) Coat the crankshaft V-pulley and the inside of the oil seal with oil.
- (3) Insert and tighten the V-pulley, making sure that the lip of the oil seal is not distorted.



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

5-3.20 Install the water pump

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



- (2) Tighten while adjusting the V-belt tension

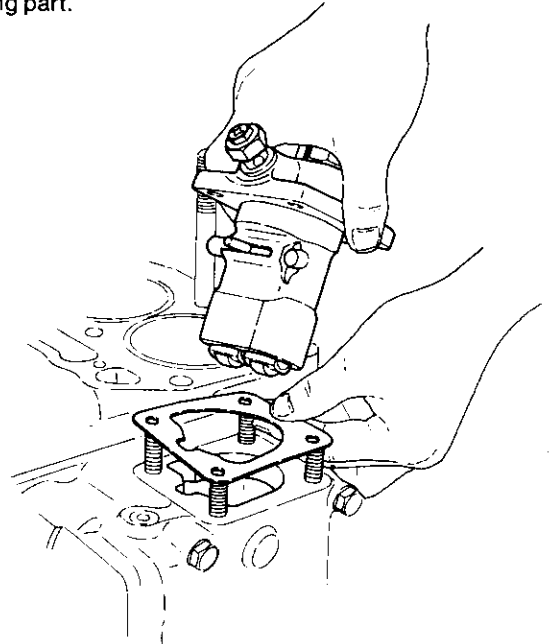
Tightening torque	2.5kgf-m(18ft-lb)
-------------------	-------------------

- (3) Install the water pipe (pump to cylinder inlet joint)

5-3.21 Install the fuel injection pump

- (1) Remove grease from both sides of the fuel injection timing adjustment shims with thinner, and coat the shims with "Screw Lock Super 203M."

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



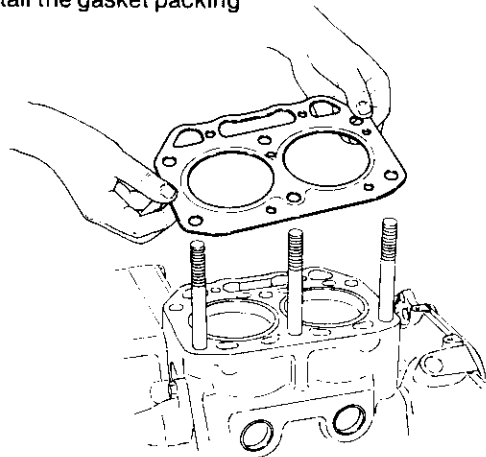
- (3) Tighten the fuel pump

Tightening torque	2.5kgf-m(18ft-lb)
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- (4) Install the gear case side cover

5-3.22 Install the cylinder head

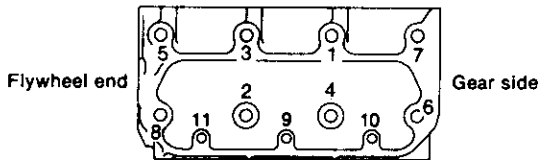
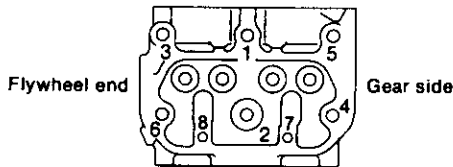
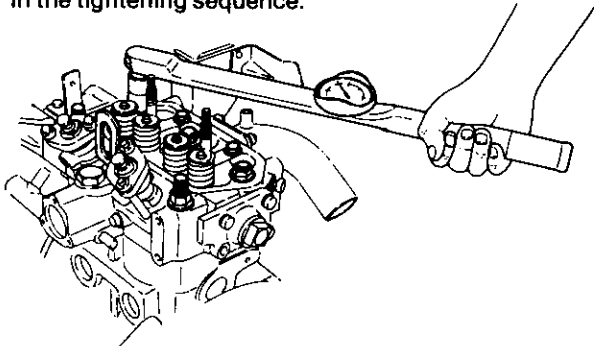
- (1) Install the gasket packing



CAUTION: Take particular notice of the surfaces to be fitted.

Fit it keeping the TOP mark to 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.

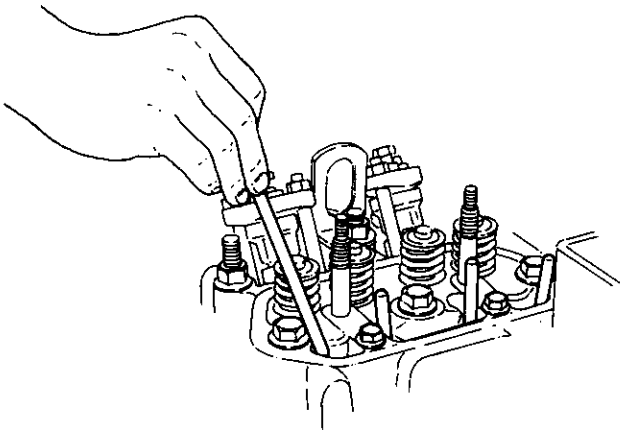


		kgf-m(ft-lb)	
		2GM20(C), 3GM30(C)	3HM35(C)
Tightening torque	Main(M12)	12.0(86.8)	13(94.0)
	Sub(M8)	3.0(21.7)	3(21.7)

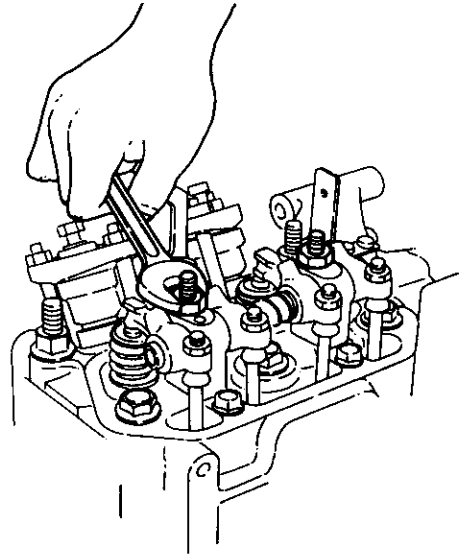
(3) Install the water pipe
(from the thermostat cover to the cylinder inlet joint)

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	3.7kgf-m(27ft-lb)
-------------------	-------------------

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

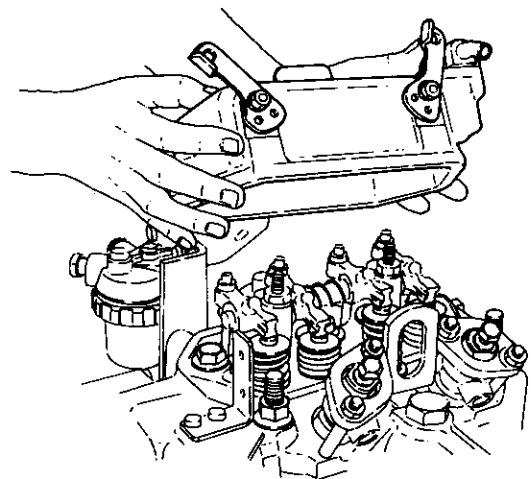
2. Check that the arm moves smoothly.

(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.)
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5-3.24 Install the rocker arm cover

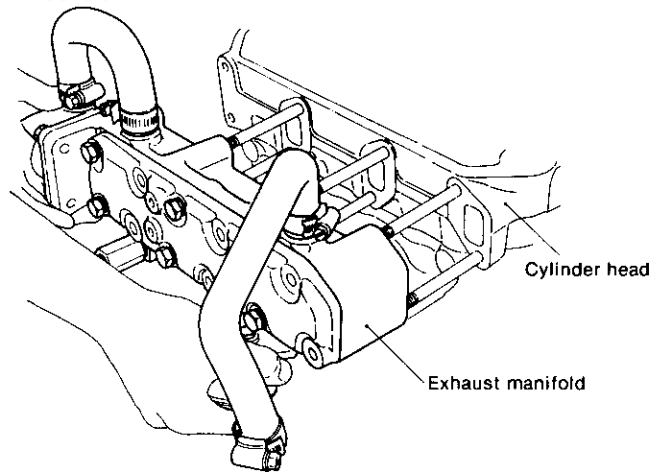
(1) Install the rocker arm cover



(2) Install the breather pipe to the air intake pipe [intake manifold . . . 3GM30(C).]

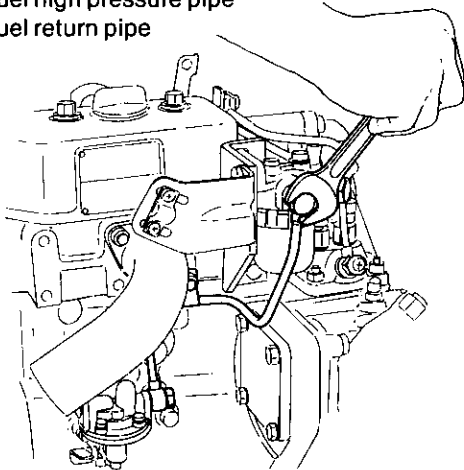
5-3.25 Install the exhaust manifold (only for 3-cylinder engine) and the mixing elbow

- (1) Install the exhaust manifold with mixing elbow [3GM30(C)].
- (2) Install the mixing elbow. [2GM20(C)].
- (3) Install the cooling water bypass hose to the thermostat cover.

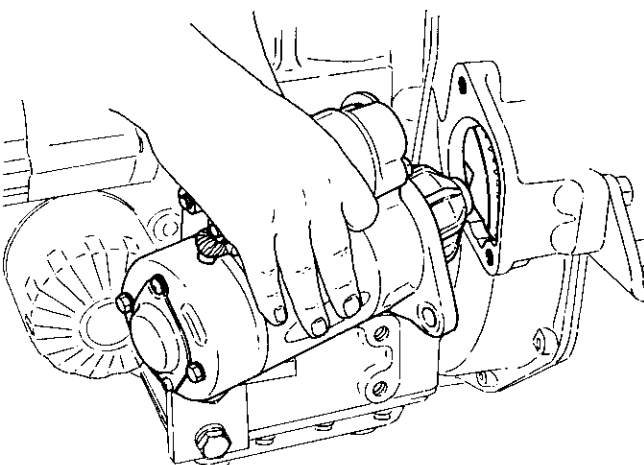


5-3.26 Install the fuel pipe

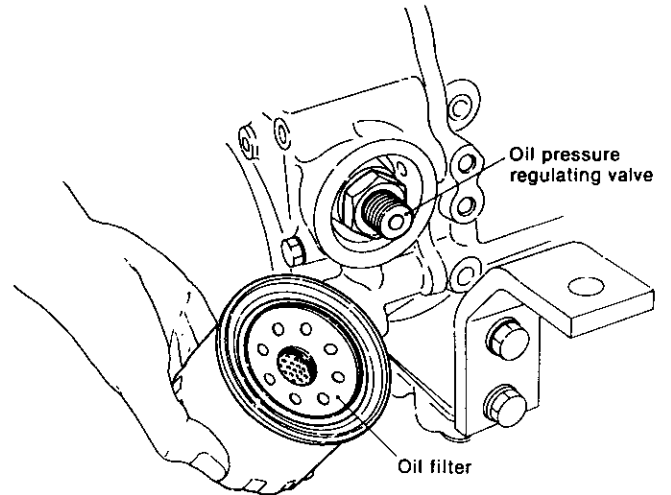
- (1) Install the feed pump to fuel filter pipe
- (2) Install the fuel filter to fuel injection pump pipe
- (3) Install the fuel high pressure pipe
- (4) Install the fuel return pipe



5-3.27 Install the starter motor

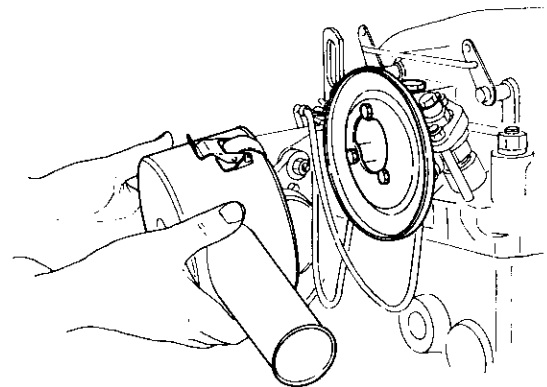


5-3.28 Install the oil filter



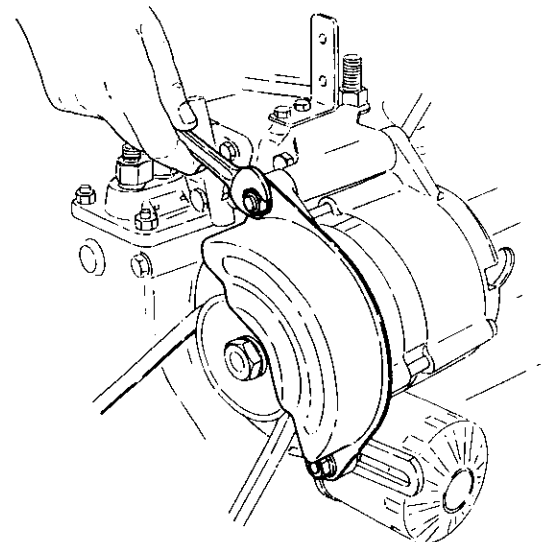
5-3.29 Install the intake silencer

- (1) Install the intake silencer cover to the air intake pipe. [intake manifold . . . 3GM30(C)].
- (2) Install the intake silencer and tighten it with the clip



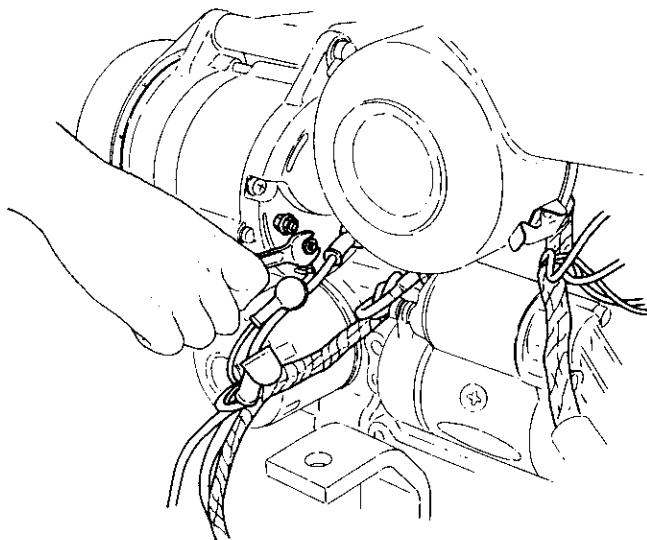
5-3.30 Install the alternator

- (1) Install the alternator to the bracket

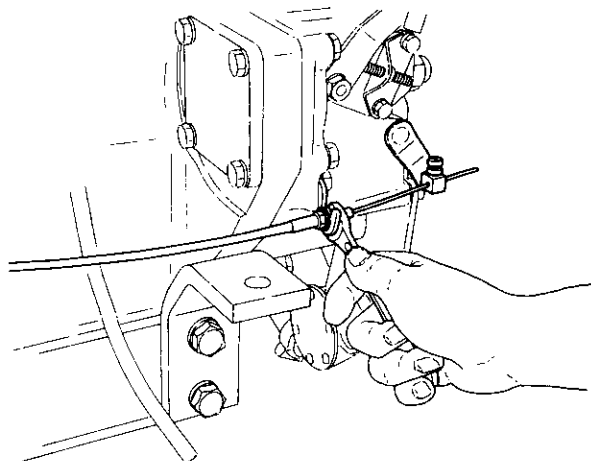


- (2) Install the V-belt and tighten the adjusting bolt while adjusting the V-belt tension.

