CHAPTER 7

REDUCTION AND REVERSING GEAR

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Marine Gear Model KBW20/KBW21

1. Construction

1-1 Construction

The Kanzaki-Carl Hurth KBW20 and KBW21 reduction reversing gears were 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 KBW20 and KBW21 consist of a multi-disc clutch and reduction gear housed in a single case. They are 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 fo 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			4JH2E			4JH2-TE		
Marine gear model			KBW20					
Reduction system			One-stage reduction, helical gear					
Reversing system			Constant mesh gear					
Clutch			Wet type multi-disc, mechanically operated					
Reduction ratio	Forward		2.17	2.62	3.28	2.17	2.62	3.28
	Reverse		3.06			3.06		
Diection 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			1.2ℓ					

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Engine model			4JH2-HTE			4JH2-DTE	4JH2-UTE	
Marine gear model			KBW21					
Reduction system			One-stage reduction, helical gear					
Reversing system			Constant mesh gear					
Clutch system			Wet type multi-disc, mechanically operated					
Reduction ratio	Forward		2.17	2.62		2.17	2.62	
	Reverse		3.06			3.06		
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			1.2 ℓ					
lube oil cooler			Sea-water cooling					

IMPORTANT:

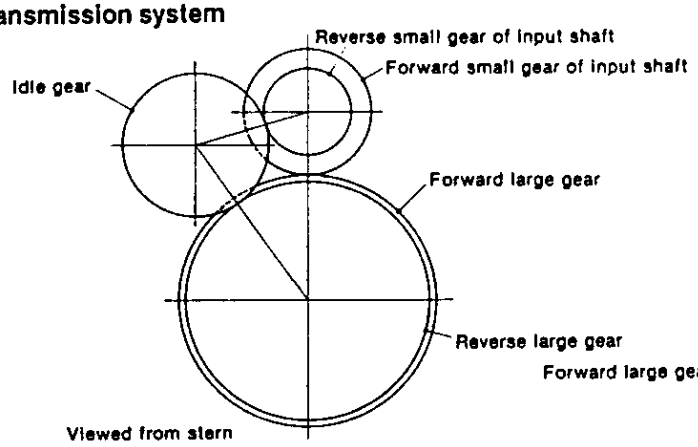
Differences between Marine Gear Models KBW20 and KBW21

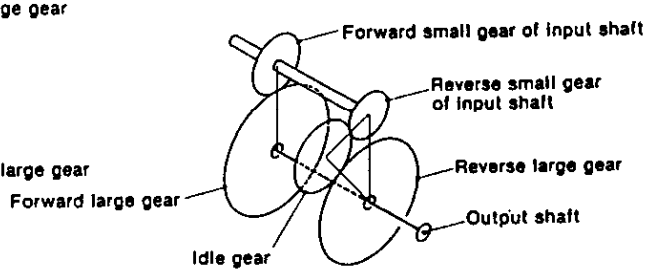
KBW 21 is provided with a lube oil cooler (of side cover monoblock construction).

The dimensions of all KBW21 internal marine gear box components are identical to those of KBW20. However, all KBW21 gears are provided with higher strength through a gear teeth hardening process.

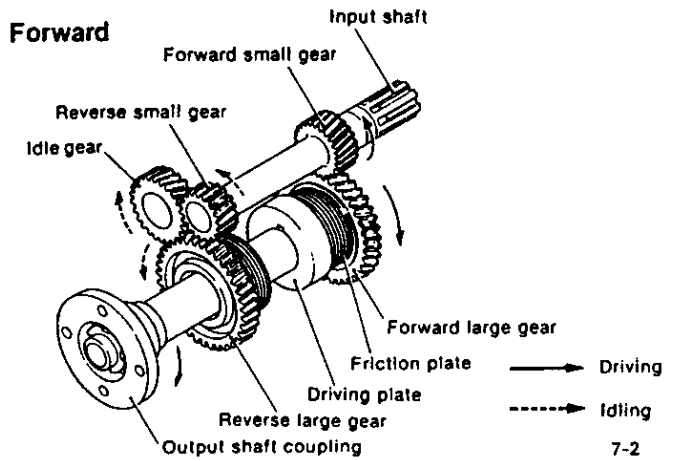
Accordingly, KBW21 can be used both for models 4JHE and 4JH-TE, however, KBW20 cannot be used for models 4JH-HTE and 4JH-DTE since KBW20 is not durable enough for these engine models.

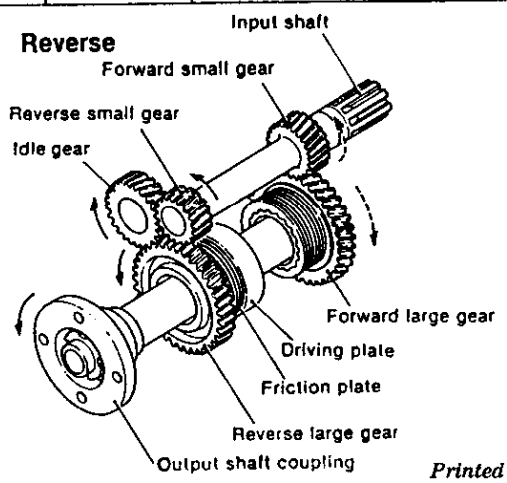
1-3 Power transmission system





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	
24	52	52/24 = 2.17	18	25	55	55/18 = 3.06
21	55	55/21 = 2.62				
18	59	59/18 = 3.28				





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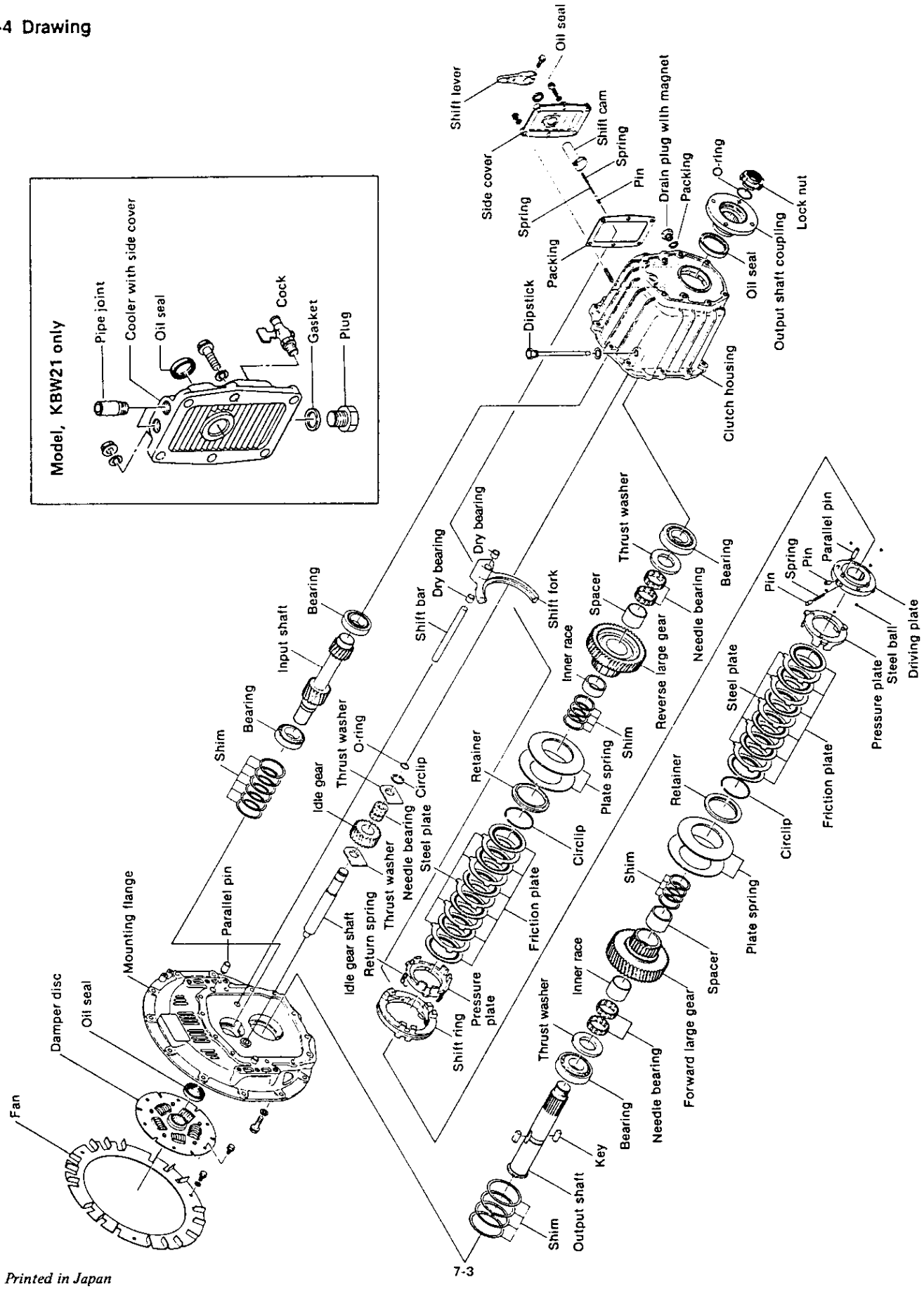
1-4 Drawing



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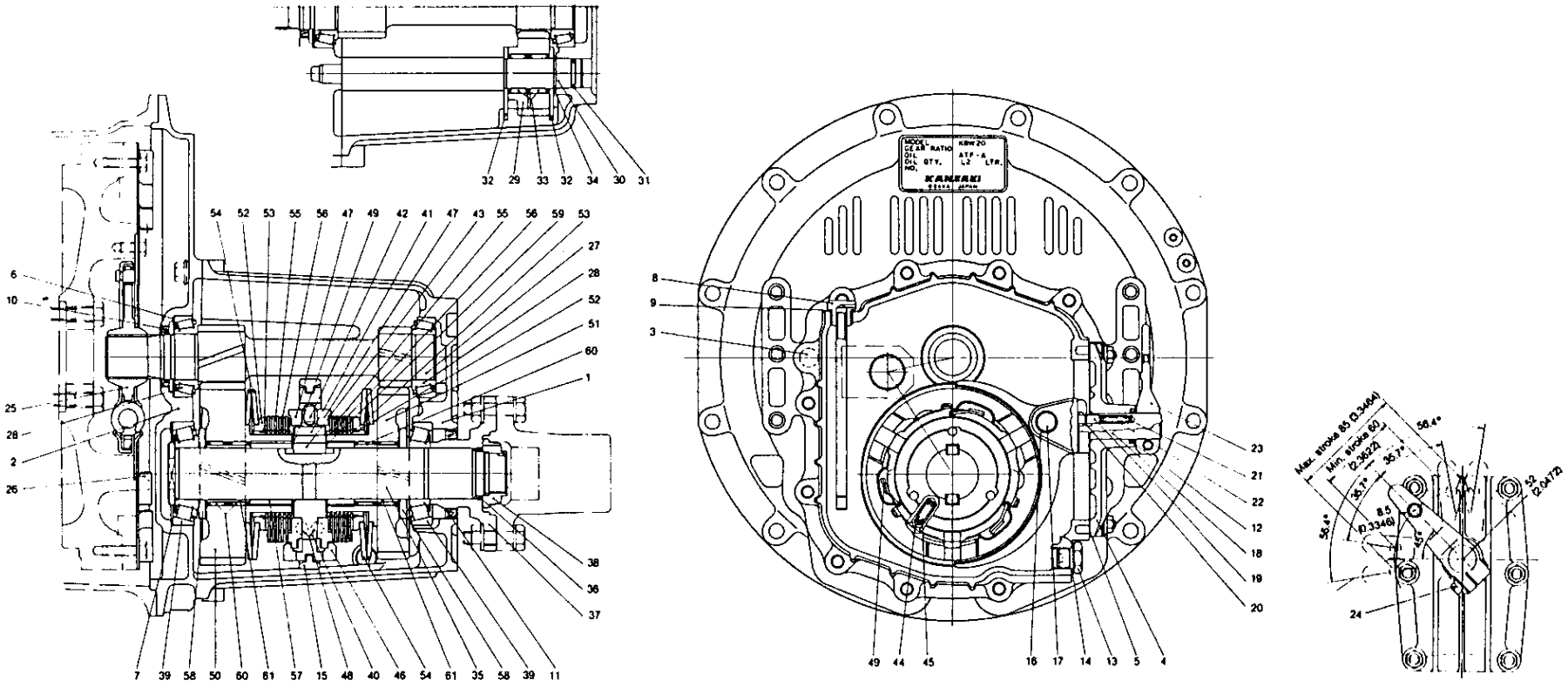
1-5 Cross section

Model: KBW20



1. Clutch housing
2. Mounting flange
3. Parallel pin
4. Side cover
5. Packing
6. Shim (input shaft)
7. Shim (output shaft)
8. Dipstick
9. Packing
10. Oil seal (input shaft)
11. Oil seal (output shaft)
12. Oil seal (shift cam)
13. Plug
14. Packing
15. Shift fork
16. Dry bearing
17. Shift bar
18. Shift cam
19. Pin
20. Circlip
21. Spring
22. Spring
23. Shift lever
24. Bolt
25. Damper disc
26. Fan
27. Input shaft
28. Roller bearing
29. Idle gear
30. Idle gear shaft
31. O-ring
32. Thrust washer
33. Needle bearing
34. Circlip
35. Output shaft
36. O-ring
37. Output shaft coupling
38. Lock nut
39. Roller bearing
40. Driving plate
41. Parallel pin
42. Parallel pin
43. Key
44. Pin
45. Spring
46. Shift ring
47. Pressure plate
48. Steel ball
49. Return spring
50. Forward gear
51. Reverse gear
52. Retainer
53. Circlip
54. Plate spring
55. Friction disc
56. Steel plate
57. Spacer
58. Thrust washer
59. Shim (output shaft)
60. Needle bearing
61. Inner race

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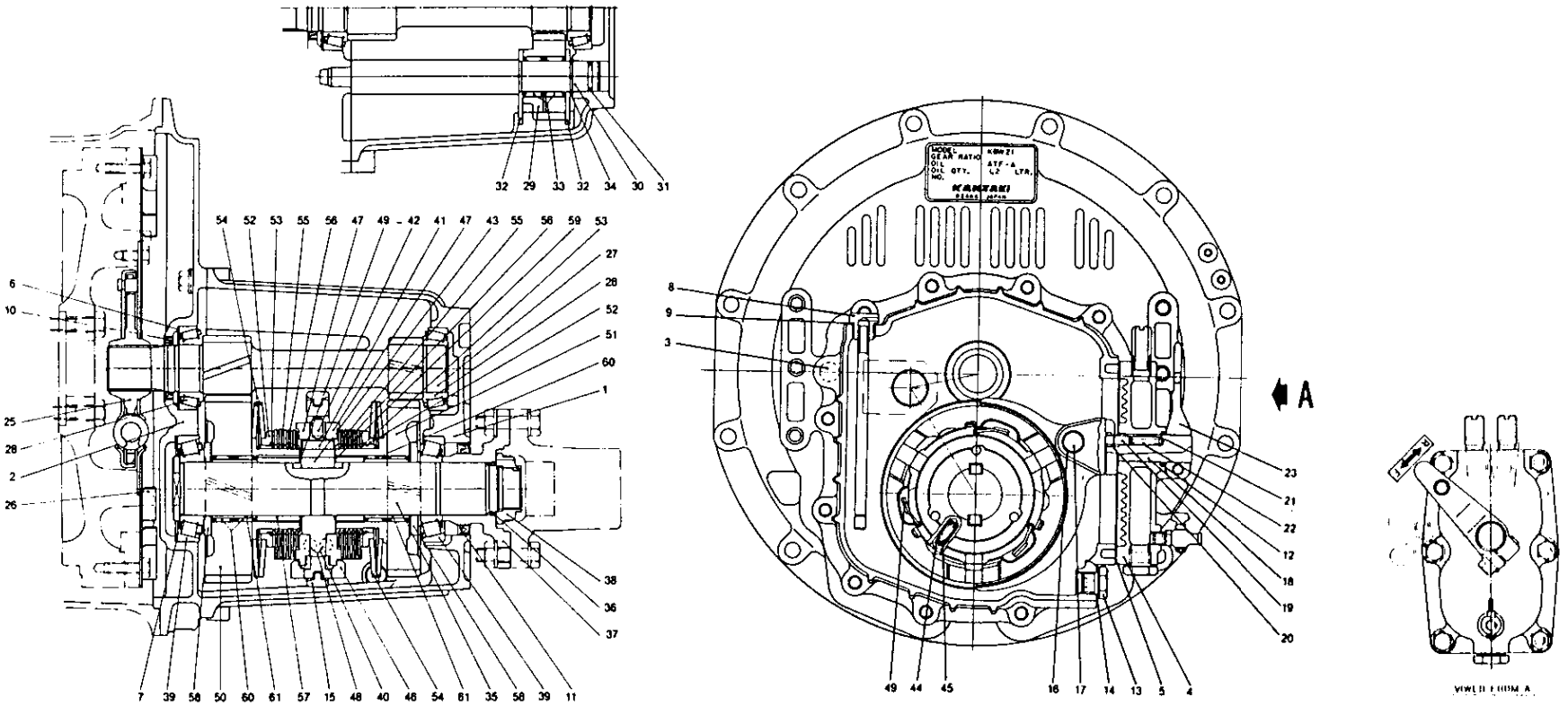
Cross section

Model: KBW21



1. Clutch housing
2. Mounting flange
3. Parallel pin
4. Side cover
5. Packing
6. Shim (input shaft)
7. Shim (output shaft)
8. Dipstick
9. Packing
10. Oil seal (input shaft)
11. Oil seal (output shaft)
12. Oil seal (shift cam)
13. Plug
14. Packing
15. Shift fork
16. Dry bearing
17. Shift bar
18. Shift cam
19. Pin
20. Circlip
21. Spring
22. Spring
23. Shift lever
24. Bolt
25. Damper disc
26. Fan
27. Input shaft
28. Roller bearing
29. Idle gear
30. Idle gear shaft
31. O-ring
32. Thrust washer
33. Needle bearing
34. Circlip
35. Output shaft
36. O-ring
37. Output shaft coupling
38. Lock nut
39. Roller bearing
40. Driving plate
41. Parallel pin
42. Parallel pin
43. Key
44. Pin
45. Spring
46. Shift ring
47. Pressure plate
48. Steel ball
49. Return spring
50. Forward gear
51. Reverse gear
52. Retainer
53. Circlip
54. Plate spring
55. Friction disc
56. Steel plate
57. Spacer
58. Thrust washer
59. Shim (output shaft)
60. Needle bearing
61. Inner race

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.

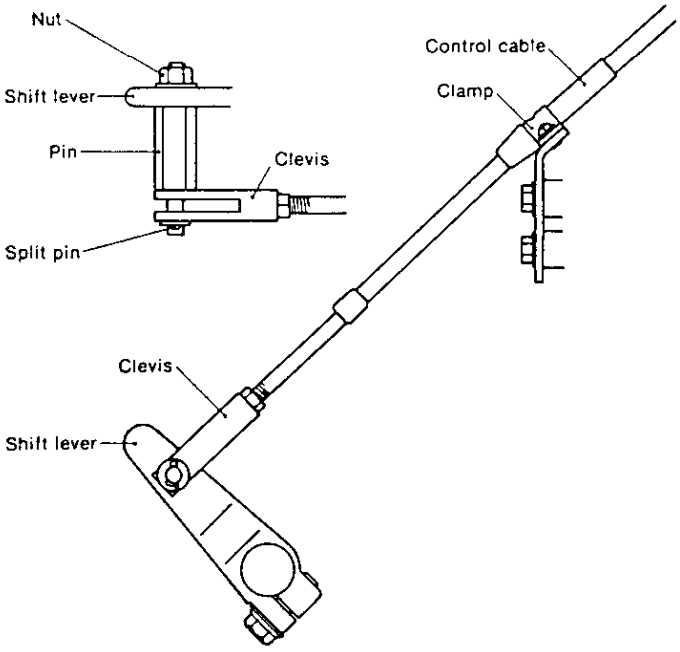
2-2 Remote control unit

This marine gearbox is designed for single lever control to permit reversing at full engine speed (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.

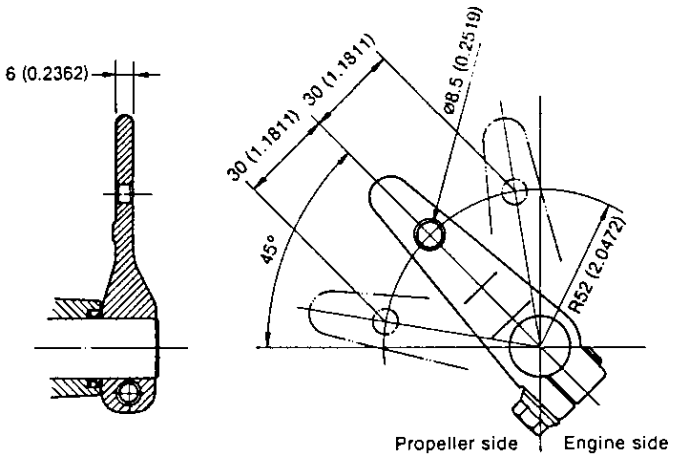
The shift play, measured at the pivot point of the shift lever, must be at least 30mm (1.1811in.) on each side (reverse and forward) of the neutral position. Greater shift play has no adverse effect on the marine gearbox. After connecting the linkage, confirm that the remote control and the shift lever 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.)

mm(in.)



Side view of clutch

2-3 Clutch operation force (reference value)

Operation position / Operation direction	Operation lever position at 52mm (2.0472in.)	Remarks
Engaging stroke	Approx. 9.5kg (20.94 lb)	Engine speed at 1000 rpm
Disengaging stroke	Approx. 11.5kg (25.35 lb)	

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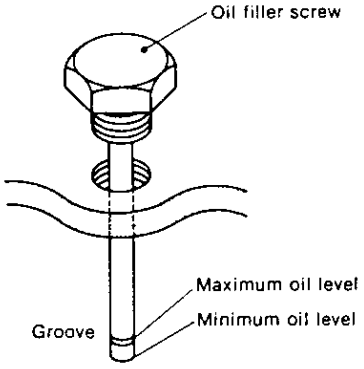
3. Operation and Maintenance

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 50 hours of operation, and every 150 hours of operation thereafter. When adding oil between oil changes, always use the same type of oil as 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.

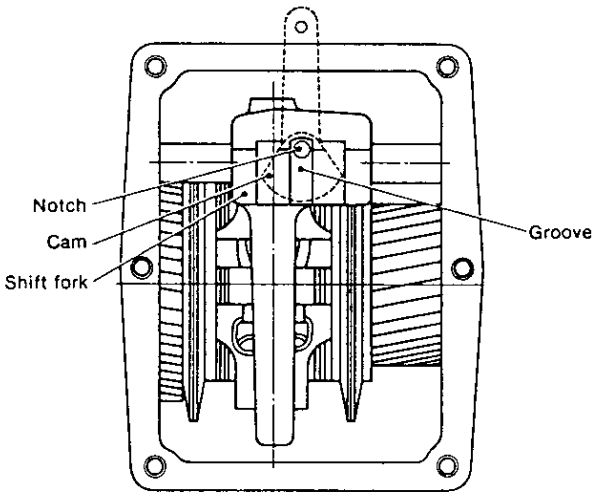
3-3 Side cover

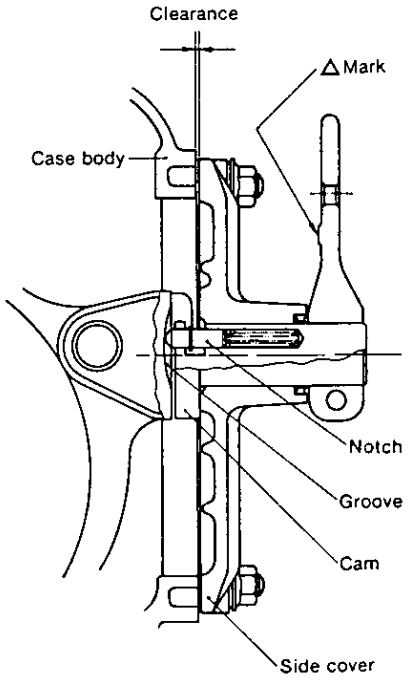
The internal shifting mechanism has been carefully aligned at the factory. Improper removal of the side cover can cause misalignment. If the side cover must be removed, proceed as follows:

—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. Use packing 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.





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4. Inspection and Servicing

4-1 Clutch case

(1) Check the clutch case for cracking with a test hammer. 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.

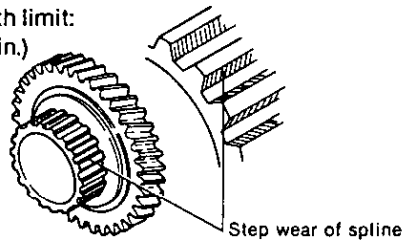
(2) Tooth surface contact
Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.

(3) Backlash
Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

mm (in.)

	Standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	0.3 (0.0118)
Input shaft reverse gear and intermediate gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	0.3 (0.0118)
Intermediate gear and output shaft reverse gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	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

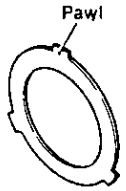
(1) Burning, scratching, cracking
Replace any steel plates that are discolored or cracked.

(2) Warping measurement

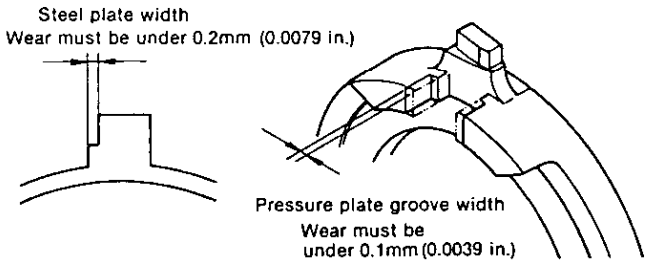
mm (in.)

	Standard	Wear limit
Warping	1.49 ~ 1.70 (0.0586 ~ 0.0669)	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.



mm (in.)

	Standard	Wear limit
Steel plate width	11.8 ~ 12.0 (0.4645 ~ 0.4724)	Worn 0.2 (0.0078)
Pressure plate groove	12.0 ~ 12.1 (0.4724 ~ 0.4763)	Worn 0.1 (0.0039)
Clearance	0 ~ 0.3 (0 ~ 0.0118)	0.3 ~ 0.6 (0.0118 ~ 0.0236)

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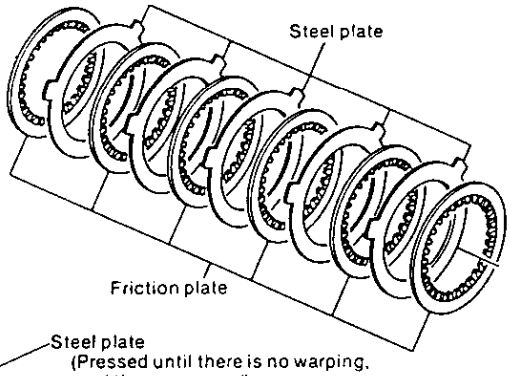
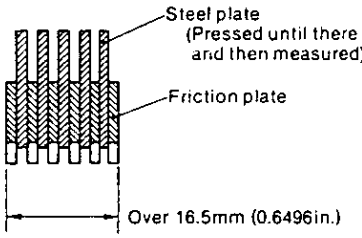
4-5 Friction plate

(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.)

	Standard	Wear limit
Friction plate thickness	1.65 ~ 1.70 (0.0649 ~ 0.0669)	1.5 (0.0590)

The assembled friction plate and steel plate dimensions must be over 16.5mm (0.6496in.).

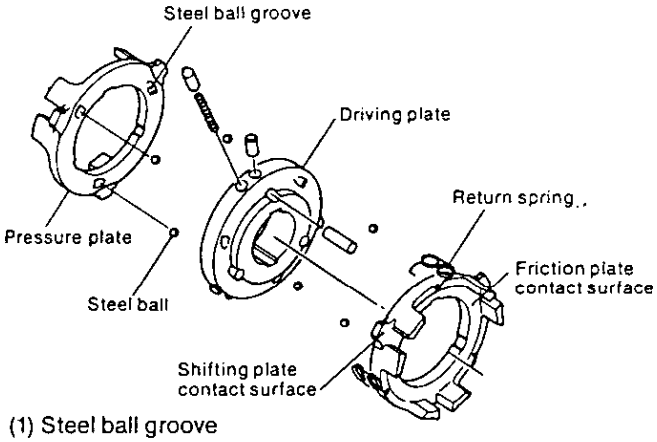
Both sides of the friction plate have a 0.35mm (0.0138in.) copper sintered layer. Replace the friction plate when this layer is worn more than 0.2mm (0.0079in.) on one side (standard thickness 1.65 ~ 1.70 (0.0650 ~ 0.0670in.)). However, the sum of the wear of the six friction plates must not exceed 1.2mm (0.0472in.). 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.)

	Standard	Wear limit
Standard backlash	0.20 ~ 0.61 (0.0078 ~ 0.0240)	0.9 (0.0354)

4-6 Pressure plate

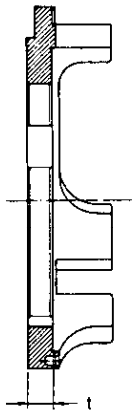


(1) Steel ball groove
Check the steel ball groove for stains and wear.
Replace the pressure plate if the groove is noticeably worn.

(2) Friction plate contact surface
Check the contact face for stains and damage.

(3) Shifting plate contact surface

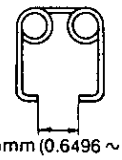
(4) Worn parts measurement



mm (in.)

	Standard	Wear limit
Thickness: t	8.0 ~ 8.1 (0.3149 ~ 0.3188)	7.9 (0.3110)

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



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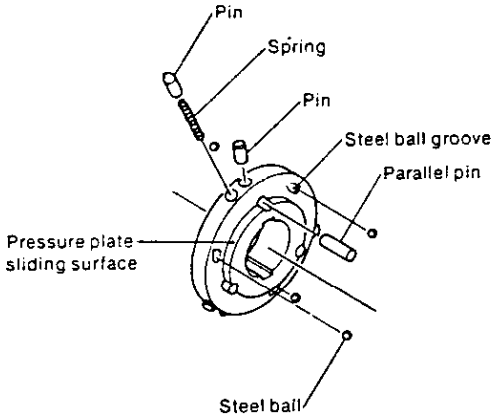
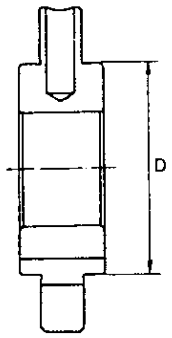
4-7 Driving plate



(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.)

	Standard	Wear limit
Outside diameter: D	ø68.366 ~ 68.440 (2.6915 ~ 2.6944)	ø68.3 (2.6889)

(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.)

	Standard	Wear limit
Spring free length	32.85 (1.2933)	32 (1.2598)

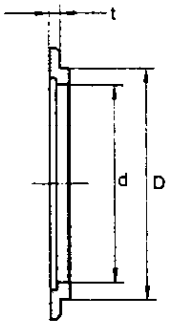
(6) Pin end wear.

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

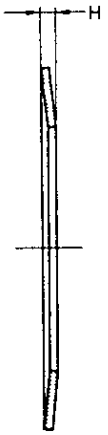


mm (in.)

	Standard	Wear limit
d	ø67.060 ~ 67.106 (2.6401 ~ 2.6419)	ø67.3 (2.6496)
D	ø75.9 ~ 76.0 (2.9881 ~ 2.9921)	ø75.7 (2.9803)
t	4.95 ~ 5.05 (0.1948 ~ 0.1988)	4.8 (0.1889)

4-9 Plate spring

(1) Permanent strain



mm (in.)

	Standard	Wear limit
H: when plate spring is free	7.2 ~ 7.6 (0.2834 ~ 0.2992)	7.05 (0.2775)

4-10 Thrust collar

The gear side of the thrust washer has a 0.3mm (0.0118in.) copper sintered layer. Replace the thrust collar when the thickness is less than 5.75mm (0.2263in.) (Standard thickness: 5.9 ~ 6.0mm (0.2322 ~ 0.2362).

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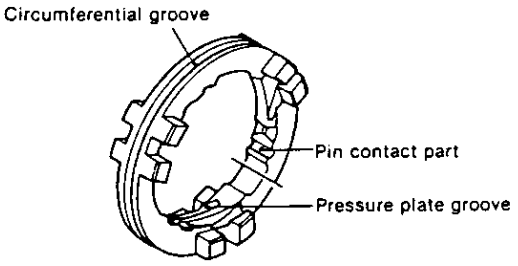
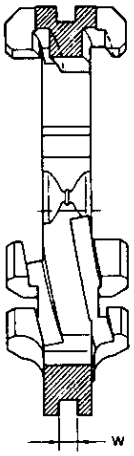
4-11 Shift ring



(1) Circumferential groove wear.

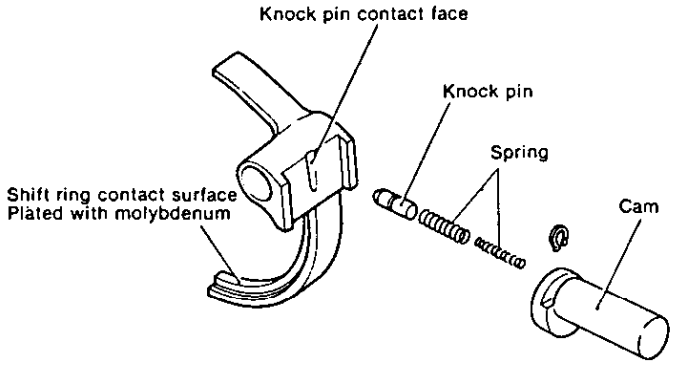


mm (in.)

	Standard	Wear limit
Shifting groove: w	6.0 ~ 6.1 (0.2362 ~ 0.2401)	6.3 (0.2480)

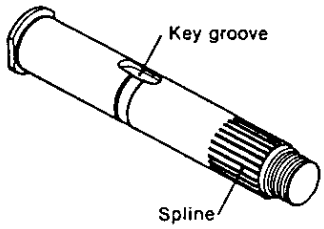
(2) Pressure plate groove wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
(3) Parallel pin contact part wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-12 Shift fork and shift lever



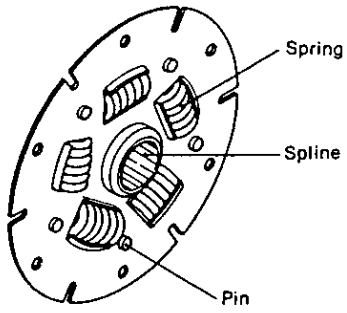
(1) End wear.
The shift ring contact surface of the shift fork is plated with molybdenum (thickness: 0.04 ~ 0.05mm (0.0016 ~ 0.0020in.)). If this plating is peeled or worn to such an extent that the base metal of the shift fork is exposed, replace the shift fork.
(2) Cam surface wear and stains.
Whenever 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.