5-3.31 Connect the electrical wiring



5-3.32 Install the remote control cables



5-3.33 Connect the interior piping

CHAPTER 15

DISASSEMBLY AND REASSEMBLY (Fresh Water Cooling Engine)

1. Disassembly of Fresh Water-Cooled Engine	15-1
2. Reassembly of Fresh Water-Cooled Engine	15-11
3. Tightening Torque	15-21
4. Packing Supplement and Adhesive Application Point	15-24

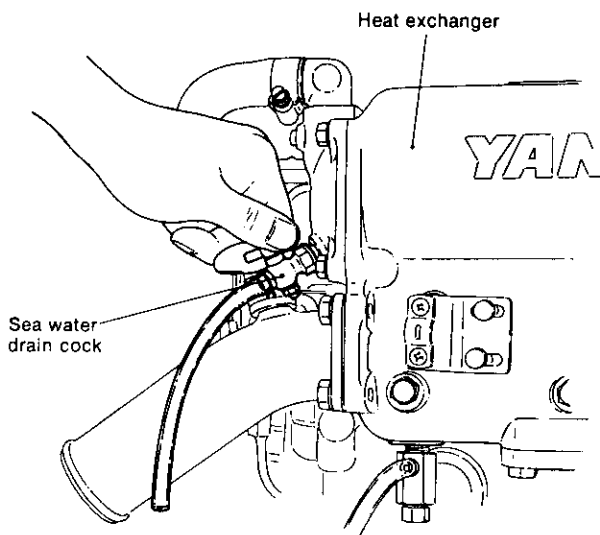
1. Disassembly of Fresh Water-Cooled Engine

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

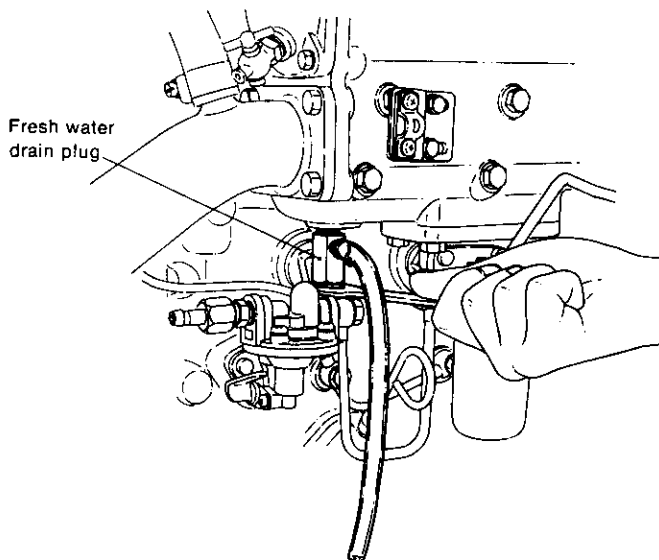
cooling water system are slightly different. Refer to the disassembly section of the sea water-cooled engine manual for the latter steps.

1-1. Draining the cooling water

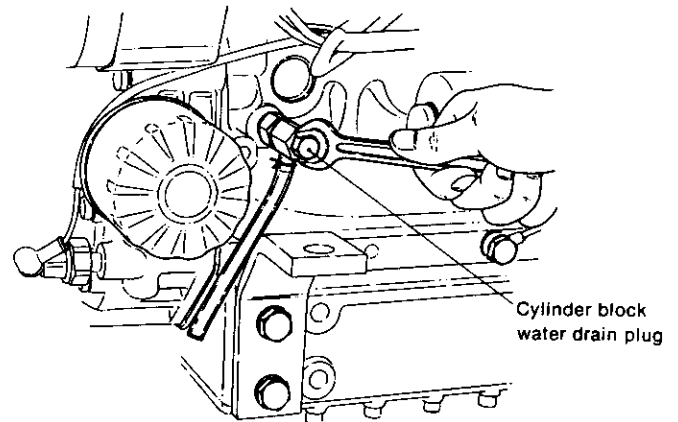
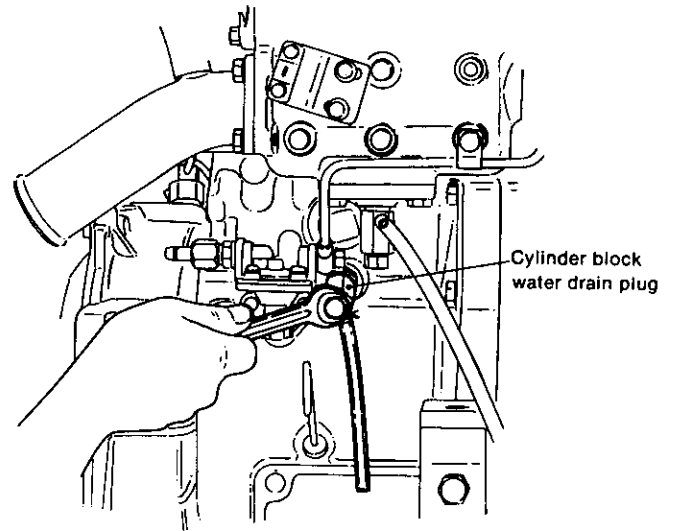
- (1) Drain the sea water from the heat exchanger. The sea water drain cock is installed on the side cover of the heat exchanger at the rear.



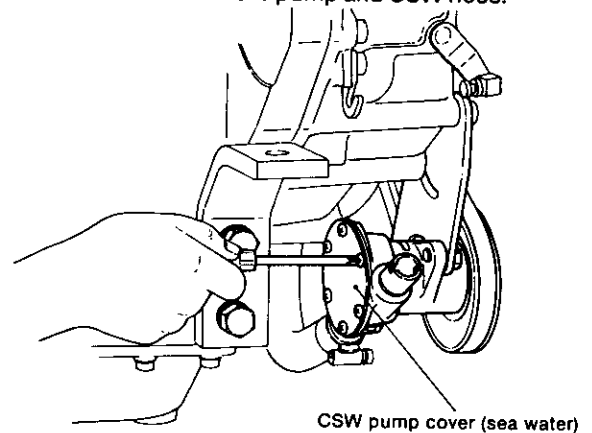
- (2) Drain the fresh water from the heat exchanger. Loosen the fresh water drain plug installed at the bottom of the heat exchanger.



- (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 2GM20F engine, and on the block wall surface at the intake side in models 3GM30F and 3HM35F 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.

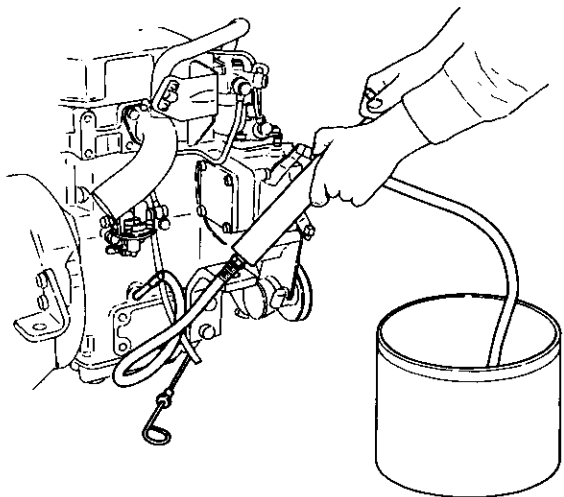


NOTE: CSW = Cooling Sea Water

1-2. Drain the lubricating oil

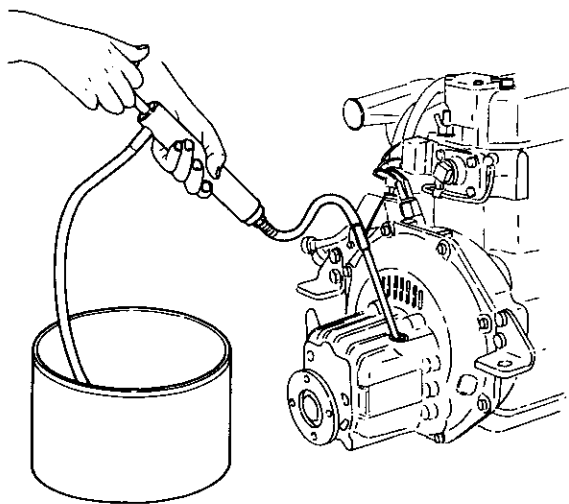
(1) Engine side

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



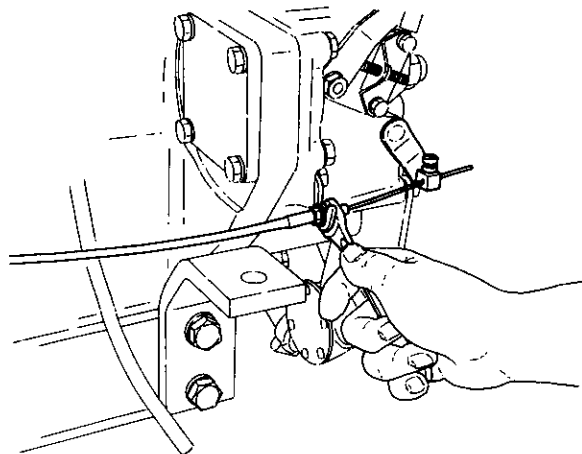
(2) Clutch side

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



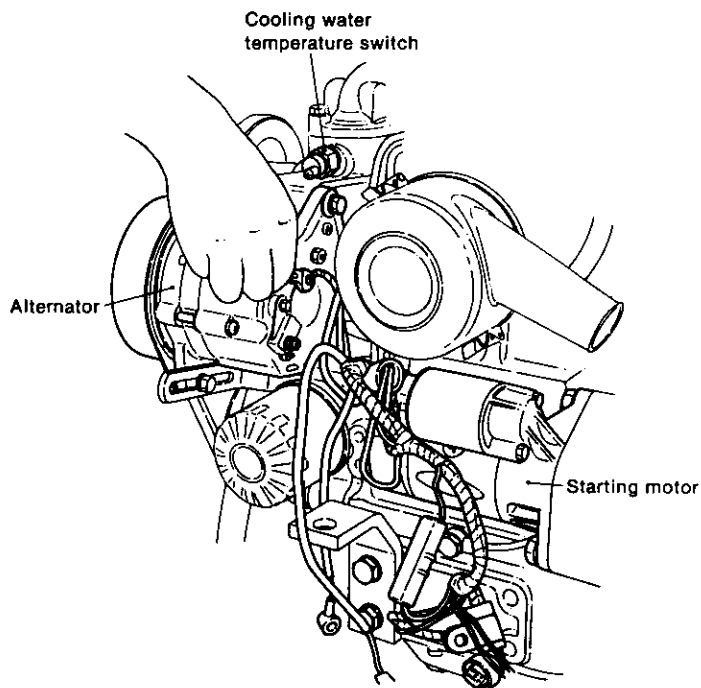
1-3. Disconnect the remote control cables

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



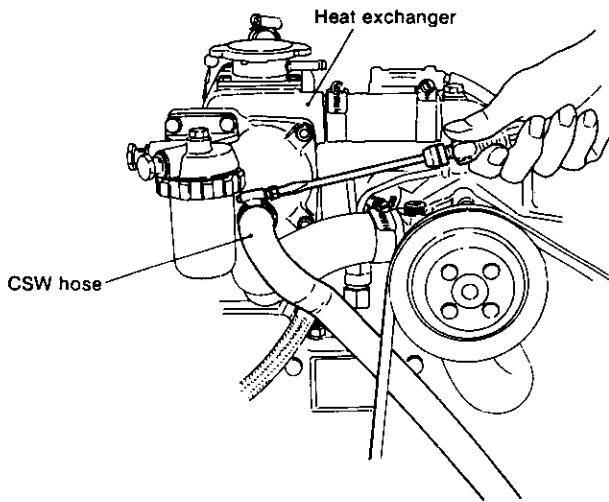
1-4. Disconnect the electrical wiring

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



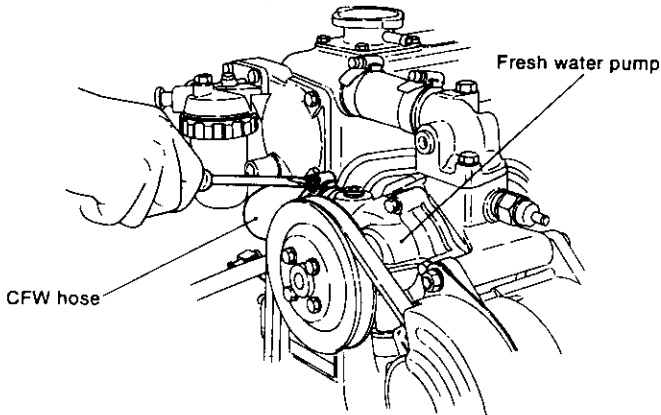
1-5. Remove the CSW hose

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

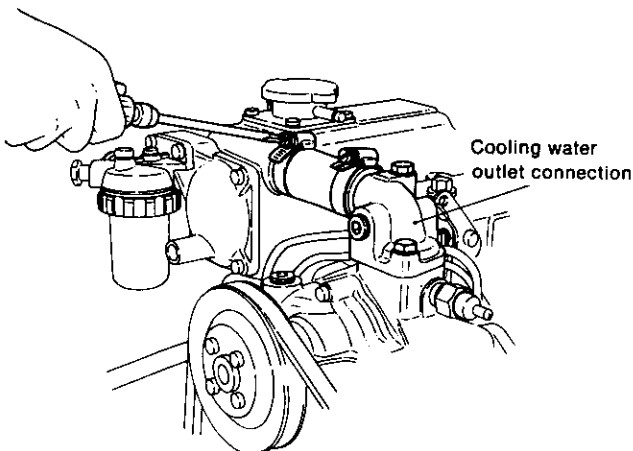


(2) Remove the CFW hose between the heat exchanger and CFW pump.