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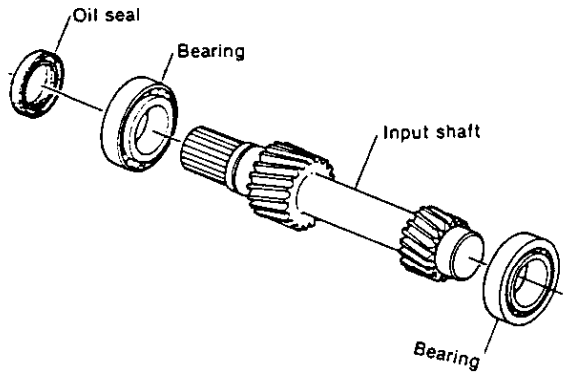
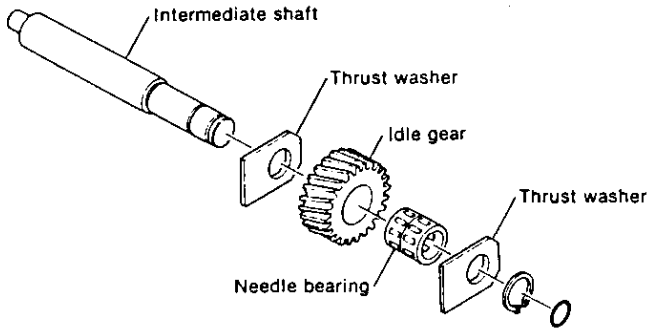
4-15 Input shaft



(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.

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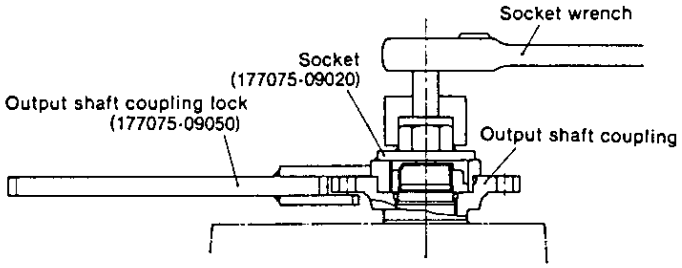
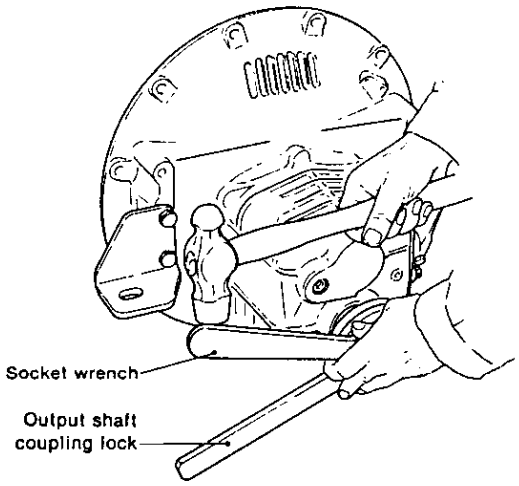
5. Disassembly

5-1 Disassembling the clutch and accessories

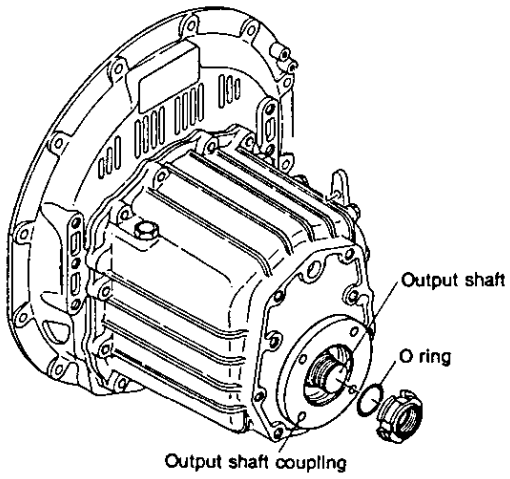
(1) Remove the drain plug and packing, and drain the oil from the clutch.

(2) Uncaulk the output shaft lock nut, and remove the nut using a disassembly tool.



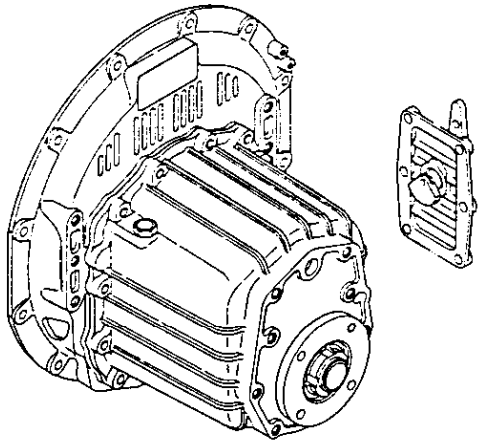


(3) Remove the output coupling with O-ring.



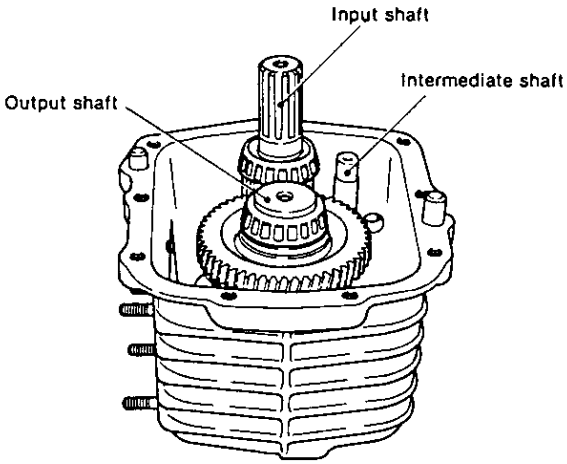
(4) Remove the dipstick and packing.

(5) Remove the case cover M8 nut and M8 bolt; remove the case cover, with the operating lever, shift cam, etc. in position.



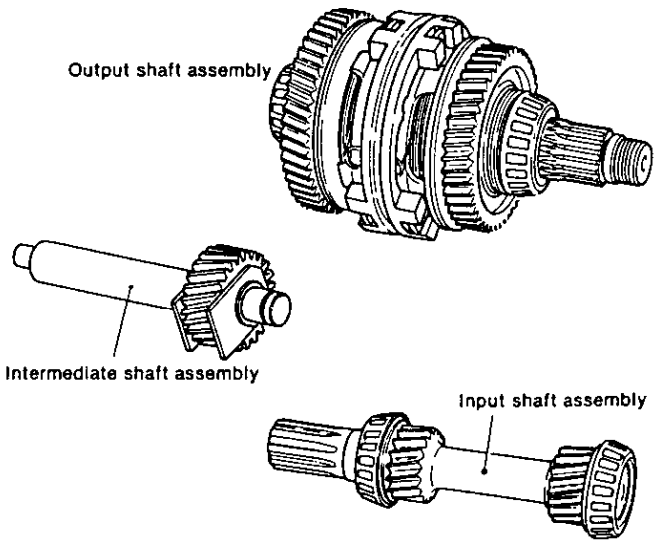
(6) Remove the M10 bolt and super lock washer on the mounting flange.

(7) 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.



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

(9) Remove the shift bar from the moving flange side.



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(10) 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.
(11) Remove the outer race of the bearing from the mounting flange as described in step (11) above.
(12) Remove the input shaft and output shaft adjusting plates.

NOTE: If the follcwing 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

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

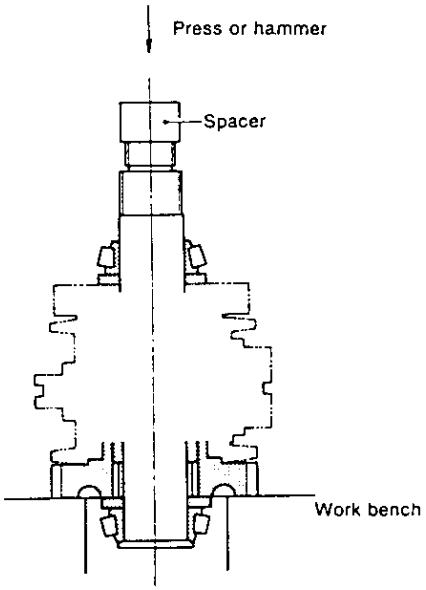
5-2 Disassembling the input shaft

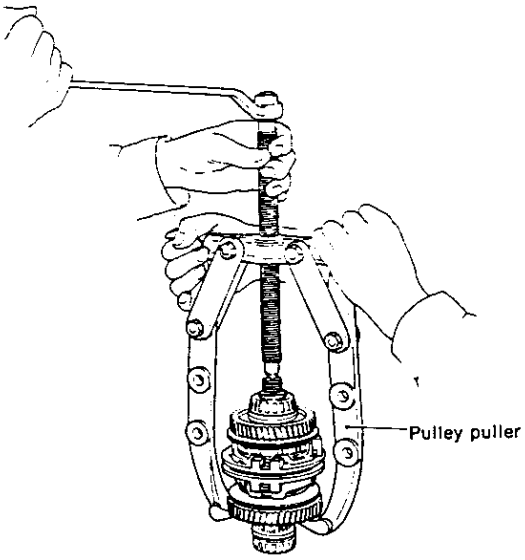
Pull the bearing from the input shaft.

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.

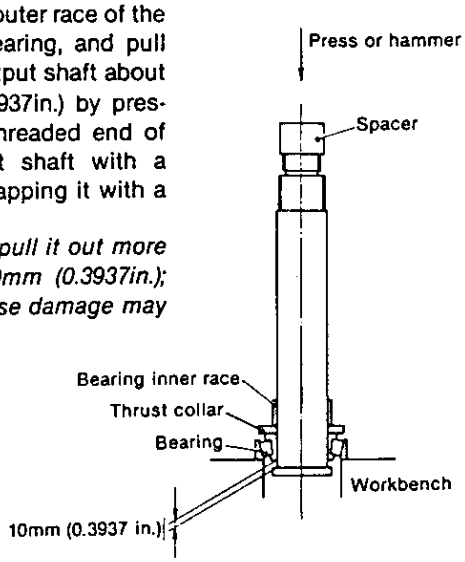
NOTE: Record the thickness of the adjusting plate to facilitate reassembly.
If the parts are not replaced, the adjusting plate may be reused without readjustment. However, if even one part is replaced, readjustment is required.

(4) Remove the key.
To facilitate removal, clamp the key with a vise.
(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.



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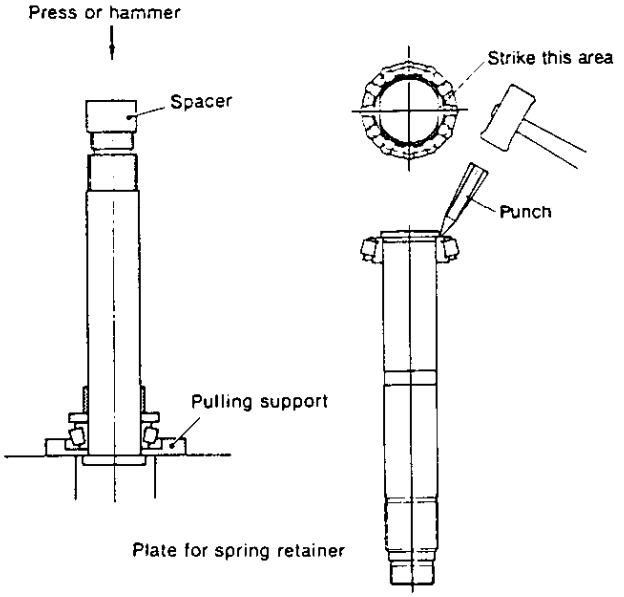
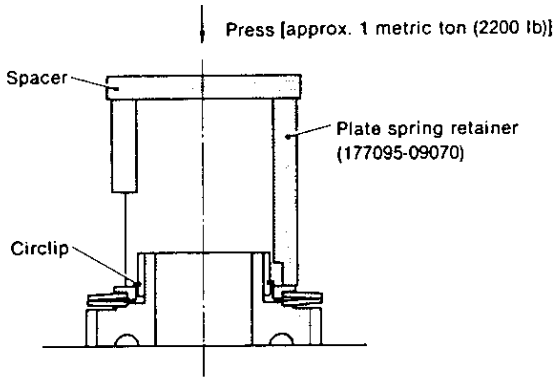
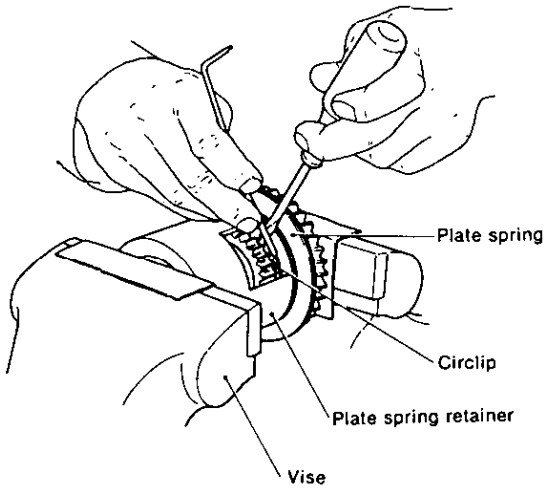
(8) Insert the disassembly tool between the collar of the output shaft and the bearing; next remove the bearing inner race, thrust collar, and bearing from the output shaft with a press or hammer.



(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.

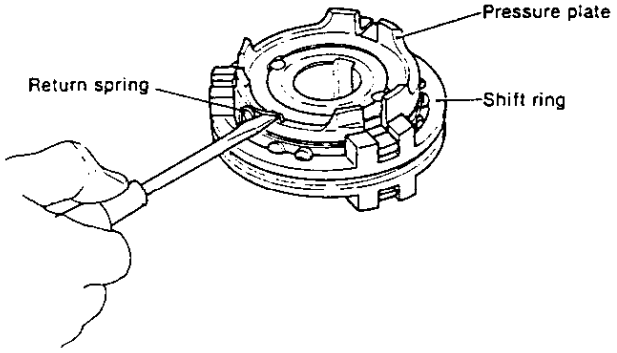




(11) Remove the retainer and plate spring.

(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.

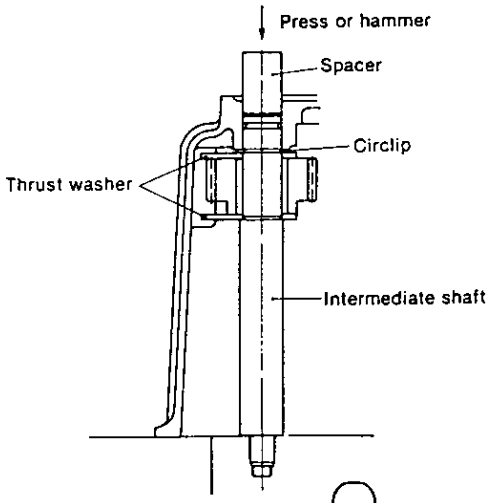


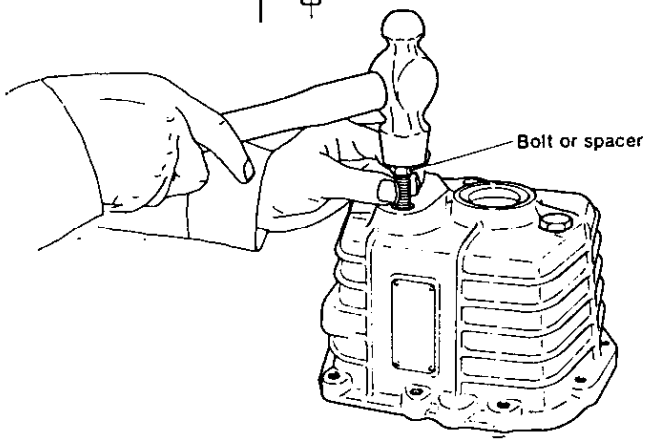
(14) Remove the shift ring.
To disassemble, remove the three knock pins. When disassembling the shift ring, cover it with a cloth to prevent it being lost.

(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.





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(2) Remove the O-ring, and then remove the circlip.
(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.

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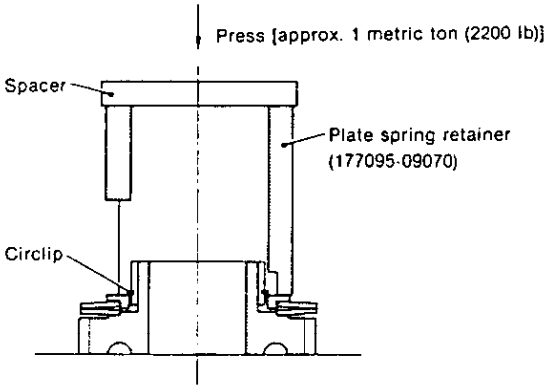
6. Reassembly

6-1 Reassembly precautions

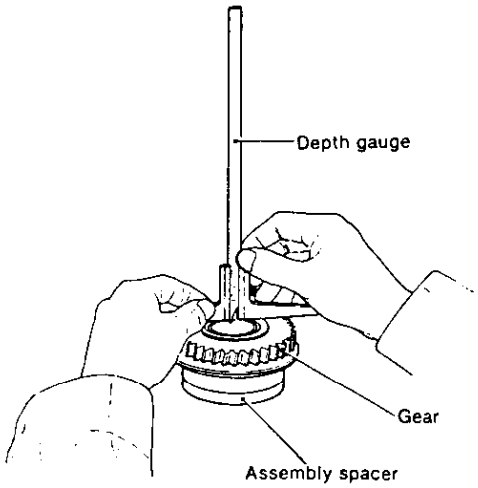
(1) Before reassembling, clean all parts in washing oil, and replace any damaged or worn parts.
Remove non-dry packing agent from the mating surface with a blunt knife.
(2) Pack the oil seal and O-ring parts with grease.
(3) Coat the mating surfaces of the case with wet packing.

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.

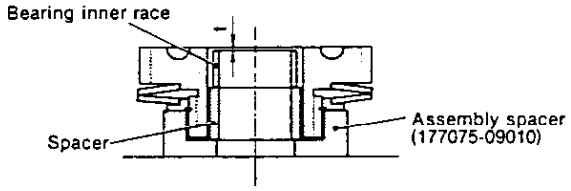


(2) Reassemble the reverse large gear and plate spring retainer, and the circlip as described in step (1) above.
(3) Determining the forward adjusting plate thickness



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

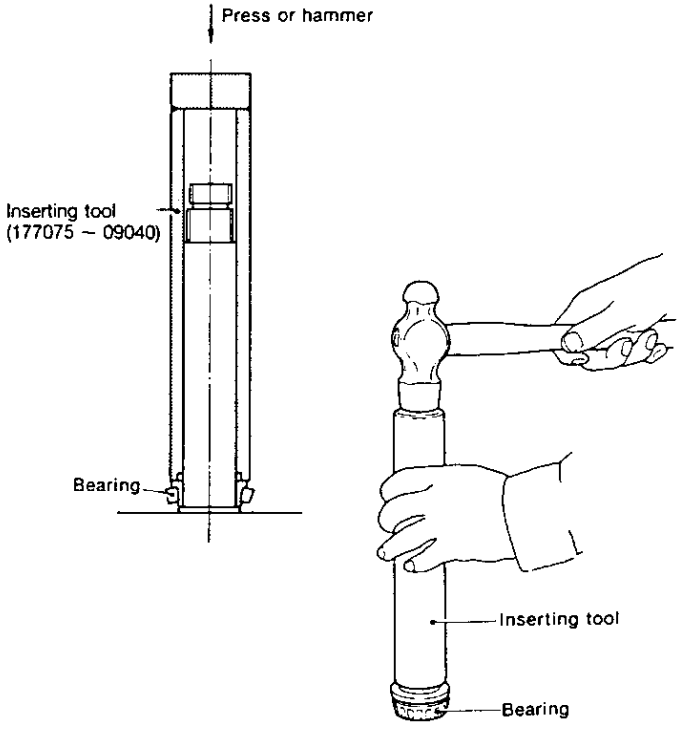
1) Position the assembled large gear on the assembly tool so that the spline part is on the bottom; insert the spacer and bearing inner race into the gear.



2) Three adjustment plates of 0.5mm (0.0196in.), 0.4mm (0.0157in.) and 0.3mm (0.0118in.) are available.
3) Measure the "t" dimension. Combine these plates to obtain a dimension from (t-0.5)mm to (t-0.5)mm.

(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 (six friction plates and five 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 (six friction plates and five 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.



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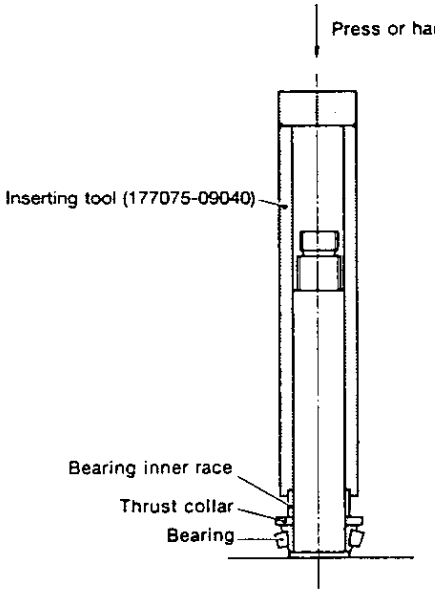
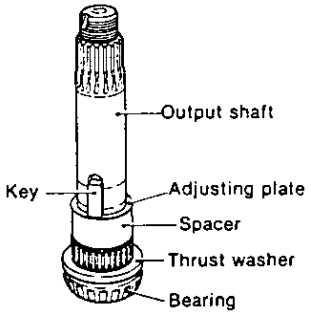
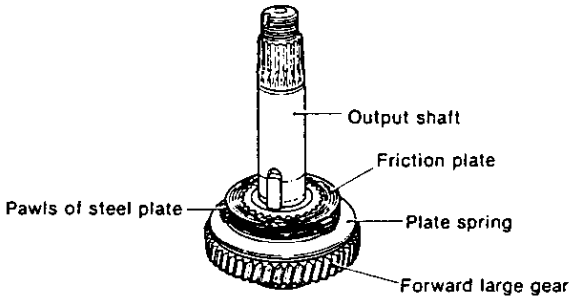
(8) Insert the thrust collar, with the sintered surface (brown surface) facing the gear side.
(9) Press the bearing inner race onto the output shaft, using an assembly tool.



(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.

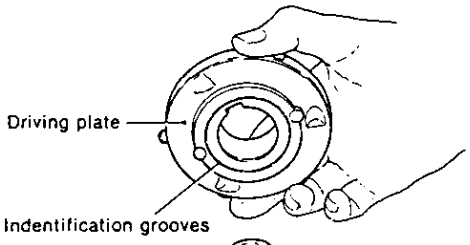


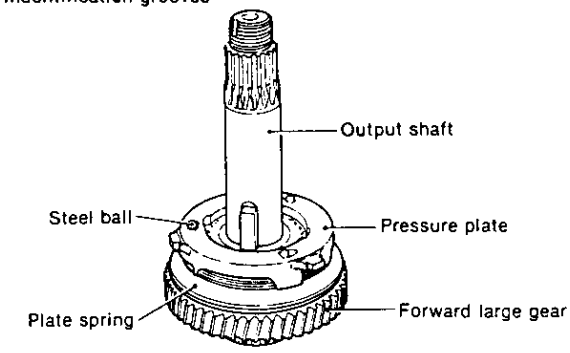
(13) Insert the forward large gear, together with the friction plates and steel plates. At this time, align the three pawls on the outside of the steel plates.

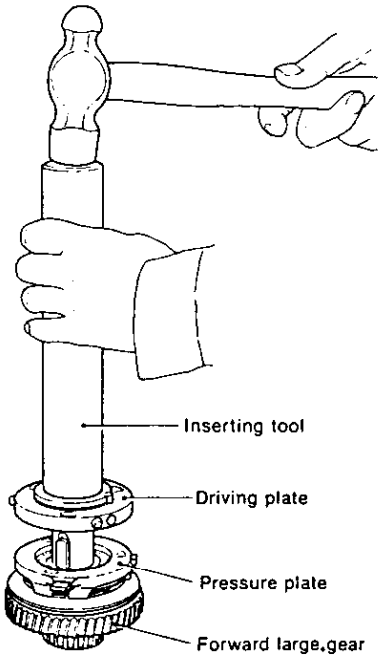


(14) Cover the friction plates and steel plates with the pressure plate so that the pawls of the steel plate fit into the three notches on the pressure plate.
(15) Insert the three steel balls into the three grooves in the pressure plate.
(16) Insert the drive plate into the output shaft so that the 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 limitter for the pressure plate.







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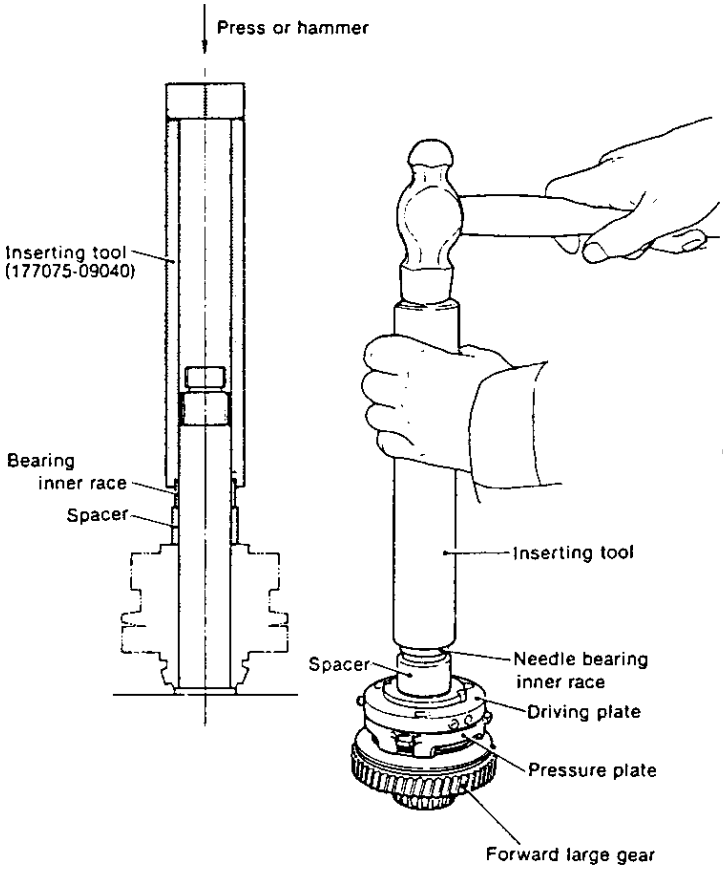
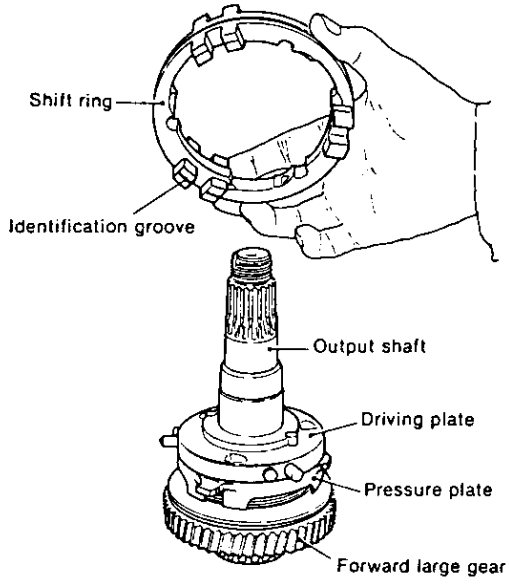
(17) Insert the adjusting plate and spacer.
(18) Press the bearing inner race, using an assembly tool.

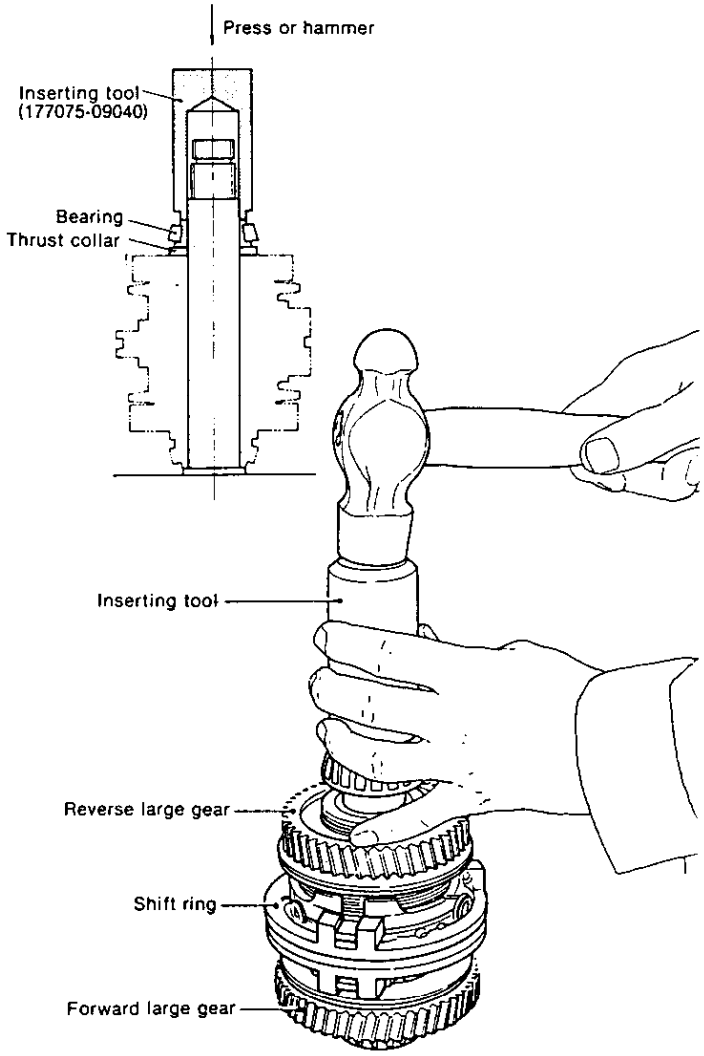


(19) Insert the knock pins and springs into the three holes around the circumference of the driving plate.
(20) Cover the driving plate with the shift ring so that the side with the identification groove faces the forward large gear side; install the ring so that the knock pins are pushed in.



(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. At this time, 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.



Insert the O-ring.
(28) 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.

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6-3 Reassembling the input shaft

Press the inner race of the bearing onto the input shaft. At this time, make sure that the direction of the bearing is correct.

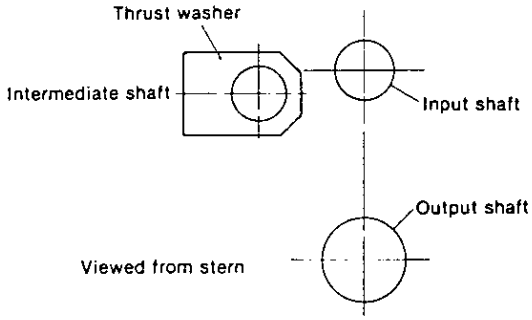
NOTE: The bearing inner race can be easily installed by preheating it to approximately 100°C.

6-4 Reassembling the intermediate shaft

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

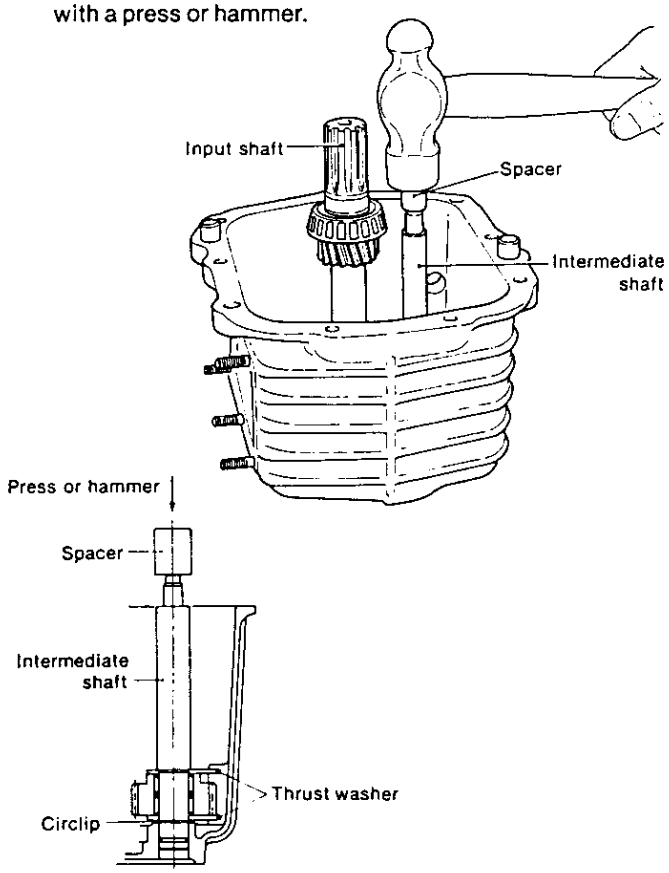
(1) Insert the thrust washer the needle bearing and idle gear on the intermediate shaft. Then insert the thrust washer.

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



(2) Insert the circlip on the intermediate shaft, and then insert the O-ring.

(3) Press the assembled intermediate shaft into the case with a press or hammer.



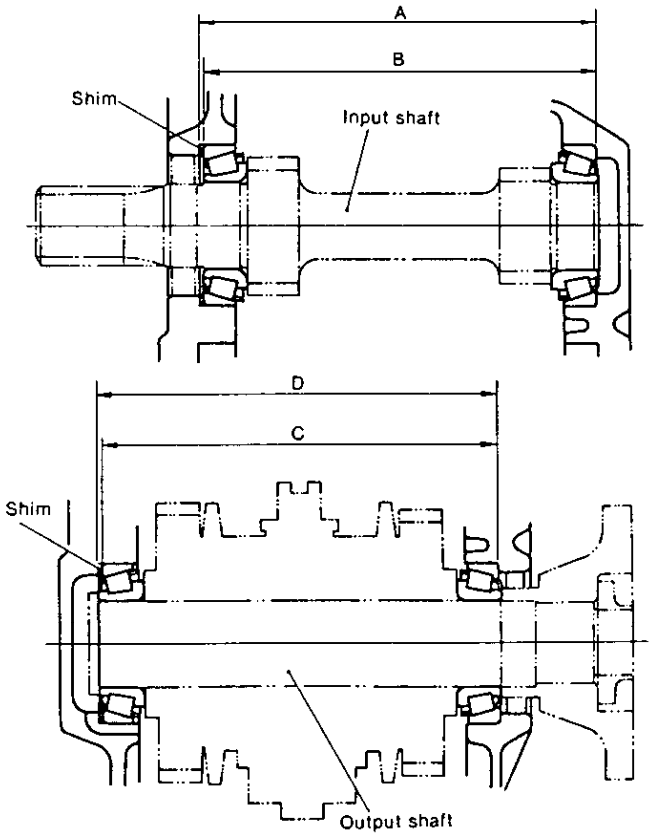
(4) Make sure that the idle gear rotates smoothly.

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) Three adjustment plates of 0.5mm (0.0196in.), 0.4mm (0.0157in.) and 0.3mm (0.0118in.) 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 liquid packing agent, and press it onto the mounting flange and case so that the spring part of the oil seal is inside the case.

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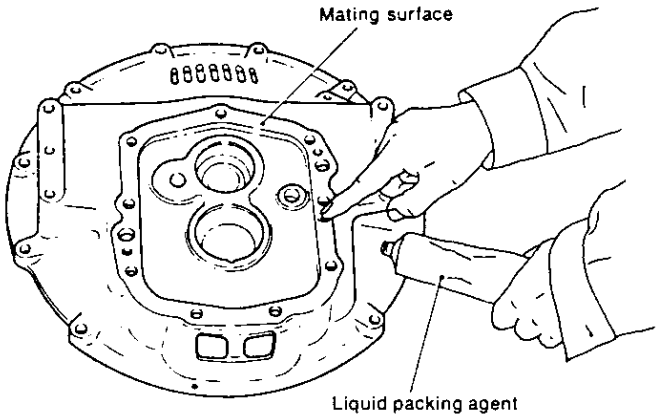
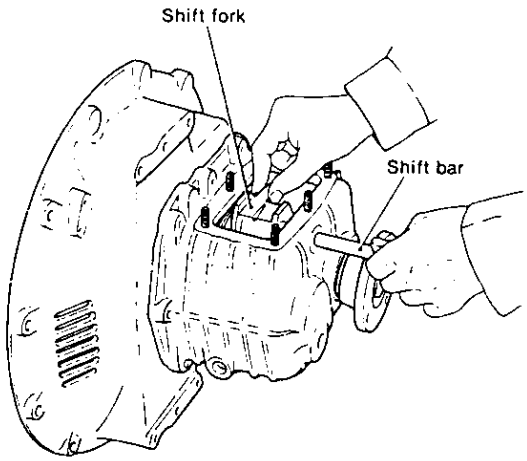
(4) Coat the mating surfaces of the mounting flange and case with a liquid packing agent.
Wipe off oil and dirt on the mating surface of the case and coat with a thin film of liquid packing agent.

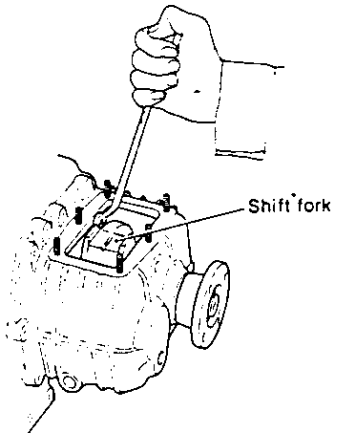


(5) Insert the input shaft into the case, assemble the intermediate shaft as described in section 6-4 and then insert the output shaft into the case, mounted with shift fork and shift ring.
(6) Align the mounting flange with the case, and insert the parallel pin by tapping the mounting flange with a 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.

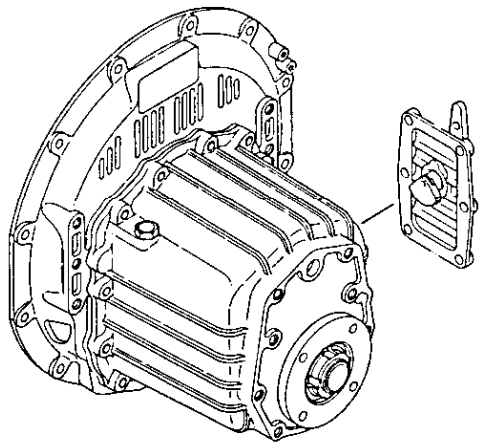
6-6 Reassembling and installing the operating system



(1) Put the shift fork into neutral before installing.



(3) Coat the circumference of the oil seal with a liquid packing agent and press the seal against 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 with operating system in 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.

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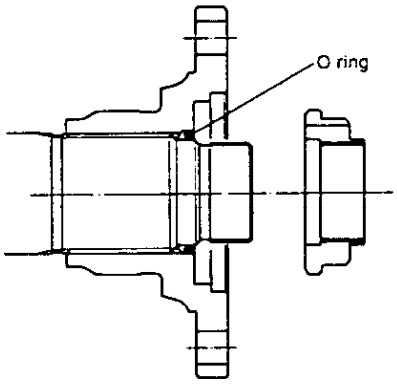
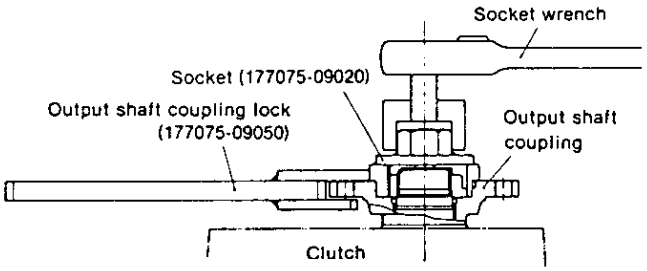
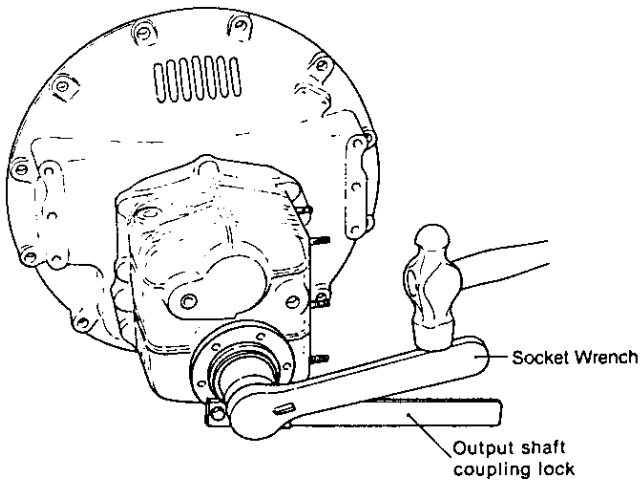
6-7 Installing the output shaft coupling

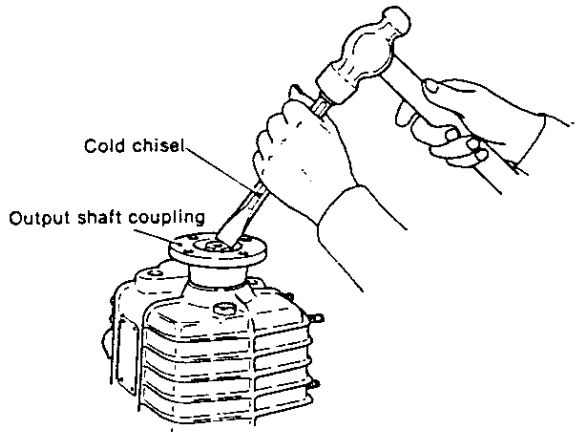
(1) Install the output shaft coupling on the output shaft and then insert the O-ring in the groove between the output shaft and the output shaft coupling.



(2) Tighten and caulk the output shaft lock nut, using the assembly tool.
Tightening torque.....15kg-m (108.5ft-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.

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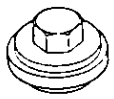
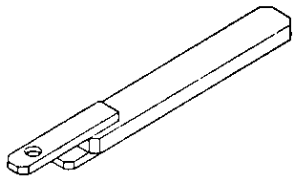
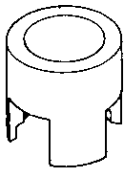
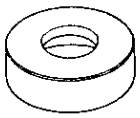
7. Special Tools

Name of tool	Part number	Illustration	Application
Socket	177075-09020		For removing and tightening the output shaft nuts.
Output shaft coupling lock	177075-09050		For removing and tightening the output shaft nut.
Plate for spring retainer	177095-09070		For removing and installing the plate spring, retainer and circlip of the large gear (forward and reverse).
Assembly spacer	177075-09010		For determining the thickness of adjusting plate.
Inserting tool	177075-09040		For installing the spacer and needle bearing inner race of the output shaft (reverse small gear side).
Inserting tool	177075-09030		For installing the thrust bearing of the input shaft.

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Marine Gear Model

KM4A

for Engine Models 4JH2-BE, 4JH2-TBE, 4JH2-HTBE and 4JH2-DTBE

1. Construction

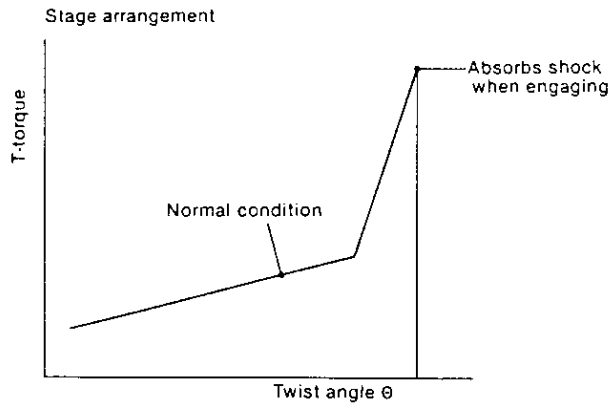
1-1 Construction

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

The construction is simple compared with other types of clutch and 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. It is also durable and reliable because high grade materials are used for the shaft and gear, and a taper roller bearing is incorporated. Power transmission is smooth because connection with the engine is made through the damper disc.

- The drive cone is made from special aluminum bronze which has high wear-resistance and durability. The drive cone is connected with the clutch shaft. The taper angle, diameter of the drive cone, twist angle, and diameter of the involute 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. This is non-corrosive in seawater.
- The damper disc is fitted to the input shaft, so power can be transmitted smoothly. Springs of different strengths are used for the damper disc 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 clutch 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. Accordingly no adjustment of the remote control cable is required.
- The cup spring on the rear of the clutch gear absorbs rotational fluctuations and stabilizes the engagement of the drive cone and the clutch gear. Thus, the durability of the cone against wear is enhanced.

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- A torque limiter is built into the input shaft gear to prevent damage caused by excessive torque.
- The lube oil temperature can be controlled because in addition to the input shaft gear which functions as a centrifugal pump, an oil cooler is also equipped.
- The oil cooler is equipped with a cooling water drain cock to prevent cracks caused by freezing in cold weather. It is therefore easy to drain the water.
- The propeller shaft can rotate in both counter clockwise (C.C.W.) and clockwise (C.W.) directions.

NOTE: Since the difference in reduction gear ratio between C.C.W. and C.W. rotations is within 0.07%, no problem occurs in operation.

1-2 Specifications of Angle Drive Marine Gear

Model		KM4A		
For engine models		4JH2E, 4JH2-TE, 4JH2-HTE, 4JH2-DTE, 4JH2-UTE		
Down angle		7 degree		
Clutch		Constant mesh gear with servo cone clutch (wet type)		
Direction of rotation	Input shaft	Counter-clockwise, viewed from stern.		
	Output shaft	Bi-rotation		
Reduction ratio		3.30	2.63	2.14
Propeller shaft rpm at cont. rating		1062	1332	1637
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	ϕ120mm (4.72")		
	Pitch circle diameter	ϕ100mm (3.93")		
	Connecting bolt holes	4–ϕ10.5mm (4–ϕ0.41")		
Position of shift lever		Right side, viewed from stern		
Lubricating oil		Same as Engine lube oil		
Lubricating oil capacity		1.3ℓ		
Lube oil cooler		Sea-water cooling		

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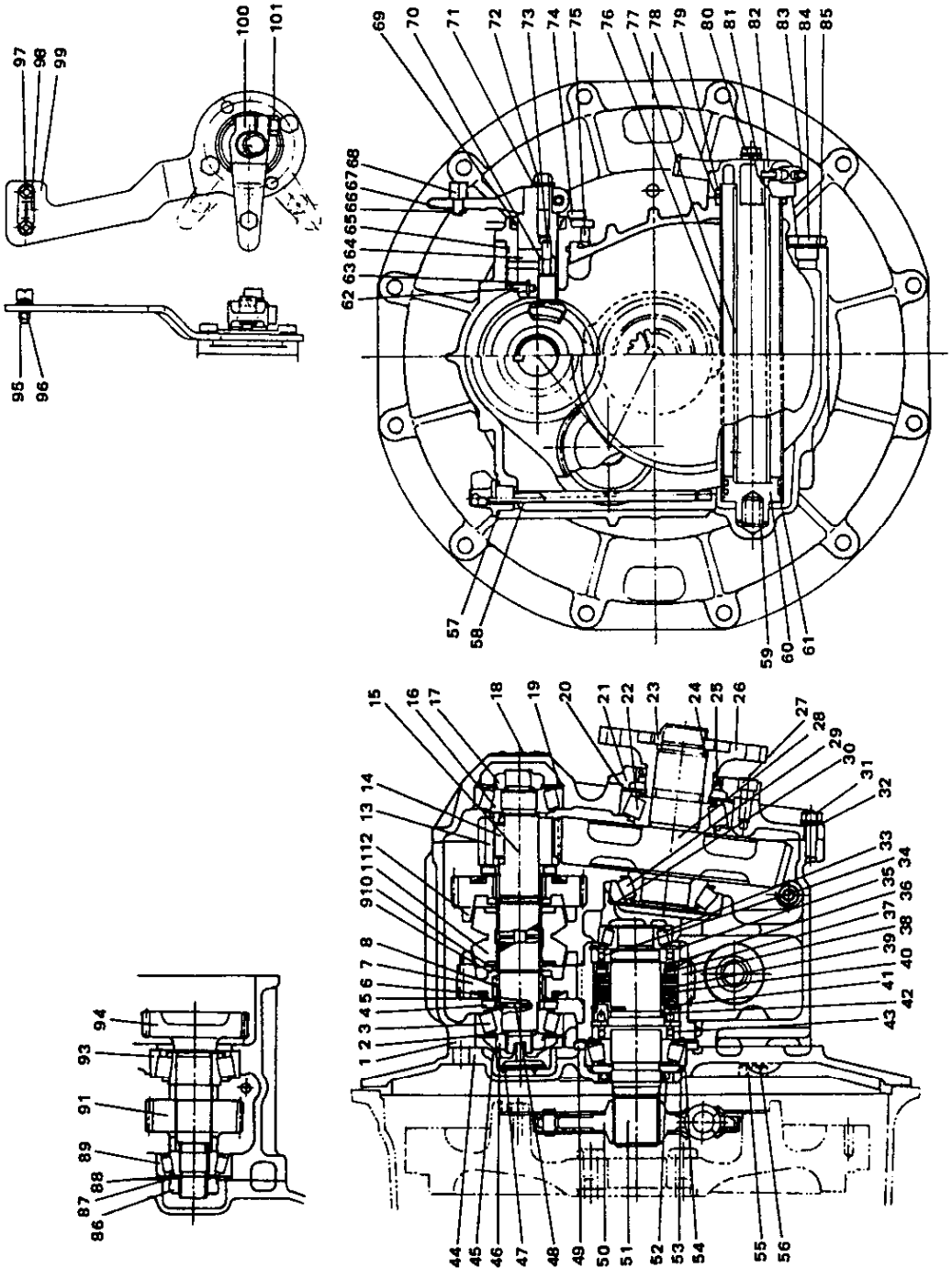
1-3 KM4A Sectional View



1 Clutch case
2 Shim
3 Bearing
4 Thrust collar(A)
5 Spring retainer
6 Cup spring
7 Clutch gear(A)
8 Needle bearing
9 Thrust collar(B)
10 Snap ring
11 Drive cone
12 Clutch gear B
13 Drive gear
14 Key
15 Clutch shaft
16 Bearing
17 End nut
18 Name plate
19 Shim
20 Shim
21 Output shaft cover
22 Bearing
23 End nut
24 O - ring
25 Oil seal
26 Output shaft coupling
27 Bolt
28 Output shaft
29 Bearing
30 Shim
31 Bolt
32 Washer
33 Bearing
34 Ball bearing
35 Snap ring
36 Cup spring
37 Spacer
38 Input shaft gear
39 Plate(A)
40 Plate(B)
41 Lock nut
42 O-ring
43 Ball bearing
44 Mounting flange
45 Lube oil filter case
46 End nut
47 Lube oil filter
48 Pin
49 Centering bush
50 Dumper disk
51 Input shaft
52 Oil seal
53 Shim
54 Bearing
55 Nut
56 Washer
57 O-ring
58 Dip stick
59 Spring
60 Cover
61 O-ring
62 Location pin
63 Spring pin
64 Shift lever shaft
65 O-ring
66 Washer
67 Split space pin
68 Pivot
69 Oil seal
70 Spring
71 Shim
72 Stopper bolt
73 Shifter
74 Bolt (M8 × 30)
75 Side cover
76 Oil - cooler body
77 Pipe
78 Shim
79 O-ring
80 Bolt
81 Washer
82 Cooler
83 Cock
84 Drain plug
85 Washer
86 End nut
87 Washer
88 Shim
89 Bearing
90
91 Idle gear
92
93 Bearing
94 Intermediate shaft gear
95 Washer
96 Lock nut
97 Bolt
98 Cable clamp
99 Cable blacket
100 Shift lever
101 Bolt(M8 × 25)

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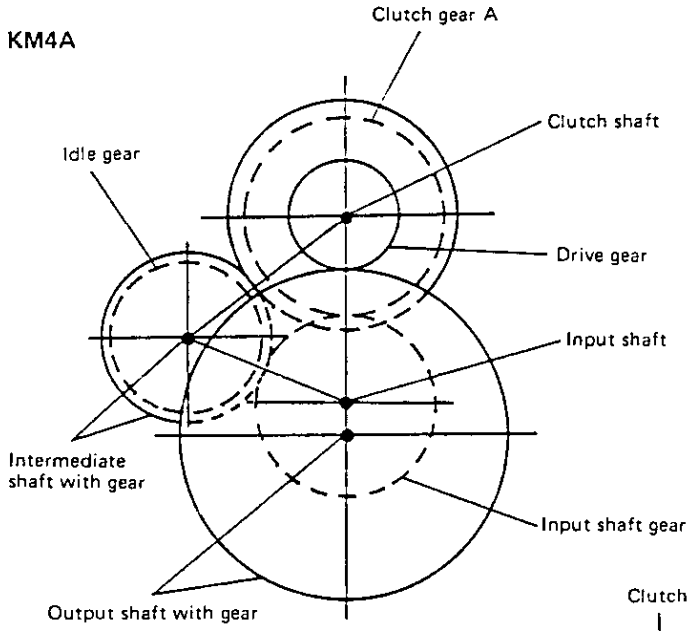
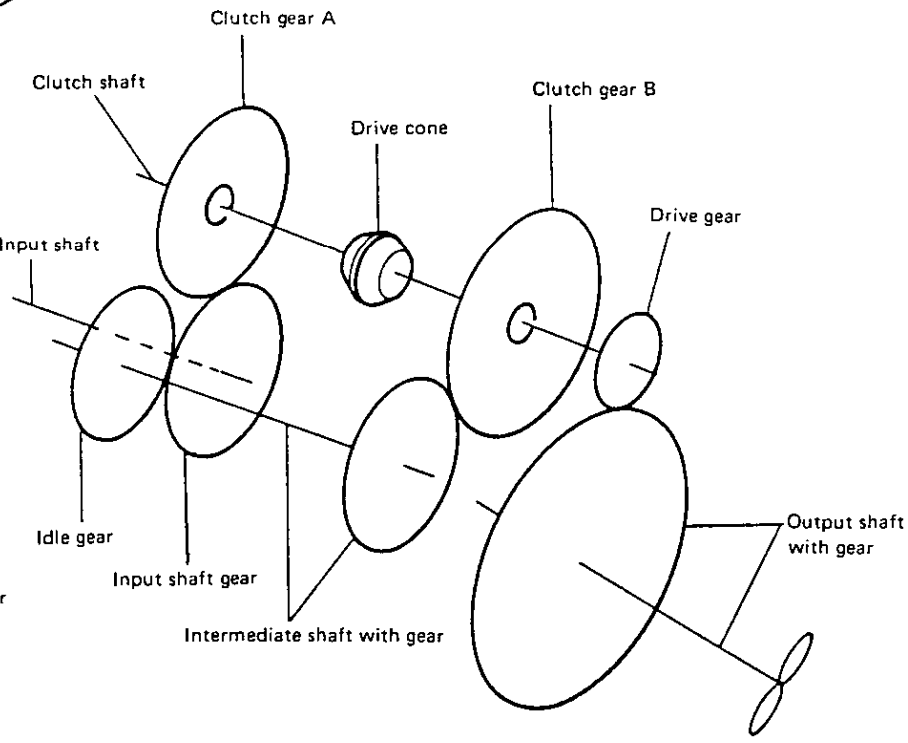
1-4 Power Transmission System

1-4-1 Arrangement of shafts and gear

KM4A





Shaft arrangement viewed from the propeller

1-4-2 Reduction ratio

Input shaft gear	Clutch gear		Intermediate shaft		Drive gear	Output shaft with gear	Reduction ratio
	A	B	Idle gear	Shaft gear			
39	41	45	31	34	30	61	2.14
					26	65	2.63
					22	69	3.30

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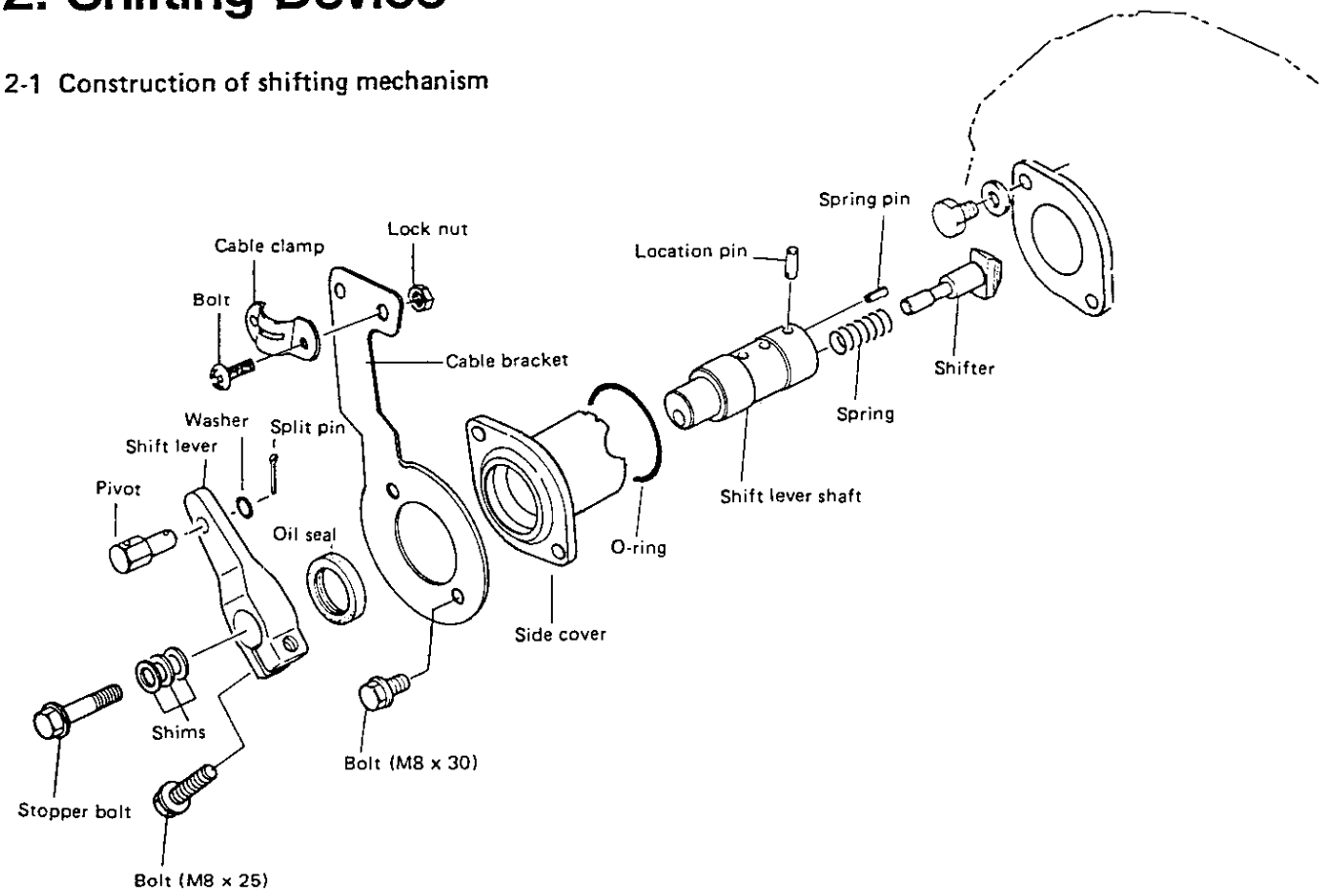
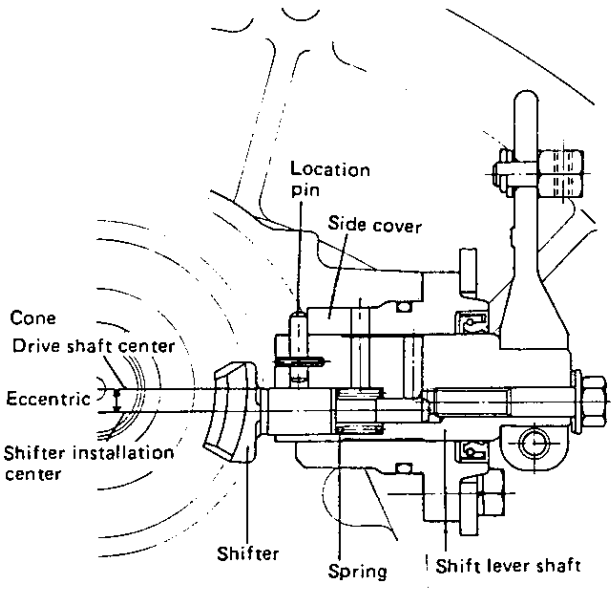
2. Shifting Device

2-1 Construction of shifting mechanism



The shift lever shaft is installed on the side cover with neutral, clutch gear (A) and clutch gear (B) positions provided on the cover. The neutral, clutchgear (A) and clutch gear (B) 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 clutch gear (A) or clutch gear (B) 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 clutch gear (A) or clutch gear (B) positions.)

NOTE:1 Clutch gear (A) position: clockwise propeller rotation viewed from propeller side (C.C.W.)
NOTE:2 Clutch gear (B) position: Counterclockwise propeller rotation viewed from propeller side (C.W.)



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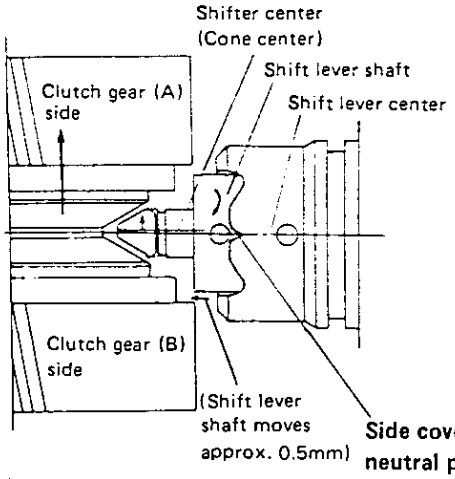
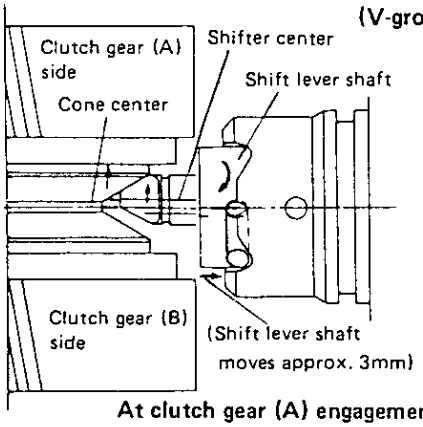
2-2 Clutch gear (A) and clutch gear (B) operation (Neutral ⇒ clutch gear (A), Neutral ⇒ clutch gear (B))

When the shift lever is moved to the clutch gear (A) 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. (The 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 clutch gear (A).



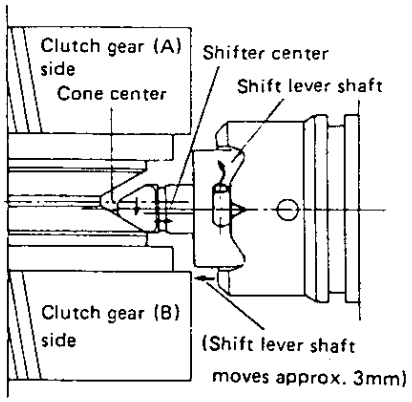
When the location pin of the shift lever shaft falls into the clutch gear (A) position groove on the side cover, the shift lever shaft moves approx. 3mm to the shift lever side, and the shifter starts to press the drive cone V-groove to the clutch gear (A) side by spring force.



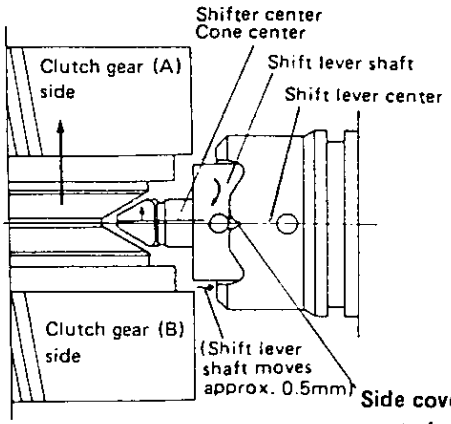
At clutch gear (A) engagement position

2-3 Engagement and disengagement of clutch (Clutch gear (A) ⇒ Neutral, Clutch gear (B) ⇒ Neutral)

When the shift lever is moved to the clutch gear (A) position from the neutral position, the shift lever shaft starts to revolve, and the location pin disengages from the clutch gear (A) position groove on 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 (clutch gear (B) side). The drive cone, however, is engaged with the clutch gear (A) as the torque force produced by the revolving centrifugal force.



Further, when the shift lever shaft starts to revolve, and the positioning pin falls into 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 clutch gear (B) 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 clutch gear (B) side. Thus, the drive cone is disengaged from the clutch gear (A). 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 spring force.



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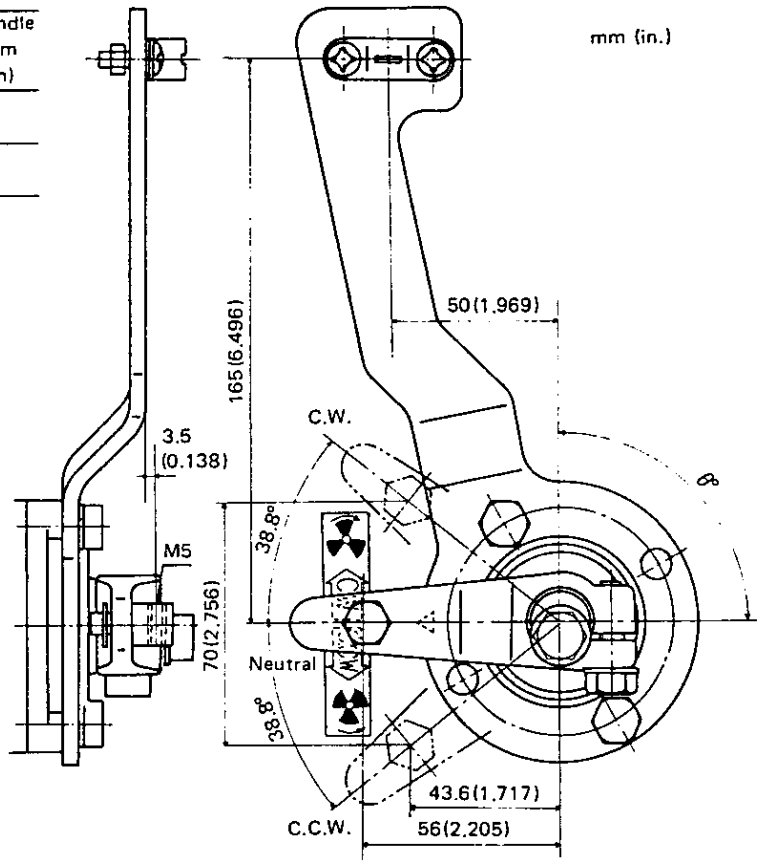
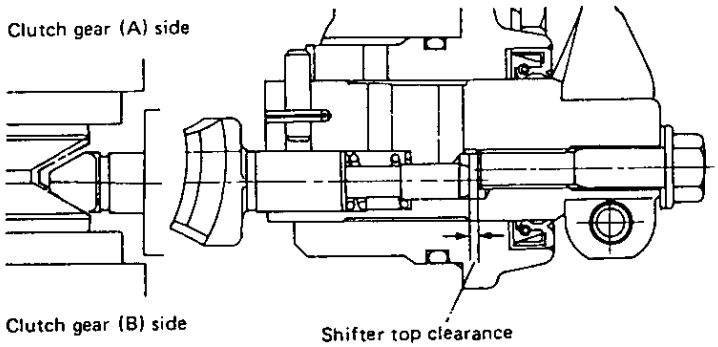
2-4 Clutch shifting force

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 with shims. When the adjustment of this clearance is inadequate, the drive cone may not connect properly when the shift lever is moved to the neutral position, either from the clutch gear (A) or clutch gear (B) position.



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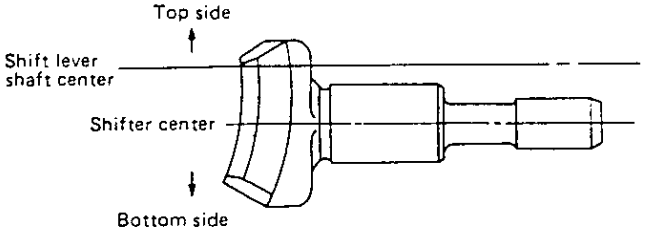
2-5-1 Measurement and adjustment of clearance

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

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



(2)Turn the shift lever 10 ~ 15 degrees either to the clutch gear (A) or clutch gear (B) position from the neutral position.

(3)Measure the L-distance between the shift lever shaft end surface and the shifter end.

(4)Measure the H-distance (the distance from the neck of the stopper bolt to its end).

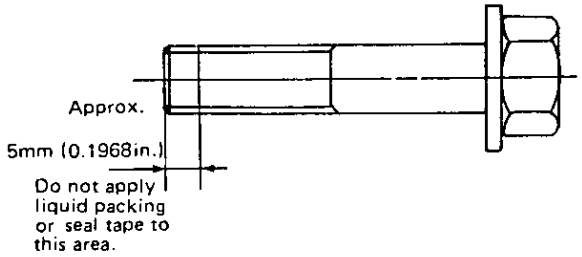
(5)Obtain the shim thickness "T" by the following formula.

$$T = (H - L + 1.25) \pm 0.1\text{mm } (0.0039\text{in.})$$

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

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

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

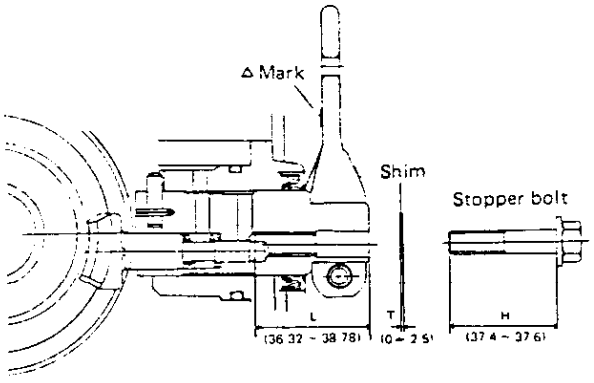


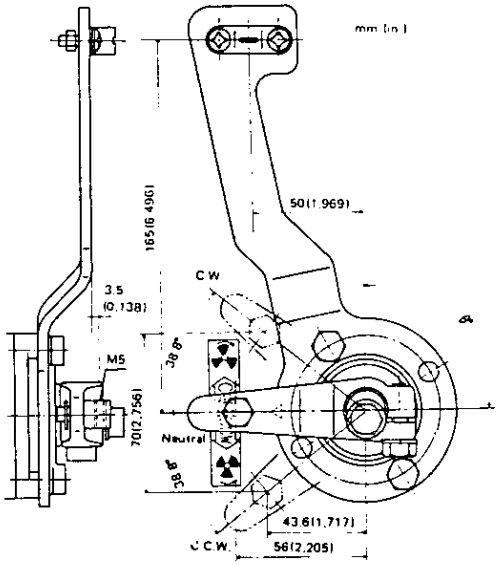
2-5-2 Inspect for the following points (to be inspected every 2-3 months)

(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.