NOTE: CFW = Cooling Fresh Water

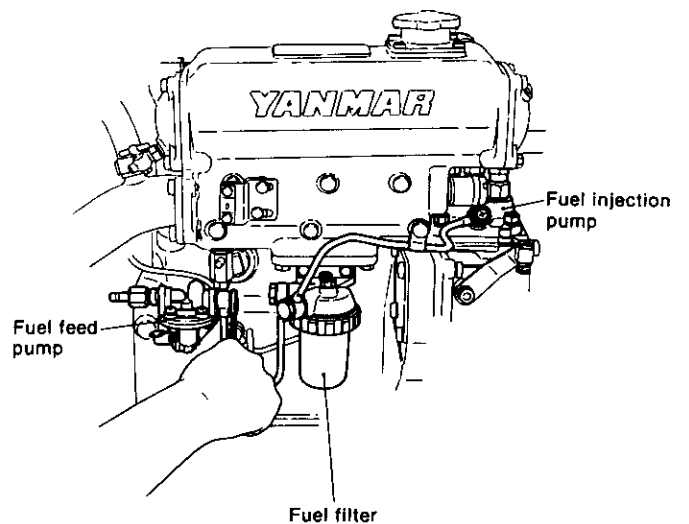
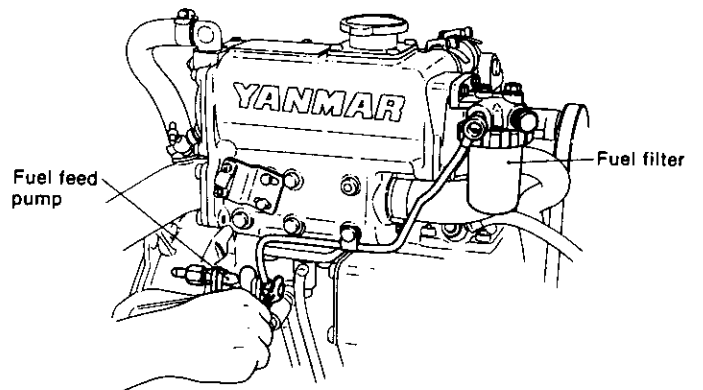
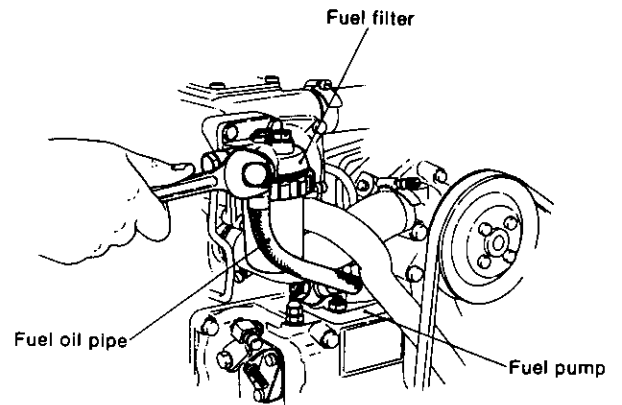


(3) Loosen the hose clamp on the CFW hose between the cylinder head and heat exchanger. The hose clamp at the heat exchanger side or the cooling water outlet connection side only need be loosened.



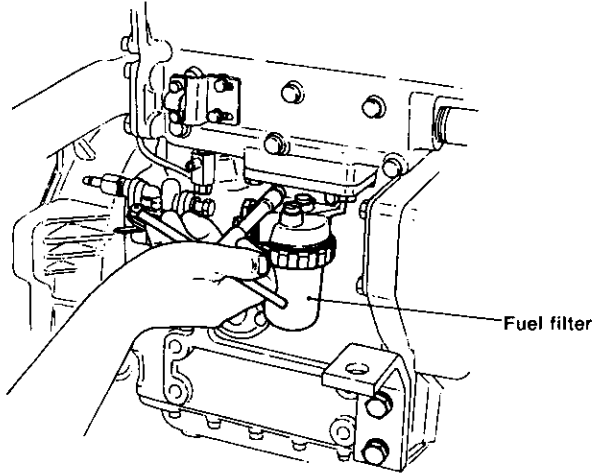
1-6. Disconnect the fuel piping

- (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

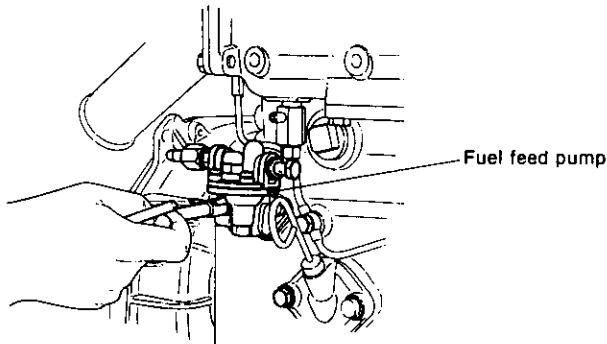
The fuel filter can be removed as assembled on the heat exchanger. However, to make removal of the heat exchanger easier, the filter should be removed separately.



1-8. Remove the fuel feed pump

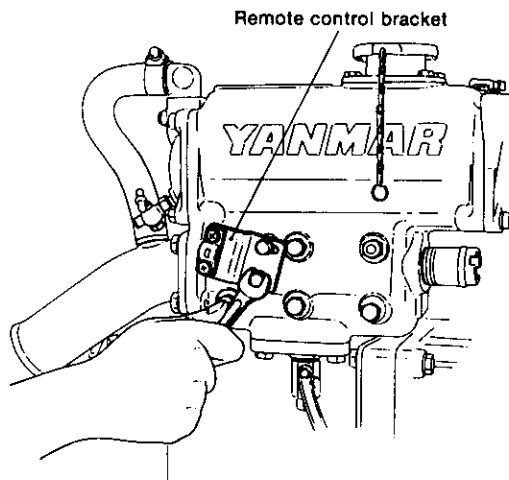
In cases of model 3GMF, the heat exchanger drain plug may jam against the fuel feed pump pipe connector. The fuel feed pump should be removed before removing the heat exchanger.

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

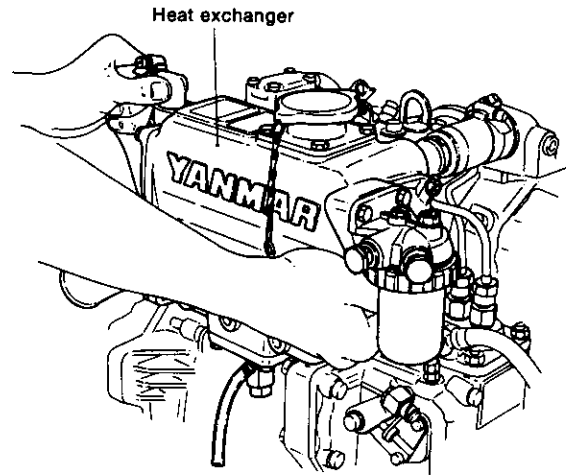


1-9. Remove the remote control bracket

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

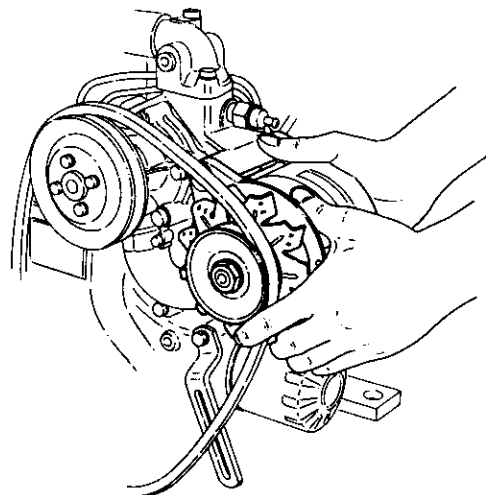
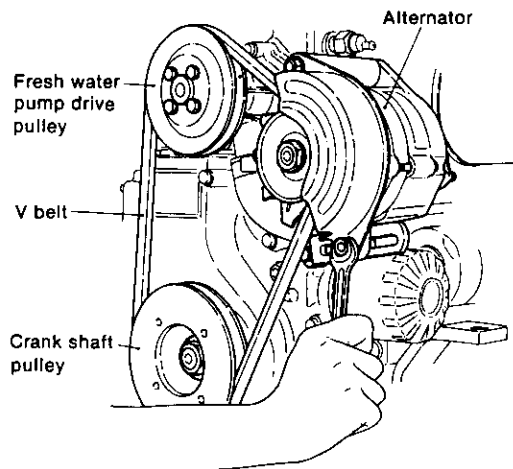


1-10. Remove the heat exchanger.



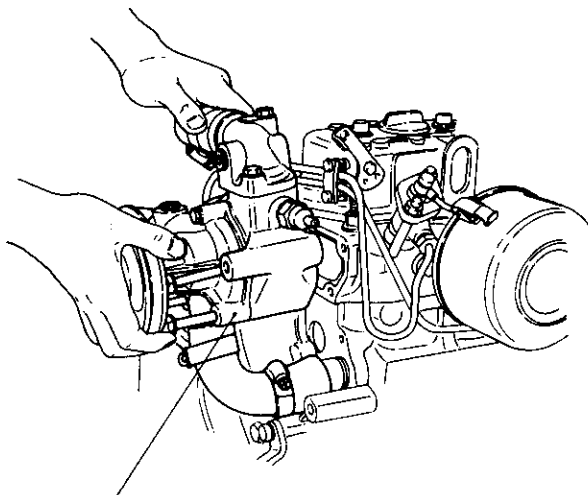
1-11. Remove the alternator

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



1-12. Remove the CFW pump

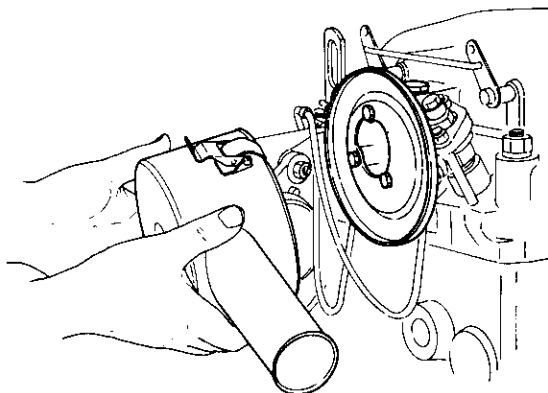
Remove the CFW pump by loosening the hose clamp on the CFW hose between the CFW pump and cylinder block at the cylinder block end.



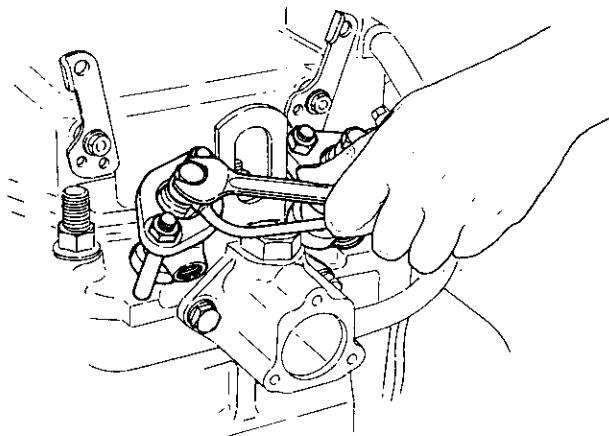
Fresh water pump

1-13. Remove the air intake silencer

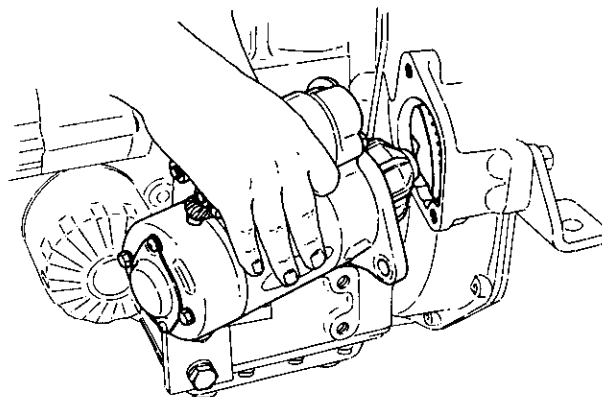
Remove the intake silencer clip and the filter element. Then remove the set screw and the cover.



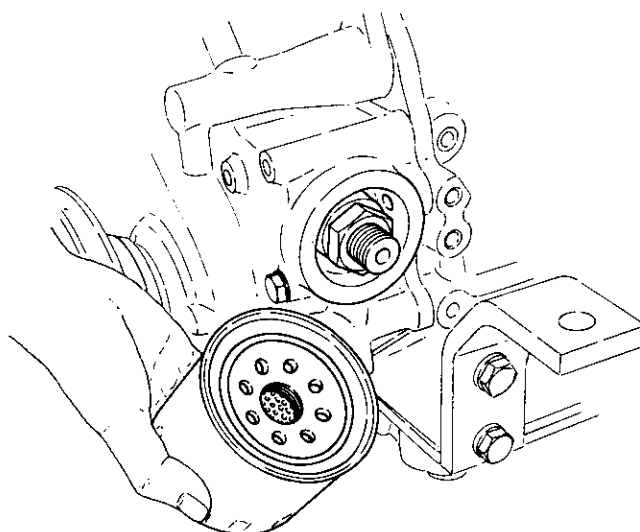
1-14. Remove the fuel high pressure pipe and fuel return pipe.



1-15. Remove the starter motor

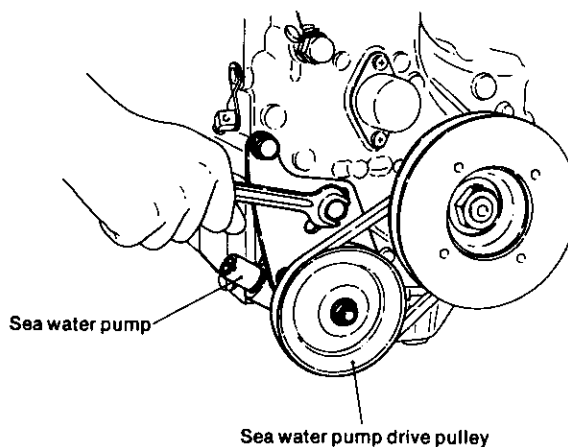


1-16. Remove the oil filter



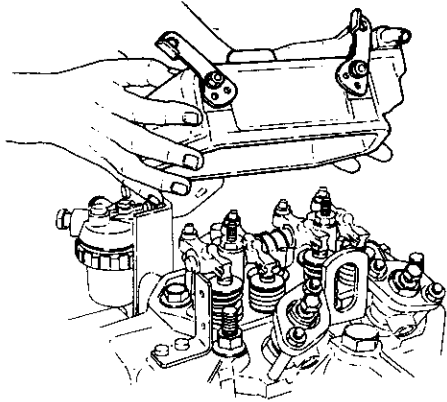
1-17. Remove the CSW pump

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 3GM30F and 3HM35F]
- (2) Remove the rocker arm chamber



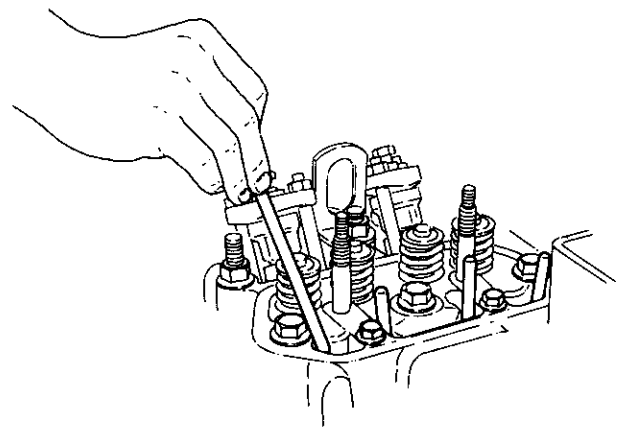
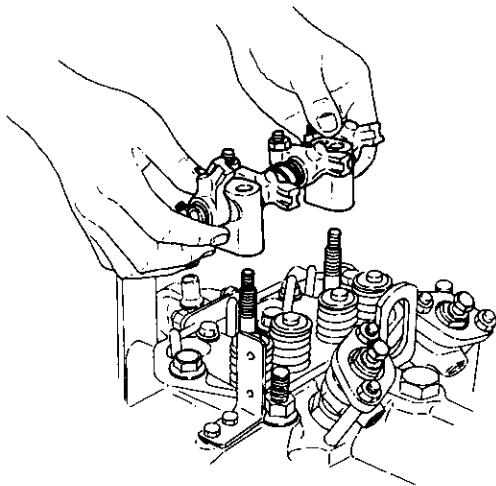
After this step disassembly is carried out in the same sequence as for the sea water-cooled engine.