(mm)





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

$\theta = 90°$

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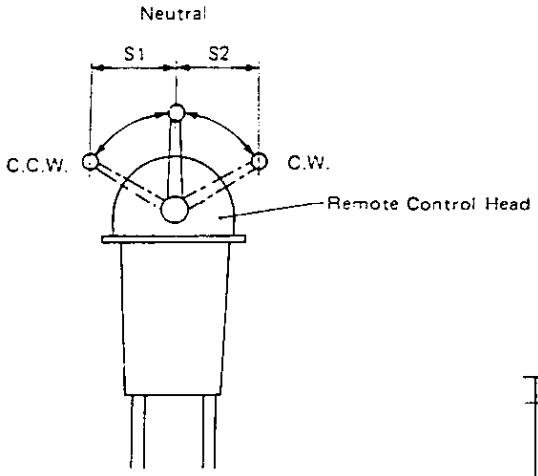
2-6 Adjustment of the remote control head Marine gearbox control side

(1)Equal distribution of the control lever stroke.

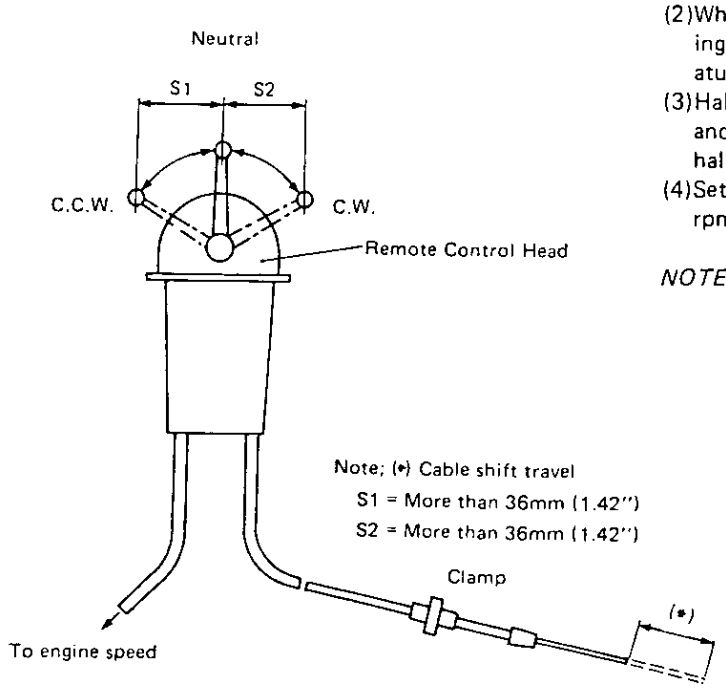


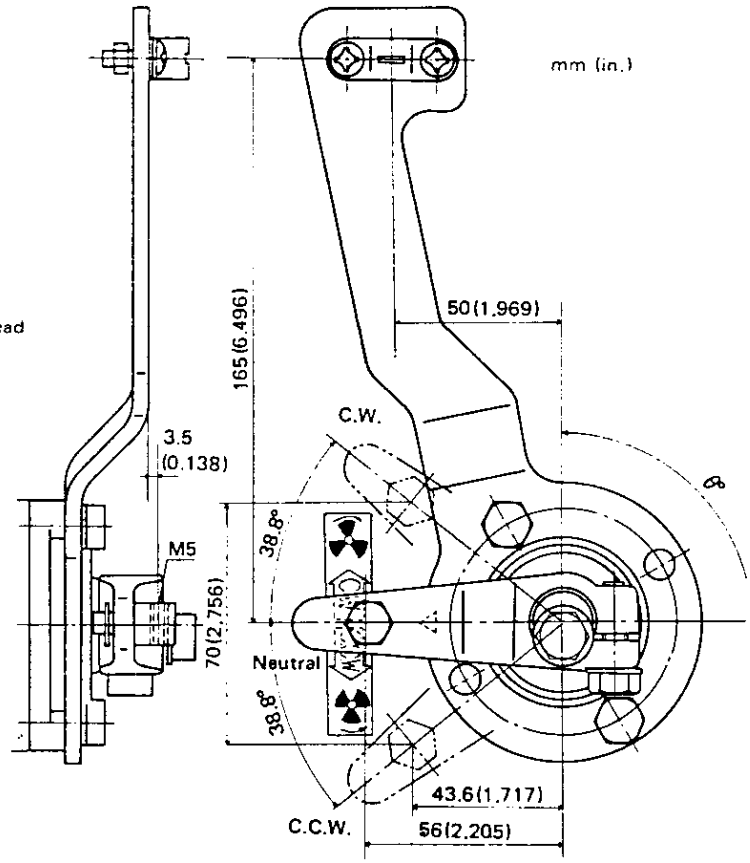
The stroke between the neutral position → C.W. position (S2), and the neutral position → C.C.W. position (S1) must be equalized.

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 so 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 800 and 850 rpm.

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

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3. Inspection and Servicing

3-1 Clutch case and cover

(1)Check the clutch case and cover for cracking with a test hammer.
Perform a color check when required.
If the case and cover are cracked, replace those together.

(2)Check for staining on the inside surface of the bearing section.
Also, measure the inside diameter of the case and cover. Replace the case and cover if these are 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.

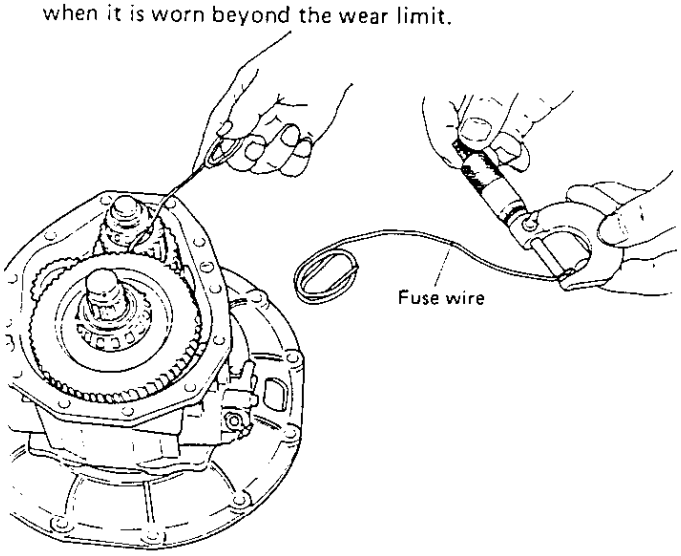
3-3 Gear

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.

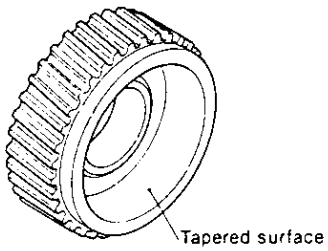


mm (in.)

	Maintenance Standard	Wear limit
All gears	0.08 ~ 0.16 (0.0031 ~ 0.0063)	0.3 (0.0118)

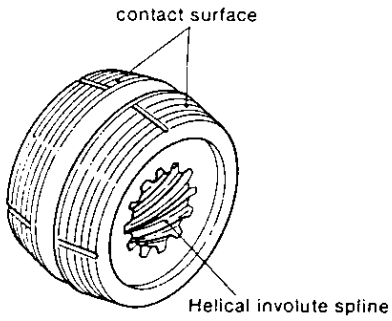
3-4 Clutch gear (A) and (B)

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



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.

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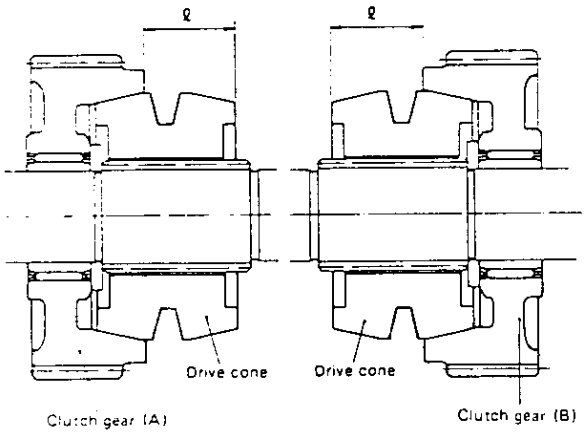
(3)Measure the amount of wear on the tapered contact surface of the drive cone, and replace the cone when the wear exceeds the specified limit.

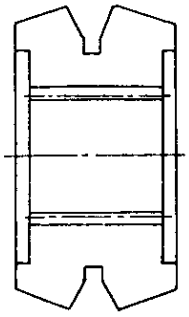


mm(in.)

	Standard dimensions	Limited dimensions
Dimensions ℓ	29.2 ~ 29.8 (1.1496 ~ 1.1732)	28.1 (1.1063)

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.



NOTE: When replacing the drive cone, the drive cone and clutch gears (A) and (B) must be lapped prior to assembly.
The lapping procedure is described below.

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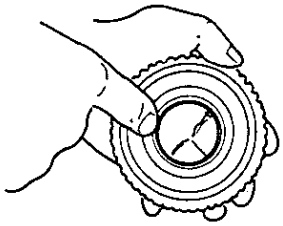
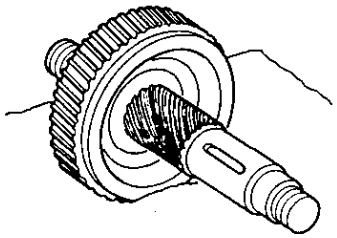
3-5-1 Lapping Procedure for Drive Cone

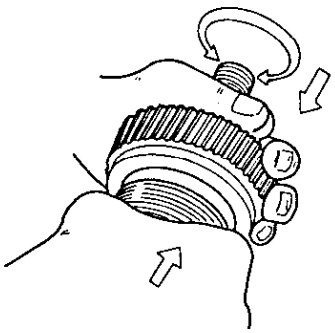
(1) Coat the lapping powder onto the cave of the clutch gear (Lapping powder: 67 micron silicon carbide =280)



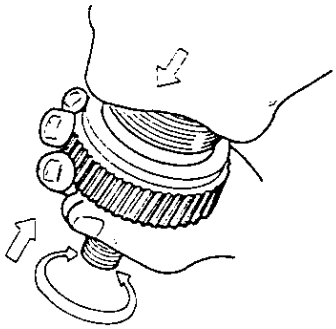
(2)Set the clutch gear on the clutch shaft with a needle bearing and then set the drive cone on the clutch shaft



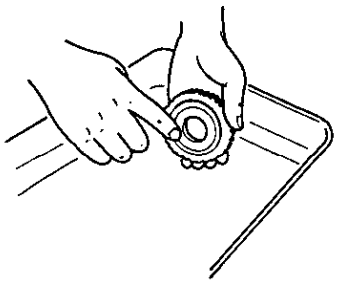
(3)Lap the clutch gear's cave and drive cone, pushing them together by hand

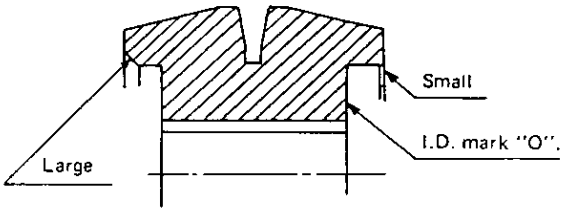


(4)Push and turn the clutch gear about 5 times both clockwise and counter-clockwise.



(5)After lapping them, wash them with washing oil. The lapped parts should be cleaned completely.





NOTE: Do not mix the combination of the lapped parts. The washing oil should be changed frequently in order to prevent residual powder being left on the parts.
When assembling the drive cone, be sure to check its alignment.
The larger chamferring face should be on the clutch gear (A) side.

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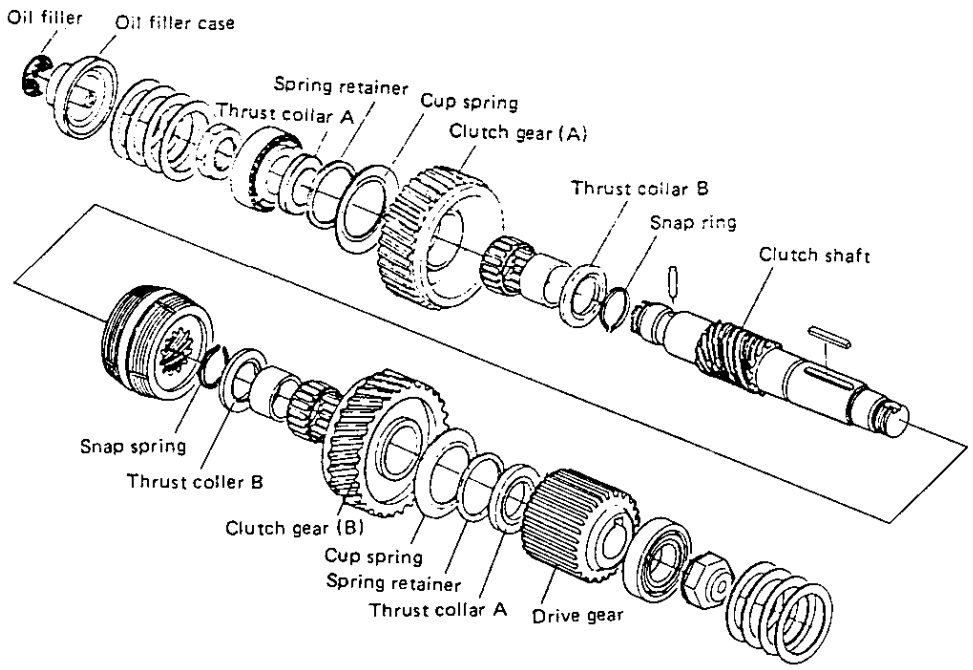
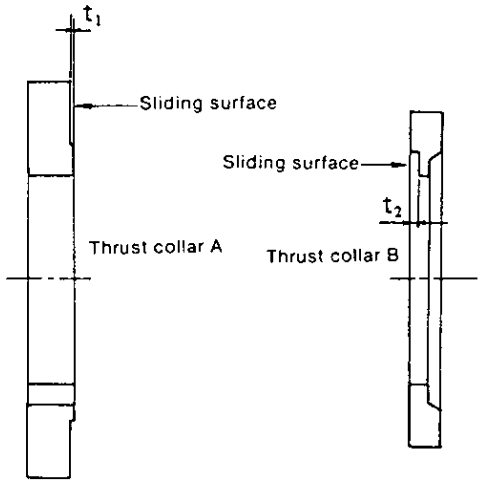
3-6 Thrust coller A and B for clutch shaft



(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.

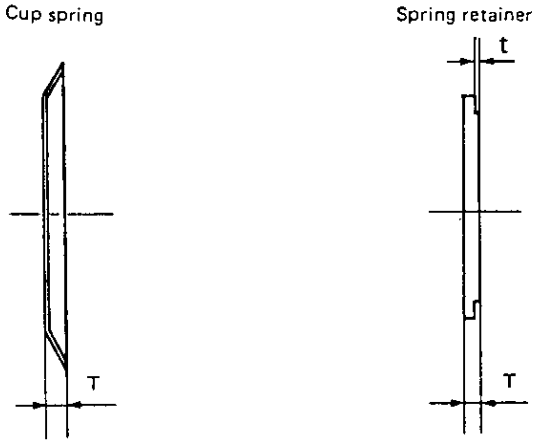


mm (in.)

Stepped wear	Standard	Limit
Thrust collar A, t_1	t_1 0.1 (0.0039)	0.05 (0.0020)
Thrust collar B, t_2	t_2 1.0 (0.0394)	0.20 (0.0079)

3-7 Cup spring and spring retainer

(1) Check for cracks and damage to the cup spring and spring retainer. Replace the part if defective.
(2) 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.



mm (in.)

	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 (0.0039)

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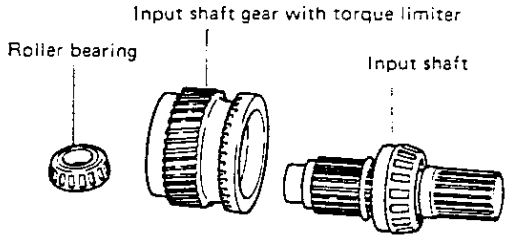
3-8 Input shaft



(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)Torque limiter parts.
If the torque limiter has slipped due to excessive torque, measure the size of the inner parts listed top right. If the parts are excessively damaged replace.

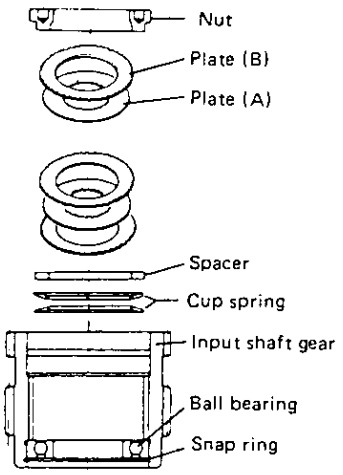
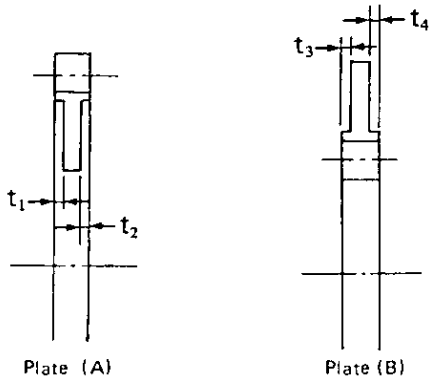


Plate (A) and (B)

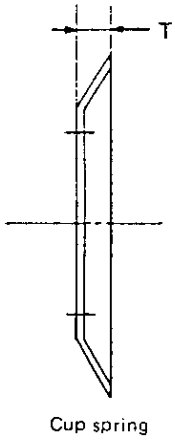
mm(in.)

Stepped wear	Standard	Limit	Q'ty/unit
Plate (A) ($t_1 + t_2$)	0.95 ~ 1.05 (0.0374 ~ 0.0413)	0.92 (0.0362)	15
Plate (B) ($t_3 + t_4$)	0.35 ~ 0.45 (0.0138 ~ 0.0177)	0.32 (0.0126)	16



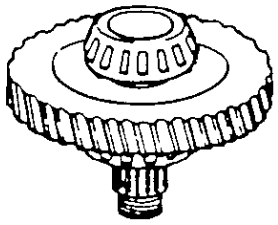
mm(in.)

	Standard	Limit
Cup spring, T	2.75 ~ 3.05 (0.1083 ~ 0.120)	2.6 (0.1024)



Cup spring

3-9 Output shaft



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

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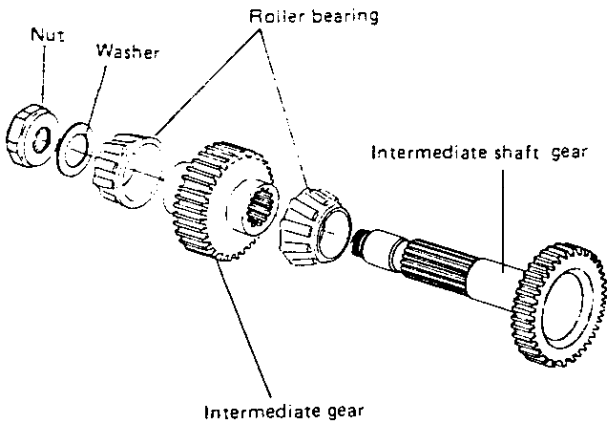
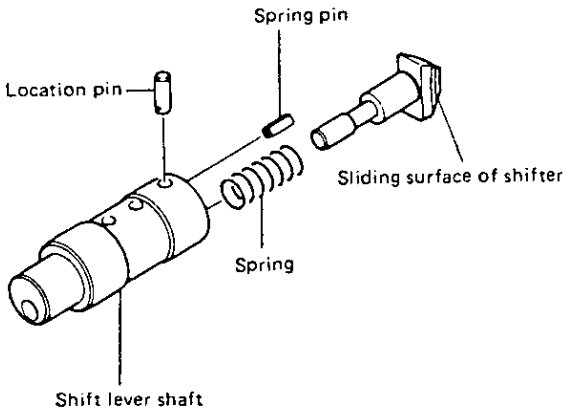
3-10 Intermediate shaft



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

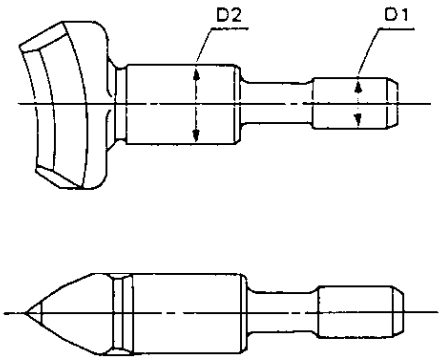
3-11 Shifting device

3-11-1 Shifter



(1)Visually inspect the surface which contacts 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.



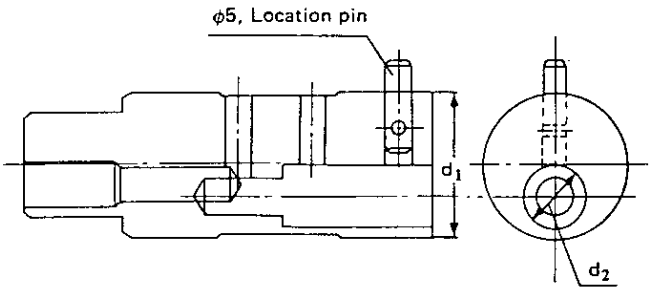
mm (in.)

	Standard	Limit
D1	6.69 ~ 6.70 (0.2634 ~ 0.2638)	6.50 (0.2559)
D2	11.966 ~ 11.984 (0.4711 ~ 0.4718)	11.95 (0.4705)
Shift lever shaft, Shifter insertion hole	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)

3-11-2 Shift lever shaft and location pin

(1)Check the shift lever shaft and location pin for damage or distortion, and replace defective parts. If the location pin must be replaced, replace it together with the shift lever shaft.

(2)Measure the diameter of the shift lever shaft and the shifter insertion hole. Replace the part if the size deviates from the standard value.



mm (in.)

	Standard	Limit
d_1	27.959 ~ 27.98 (1.1001 ~ 1.1016)	27.90 (1.0984)
d_2	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Side cover, Shift insertion hole	28.0 ~ 28.021 (1.1024 ~ 1.1032)	28.08 (1.1055)

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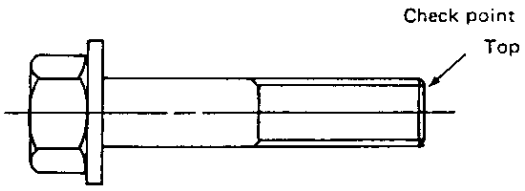
3-11-3 Shifter spring

(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	0.854 kg/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)

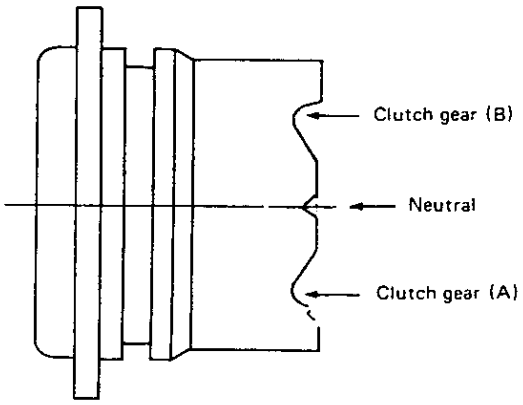
3-11-4 Stopper bolt

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

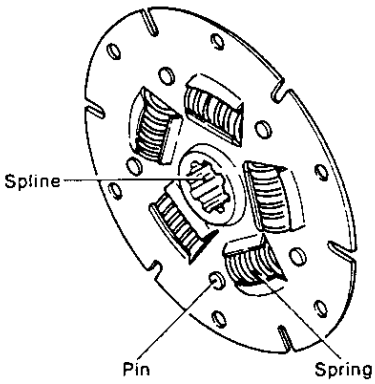


3-11-5 Side cover and oil seal

(1)Check the neutral, clutch gear (A) and clutch gear (B) 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.



3-12 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.

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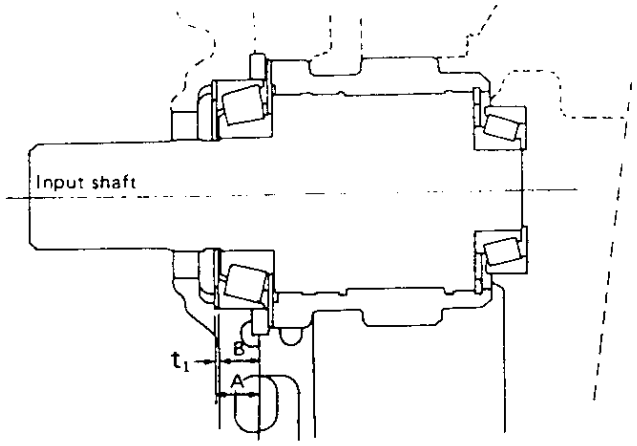
3-13 Shim adjustment for output and input shafts

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

For input shaft parts : input shaft, bearing.
For output shaft parts: output shaft, bearing.
For intermediate shaft parts : intermediate shaft, spacer, gear bearing.
For clutch shaft parts : clutch shaft, thrust collar (A), (B), gear, bearing.

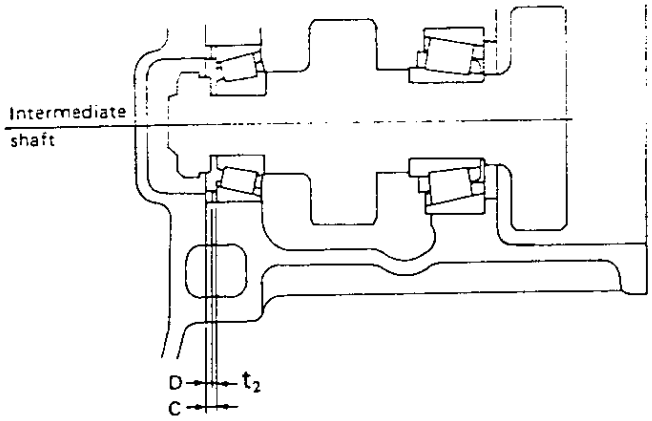
(1) Input Shaft
Measure the distance A and B.
Thickness of Shim t_1

$$t_1 = (A - B)^{\pm 0.05}$$



(2) Intermediate Shaft
Measure the distance C and thickness D

$$t_2 = (C - D)^{\pm 0.05}$$



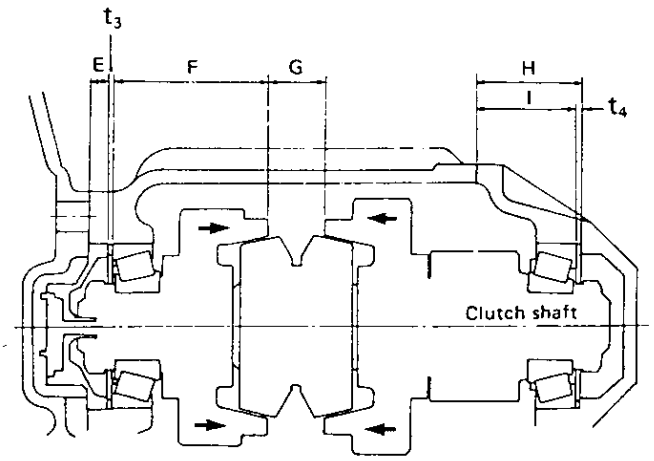
(3) Clutch Shaft
Measure the distance E, F and G.

$$t_3 = \left(78 - E - F - \frac{G}{2}\right)^{\pm 0.05}$$

NOTE: When measuring the distances F and G, the clutch gears must be pushed in the direction of the drive cone.

Then measure distances H and I.

$$t_4 = (H - I)^{\pm 0.05}$$



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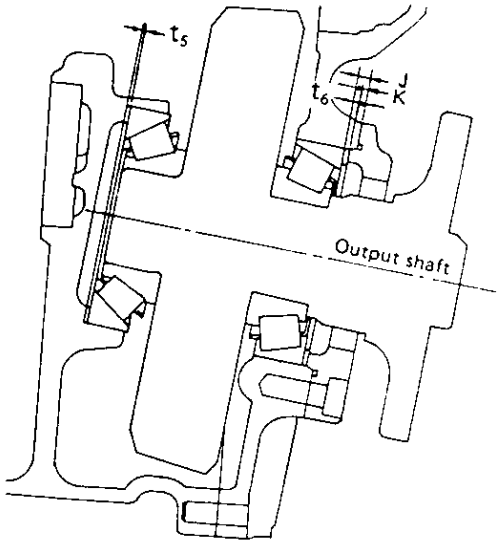
(4)Output Shaft

Adjust the thickness of Shim t_5 to make the backlash of gear at 0.08~0.16mm (0.0032~0.0063in).
Then measure the distances J and K.

$$t_6 = (J - K)^{+0}_{-0.1}$$



(5)Standard size of parts

mm (in.)

A	B	C	D	E	F	G	H	I	J	K	Drive cone neutral center position
14.0 ~ 14.2 (0.551 ~ 0.559)	11.4 ~ 12.9 (0.449 ~ 0.508)	2.3 ~ 3.7 (0.091 ~ 0.146)	1.9 ~ 2.1 (0.075 ~ 0.083)	7.4 ~ 7.5 (0.291 ~ 0.295)	57.8 ~ 58.7 (2.276 ~ 2.311)	20.3 ~ 21.2 (0.799 ~ 0.835)	39.9 ~ 40.3 (1.571 ~ 1.587)	37.7 ~ 39.5 (1.484 ~ 1.555)	3.6 ~ 4.7 (0.142 ~ 0.185)	2.4 ~ 2.6 (0.094 ~ 0.102)	78 (3.071)

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

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Adjusting point	Part No.	Thickness. mm (in.)	No. of shims
t1	177095-02150	0.1 (0.0039)	2
		0.3 (0.0118)	1
		0.5 (0.0197)	2
		1.0 (0.0394)	1
t2	177090-02250	0.1 (0.0039)	2
		0.3 (0.0118)	1
		0.5 (0.0197)	1
		1.0 (0.0394)	1
t3 & t4	177075-02150	0.3 (0.0118)	4
		0.4 (0.0157)	4
		0.5 (0.0197)	4
t5 & t6	177090-02310	0.1 (0.0039)	4
		0.3 (0.0118)	2
		0.5 (0.0197)	2
		1.0 (0.0394)	2

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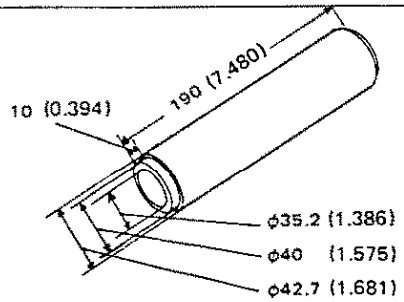
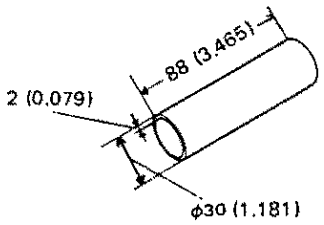
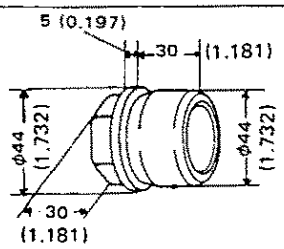
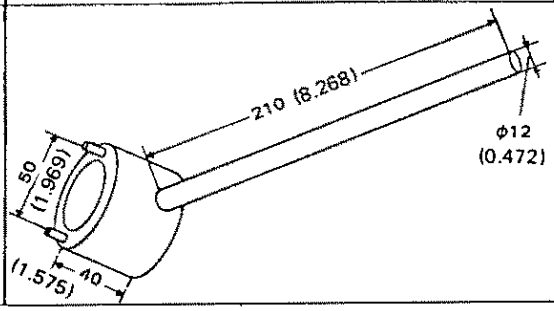
4.Special Tools

Name of tool	Shape and size mm(in.)	Application
Inserting tool Part No. 177075-09030		For installing input and output shaft bearings.
Inserting tool Part No. 177088-09150		For installing intermediate shaft and clutch shaft bearings.
Spline socket Part No. 177073-09020		For checking limiter torque of the torque limiter
Ring nut wrench Part No. 177073-09010		For removing and tightening the torque limiter

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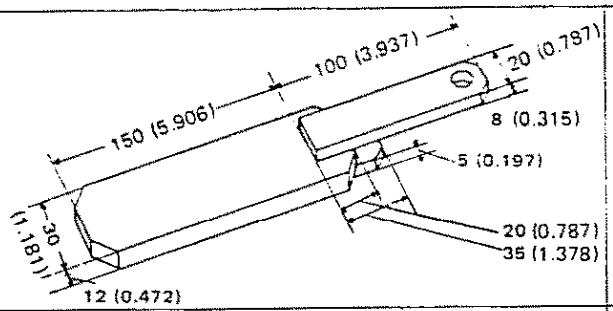
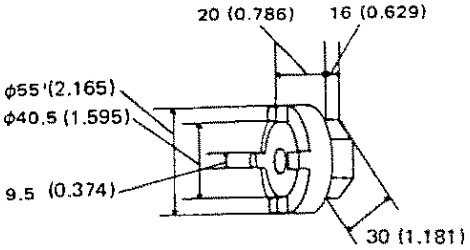
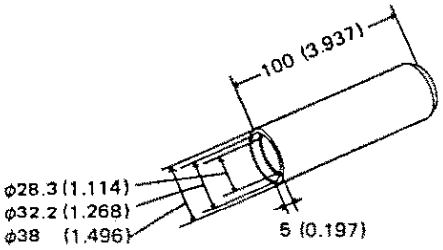
Special tools

Name of tool	Shape and size mm (in.)	Application
Output shaft coupling lock Part No. 177075-09050		For removing and tightening the output shaft nut.
Socket Part No. 177073-00050		For removing and tightening output shelf nut.
Inserting tool Part No. 177073-09030		For installing the clutch shaft bearing

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5.Disassembly

5-1 Disassembling the clutch and accessories.

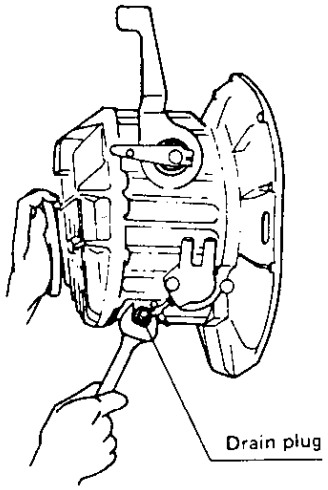
(1)Remove the remote-control cable and the C.W. hose of L.O. cooler.

(2)Dismount the clutch main body from the mounting flange.

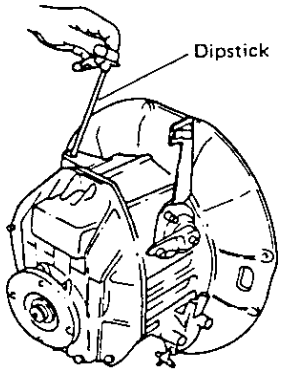
(3)Drain the lubricating oil

Drain the lubricating oil by loosening the plug at the bottom of the clutch case. Also remove the dipstick from the clutch case at the same time.

(4)Remove the drain plug and pull out the L.O.

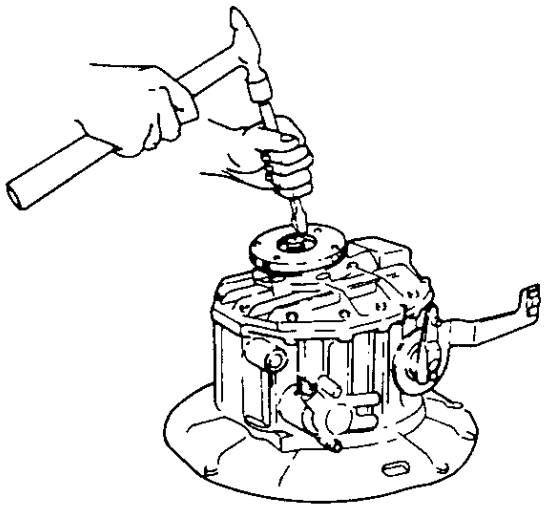


(5) Remove the dipstick.

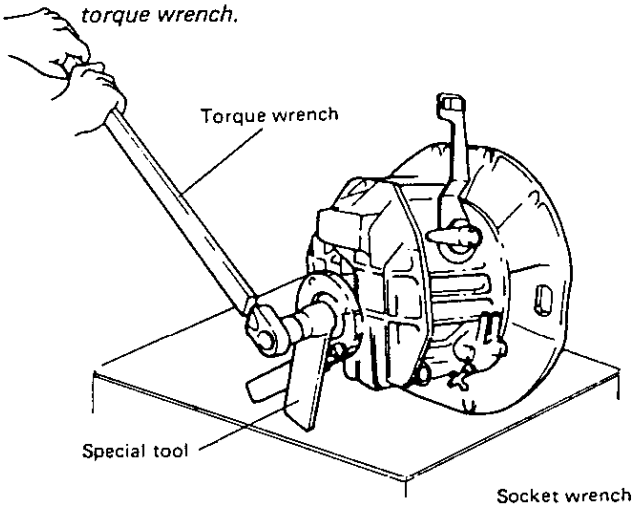


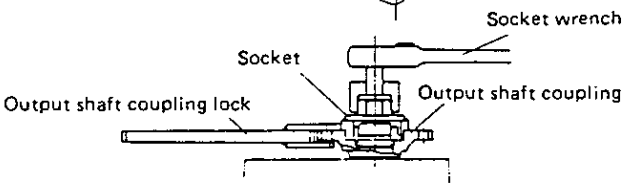
(6) Remove the end nut and output shaft coupling

1) Loosen the calking of the endnut.

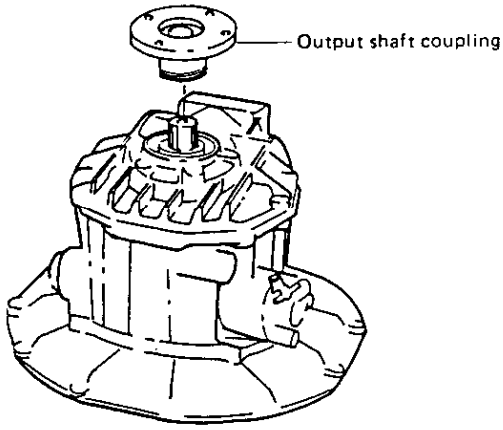


NOTE: Loosen the endnut with the special tool and a torque wrench.





2)Remove the output shaft coupling



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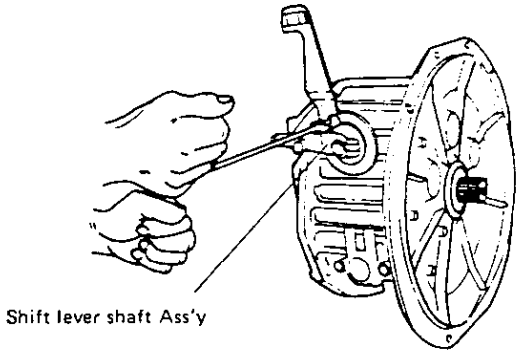
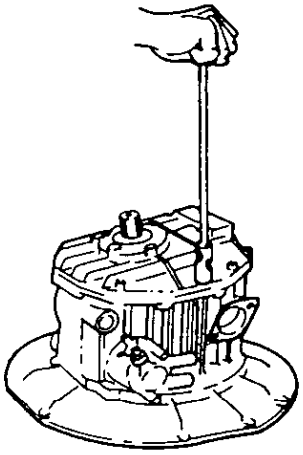
(7) Remove the fixing bolts on the side cover of clutch case, and also remove the shift lever shaft assembly.

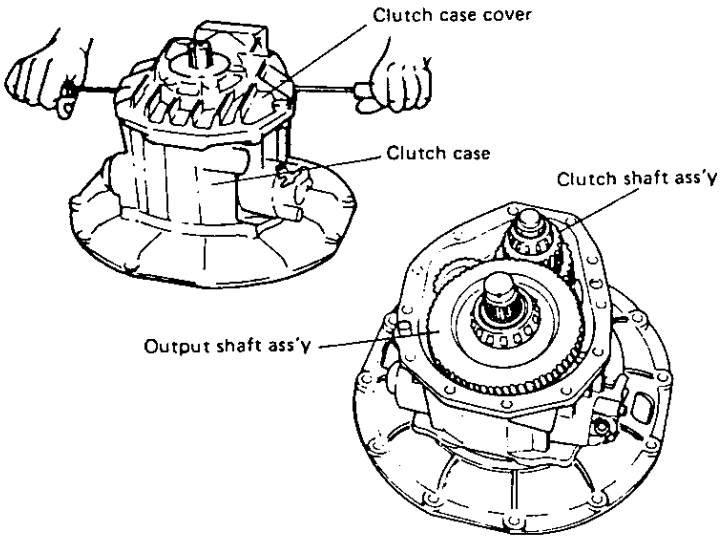


(8) Remove the clutch case cover.

1) Remove the bolt of the clutch case cover

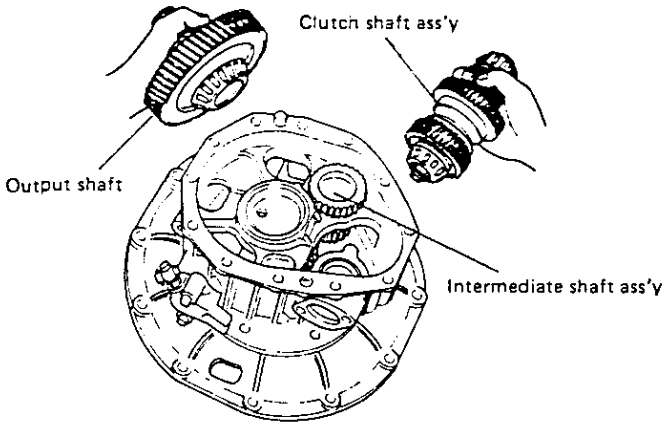


2) Remove the clutch case cover from the clutch case.



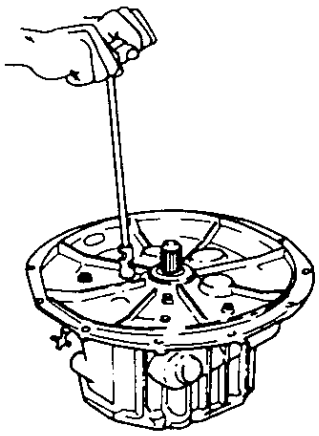
NOTE: To remove the case cover and the case, insert two drivers into the two depressed points at the joint between the case cover and the case. This makes removal easy.

(9) Removing the output shaft assembly and clutch shaft assembly.

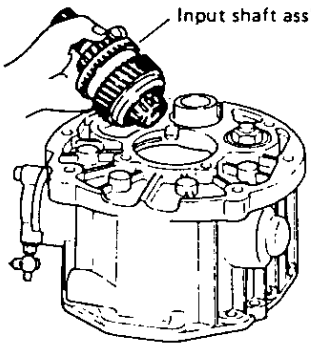


(10) Removing the mounting flange

Remove the fastening bolt of the mounting flange and then remove the mounting flange.



(11) Removing the input shaft assembly.
Draw out from the mounting flange side of the case.



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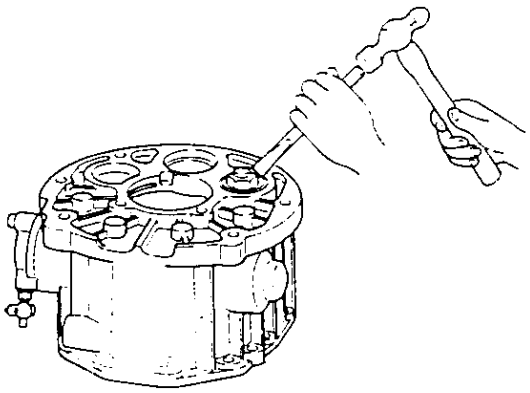
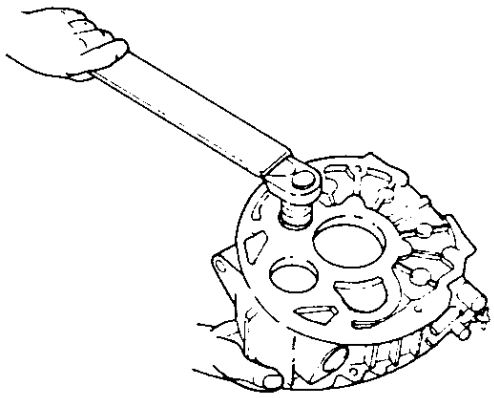
(12) Removing the intermediate shaft.

1) Loosen the calking of locknut of the intermediate shaft.

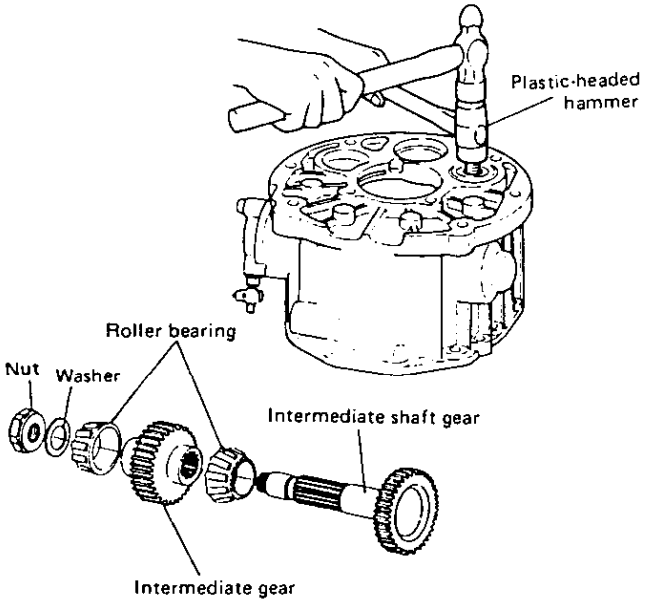


2) Remove the locknut.

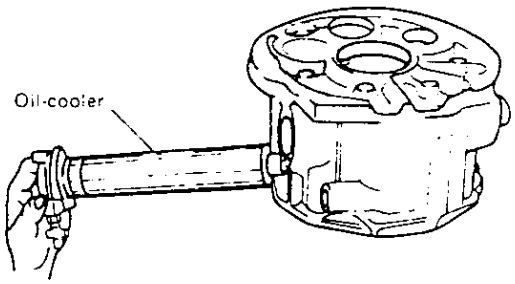


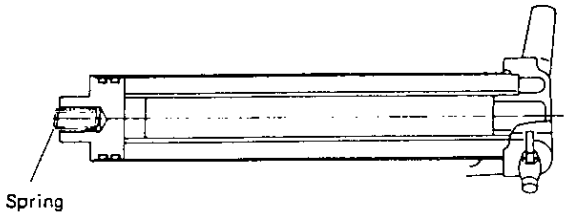
NOTE: Thread of the locknut is left-handed.

3) Draw out the intermediate shaft tapping to the case cover side with a plastic-headed hammer.

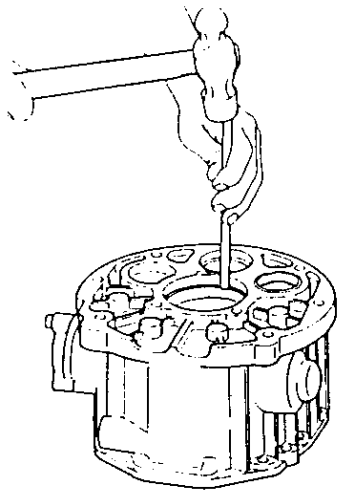


(11) Removing the oil-cooler.





(14) Draw out the outer bearing races.



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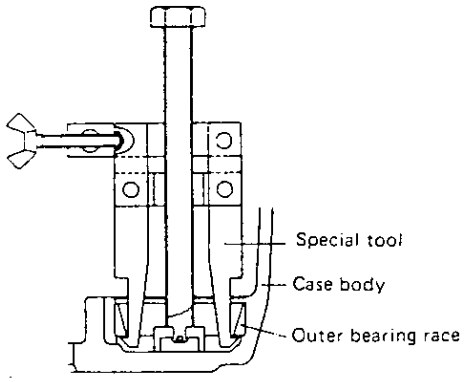
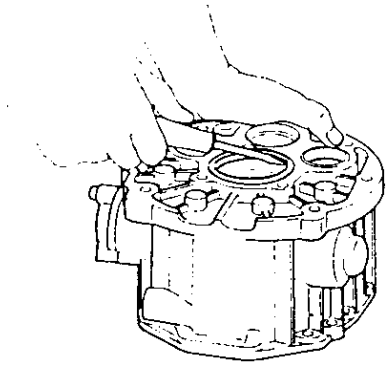
1) Remove the outer bearing races of the mounting flange, the case cover and the case.

NOTE: Remove the outer bearing races with a special tool.



(15) Remove the oil seals of the mounting flange and the case cover.



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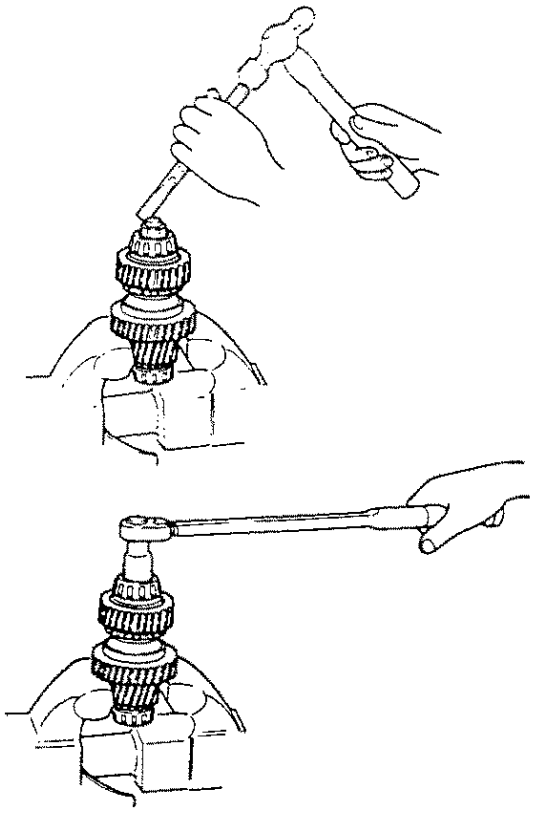
5-2 Disassembling the clutch shaft.

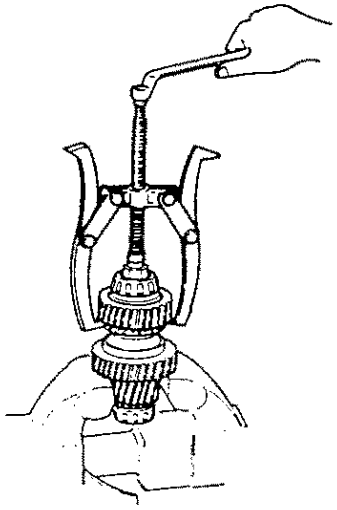
5-2-1 Clutch gear (A) side

(1) Loosen the calking of the end nut and remove the nut. Remove the nut by a torque wrench, fixing the clutch shaft in a vice.

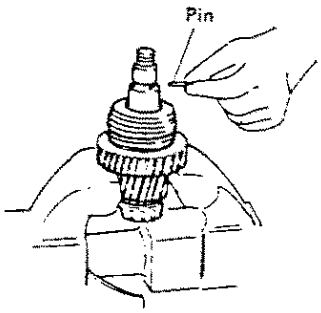


NOTE: Remember that the nut has a left-handed thread.

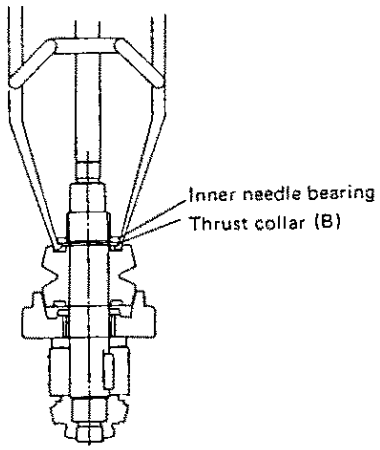
(2) Take out the clutch gear (A), Thrust collar (A), cup spring, spring retainer and inner bearing trace. The clutch gear (A) must be withdrawn using a pulley extracter, with the clutch shaft fixed in a vice.



(3) Remove the pin

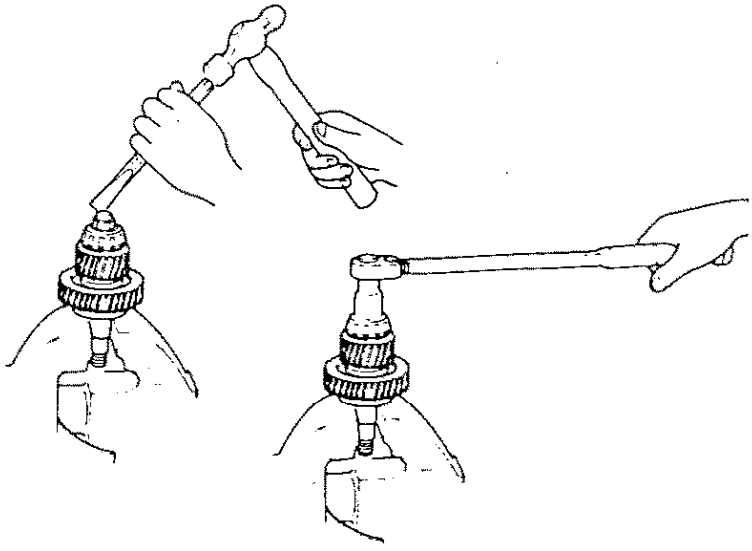


(4) Withdraw the thrust collar (B), inner needle bearing by pulley extractor.



5-2-2 Clutch gear (B) side

(1) Loosen the calking of the end nut and remove the nut. Remove the nut by a torque wrench, with the clutch shaft fixed in a vice.



NOTE: Remember that as the nut has a left-handed thread.

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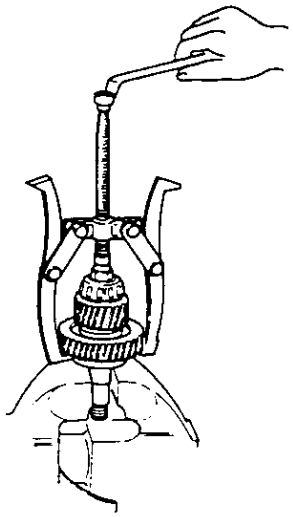
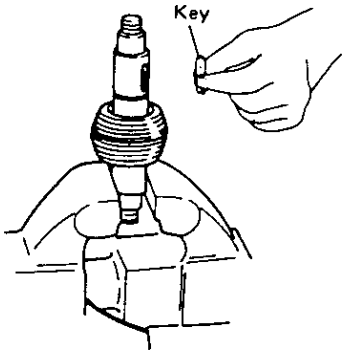
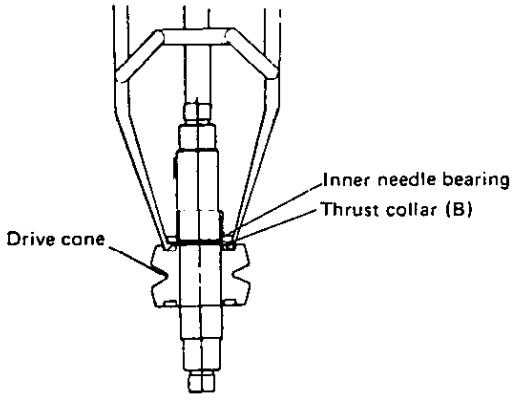
(2)Withdraw the large gear (B), thrust collar (A), cup-spring, spring retainer, drive gear and inner bearing race.
Use a pulley extracter, with the clutch shaft fixed in a vice.



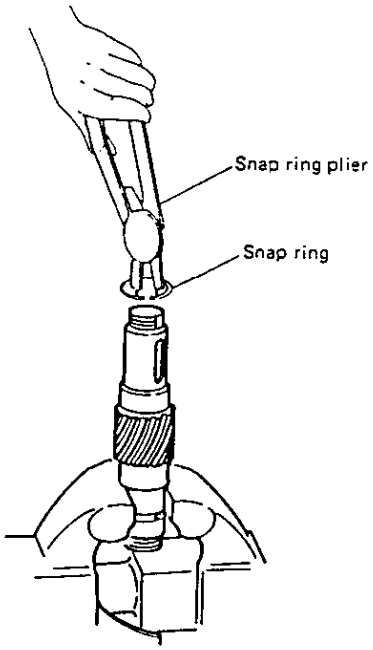
(3)Remove the key



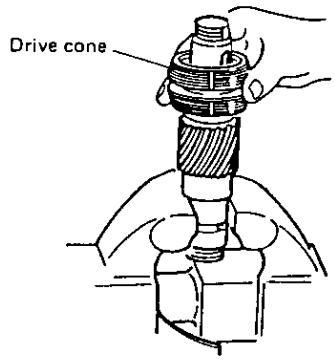
(4)Withdraw the thrust collar (B) and inner needle bearing race with the pulley extractor.



(5)Remove the snap rings



(6)Draw out the drive cone.



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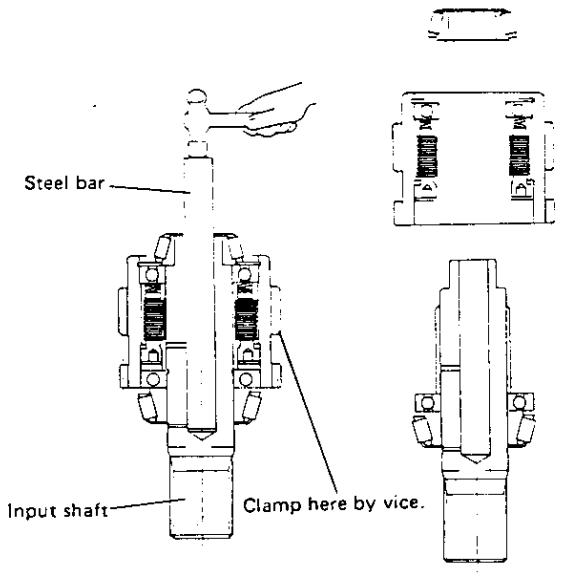
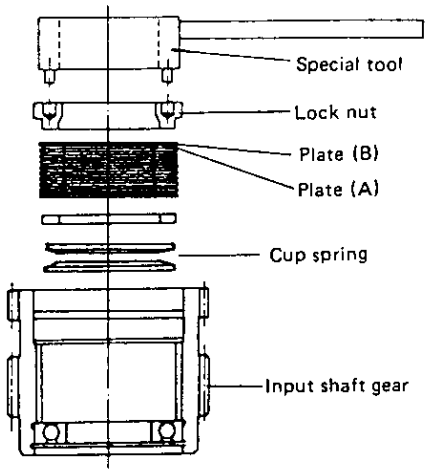
5-3 Disassembling the input shaft.

1) Draw out the input shaft tapping to the small roller bearing side with a steel bar.

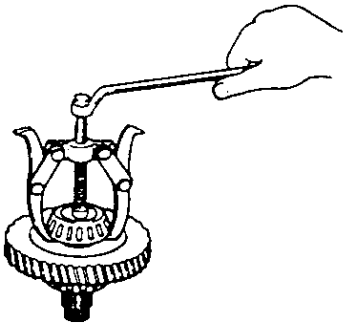


(2) Fix the input shaft gear in a vice, and remove the lock nut with a special tool.



5-4 Disassembling the output shaft

(1) Remove the bearing inner race from the output shaft. Use a pulley extracter, fixing the output shaft in a vice.



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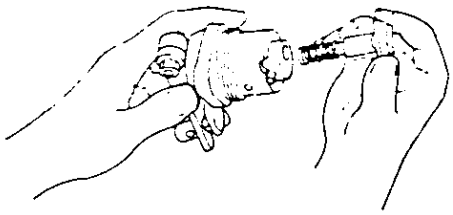
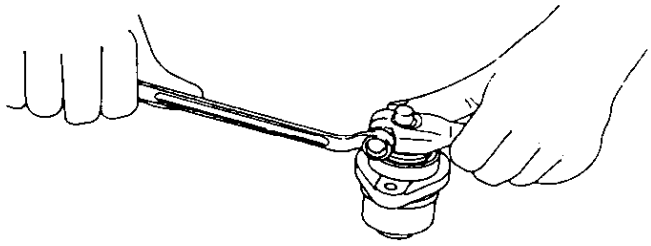
5-5 Disassembling the shifting device

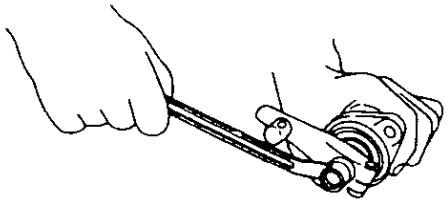
(1)Take out the shifter and shifter spring



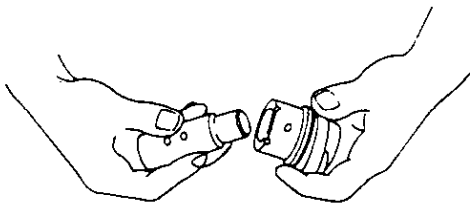
(2)Remove the stopper bolt of the shifter and shim.



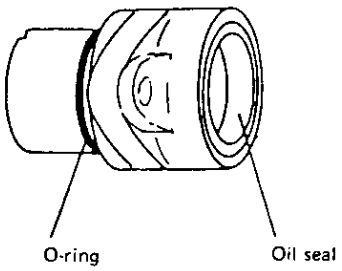
(3)Loosen the belt of the shift lever and remove the shift lever and cable bracket



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



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



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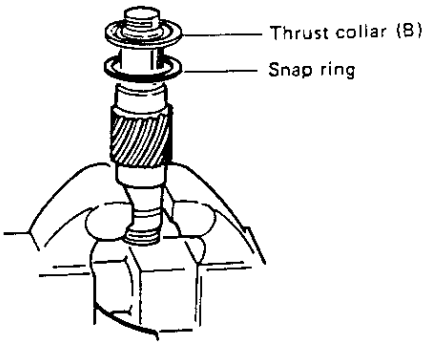
6.Reassembly

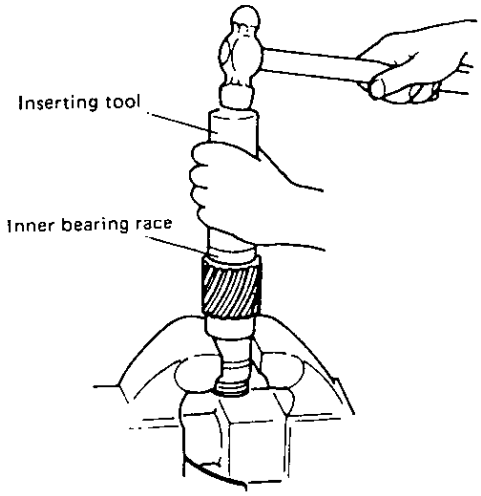
6-1 Reassembly of clutch shaft

6-1-1 Clutch gear (B) side

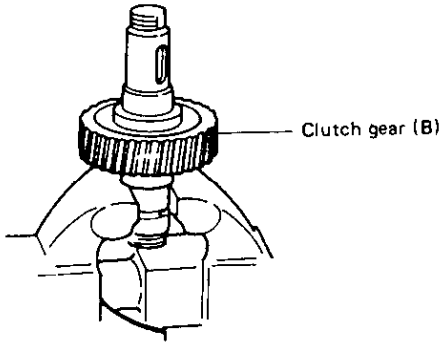
(1)Fit the clutch gear (B) side snap ring and thrust collar (B) onto the shaft.



(2)Drive in the inner needle bearing race using the inserting tool.

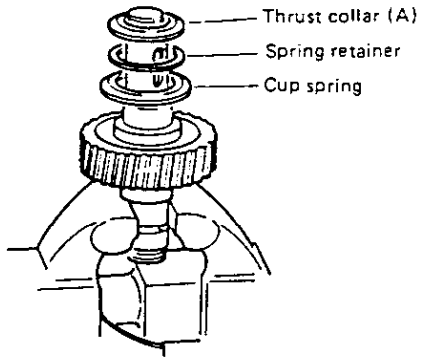


(3)Assemble the needle bearing and clutch gear (B)



NOTE: Check that the clutch gear (B) rotates smoothly.

(4)Fit the cup spring, spring retainer, thrust collar (A).

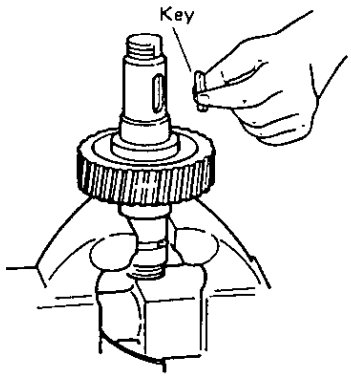


NOTE: 1) Drive in with a plastic headed hammer. Do not hit hard.

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

3) Check that the clutch gear (B) rotates smoothly.

(5)Fit the key



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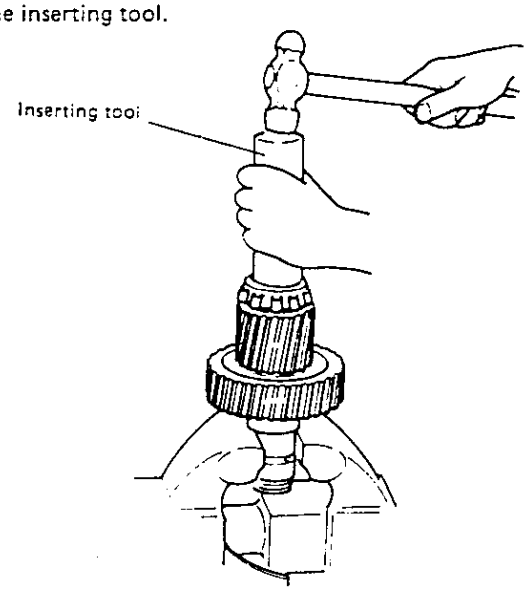
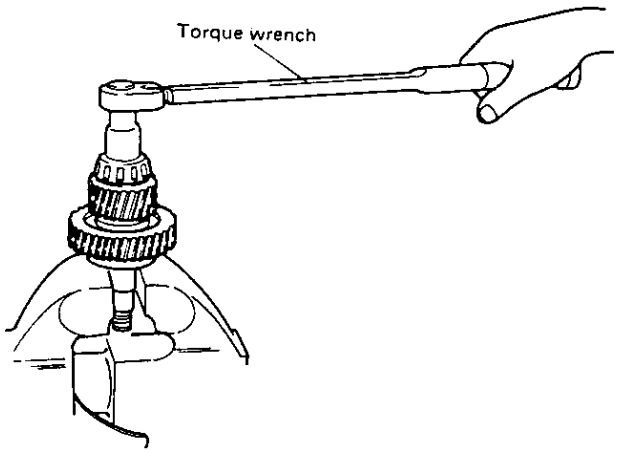
(6)Drive in the driving gear and inner bearing race using the inserting tool.



(7)Set and tighten the clutch gear (B) end nut
Fit the clutch shaft in a vice, and tighten the nut with a torque wrench.

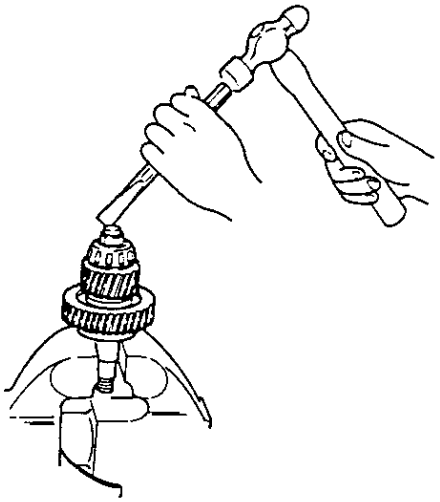


Tightening torque	8.5 – 11.5 kg-m (61.5 – 83.2 ft-lb)

NOTE: 1) Remember it is a left-handed thread.

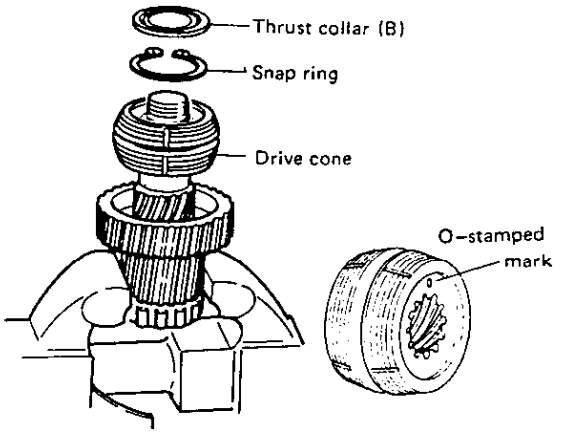
2) Use the clutch gear (A) side nut which was used before dismantling for the clutch gear (B) end nut. This is to provide effective calking to the nut.

(8)Calking the end nut and clutch shaft.



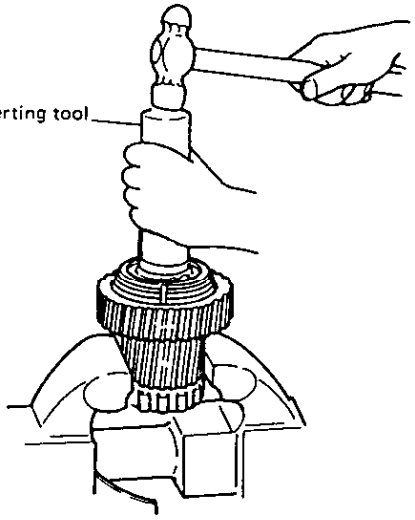
6-1-2 Clutch gear (A) side

(1)Insert the drive cone, snap ring and thrust collar (B).



NOTE: Insert it keeping the O-stamped mark surface toward the clutch gear (B) side.

(2)Drive in the inner needle bearing race, using an inserting tool.



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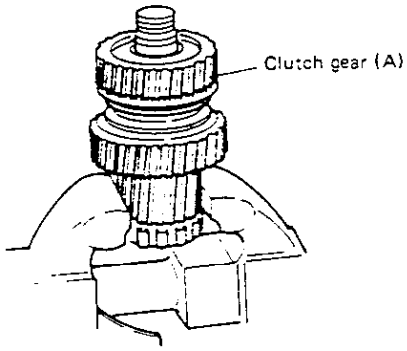
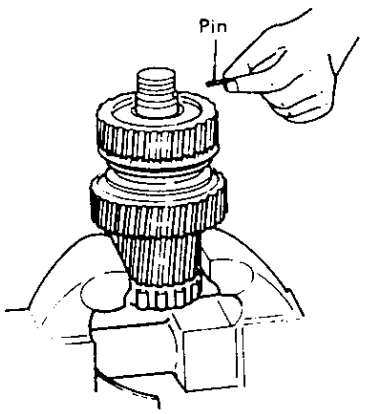
(3)Assemble the needle bearing and clutch gear (A)

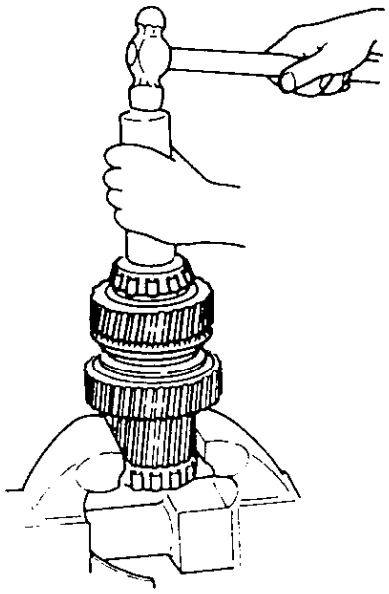


NOTE: Check that the clutch gear (A) rotates smoothly.