The details are given in Section 4.3.14 "Remove the rocker arms" P14-23 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.

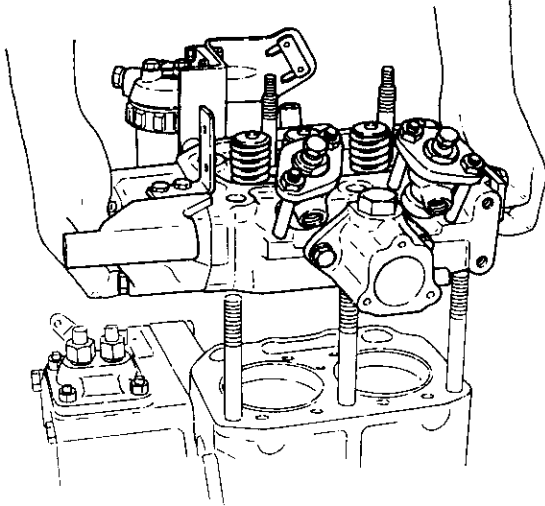


- (3) Remove the cotter pins of the intake and exhaust valve springs.

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

4-3.15 Remove the cylinder head

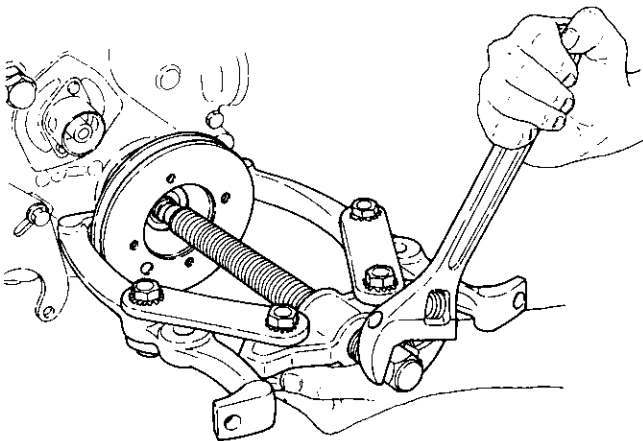
- (1) Disconnect the lubricating oil pipe.
- (2) Remove the cylinder head nuts in the prescribed order, and remove the cylinder head.
- (3) Remove the gasket packing.



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

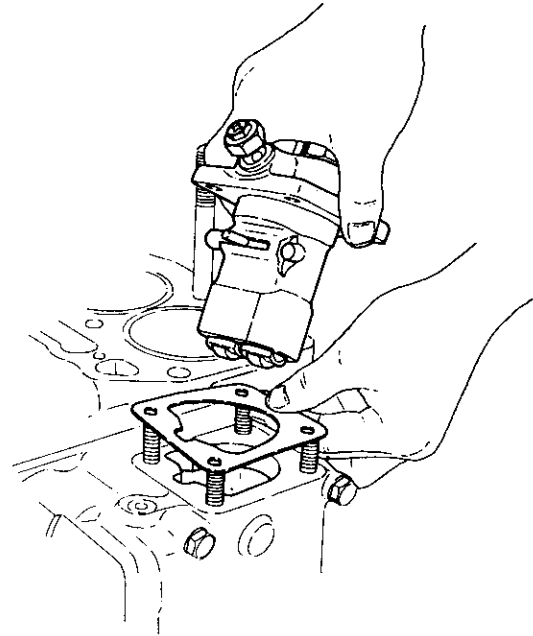
4-3.16 Remove the crankshaft pulley

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



4-3.17 Remove the injection pump

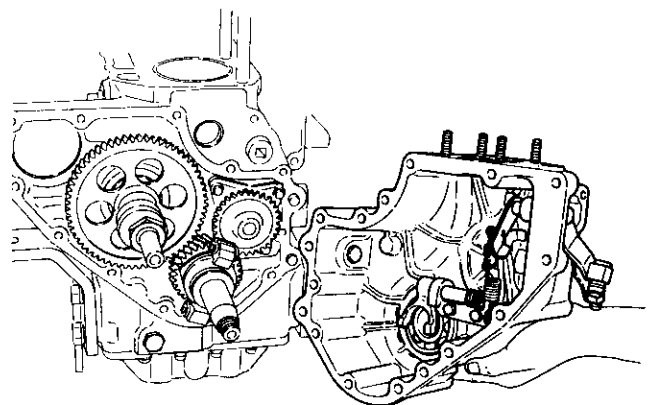
- (1) Remove the injection pump nut.
- (2) Remove the gear case side cover, move the governor lever 2, take out the fuel injection pump by matching the control rack with the cut-off part of the gear case.



- (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

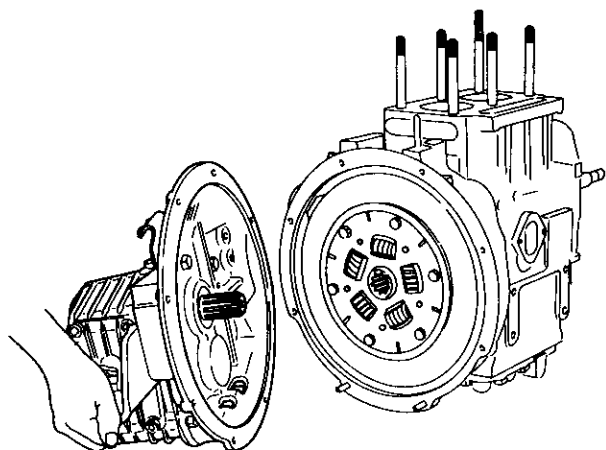
- (1) Remove the gear case



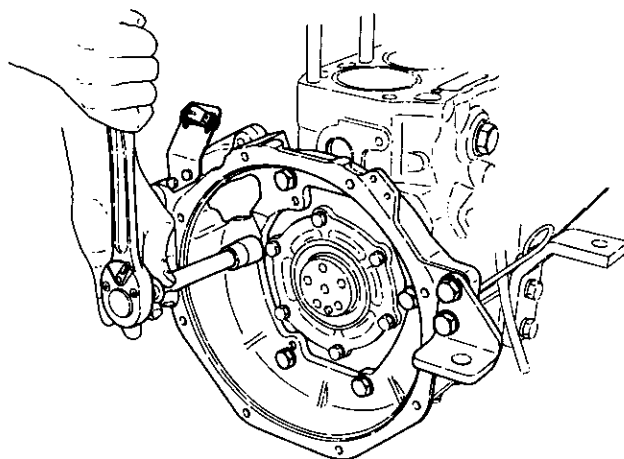
- (2) Remove the thrust collar, thrust needle bearing, and governor sleeve.

4-3.19 Remove the clutch assembly

Loosen the mounting flange bolts and remove the clutch assembly.

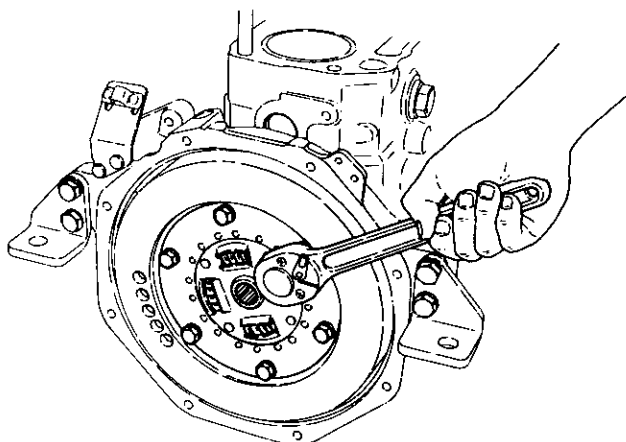


4-3.21 Remove the flywheel housing



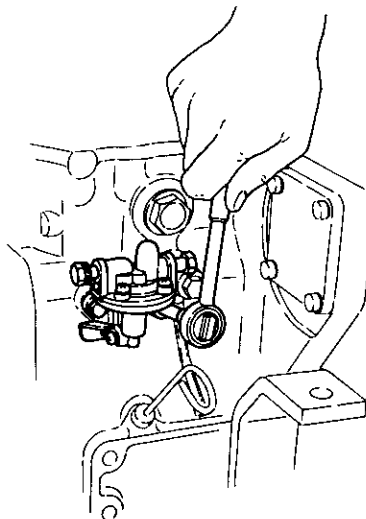
4-3.20 Remove the flywheel

(1) Remove the damper disk.



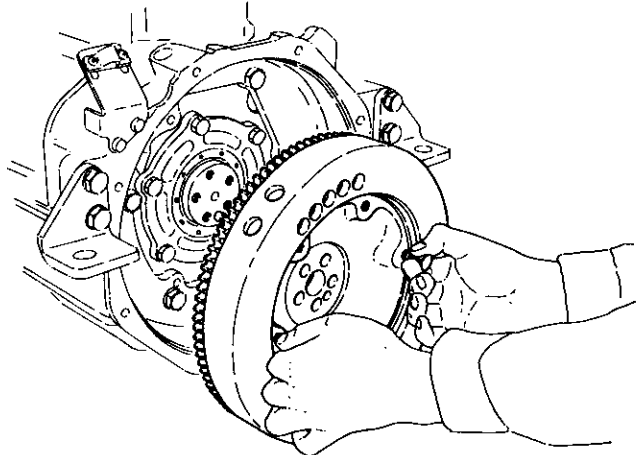
4-3.22 Remove the lubricating oil dipstick

4-3.23 Remove the feed pump



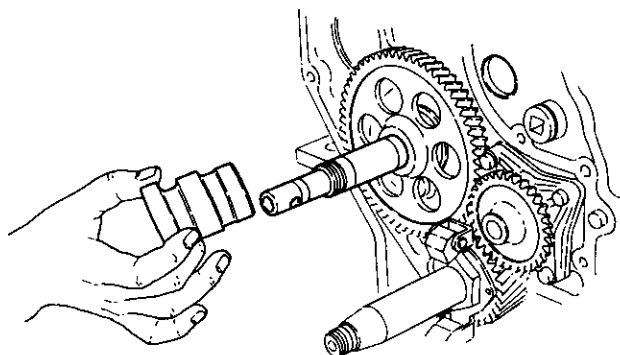
(2) Remove the flywheel.

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

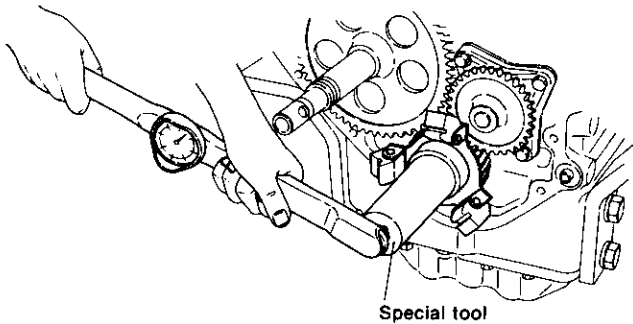


4-3.24 Remove the fuel cam

Remove the camshaft end nut and remove the fuel cam.



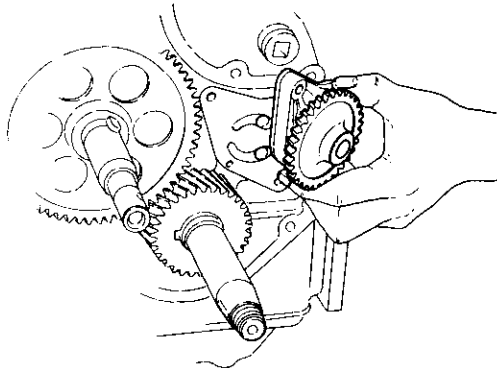
4-3.25 Remove the governor weight assembly



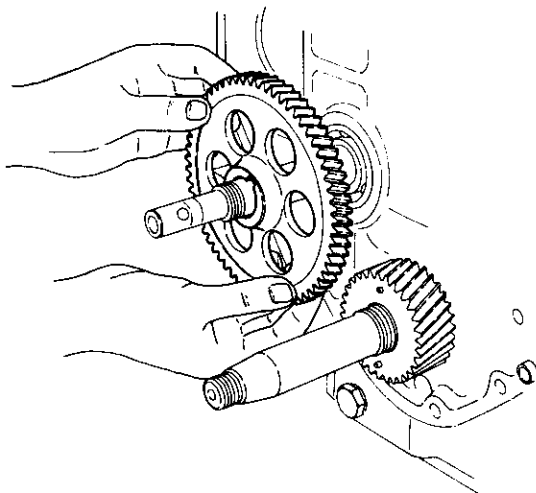
Special tool

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

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



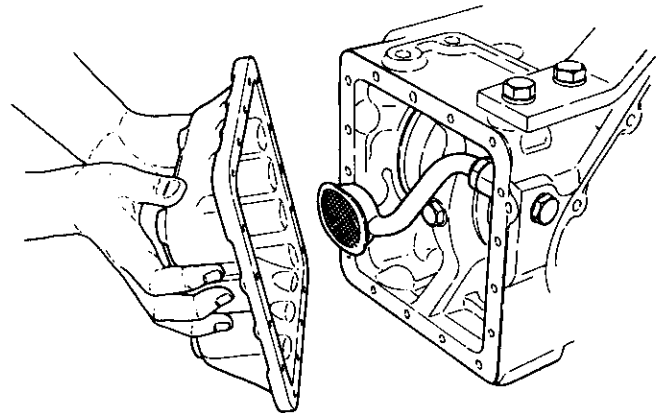
4-3.27 Remove the camshaft gear and the crankshaft gear



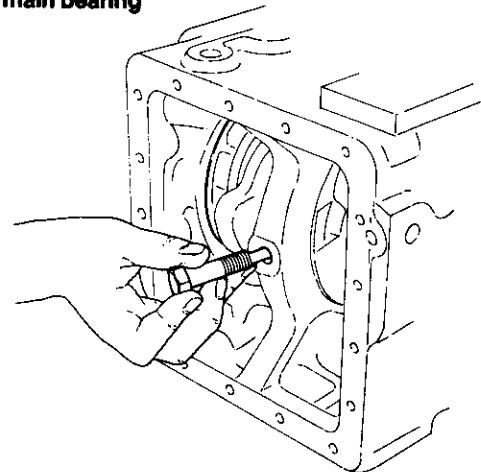
4-3.28 Turn the engine onto its side

- (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 oil intake pipe

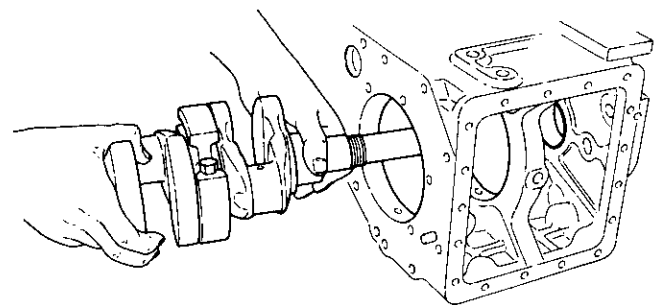


4-3.32 Remove the mounting bolt of the intermediate main bearing



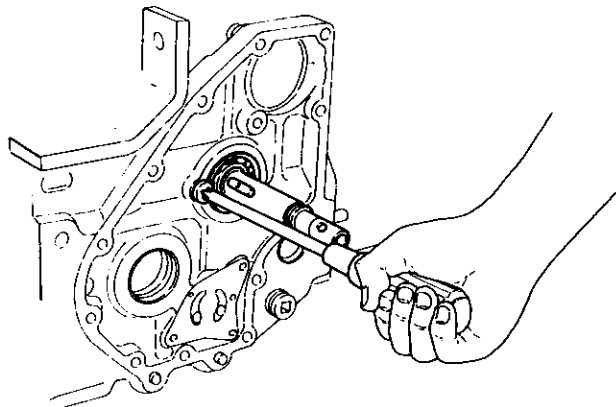
There are two intermediate main bearings, viz. No.1 and No.2, for engine model 3GM30F.

4-3.33 Pull the crankshaft

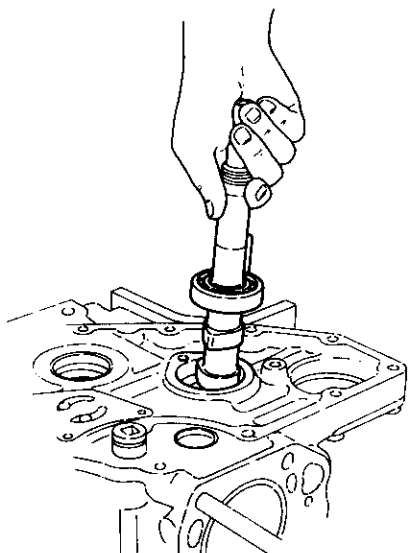


4-3.34 Remove the camshaft

(1) Remove the camshaft bearing set screw.

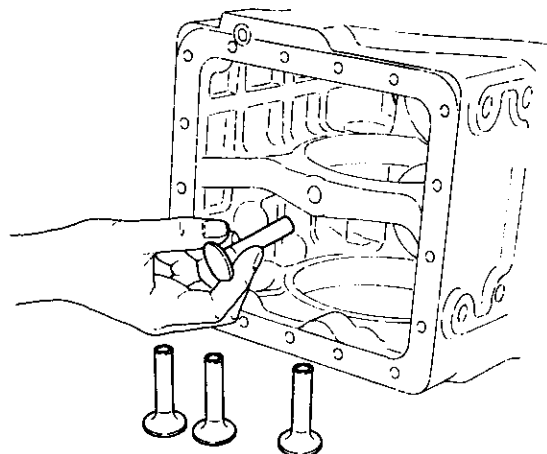


(2) Place the cylinder block upside down or raise the cylinder block by inserting a plate beneath it in order to prevent contact between the tappet and the cam.



(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.

2. Reassembly of fresh water-cooled engine

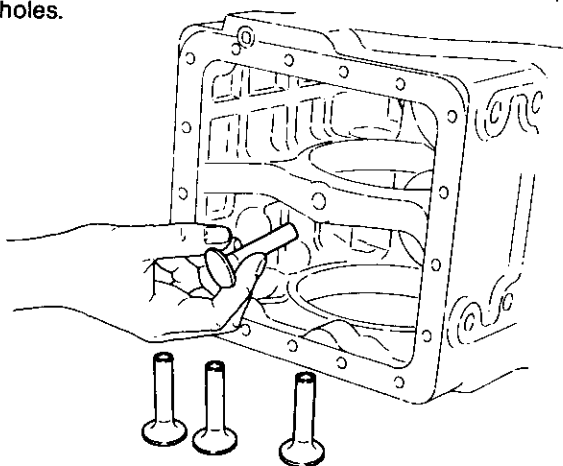
In general, the reassembly of the fresh water-cooled engine is the same as that for a sea water-cooled engine, except for cooling system components such as the heat exchanger, fresh water pump, cooling water pipe and related parts.

For details of the reassembly sequence refer to chapter 14, Page 14-28~14-43 (Reassembly of Direct Sea-Water Cooling Engine)

For reference

5-3.1 Insert the tappets

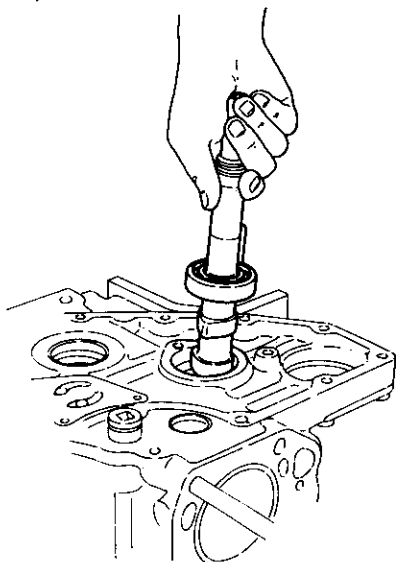
- (1) Turn the cylinder block over or turn it upside down.
- (2) Coat the tappets with oil and insert into the tappet holes.



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

5-3.2 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.

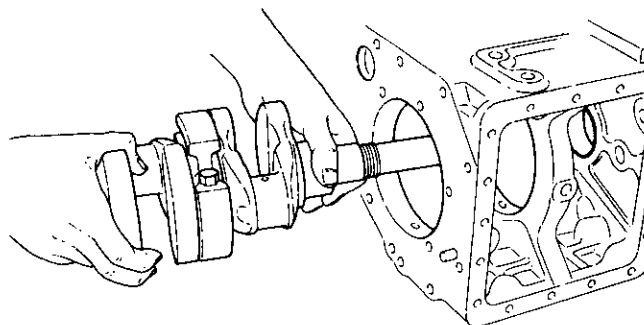


NOTE: Be careful not to damage the groove in the end of the shaft.

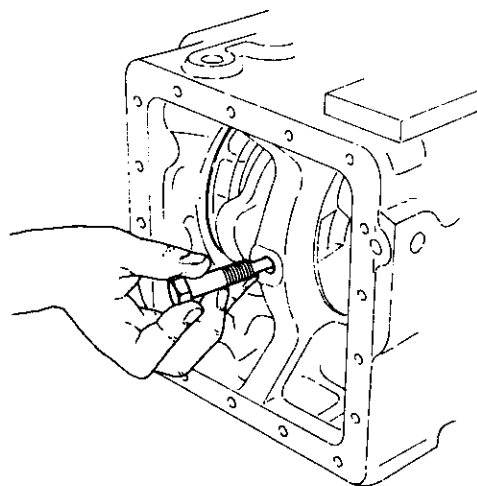
- (2) After inserting the camshaft, check that it rotates smoothly before tightening the camshaft bearing set screw.

Tightening torque	2kgf-m(14.5ft-lb)
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5-3.3 Install the crankshaft



5-3.4 Tighten the set bolt of the intermediate main bearing

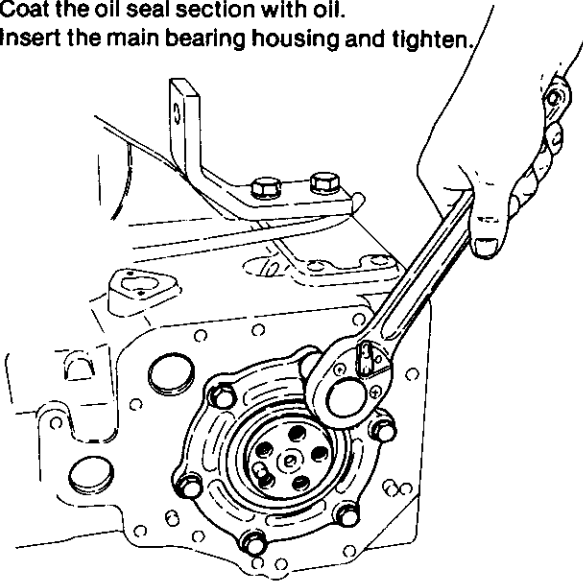


There are two intermediate main bearings, viz No.1 and No.2, for model 3GM30F

	kgf-m(ft-lb)	
	2GM20F,3GM30F	3HM35F
Tighten torque	4.5~5.0 (32.5~36.2)	7.0~7.5 (50.6~54.2)

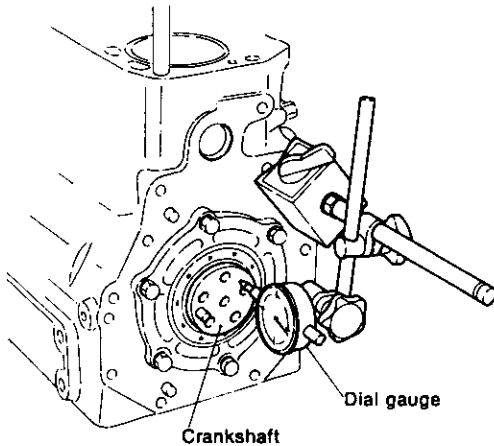
5-3.5 Install the main bearing housing

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



Tightening torque	2.5kgf-m(18ft-lb)
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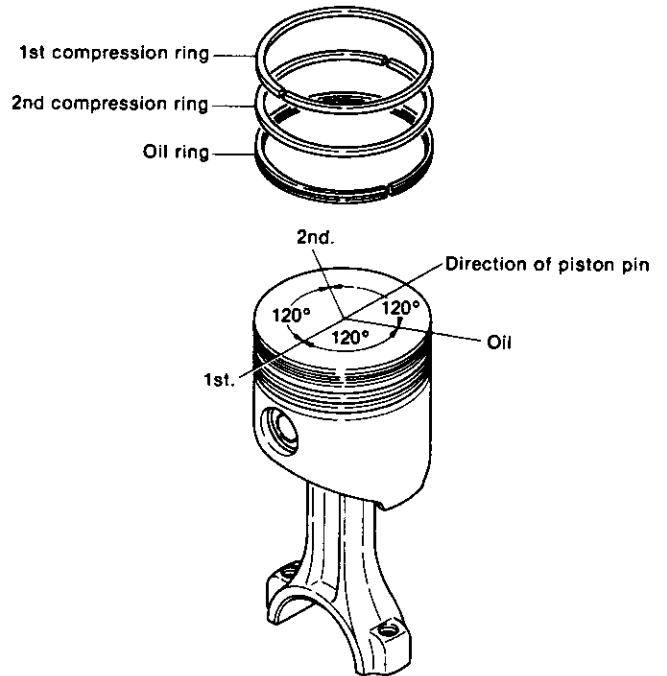
- (3) Check that the crankshaft rotates smoothly.
- (4) Measure the crankshaft side gap, and adjust it to the prescribed value using the thickness of the packing.



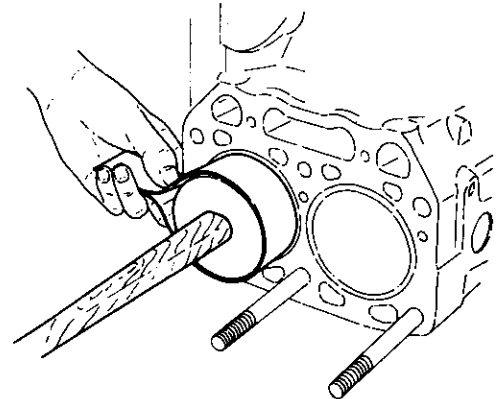
Crankshaft side gap	0.09 ~ 0.18mm (0.035 ~ 0.0071in.)
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5-3.6 Assemble the piston and connecting rod assembly

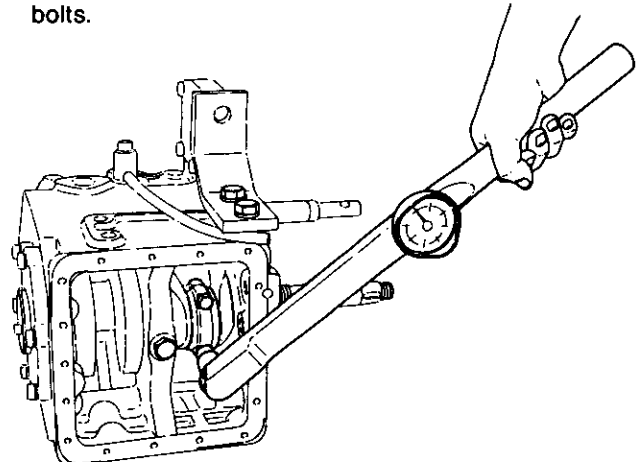
- (1) Coat the crankpin section with oil and position it so that the insertion side crank is at the top.
- (2) Coat the piston and crankpin bearing with oil.
- (3) Position the piston rings so that the gaps are 120° apart; make sure that there is no gap at the side pressure section.



- (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 makes contact with 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.

	2GM20F,3GM30F	3HM35F
Tightening torque	2.5(18.1)	4.5(32.5)

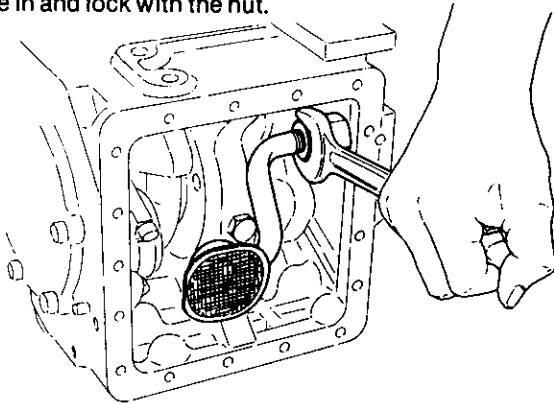
(7) Measure the side clearance

Side clearance	0.2~0.4mm (0.0079~0.0157in.)
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(8) Check that the crankshaft rotates smoothly.

5-3.7 Install the lubricating oil intake pipe

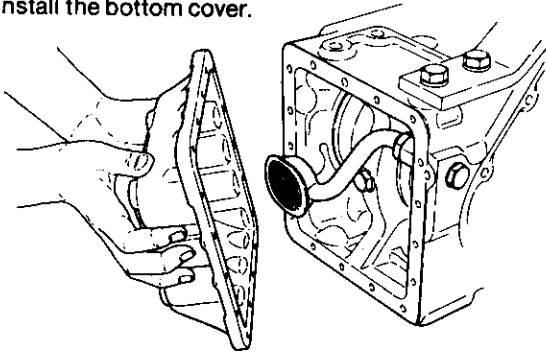
Coat the threads with "Screw Lock Super 203M", screw the pipe in and lock with the nut.



Screw-in distance	8 ~ 10mm (about 6 turns) (0.3149 ~ 0.3937in.)
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5-3.8 Install the engine bottom cover (oil pan)

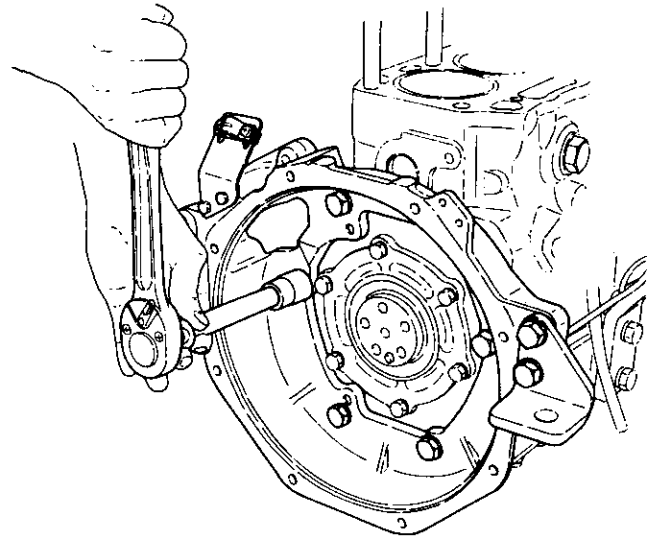
(1) Change the packing.
 (2) Install the bottom cover.