(4)Insert the pin.



(5)Fit the cup spring, spring retainer and thrust collar (A) and drive in the inner bearing race using the inserting tool.

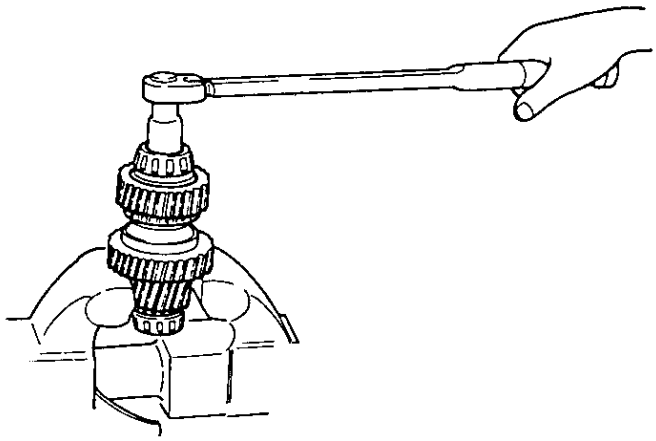


NOTE: 1) When fitting the thrust collar (A), note the fitting direction. Fit it keeping the stepped surface toward the roller bearing side.

2) The pin cannot be fitted after the inner bearing race has been driven in.

3) Check that the large gear (B) rotates smoothly.

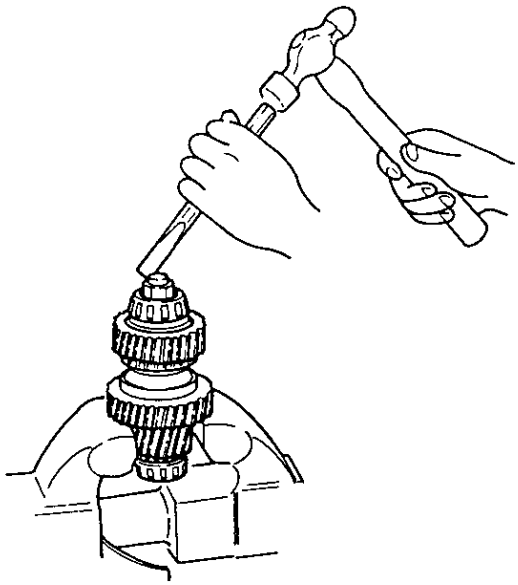
(6)Set and tighten the clutch gear (A) end nut. Fix the clutch shaft in a vice and tighten the nut with a torque wrench.



Tightening torque	8.5 – 11.5 kg-m (61.5 – 83.2 ft-lb)

NOTE: 1) Remember it is a left-handed thread.

(7)Calk the end nut and clutch shaft.



NOTE: Use the clutch gear (A) side nut which was used before dismounting for the clutch gear (B) end nut. This to provide effective calking to the nut.

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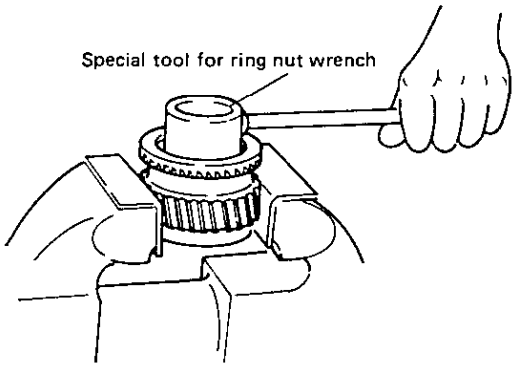
6-2 Reassembly of input shaft

(1)Drive in the ball bearing and fit the snap ring into the input shaft gear.

(2)Insert the cup springs, spacer, plates (A) and plates (B) and temporarily lock the lock nut.

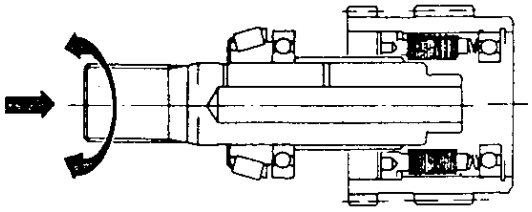


NOTE: Apply lube oil to each insert part.

(3)Fit the O-ring onto the input shaft.

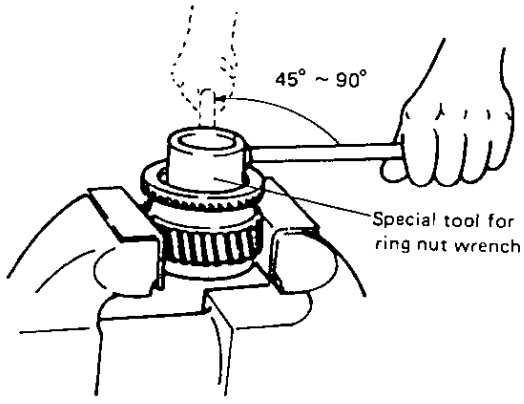
(4)Drive the ball bearing and the inner bearing race using an inserting tool.

(5)Insert the input shaft into the plate (A).

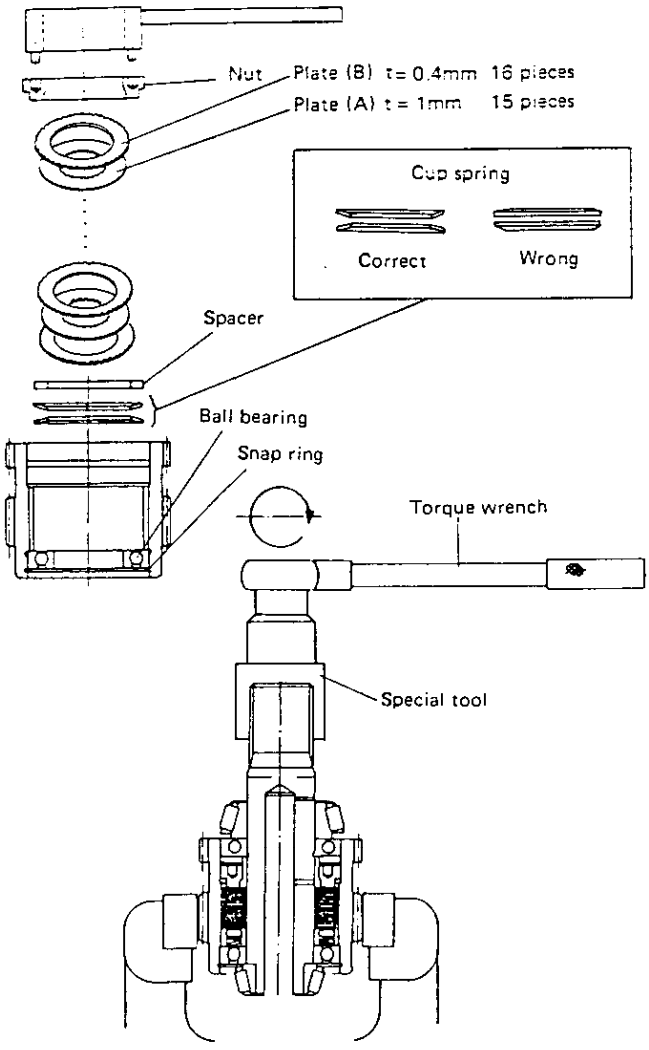


(6)Take the input shaft out again.

(7)Tighten the nut firmly using the special tool, then return the nut by 45 — 90 degrees.



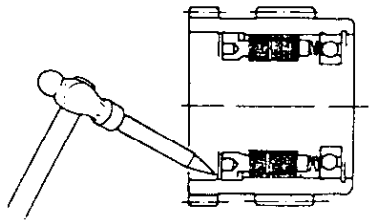
(8)Insert the input shaft, then measure its torque using a torque wrench.



Torque:	55 – 60 kg-m (398 – 434 ft-lb.)

NOTE: Match up the teeth of plate (A).

(9)Take out the input shaft and caalking at the lock nut end ot the thread.



(10)Insert the input shaft into the input gear assembly.

(11)Drive the inner bearing race onto the input shaft end.

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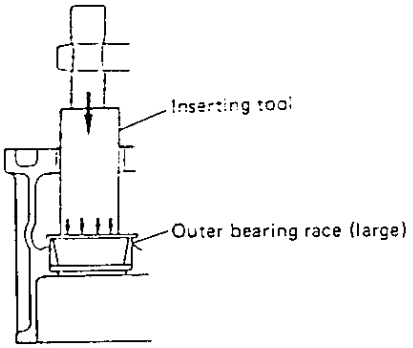
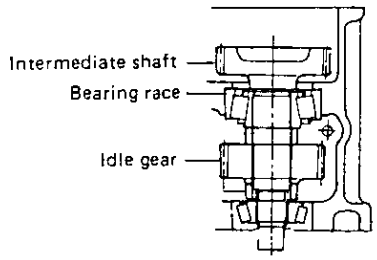
6-3 Reassembly of the clutch case

6-3-1 Reassembly of the intermediate shaft

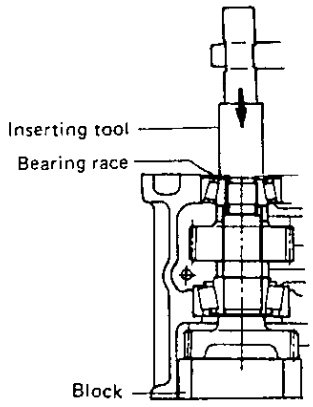
(1)Drive in the outer bearing race (large) into the clutch case.



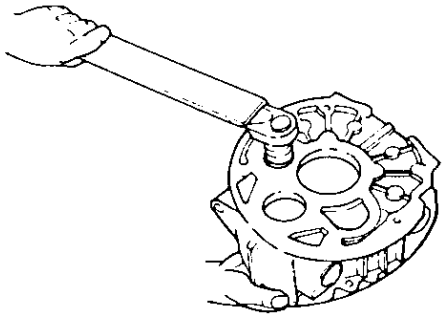
(2) Insert the inner bearing races and idle gear and drive in the intermediate shaft



(3)Drive the outer bearing race into the clutch case.



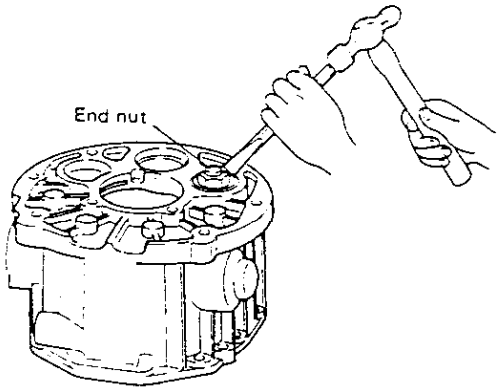
(4)Insert the washer and tighten the end nut using a torque wrench.



Tightening torque	8.5 ~ 11.5 kg-m (61.5 ~ 83.2 ft-lb)

NOTE: Remember it is a left-handed thread

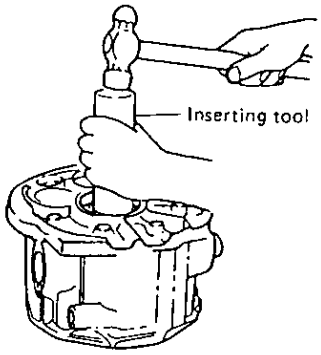
(5)Calk the end nut



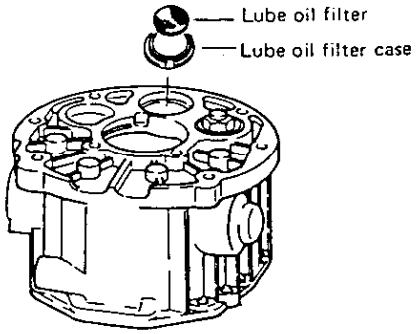
(6)Insert the shims into the clutch case.

6-3-2 Reassembly of the bearing outer races and shims in the clutch case

(1)Drive the input shaft outer bearing race and clutch shaft outer bearing race into the clutch case.



(2)Insert the clutch shaft shim, lube oil filter case and filter into the clutch case.



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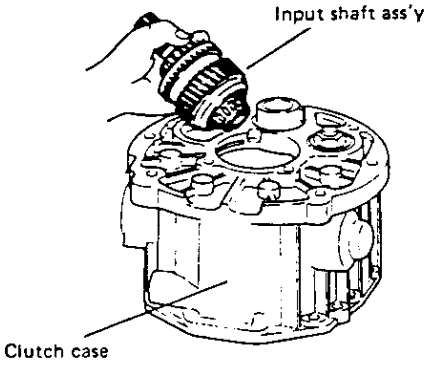
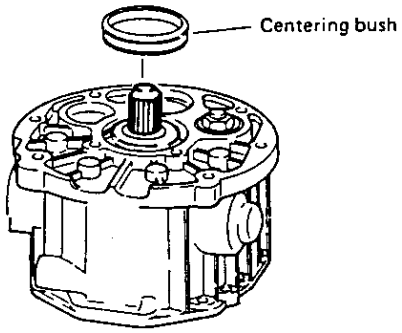
6-3-3 Reassembly of the input shaft

(1)Insert the input shaft assembly into the clutch case.



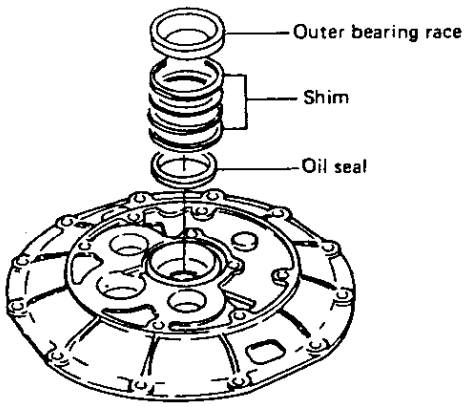
(2)Drive the centering bush into the clutch case.



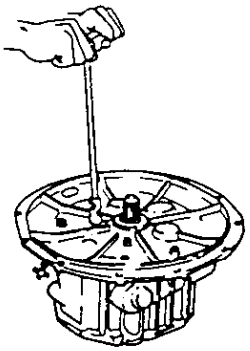
6-3-4 Reassembly of the mounting flange

(1)Insert the oil seal and the shim into the mounting flange.

(2)Drive the outer bearing race into the mounting flange.

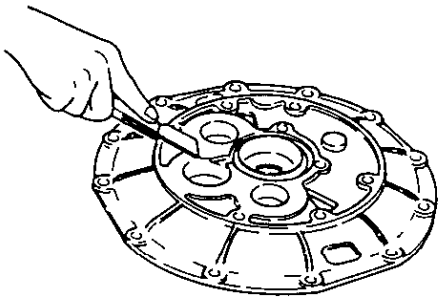


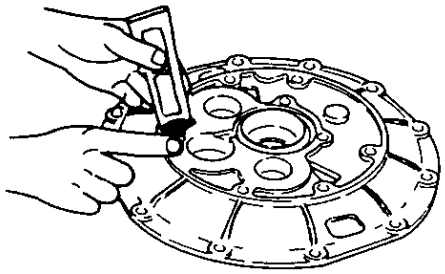
(3)Fit the mounting flange onto the clutch case, and tighten the bolt.



Tightening torque	5 – 6 kg-m (36.2 – 43.4 ft-lb)

NOTE: Apply non-drying liquid packing to the matching surface of the mounting flange and the clutch case.





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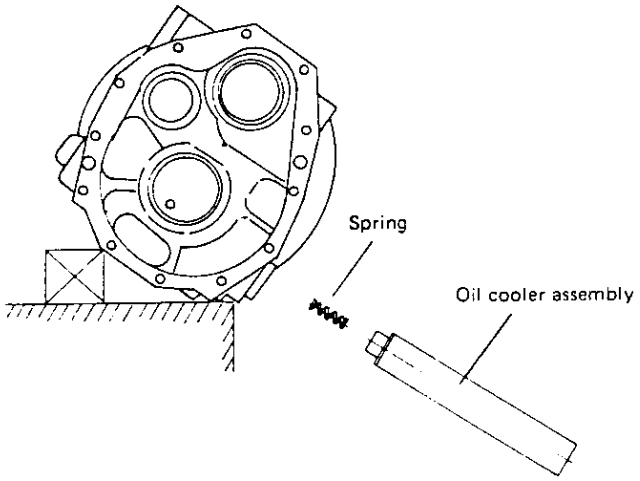
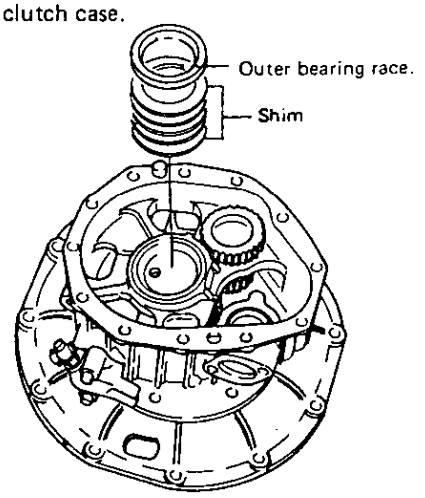
6-3-5 Reassembly of the oil cooler

NOTE: Fasten taking care not to allow the spring at the tip of the oil cooler to drop out.

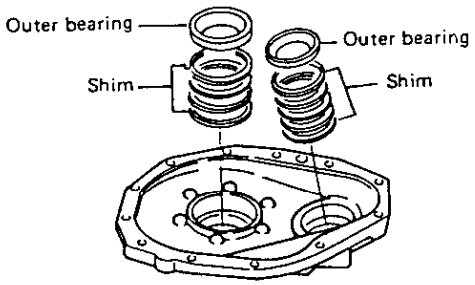


6-3-6 Reassembly of the clutch case cover.

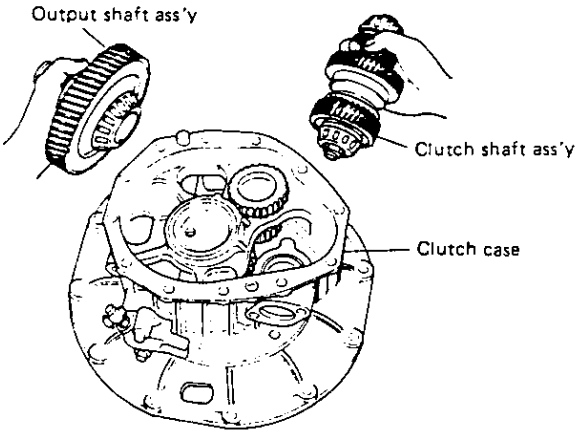
(1)Drive the output shaft shim and the outer bearing race into the clutch case.

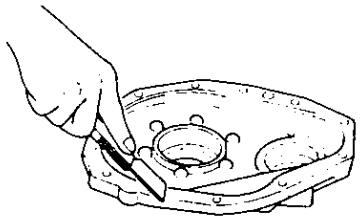


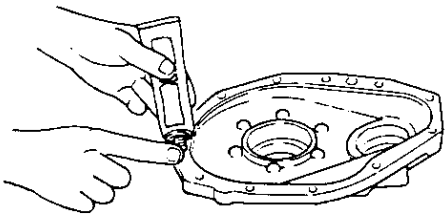
(2)Drive the shims and the outer bearing races into the clutch case cover



(3)Insert the clutch shaft assembly and the output shaft into the clutch case.

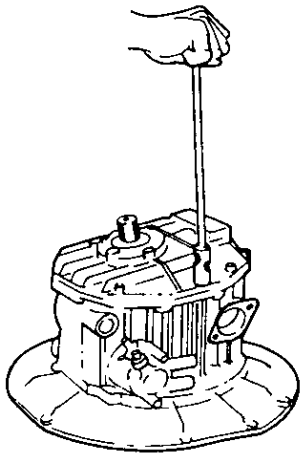






NOTE: Apply non-drying liquid packing to the maching surface of the clutch case cover and the clutch case.

(4)Fit the clutch case cover on the clutch case, and tighten the bolt.



Tightening torque	2.3 – 2.8 kg-m (16.6 – 20.3 ft-lb)

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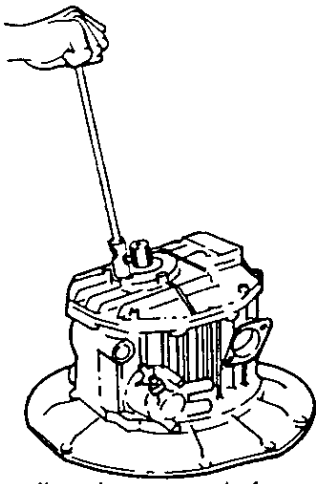
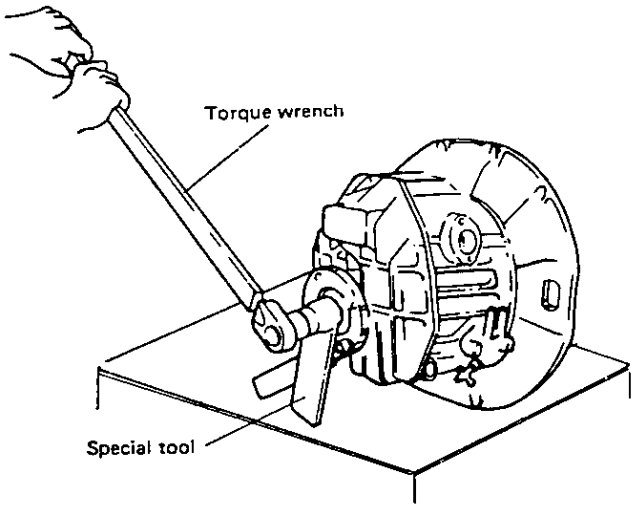
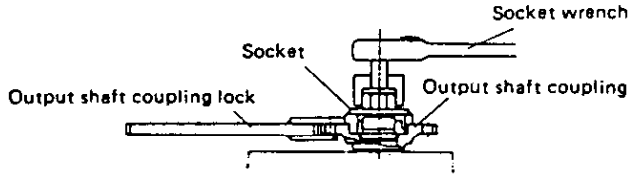
(5)Insert the outer bearing race, shim and the output shaft cover, and tighten the bolt.



(6)Insert the oil seal, output shaft coupling, O-ring and the end nut into the output shaft.

(7)Tighten the end nut with the special tool and a torque wrench, then calk it.

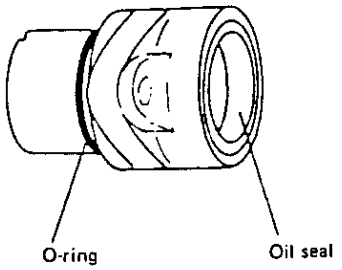




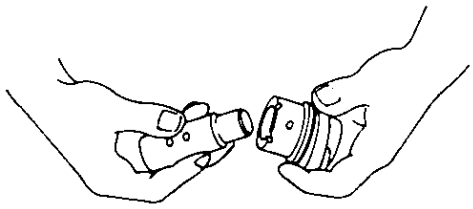
Tightening torque	54 – 56 kg-m (391 – 405 ft-lb)

6-3-7 Reassembly of the shifting device

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

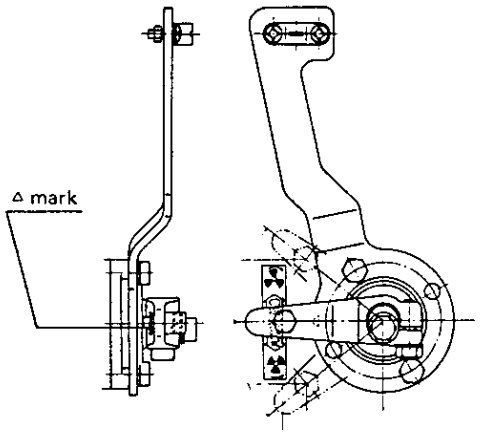


(2)Insert the shift lever shaft to the side cover

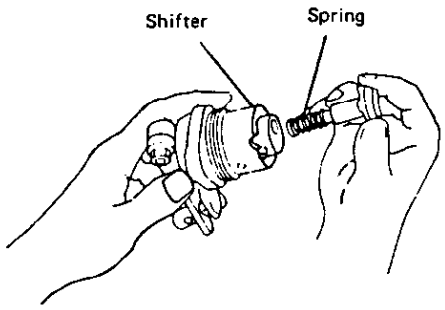


(3)Fit the shift lever to the shift lever shaft

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



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



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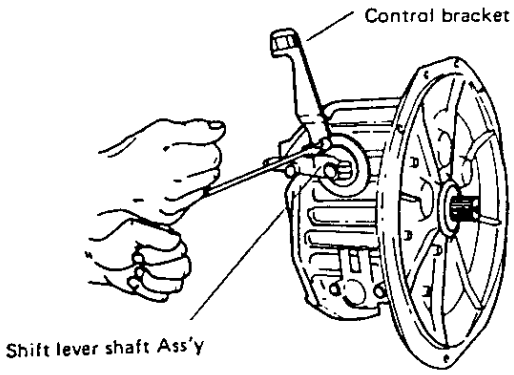
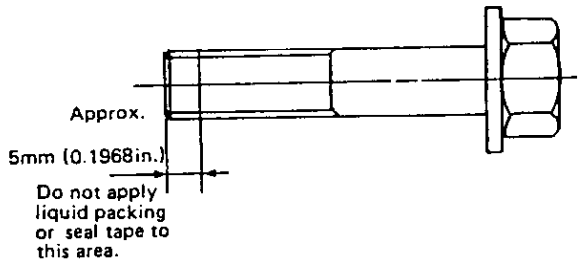
(5) Fit the side cover assembly and the remote control bracket to the clutch case.



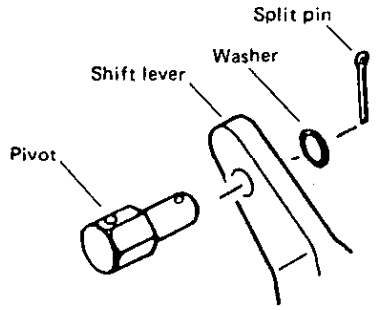
NOTE: 1) Check the direction of the shifter (Top and bottom side)
2) The shift lever may not turn smoothly if the clutch case is not filled with lubricating oil.

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

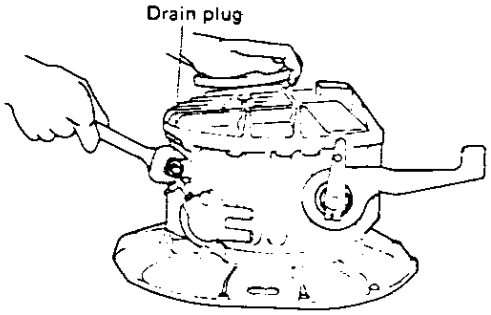
NOTE: Apply non-drying liquid packing or seal tape to the thread of the stopper bolt.

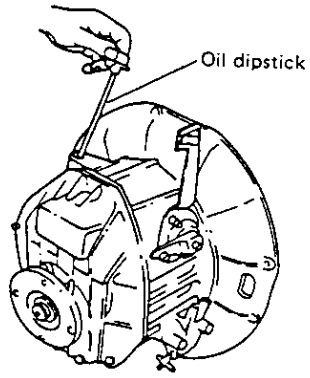


(7) Fit the pivot to the shift lever.



6-3-8 Reassembly of the lube oil drain plug and the dipstick





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Marine Gear Models

KM3P2

for Engine Models 4JH2E

1. Construction

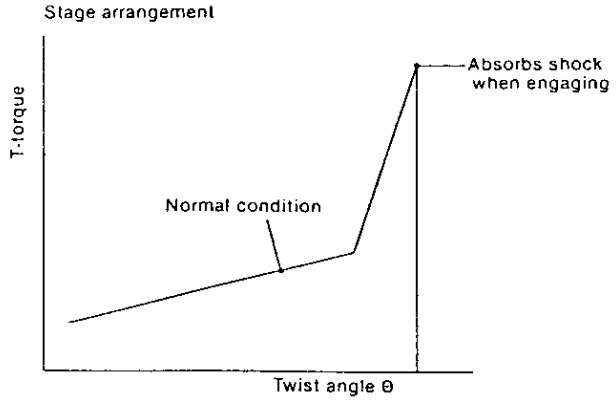
1-1 Construction

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 if 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 also reliable because high grade materials are used for the shaft and gear, and a taper roller bearing is incorporated. Power transmission is smooth because 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.

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1-2 Specifications

Model			KM3P2	
For engine models			4JH2E	
Clutch			Constant mesh gear with servo cone clutch (wet type)	
Reduction ratio	Forward		2.36	2.61
	Reverse		3.16	3.16
Propeller shaft rpm (Forward)			1441	1303
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 20/30	
Lubricating oil capacity			0.35 ℓ	
Dry weight			11.5 kg (25.4 lbs)	

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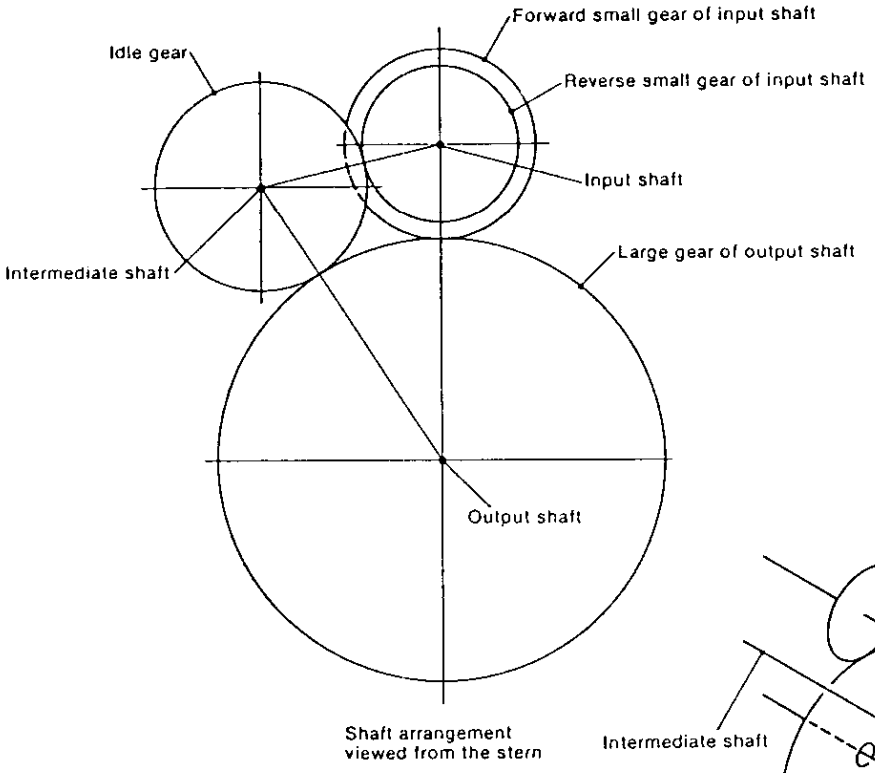
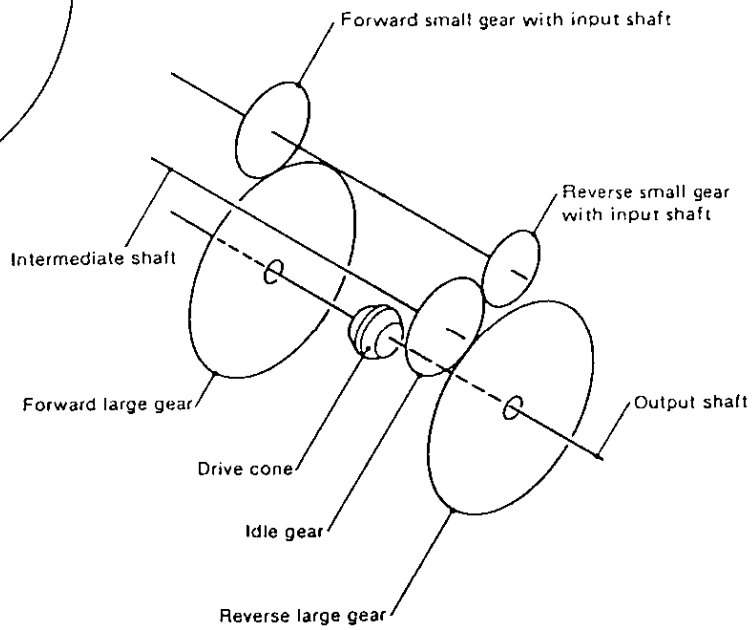
1-3 Power transmission system

1-3.1 Arrangement of shafts and gears



Shaft arrangement viewed from the stern



1-3.2 Reduction ratio

Forward

Model	No. of teeth of forward small gear Zif	No. of teeth of forward large gear Zof	Reduction ratio Zof/Zif
KM3P2	25	59	59/25 = 2.36
	23	60	60/23 = 2.61

Reverse

Model	No. of teeth of reverse small gear Zir	No. of teeth of intermediate shaft gear Zi	No. of teeth of reverse large gear Zdr	Reduction ratio Zi/Zir•Zdr/Zi
KM3P2	19	26	60	60/19 = 3.16

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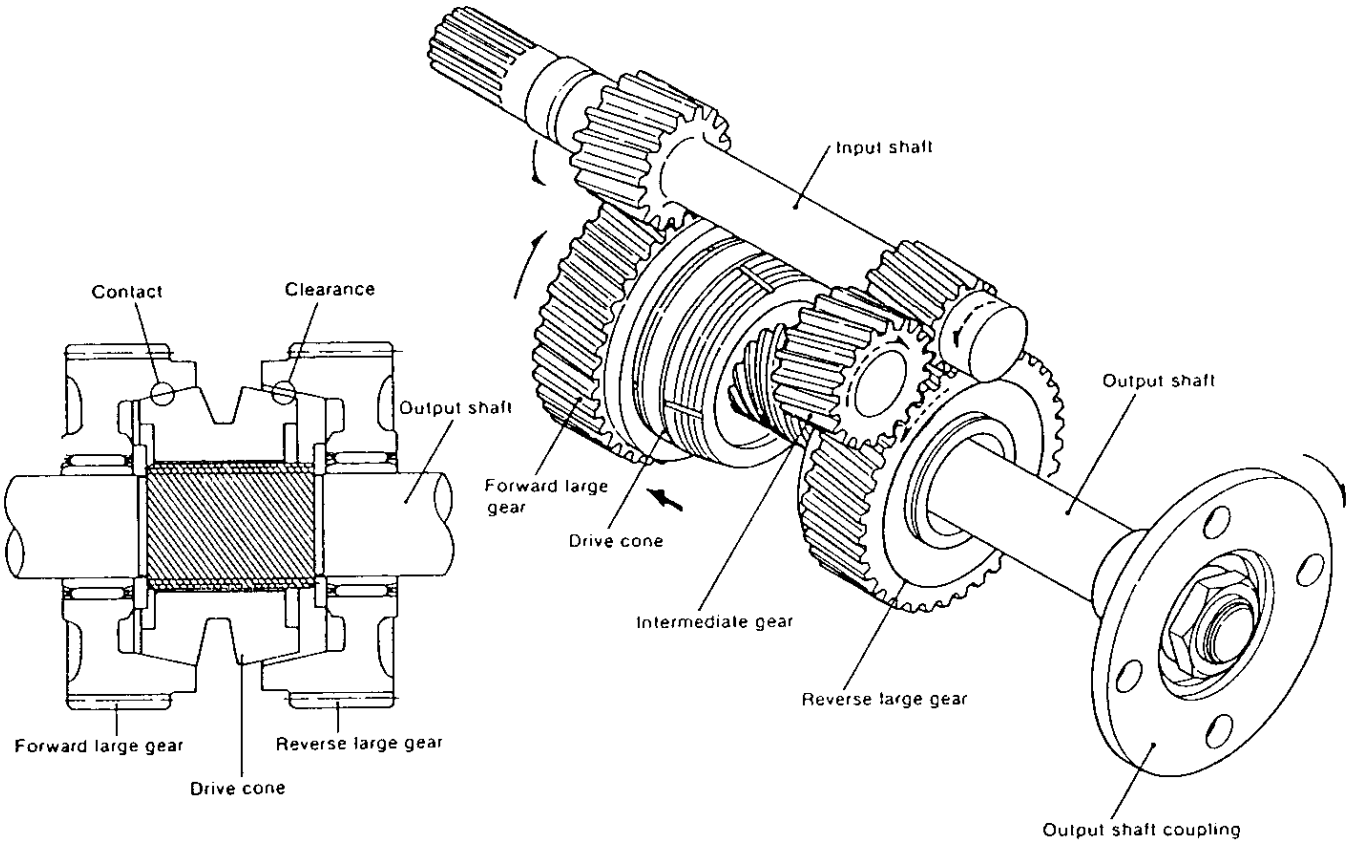
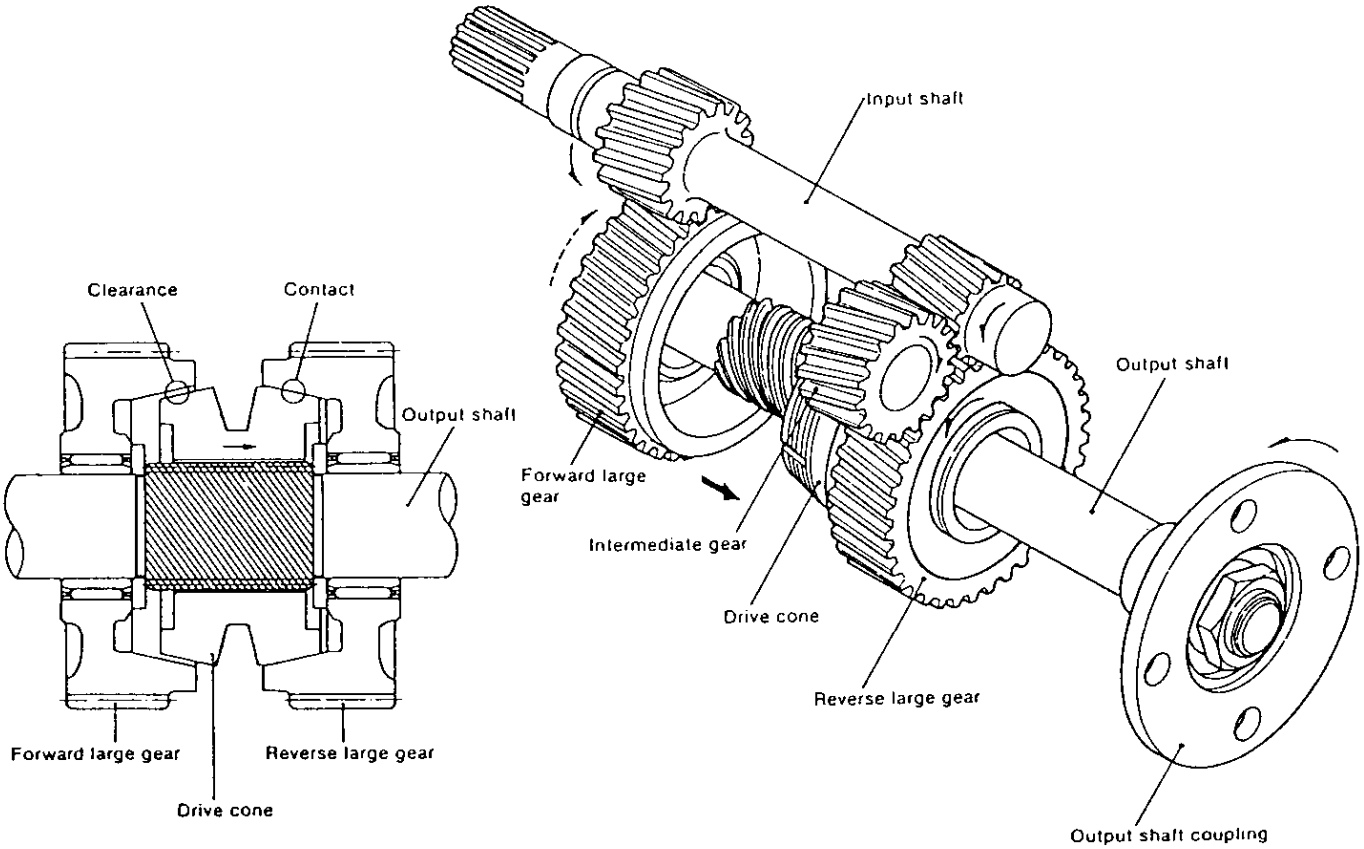
1-3.3 Power transmission routine — Forward



1-3.4 Power transmission routine — Reverse



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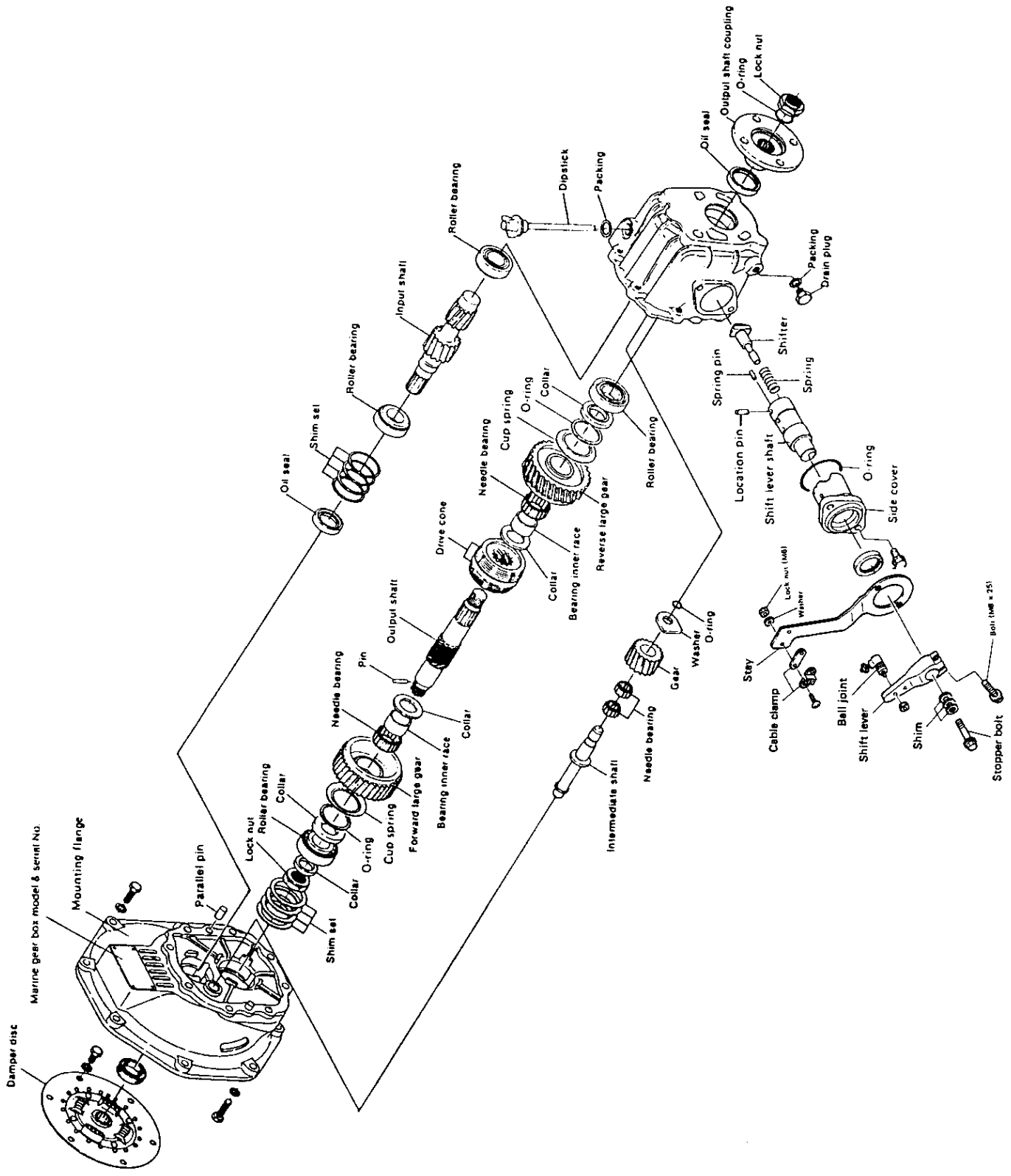
1-4 Drawing



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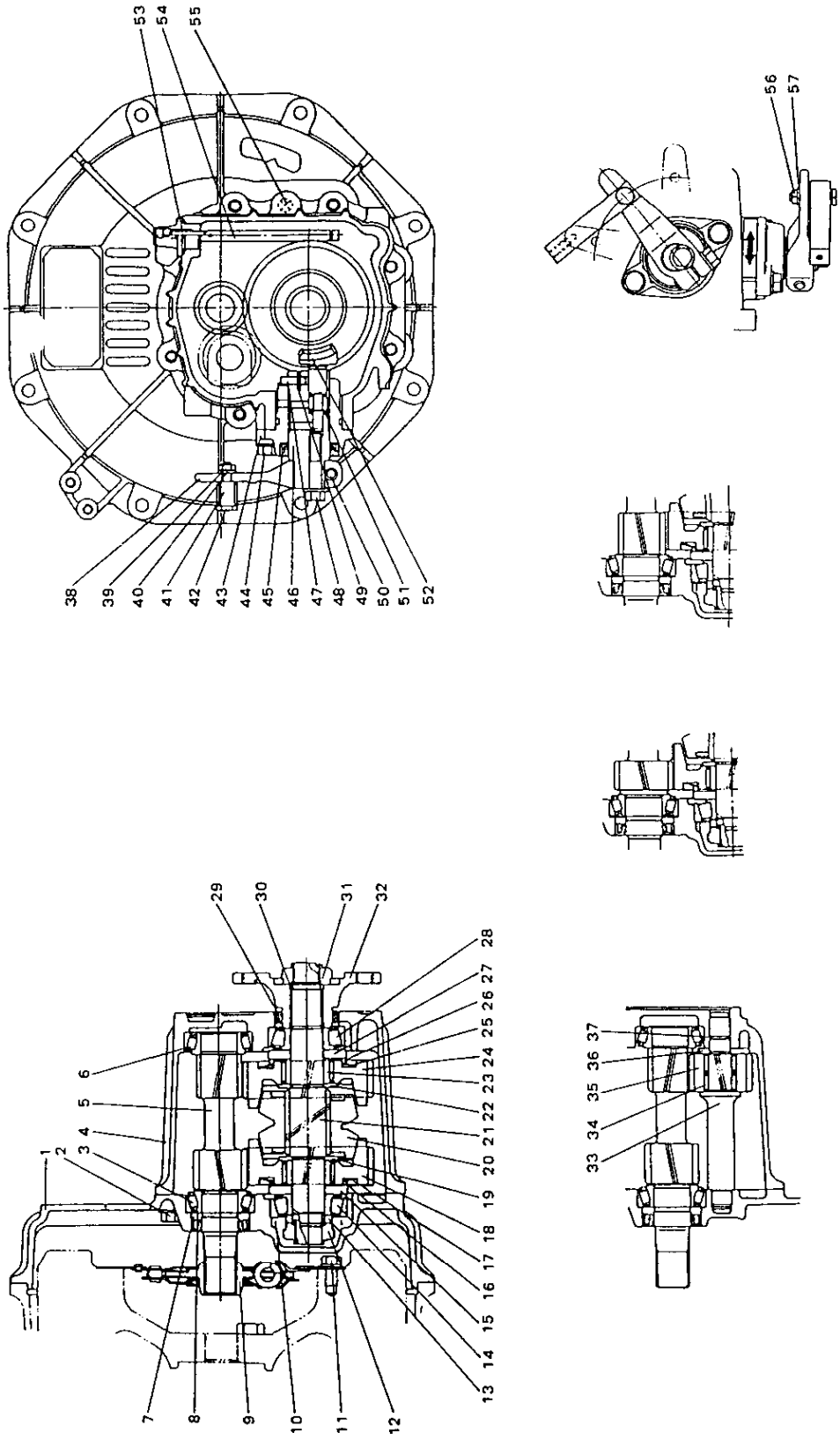
1-5 Sectional view



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

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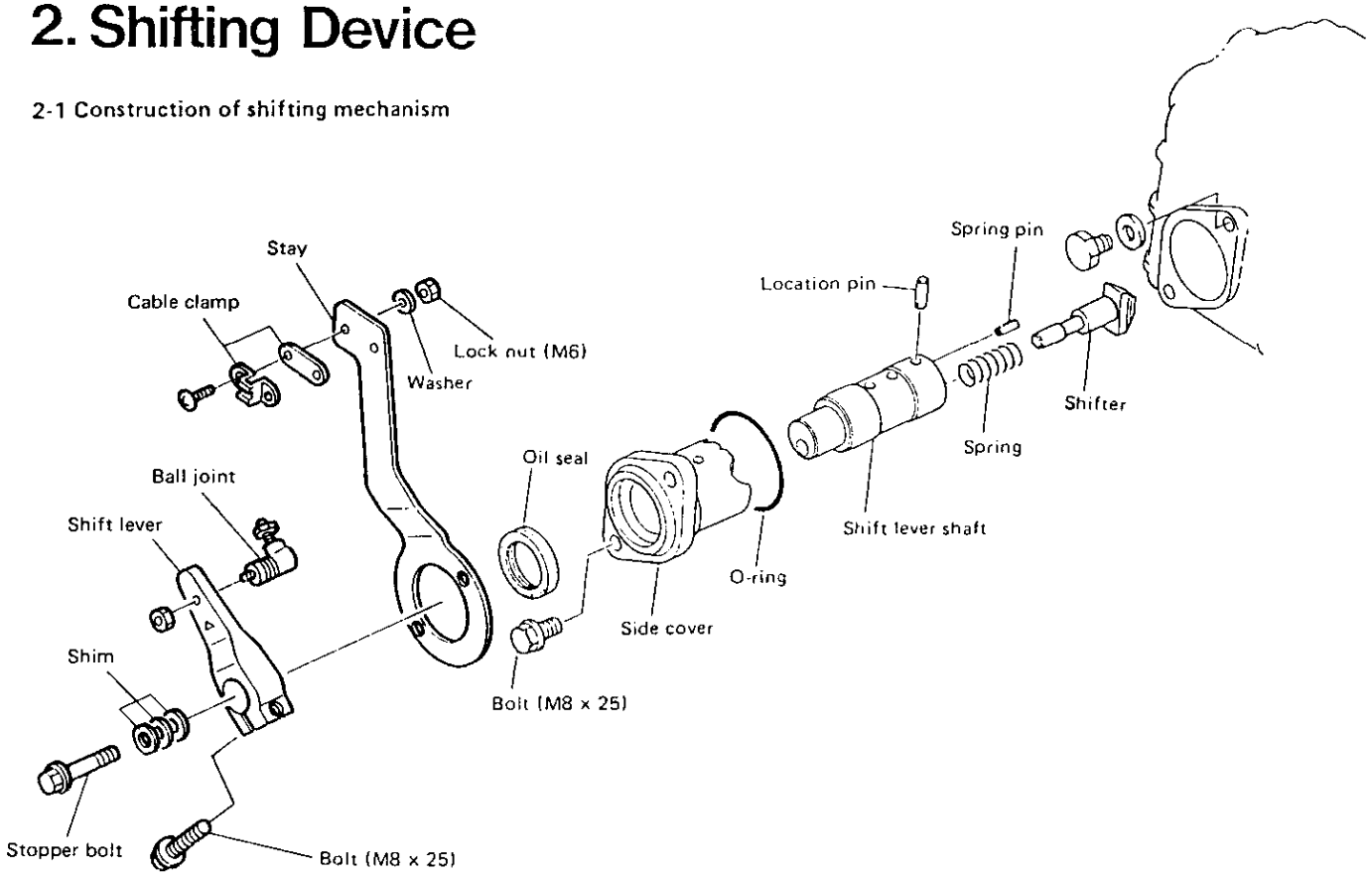
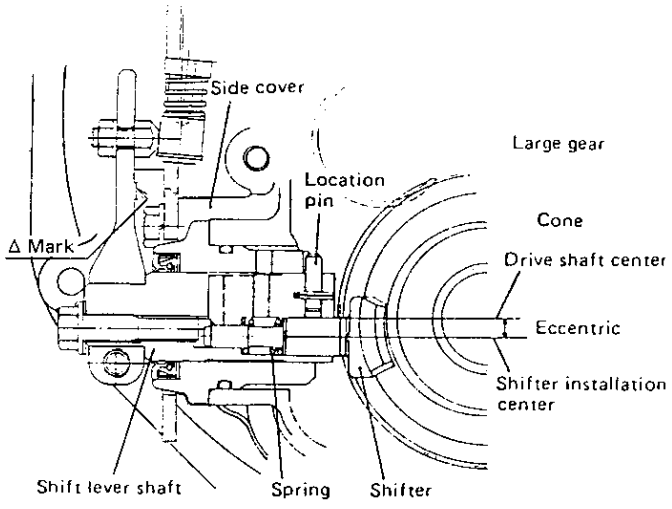
2. Shifting Device

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.)



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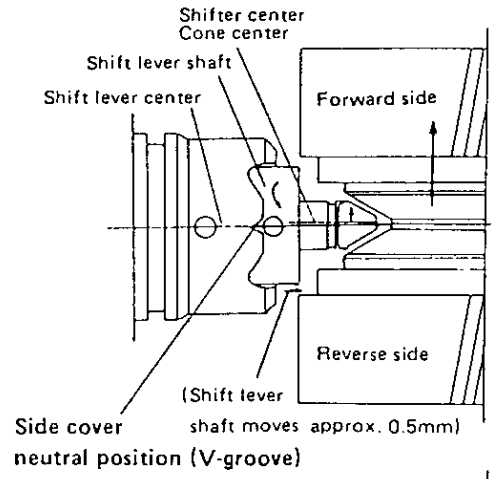
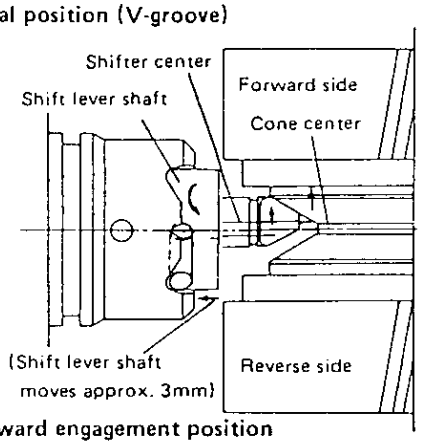
2-2 Forward and reverse clutch operation
(Neutral ⇒ Forward; Neutral ⇒ Reverse)

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.



neutral position (V-groove)

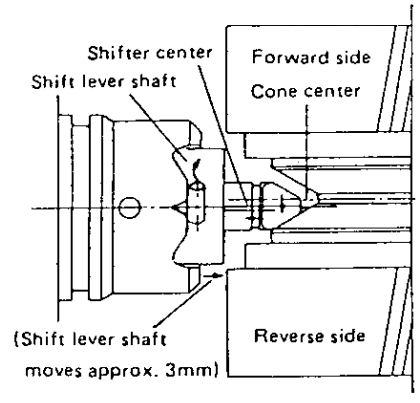
When the location pin of the shift lever shaft falls in the forward position groove of the side cover, the shift lever shaft moves approx. 3mm to the shift lever side, and the shifter starts to press the drive cone V-groove to the forward large gear side through the spring force.



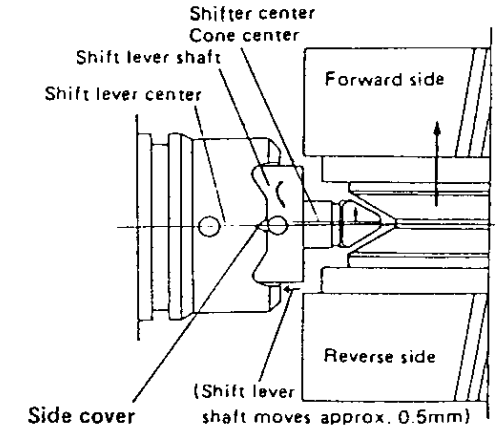
At forward engagement position

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 gr[illegible] of the side cover. (The shift lever shaft moves ap[illegible]x. 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.



neutral position (V-groove)

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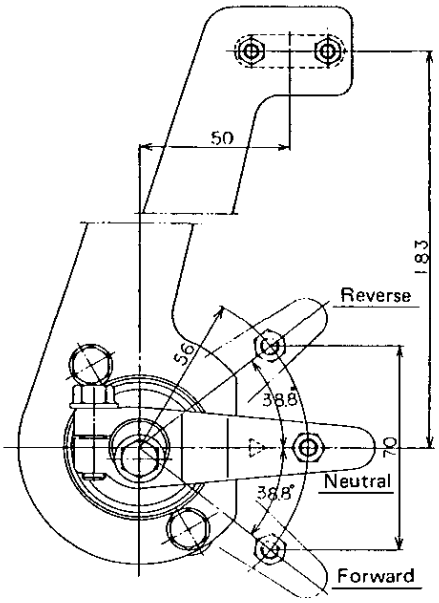
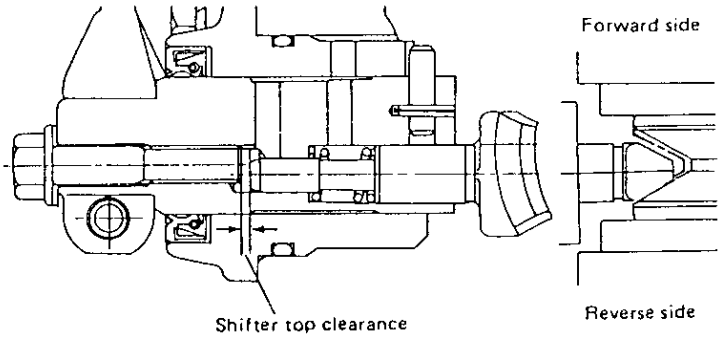
2-4 Clutch shifting force

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 be improperly fitted when the shift lever is moved to the neutral position from either the forward or the reverse position.



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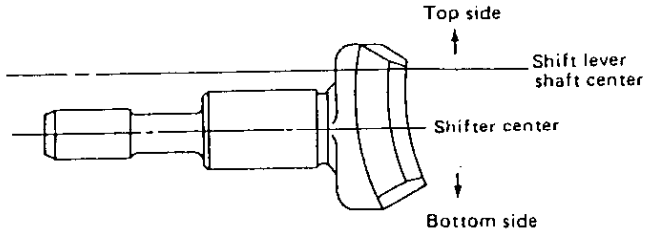
2-5.1 Measurement and adjustment of clearance

(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).

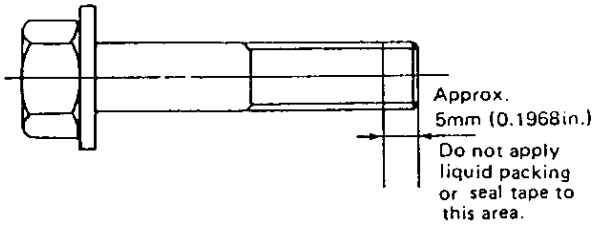
(e)Obtain the shim thickness "T" by the following formula.

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

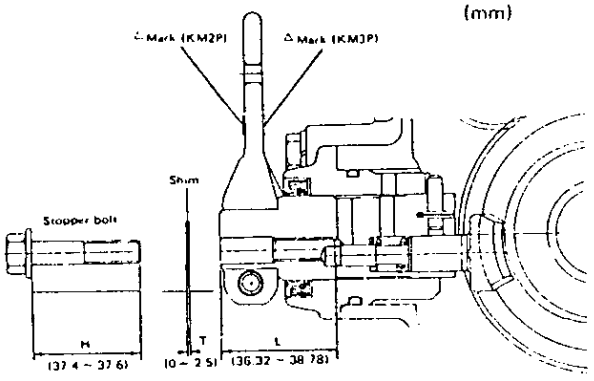
NOTE:Shim set includes one piece each of 1mm, 0.4mm, 0.3mm, 0.25mm shims.
(YANMAR Part No.177088-06380)

(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.



(mm)



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.

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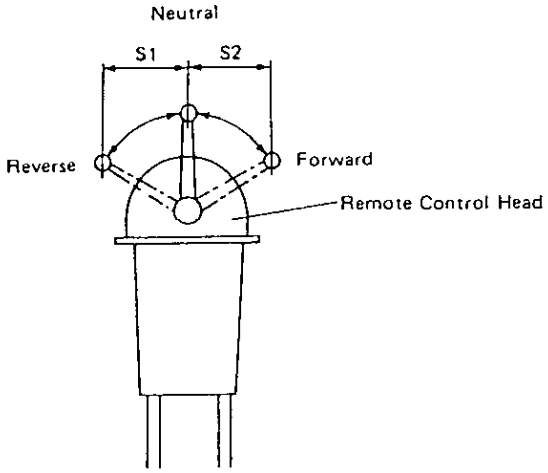
2-6 Adjustment of the remote control head

Marine gearbox control side

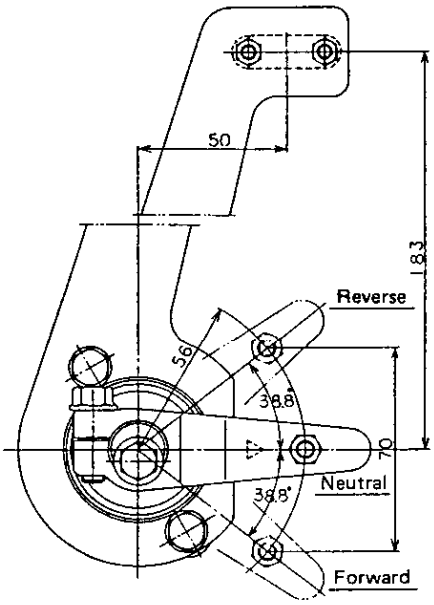
(1)Equal distribution of the control lever stroke.



The stroke between the neutral position → forward position (S2), and the neutral position → reverse positon (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 so that the cable shift travel of the S_1 and S_2 control lever strokes becomes identical.



2-7 Cautions

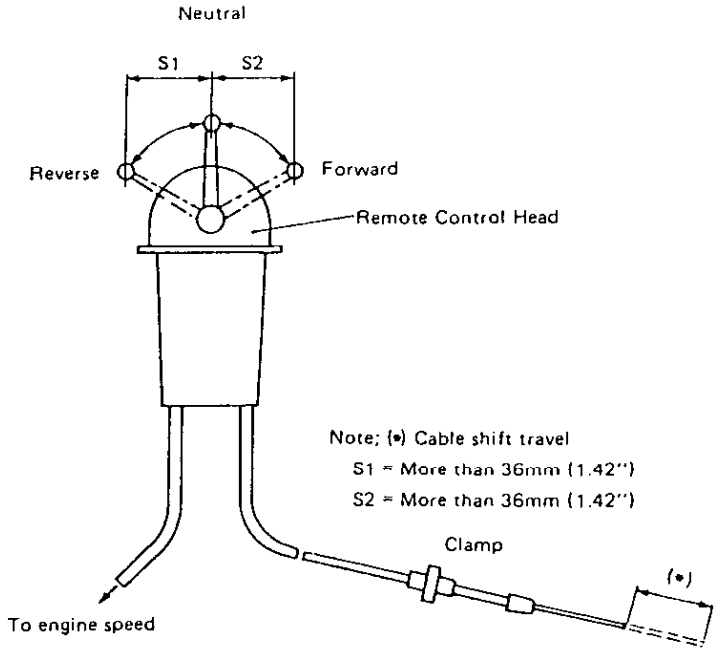
(1)Always stop the engine when attaching, adjusting, and inspecting.

(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.



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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

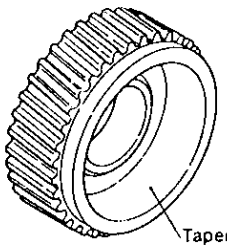
Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.
(1) Tooth surface wear.
Check the tooth surface for pitting, abnormal wear, dents, and cracks. Repair the lightly damaged gears and replace heavily damaged gears.
(2) Tooth surface contact.
Check the tooth 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.

mm (in.)

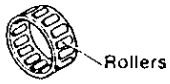
	Maintenance standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Input shaft reverse gear and intermediate gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Intermediate gear and output shaft reverse gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2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

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.

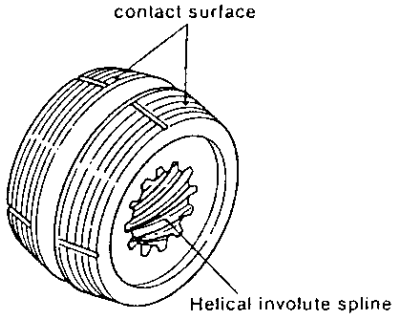


(2) Forward/reverse gear needle bearing.
When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.

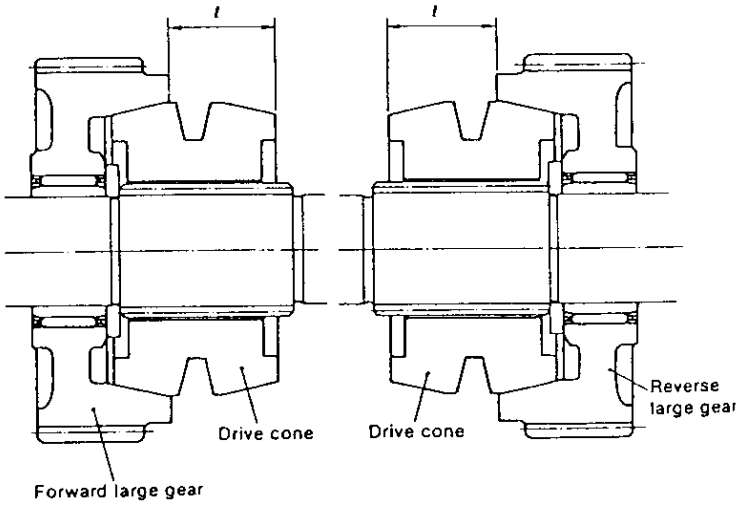


3-5 Drive cone

(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.



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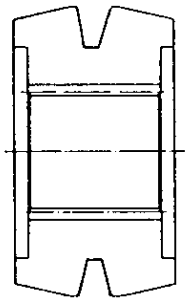
mm (in.)

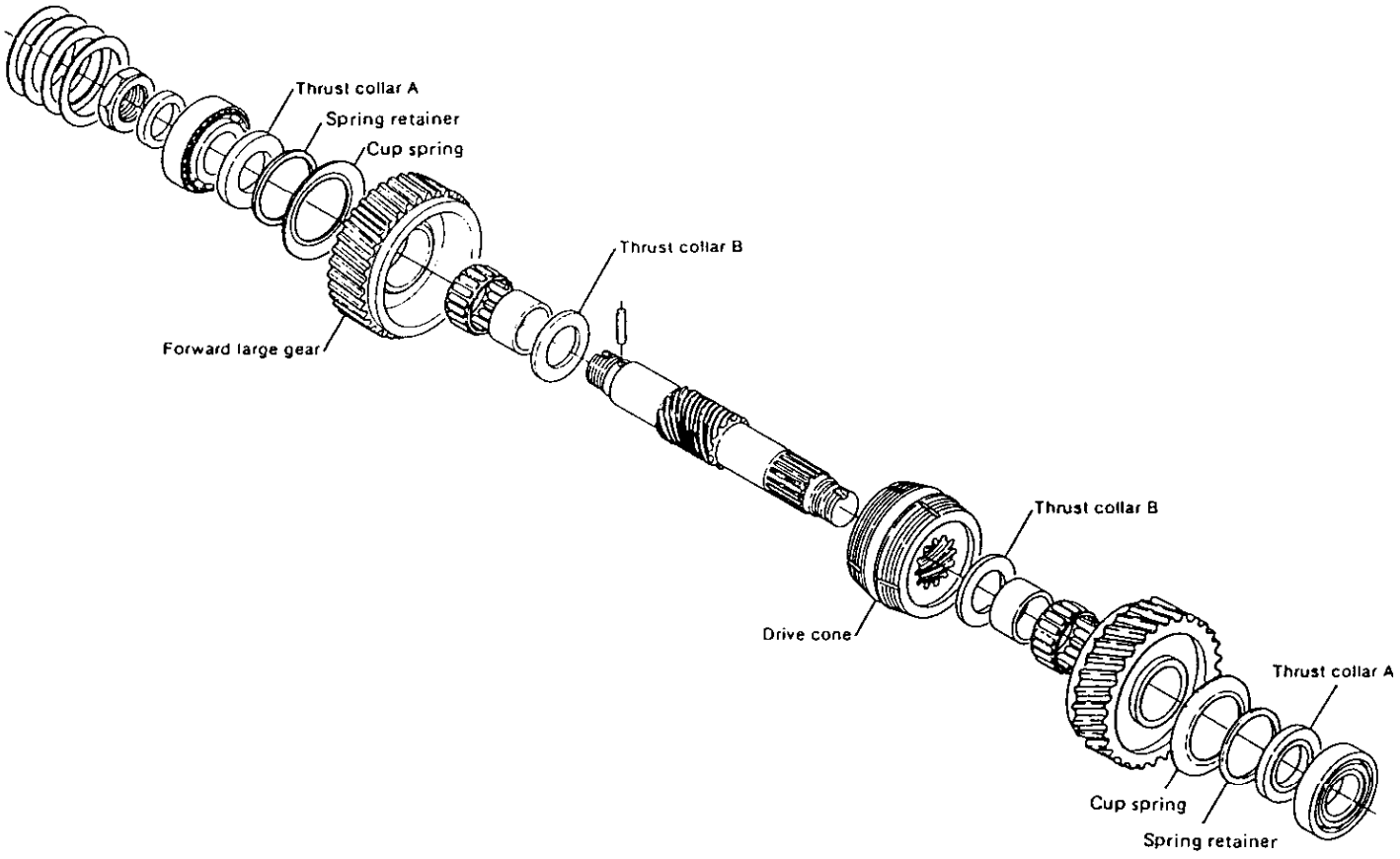
		Standard dimensions	Limited dimensions
Dimensions *l*	KM3P2	32.7 ~ 33.3 (1.2874 ~ 1.3110)	32.4 (1.2756)

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



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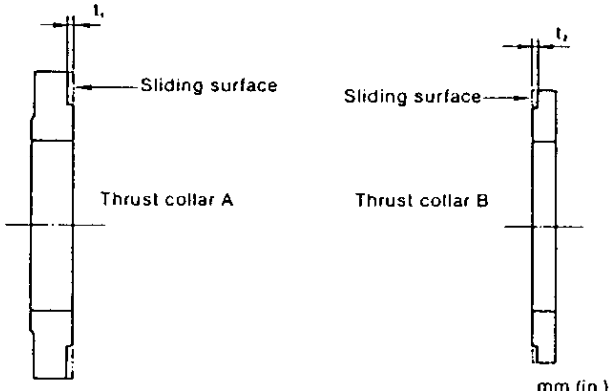
(1) Visually inspect the sliding surface of thrust collar A or B to check for signs of overheating, scoring, or cracks. Replace the collar if any abnormal condition is found.
(2) Measure the thickness of thrust collar A or B, and replace it when the dimension exceeds the specified limit.