Tightening torque	0.9kgf-m(6.5ft-lb)
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5-3.9 Install the mounting flange

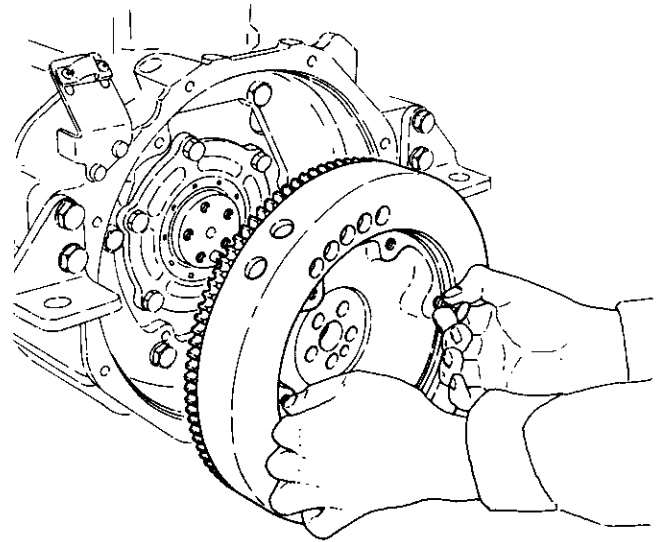
(1) Set the engine upright.
 (2) Align the positioning pins and tighten the flange.



Tightening torque	4.5kgf-m(32.5ft-lb)
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5-3.10 Install the flywheel

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

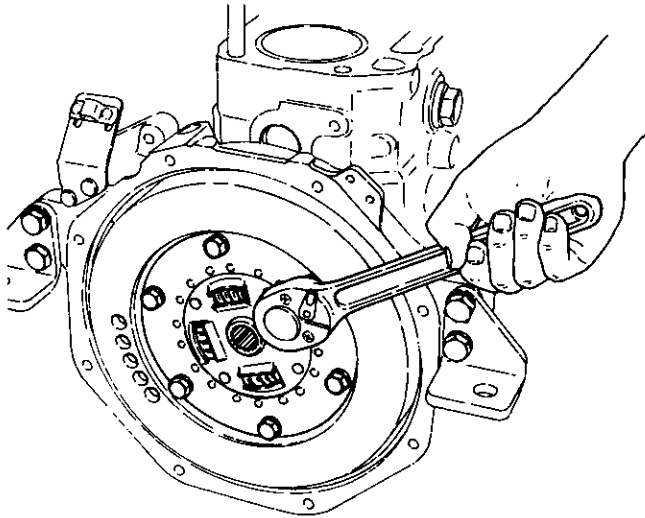


Tightening torque	6.5~7.0kgf-m (47~50.6ft-lb)
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NOTE: After tightening, check the end run-out.

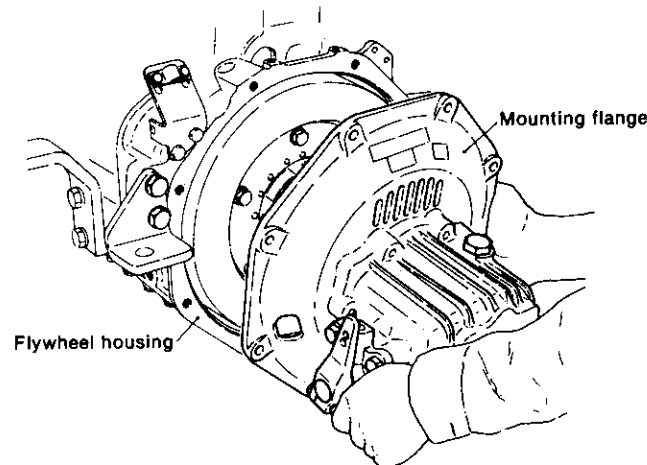
5-3.11 Install the clutch assembly

(1) Install the clutch disc on the flywheel.



Tightening torque	2.5kgf-m(18ft-lb)
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(2) Align the disc and input shaft spline, and install the clutch assembly on the mounting flange.



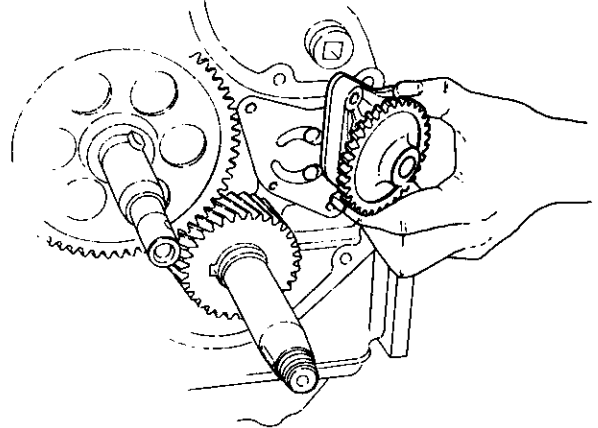
Tightening torque	2.0~2.5kgf-m(14.5~18.1ft-lb)
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5-3.12 Install the engine feet and set the engine in position

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

5-3.13 Install the lubricating oil pump

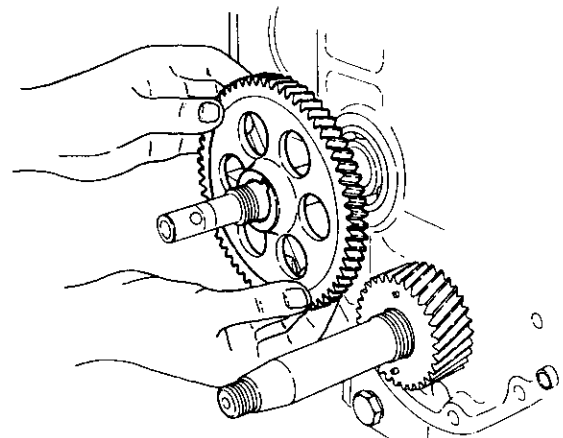
Install the lubricating oil pump and driving gear assembly.



Lube pump body mounting bolt	0.9kgf-m(6.5ft-lb)
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5-3.14 Assemble the camshaft gear and fuel cam

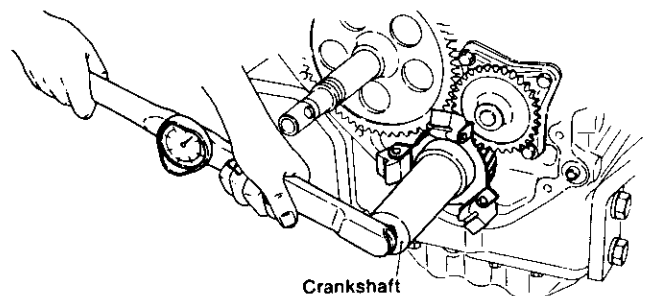
- (1) Coat the shaft hole of the camshaft gear with oil and insert the gear.
- (2) Coat the fuel cam with oil and insert the cam by aligning the "0" mark opposite the camshaft gear.



(3) Tighten the camshaft end nut.

Tightening torque	7~8kgf-m(50.6~57.9ft-lb)
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5-3.15 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.

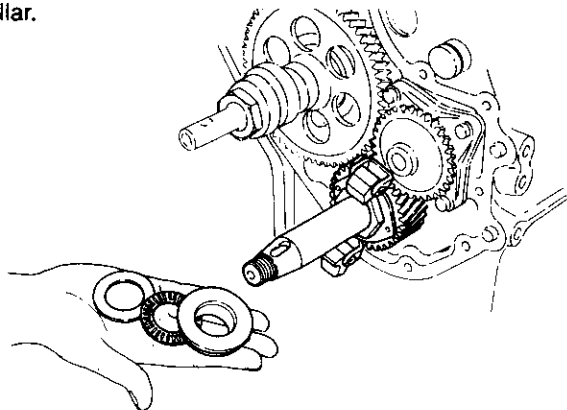
Backlash	0.05 ~ 0.13mm (0.0020 ~ 0.0051in.)
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(4) Install the governor weight assembly and tighten the crankshaft end nut.

Tightening torque	8~10kgf-m(57.9~72.3ft-lb)
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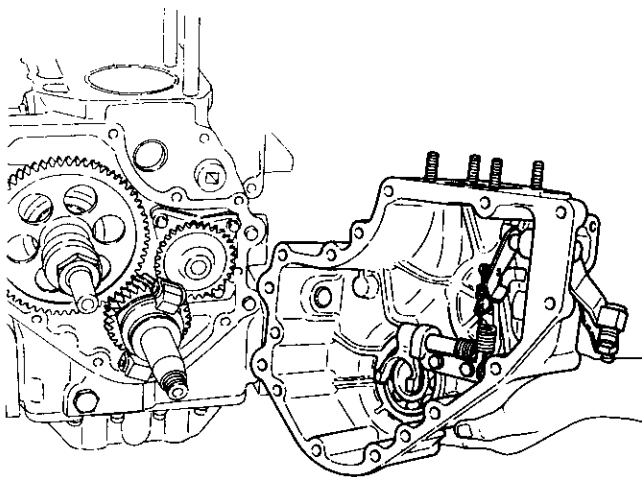
5-3.16 Install the governor sleeve

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



5-3.17 Install the timing gear case

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

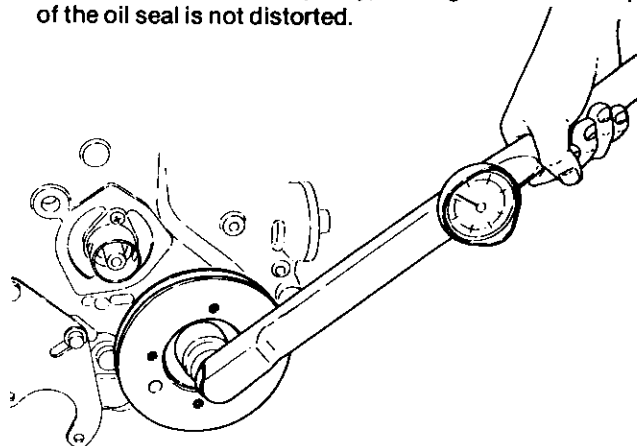


Tightening torque	2.5kgf-m(18ft-lb)
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5-3.18 Install the crankshaft V-pulley

- (1) Install the crankshaft key.
- (2) Coat the crankshaft V-pulley and the inside of the oil seal with oil.

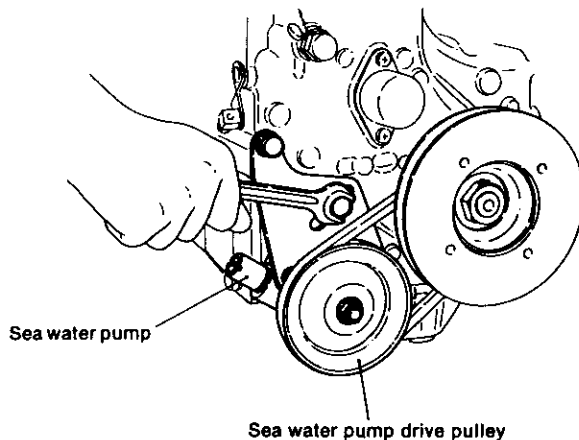
(3) Insert and tighten the V-pulley, making sure that the lip of the oil seal is not distorted.



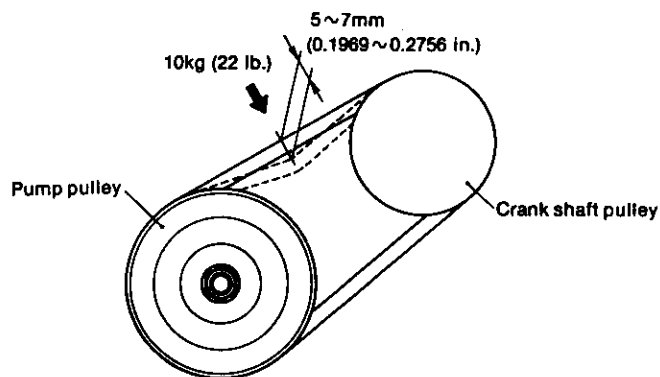
Tightening torque	10kgf-m(72.3ft-lb)
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5-3.19 Install the water pump

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



(1) V-belt tension

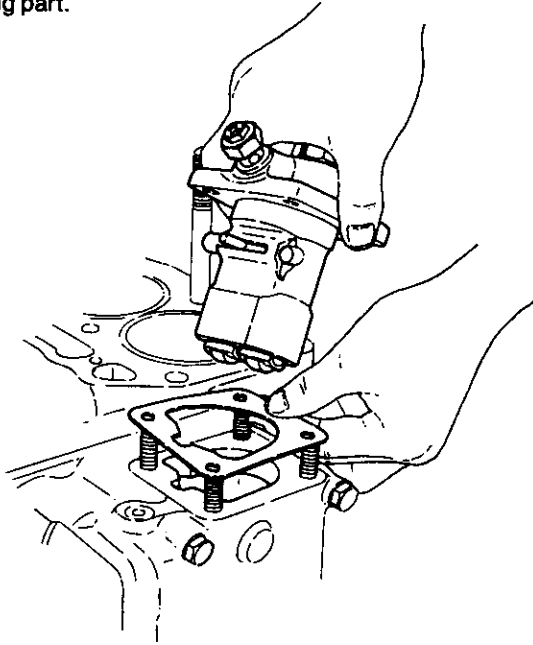


V-belt tension Pushed with a force of 10kg (22 lb.)	5 ~ 7mm (0.1969 ~ 0.2756 in.)
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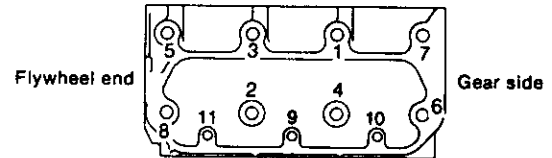
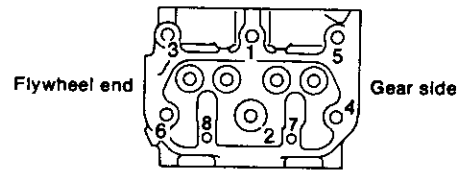
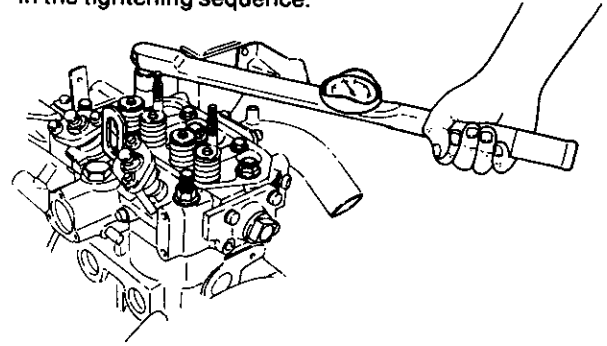
(2) Tightening torque.

Tightening torque	2.5kgf-m(18ft-lb)
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(3) Insert the pump by looking through the gear case side cover, and align the governor No.2 lever and rack connecting part.



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



kgf-m(ft-lb)

		2GM20F, 3GM30F	3HM35F
Tightening torque	Main (M12)	12.0(86.8)	13 (94.0)
	Sub (M8)	3.0(21.7)	3 (21.7)

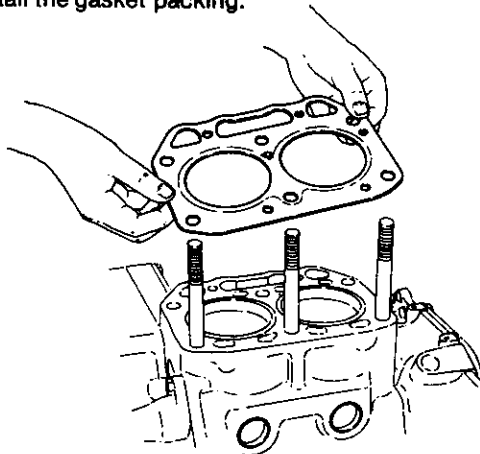
(4) Tighten the fuel pump

Tightening torque	2.5kgf-m(18ft-lb)
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(5) Install the gear case side cover.

5-3.20 Install the cylinder head

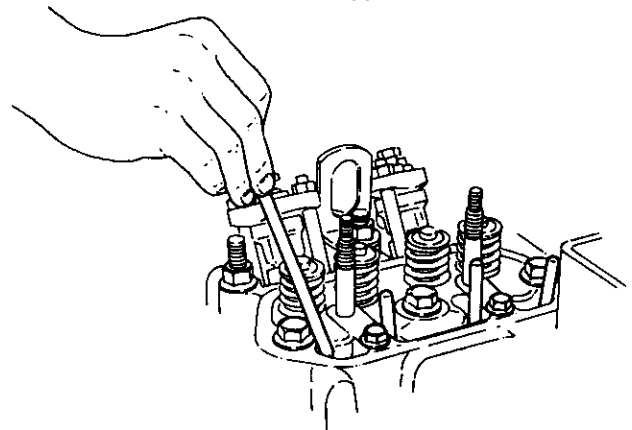
(1) Install the gasket packing.



(3) Install the water pipe
 (from the thermostat cover to the cylinder inlet joint).

5-3.21 Install the rocker arms

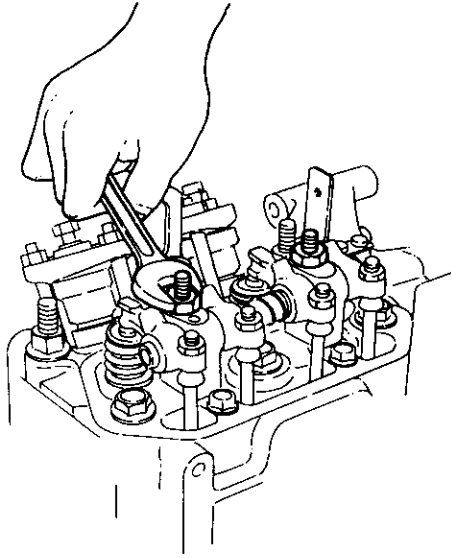
(1) Install the push rods on the tappets.



CAUTION: Take particular notice of the surfaces to be fitted.

Keep the TOP mark on the cylinder head side.

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



Tightening torque	3.7kgf-m(27ft-lb)
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CAUTION: 1. Loosen the valve head clearance adjusting screw in advance.

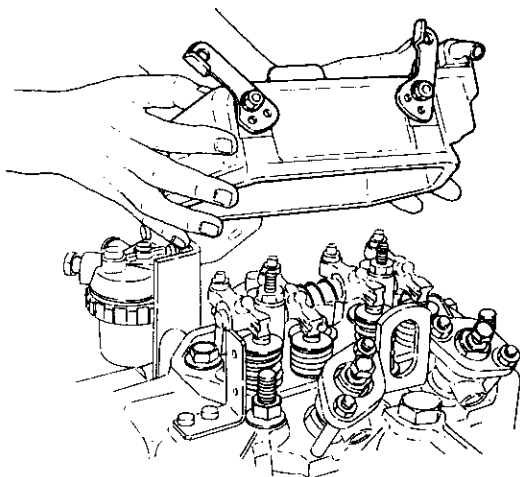
2. Check that the arm moves smoothly.

- (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.)
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5-3.22 Install the rocker arm cover

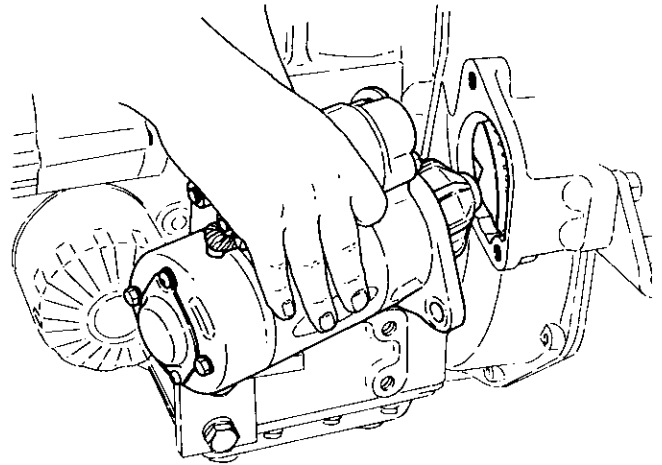
- (1) Install the rocker arm cover.



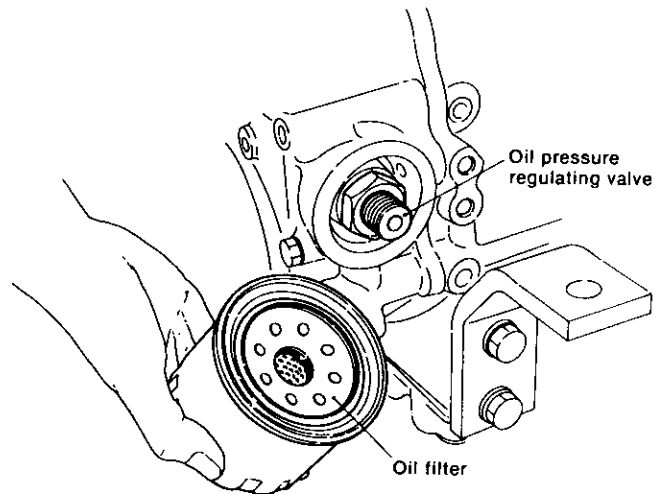
- (2) Install the breather pipe to the air intake pipe (intake manifold ... 3GM30F).

The following sequence is different from that of a sea water-cooled engine.

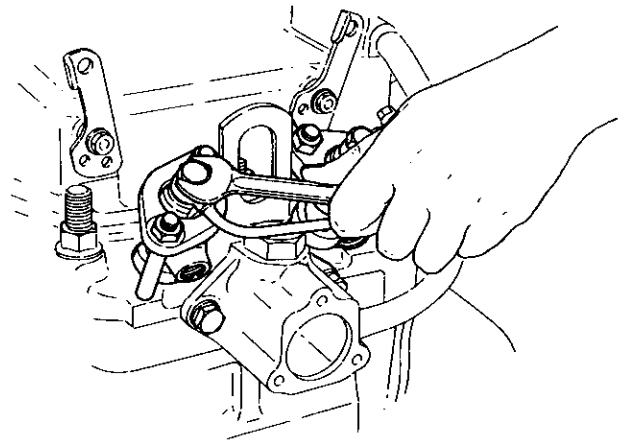
2-1. Install the starter motor



2-2. Install the oil filter

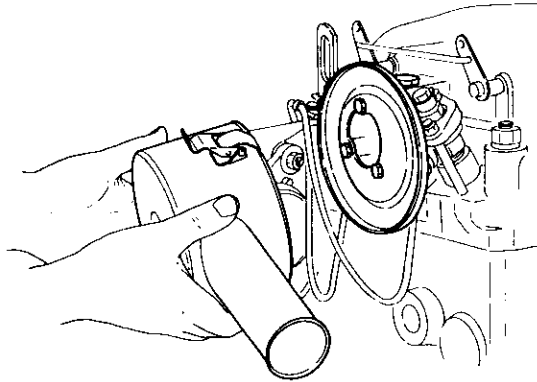


2-3. Assemble the high pressure fuel pipe and fuel return pipe

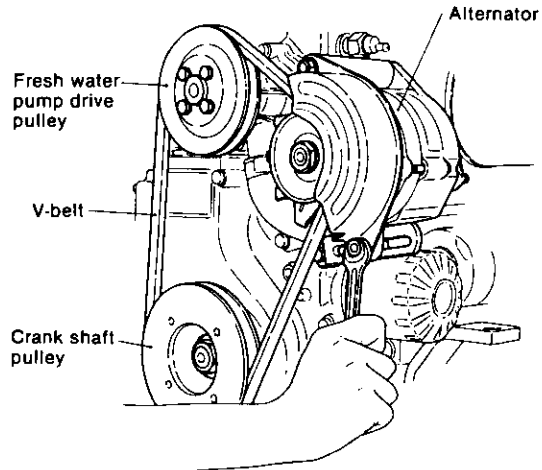


2-4. Install the intake silencer

- (1) Install the intake silencer cover to the air intake pipe.
 [intake manifold . . . 3GM30F and 3HM35F]
- (2) Install the intake silencer and tighten it with the clip.

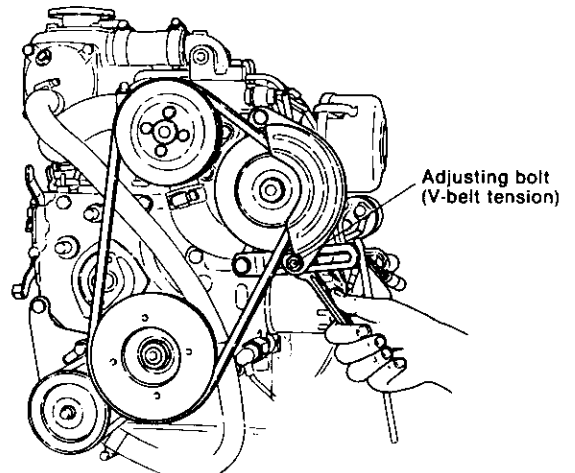
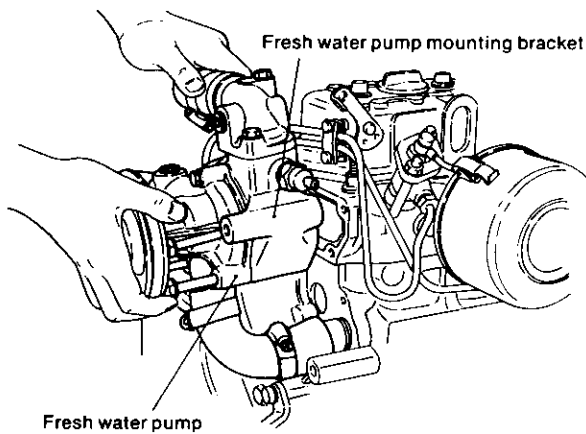


- (2) Install the V-belt and tighten the adjusting bolt while adjusting the V-belt tension.

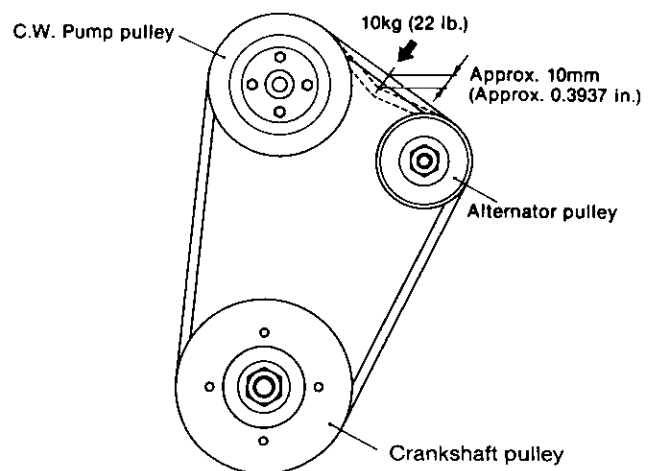


2-5. Assemble the CFW pump

Mount the CFW pump and replace the CFW hose between the CFW pump and cylinder block by connecting at the CFW pump and at the cylinder block.

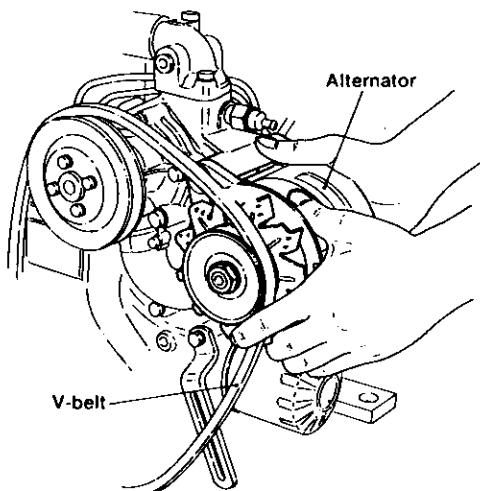


Tightening torque for CFW pump fixing bolt	2~2.5kgf-m (14.5~18ft-lb)
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2-6. Install the alternator

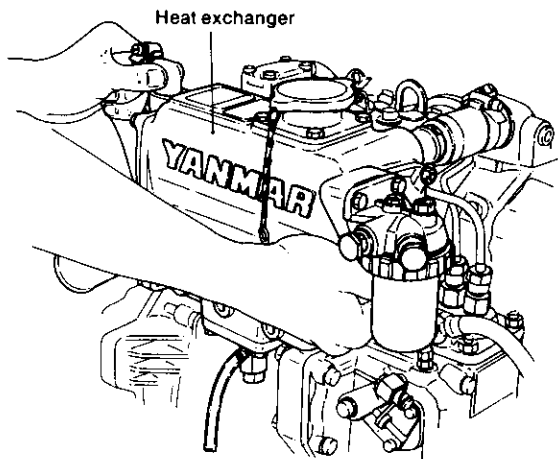
- (1) Install the alternator to the bracket.



V-belt tension Pushed with a force of 10kg (22 lb.)	Approx. 10mm (Approx. 0.3937 in.)
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2-7. Assemble the heat exchanger

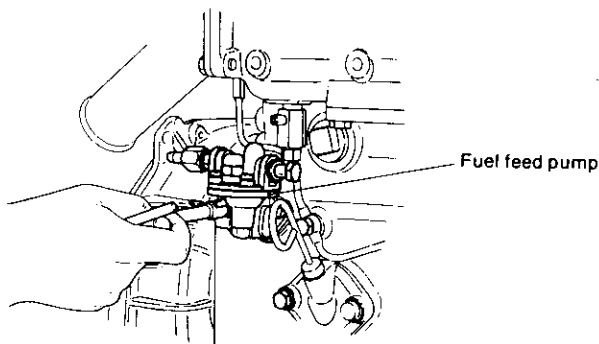
Mount the heat exchanger and replace the CFW hose at the thermostat cover side by connecting the hose to the heat exchanger. Tighten the hose clamp after the heat exchanger is assembled.



Tightening torque for heat exchanger fixing bolt	2~2.5kgf·m (14.5~18ft·lb)
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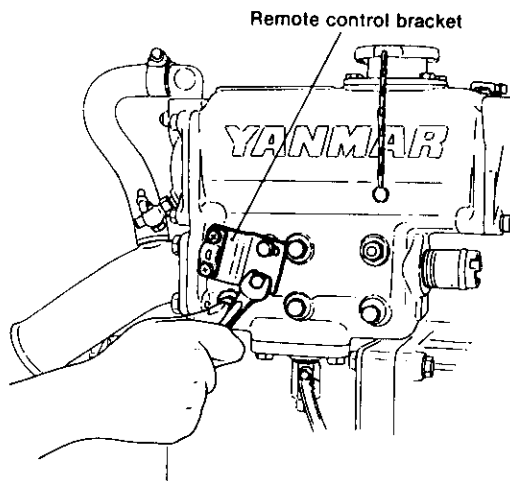
2-8. Assemble the fuel feed pump (3GM30F)

For model 3GM30F engine assemble the fuel feed pump after the heat exchanger is assembled.



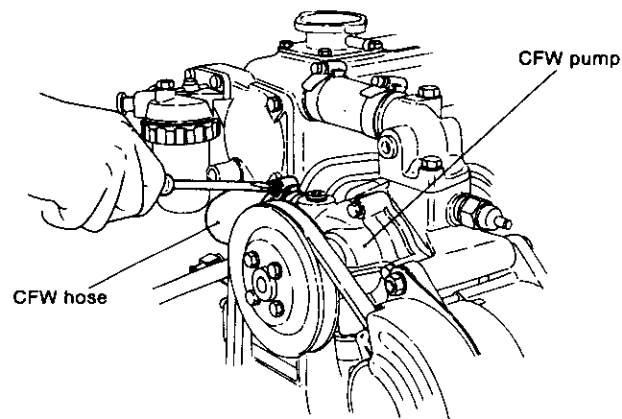
2-9. Assemble the fuel oil pipe

- (1) Fuel feed pump — fuel filter
- (2) Fuel filter — fuel injection pump

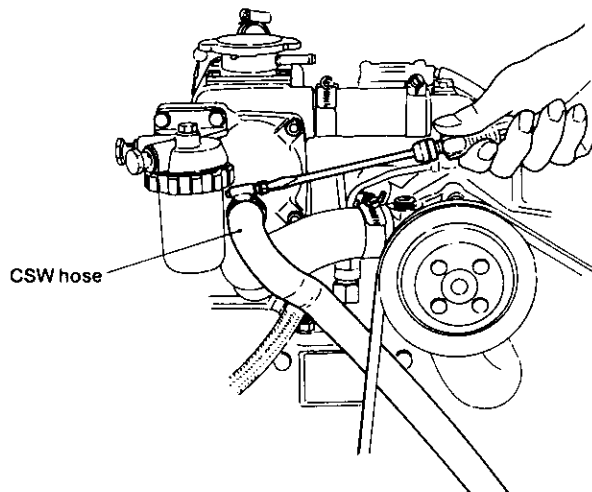


2-10. Assemble the cooling water pipe

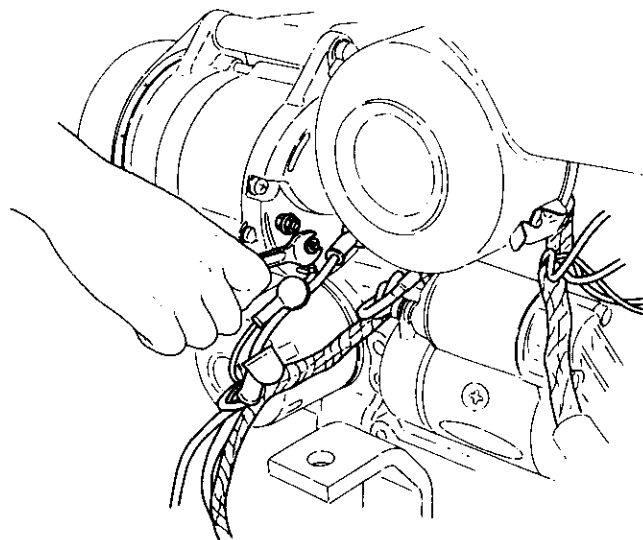
- (1) CFW hose (heat exchanger — CFW pump)



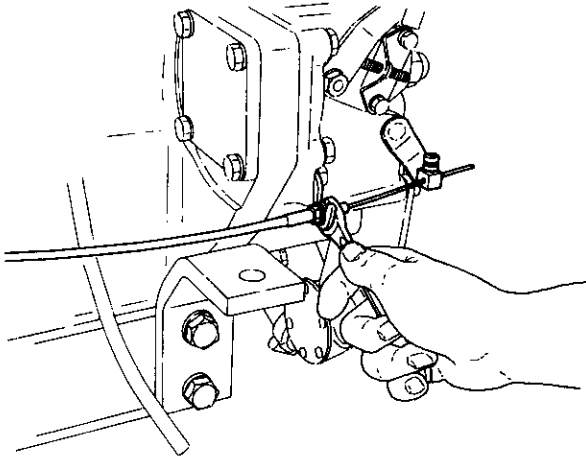
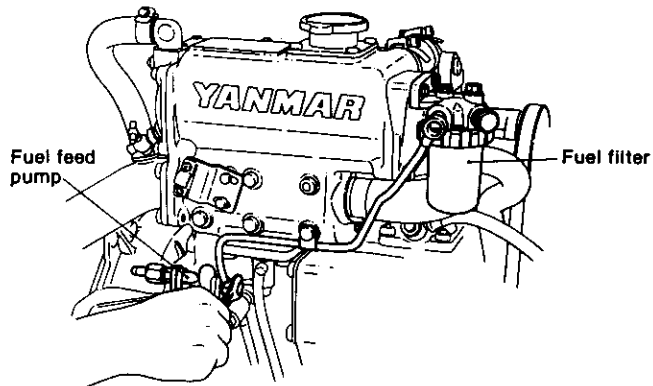
- (2) CSW hose (CSW pump — heat exchanger)



2-11. Connect the electrical wiring



2-12. Install the remote control cables



2-13. Connect the interior piping

3. Tightening Torque

The bolts and nuts used in this engine employ ISO general metric threads stipulated in JIS (Japanese Industrial Standards). Pay careful attention to the thread dimensions when replacing bolts and nuts.

Tighten the bolts and nuts to the tightening torque given in the table below.

3-1 Main bolt and nut tightening torque

Location	Bolt/nut		1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)	Remarks	
Cylinder head	Cylinder head tightening bolt and nut	Thread diameter	M10	M12			Nut and bolt	
			—	M8			Aux. bolt	
		Quantity	4	6	8	8	Nut and bolt	
			—	2	3		Aux. bolt	
		Tightening torque kgf-m(ft-lb)	7.5(54.248)	12.0(86.8)		13(94.029)	Nut and bolt	
			—	3.0(21.7)		3(21.699)	Aux. bolt	
	Rocker arm support nut	Thread diameter	M8	M10				
		Quantity	1	2	3	3		
		Tightening torque kgf-m(ft-lb)	3.7(26.762)					
	Exhaust manifold nuts	Thread diameter × pitch mm	M8 × 1.25					
		Quantity	2	3	6			
		Tightening torque kgf-m(ft-lb)	4.5(32.549)					
Anticorrosion zinc	Thread diameter	—	M25					
	Quantity	—	1					
	Tightening torque kgf-m(ft-lb)	—	5~6(36.165~43.398)					
Timing gear	Timing gear case mounting bolt	Thread diameter × pitch mm	M6 × 1.0	M8 × 1.25				
		Quantity	12					
		Tightening torque kgf-m(ft-lb)	0.9(6.510)	2.5(18.083)				
	Camshaft end nut	Thread diameter × pitch mm	M20 × 1.5			M18 × 1.5		
		Quantity	1					
		Tightening torque kgf-m(ft-lb)	7~8(50.631~57.864)					
	Governor weight set nut	Thread diameter × pitch mm	M26 × 1.5					
		Quantity	1					
		Tightening torque kgf-m(ft-lb)	8~10(57.864~72.330)					

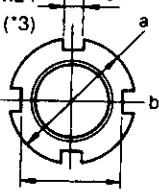
Chapter 15 Disassembly and Reassembly
3. Tightening Torque

SM/GM(F)(C)-HM(F)(C)

Location	Bolt/nut		1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)	Remarks	
Cylinder block	Mounting flange bolt	Thread diameter × pitch mm	M10 × 1.5					
		Quantity	6					
		Tightening torque kgf-m(ft-lb)	4.5(32.549)					
	Bottom cover bolt	Thread diameter × pitch mm	M6 × 1.0					
		Quantity	13	17	21	23		
		Tightening torque kgf-m(ft-lb)	0.9(6.510)					
	Oil pressure switch mounting	Thread diameter	PT 1/8					
		Quantity	1					
		Tightening torque kgf-m(ft-lb)	1.0(7.233)					
Crankshaft, pistons	Main bearing housing bolt	Thread diameter × pitch mm	M8 × 1.25					
		Quantity	6					
		Tightening torque kgf-m(ft-lb)	2.5(18.083)					
	Connecting rod bolt	Thread diameter × pitch mm	M7 × 1.0			M9 × 1.0		
		Quantity	1 × 2 = 2	2 × 2 = 4	3 × 2 = 6			
		Tightening torque kgf-m(ft-lb)	2.5(18.083)			4.5(0.6221)		
	Crankshaft V-pulley bolt	Thread diameter	M18					3HM35(F)(C) Counterclockwise screw
		Quantity	1					
		Tightening torque kgf-m(ft-lb)	10(72.330)					
	Flywheel bolt	Thread diameter × pitch mm	M10 × 1.25					
		Quantity	5					
		Tightening torque kgf-m(ft-lb)	6.5~7.0(47.015~50.631)					
	Diameter disk bolt	Damper diameter × pitch mm	M8 × 1.25					
		Quantity	6			8		
		Tightening torque kgf-m(ft-lb)	2.5(18.083)					
	Intermediate main bearing housing bolt	Thread diameter × pitch mm	—	M8 × 1.25				
		Quantity	—	2 × 2 = 4	3 × 2 = 6			
		Tightening torque kgf-m(ft-lb)	—	3.0~3.5 (21.699~25.316)		4.5~5.0 (32.549~36.165)		
Intermediate main bearing housing set bolt	Thread diameter × pitch mm	—	M10 × 1.25					
	Quantity	—	1	2				
	Tightening torque kgf-m(ft-lb)	—	4.5~5.0 (32.549~36.165)		7.0~7.5 (50.631~54.248)			
Cooling system	Water temperature sender bolt	Thread diameter	PT 3/8					
		Quantity	1					
		Tightening torque kgf-m(ft-lb)	1.0~1.5(7.2330~10.850)					

Chapter 15 Disassembly and Reassembly
3. Tightening Torque

SM/GM(F)(C)-HM(F)(C)

Location	Bolt/nut		1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)	Remarks	
Cooling system	Anticorrosion zinc mounting (Cylinder block)	Thread diameter × pitch mm						1GM10(C): Flange type 2GM20(C), 3GM30(C) and 3HM35(C): Plug type
		Quantity	1		2			
		Tightening torque kgf-m(ft-lb)	5~6(36.165~43.498)					
	Cooling water inlet joint	Thread diameter × pitch mm						
		Quantity	1					
		Tightening torque kgf-m(ft-lb)						
Water pump body bolt	Thread diameter × pitch mm	M6×1.0	M8×1.25					
	Quantity	3	2					
	Tightening torque kgf-m(ft-lb)	0.9(6.5097)	2.5(18.083)					
Fuel system	Nozzle nut	Thread diameter × pitch mm	M20×1.5					
		Quantity	1	2	3			
		Tightening torque kgf-m(ft-lb)	10(72.330)					
	Delivery valve holder	Thread diameter	M18					
		Quantity	1	2	3			
		Tightening torque kgf-m(ft-lb)	4.0~4.5(28.932~32.549)					
	Fuel injection nozzle flange nut	Thread diameter × pitch mm	M8 × 1.25					
		Quantity	2 × 1 = 2	2 × 2 = 4	2 × 3 = 6			
		Tightening torque kgf-m(ft-lb)	2(14.466)					
Clutch system	Clutch housing nut	Thread diameter × pitch mm	M8×1.25				(*2) GM-series: M18 x 1.5 3HM35(F)(C): M24  a: 39.5 (1.5551) b: 32 (1.2598) c: 7 (0.2755)	
		Quantity	8					
		Tightening torque kgf-m(ft-lb)	2.0~2.5(14.466~18.083)					
	Clutch mounting bolt	Thread diameter × pitch mm	M8×1.25					
		Quantity	8					
		Tightening torque kgf-m(ft-lb)	2.0~2.5(14.466~18.083)					
	Output shaft coupling tightening nut	Thread diameter × pitch mm	(*2)					
		Width B/C mm(in.)	30/34.6(1.1811/1.3622)		(*3)			
		Quantity						
		Tightening torque kgf-m(ft-lb)	10±1.5 (72.330~10.850)		9.5 (68.714)			
	Starter motor mounting top	Thread diameter × pitch mm	M10×1.5			M12		
		Quantity	2					
Tightening torque kgf-m(ft-lb)		4.5~5.0 (32.549~36.165)			7.5~8.0 (54.248~57.864)			
AC generator mounting bolt	Thread diameter × pitch mm	M8×1.25						
	Quantity	3						
	Tightening torque kgf-m(ft-lb)	2.2~2.7(15.913~19.530)						

3-2 General bolt and nut tightening torque

Diameter of thread	kgf-m(ft-lb)	
	General bolts 7T	Pipe joint bolts
M6	0.9±0.1 (5.9 ~ 7.2)	—
M8	2.5±0.2 (16.6 ~ 19.5)	1.2 ~ 1.7 (8.7 ~ 12.3)
M10	4.7±0.3 (31.8 ~ 36.2)	—
M12	8.0±0.5 (54.2 ~ 61.5)	2.5 ~ 3.5 (18.1 ~ 25.3)
M14	13.0±0.5 (90.4 ~ 97.6)	4.0 ~ 5.0 (28.9 ~ 36.2)
M16	20.5±0.5 (144.7 ~ 151.9)	5.0 ~ 6.0 (36.2 ~ 43.4)

4. Packing Supplement and Adhesive Application Points

The packing used in this engine is asbestos sheet sealed at both mating faces.

Be sure to use the correct supplement in accordance with the table below.

Location	Packing (coated)	Packing agent and adhesive
Cylinder head	Both sides of cylinder head side cover packing Cylinder head top and bottom casting sand hole plug Rocker arm chamber packing (rocker arm chamber side) Both sides of cylinder head gasket packing Intake and exhaust manifold bolt threads Exhaust manifold stud bolt thread Rocker arm support stud bolt Cooling water outlet joint threads	"Three Bond No. 4" "Three Bond No. 50" "Screw Lock Super 203M" "Screw Lock Super 203M"
Timing gear	Both sides of timing gear case packing Both sides of fuel injection timing adjustment shims Both sides of governor chamber packing Governor drive shaft bearing cover packing	"Three Bond 3B8-005" "Screw Lock Super 203M" "Three Bond 3B8-005"
Cylinder block	Both sides of oil pan packing Outside surface of cylinder liner Cooling water pipe joint threads Lubricating oil suction pipe threads Lubricating oil intake pipe blind plug threads Oil pressure regulator valve threads Oil pressure switch threads Cylinder head bolt stud Mounting flange face Lube oil pump face Both sides of bushing shell packing Both sides of dipstick flange packing Both sides of fuel pump packing	"Three Bond 3B8-005" White paint "Three Bond No. 20" "Screw Lock Super 203M" "Three Bond 3B8-005"
Crankshaft, piston	Crankshaft V-pulley key groove tightening section Connecting rod bolt threads	"Three Band 3B8-005"
Cooling system	Both sides of water pump packing Both sides of water pump packing Anticorrosion zinc flange threads Water temperature switch threads Water drain joint (cylinder, exhaust pipe)	"Three Bond No. 2" "Three Bond No. 4"
Clutch system	Mounting flange face Clutch housing face	



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