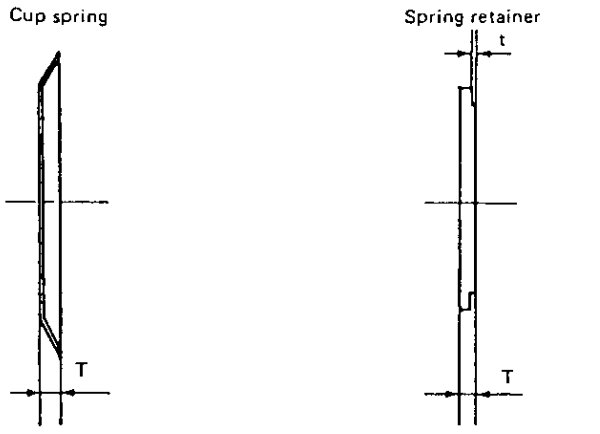


mm (in.)

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

(1)Check for cracks and damage to the cup spring and spring retainer. Replace the part if defective.
(2)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.



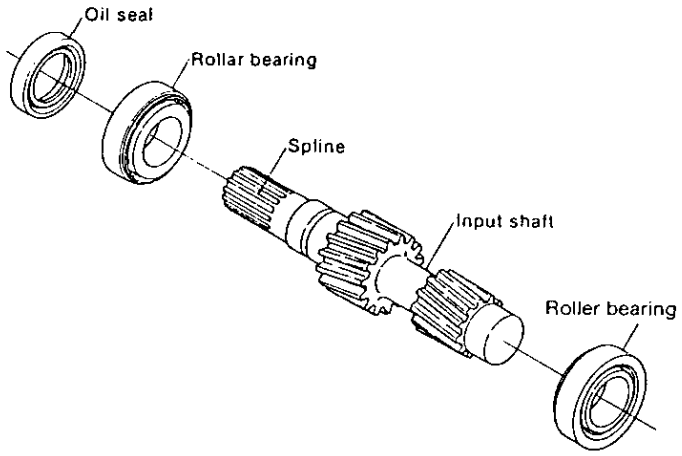
mm (in.)

	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

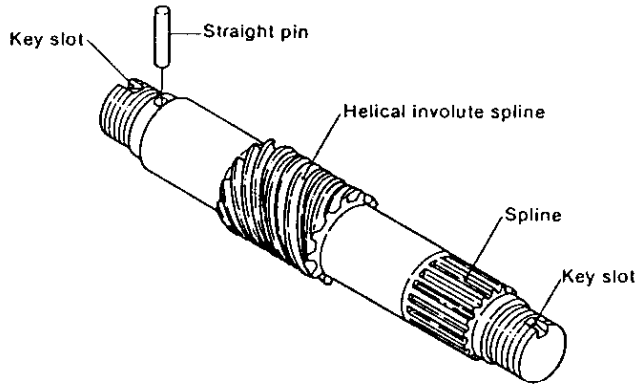
Visually inspect the oil seal of the output shaft to check if there is any damage or oil leakage; replace the seal when any abnormal condition is found.

3-9 Input shaft



(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.

3-10 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.

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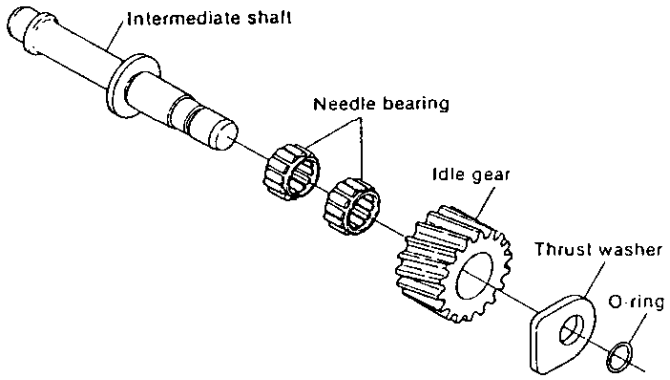
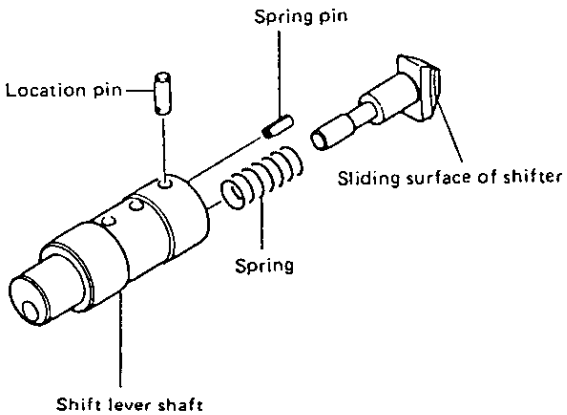
3-11 Intermediate shaft



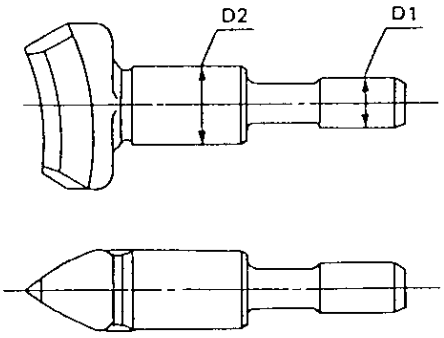
(1) Needle bearing dimensions, staining.
Check the surface of the roller to see whether the needle bearing sticks or is damaged. Replace if necessary.

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.

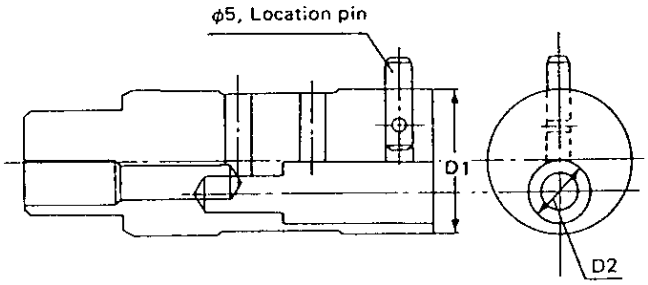


mm (in.)

	Standard	Limit
D1	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)

3-12.2 Shift lever shaft and location pin

(1)Check the shift lever shaft and location pin for damage or distortion, and replace defective parts. If the location pin must be replaced, replace it together with the shift lever shaft.
(2)Measure the diameter of the shift lever shaft and the shifter insertion hole. Replace the part if the size deviates from the standard value.



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, Shift insert hole	28.0 ~ 28.021 (1.1024 ~ 1.1032)	28.08 (1.1055)

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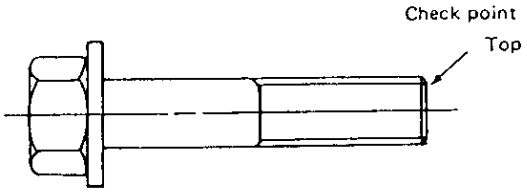
3-12.3 Shifter spring

(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	0.854 kg/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)

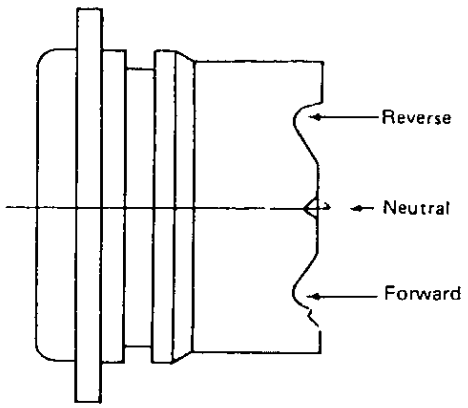
3-12.4 Stopper bolt

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

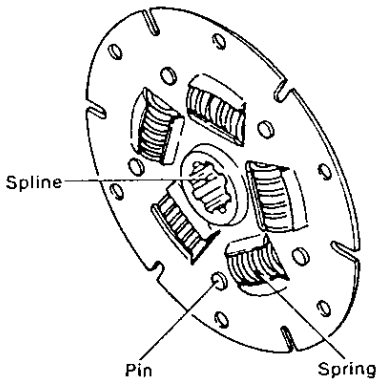


3-12.5 Side cover and oil seal

(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 the 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.

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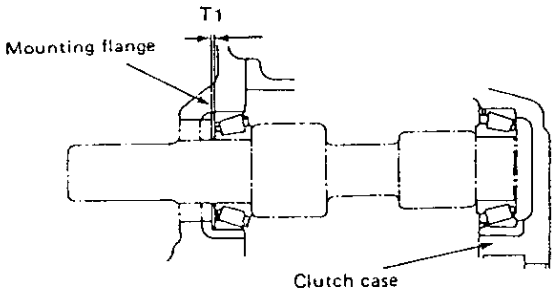
(1)Shim thickness (T1) measurement of input shaft

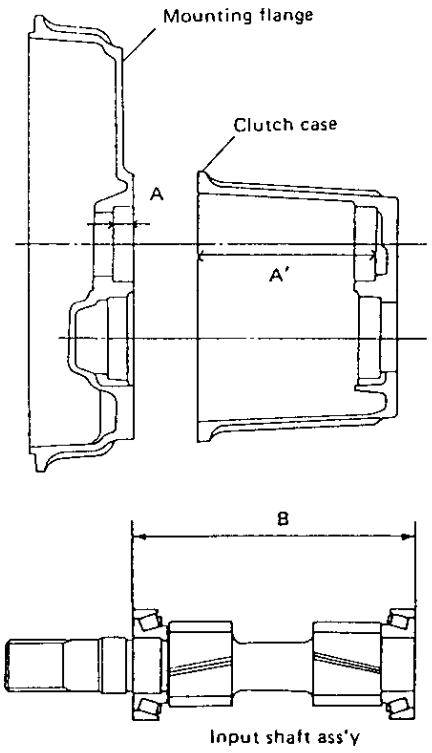
(a)Measure the bearing insertion hole depth (A) of the mounting flange, and the bearing insertion hole depth (A') of the clutch case.

(b)Measure the length (B) between the bearing outer races of the input shaft assembly.

(c)Obtain the (T1) thickness by the following formula:

$T_1 = A + A' - B$ (T_1: Clearance ± 0.05mm)



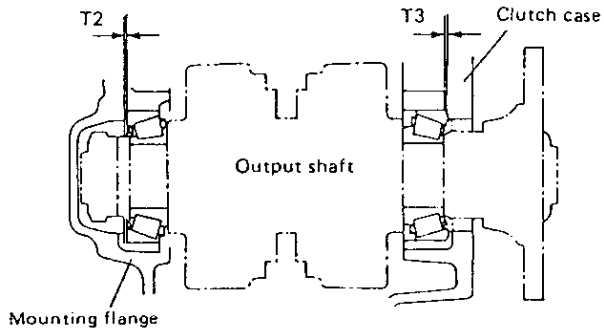


(2)Shim thickness (T2, T3) measurement of output shaft

(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.



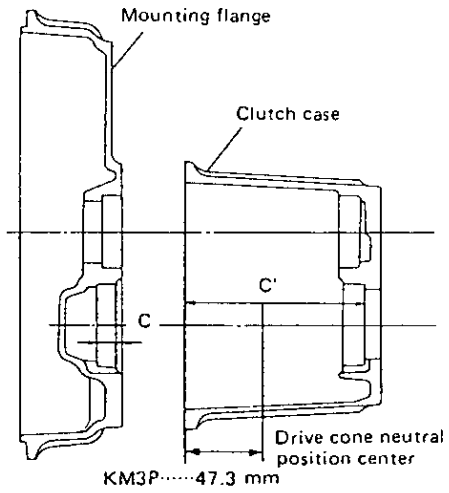
(c)Measure lengths (F) and (E) from the outer race end of the clutch case bearing included in the output shaft assembly.

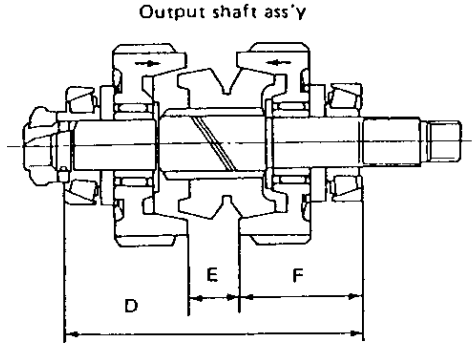
NOTE: Before measuring length (F) and (E), press the forward large gear and the reverse large gear to the drive cone until there is no clearance.

(d)Obtain thicknesses (T_2) and (T_3) by the following formulas:

$T_2 = C + C' - D - T_3$ (T_2: Clearance $\pm^{0.1\text{mm}}_{0}$)

T_3 (KM3P) $= C' - 47.3 - \frac{E}{2} - F$ (Tolerance ± 0.05mm)





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(3)Standard size of parts

mm (in.)

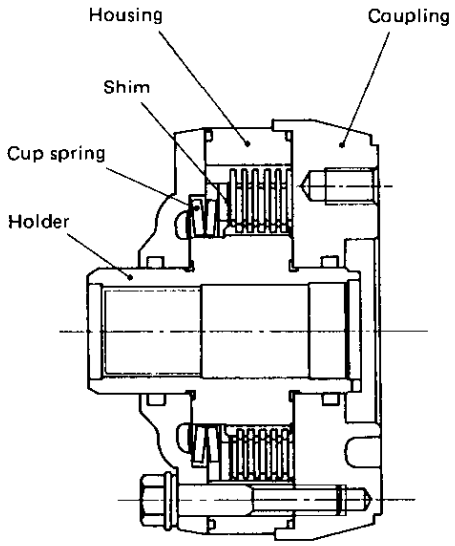
	A + A'	B	C + C'	D	E	F	Drive cone neutral center position
KM3P2	132.40 ~ 132.75 (5.2126 ~ 5.2264)	131.20 ~ 132.10 (5.1654 ~ 5.2008)	141.20 ~ 141.55 (5.5591 ~ 5.5728)	139.56 ~ 141.00 (5.4945 ~ 5.5512)	23.50 ~ 24.10 (0.9252 ~ 0.9488)	57.83 ~ 58.65 (2.2768 ~ 2.3091)	47.3 (1.8622)

NOTE:Compare your measurements with the above standard size. If your measurements differ largely 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

13-13. Torque limiter



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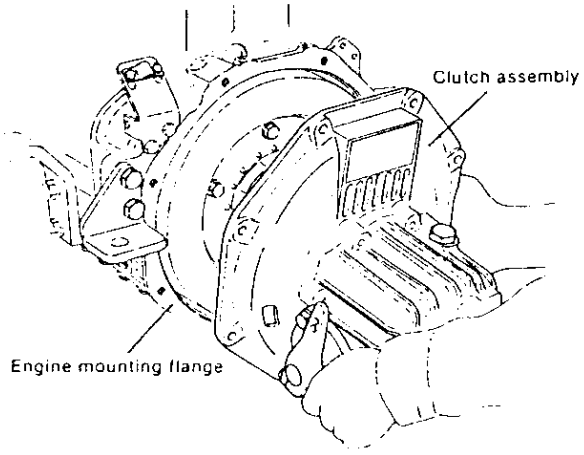
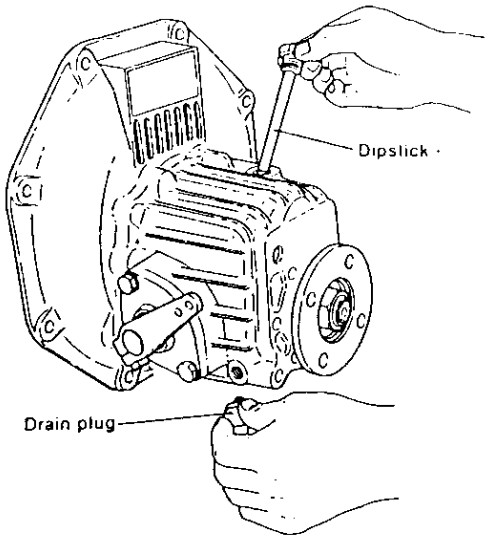
4. Disassembly

4-1 Dismantling the clutch

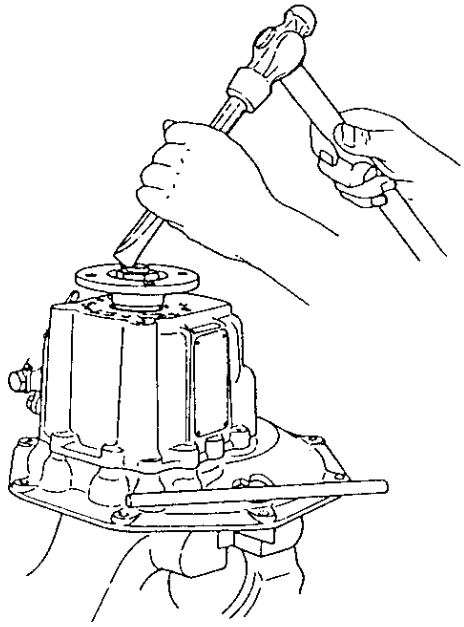
(1) Remove the remote control cable.
(2) Remove the clutch assembly from the engine mounting flange.

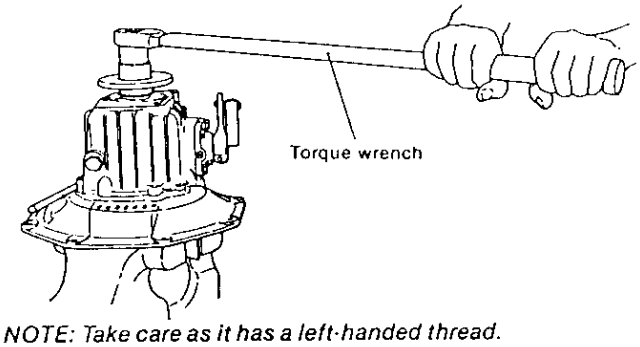


(3) Drain the lubricating oil.
Drain the lubricating oil by loosening the plug at the bottom of the clutch case.



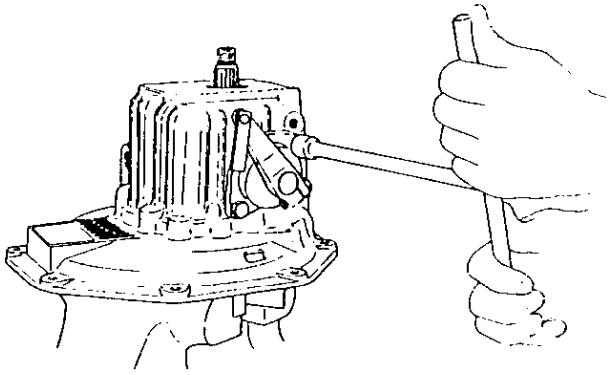
(4) Remove the end nut and output shaft coupling.





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.



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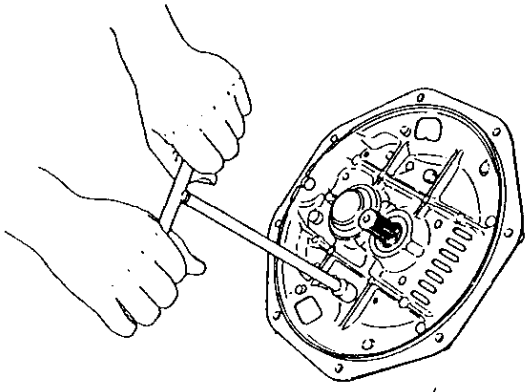
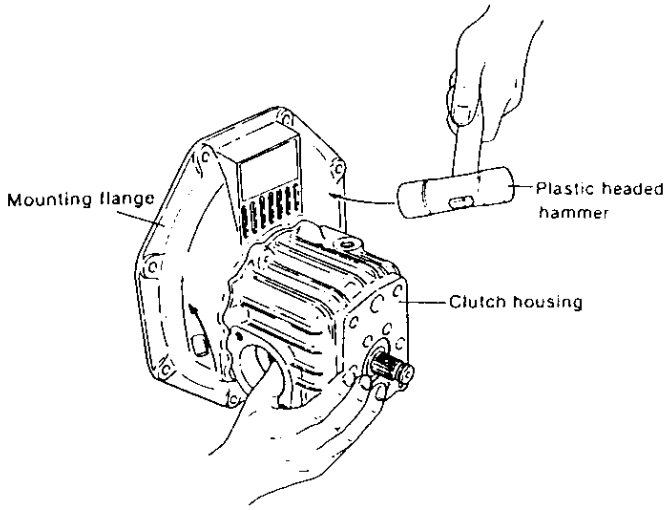
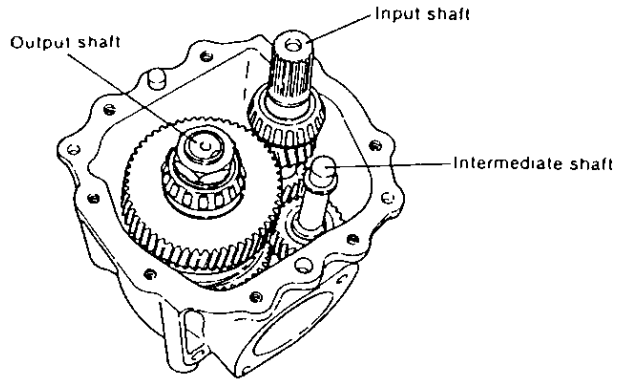
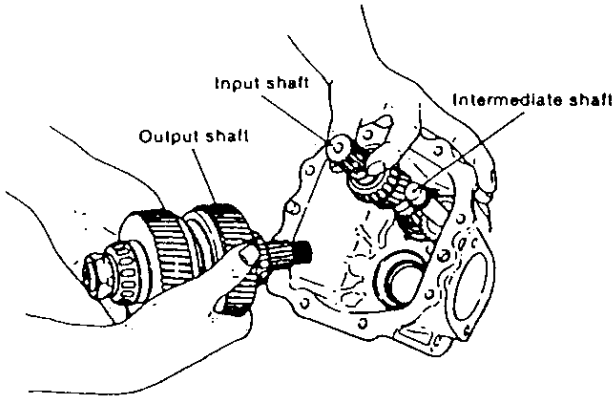
(7) Remove the bolts which secure the mounting flange to the case body, give light taps to the left and right with a plastic headed hammer while supporting the clutch case with your hand, then remove the mounting flange.



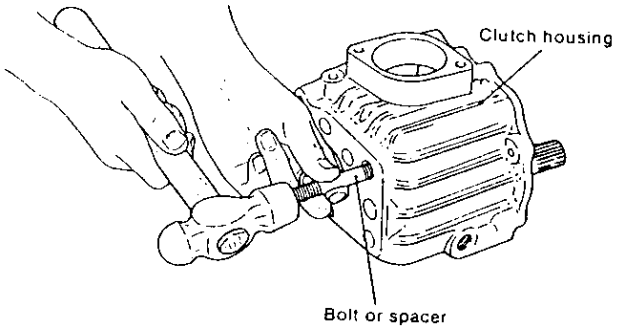


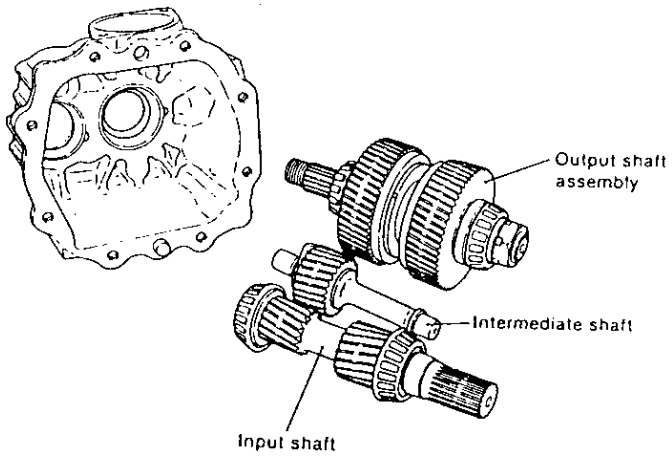
(8) Withdraw the output shaft assembly.





(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.





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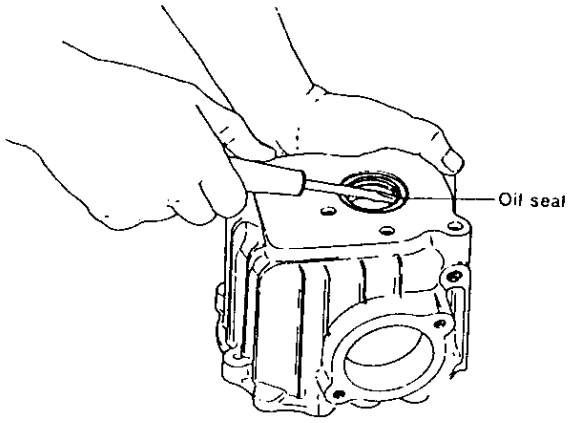
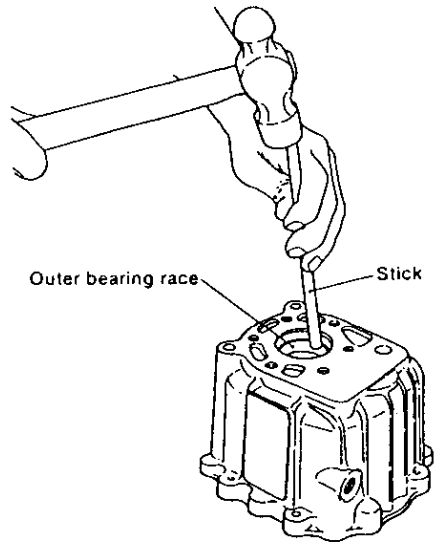
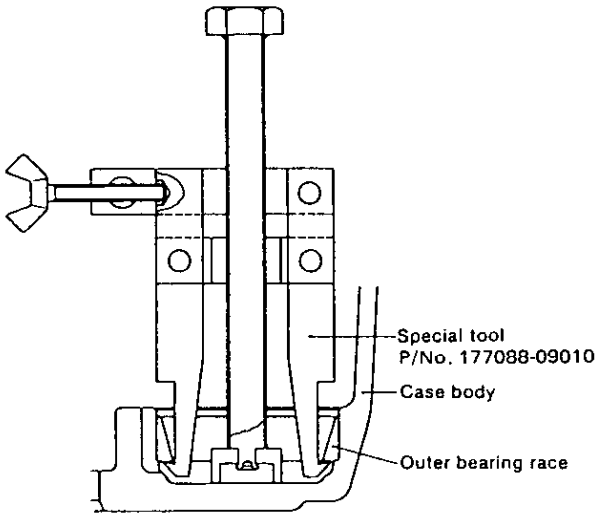
(10) Remove the oil seal of the output shaft from the case body.



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



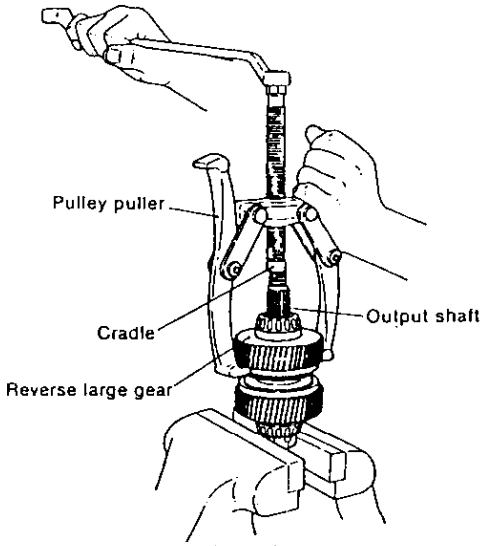


(12) Remove the oil seal of the input shaft from the mounting flange.
(13) Remove the outer bearing race from the mounting flange in the same way as with the case body.
(14) Remove each adjusting plate from the input or output shaft.

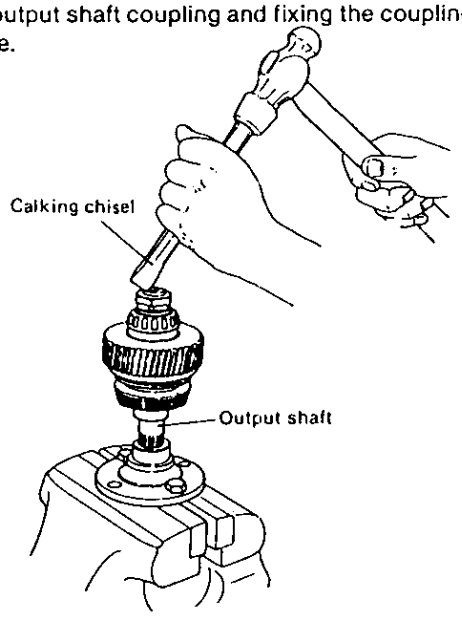
NOTE: The same adjusting plates can be reused when the following parts are not replaced. When any part is replaced however, re-adjustment is necessary.

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 extracter, 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.



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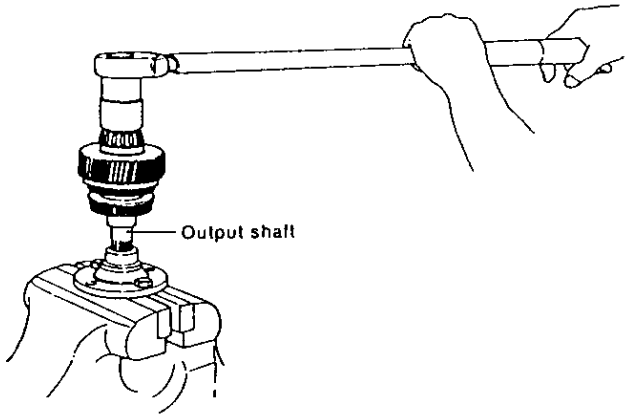
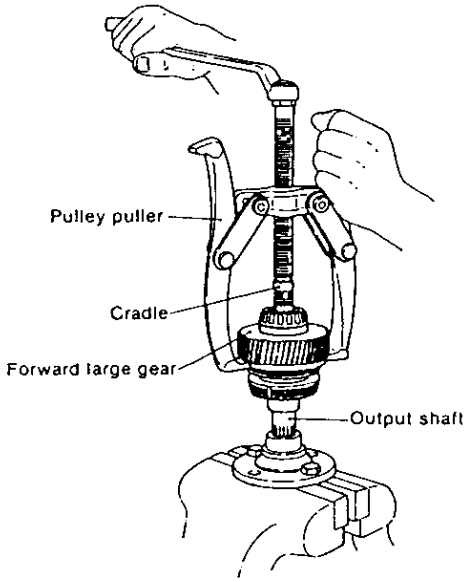
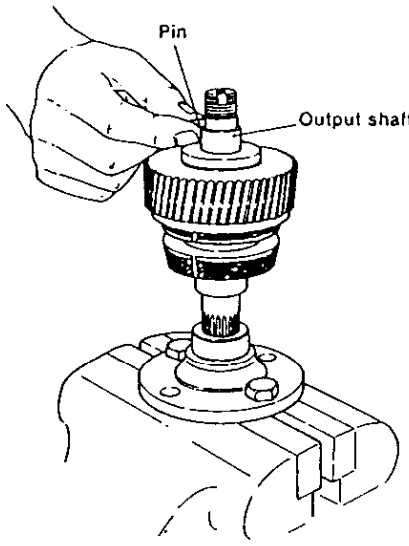


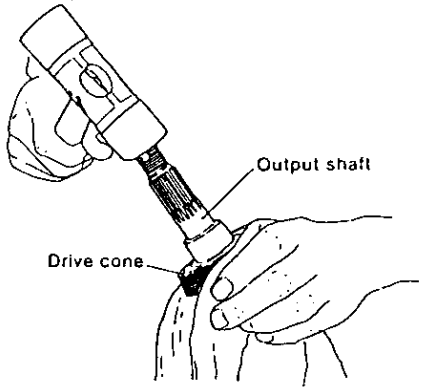
(3)Place the pulley extractor against the end surface of the forward large gear, and withdraw the forward large gear, thrust collar A, cup spring, spring retainer and inner bearing race.

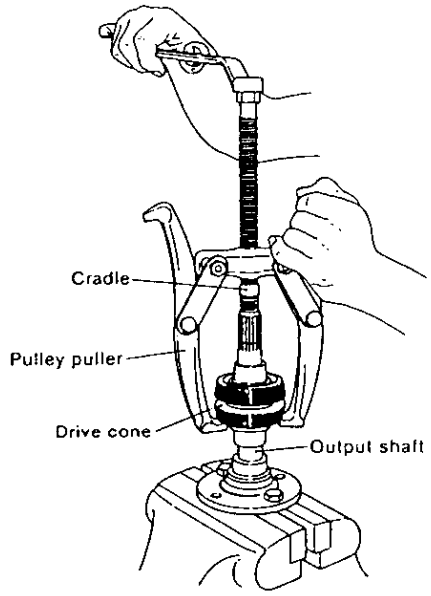




NOTE: Take care as the nut has left-handed thread.

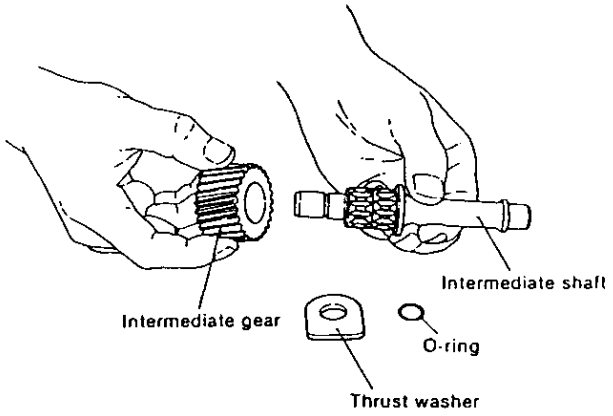
(4)While gripping the drive cone, tap the end of the shaft with a plastic headed hammer, and withdraw the thrust collar B and inner needle bearing race. A pulley extractor may be used.





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.



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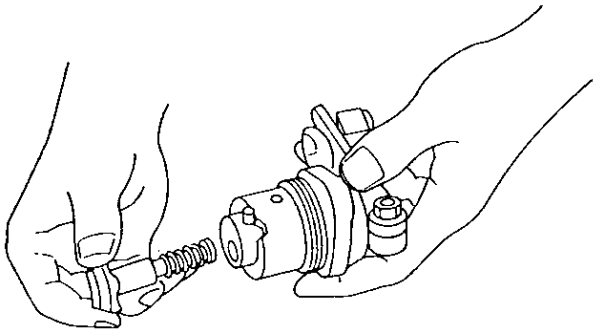
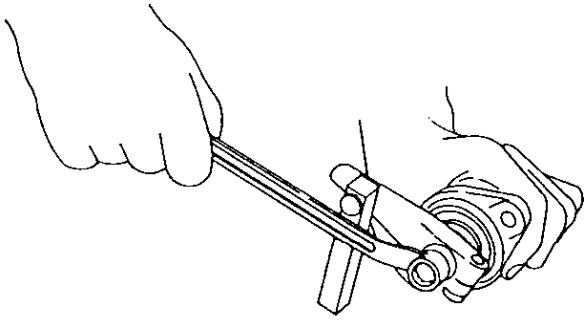
4-4 Dismantling the shifting device

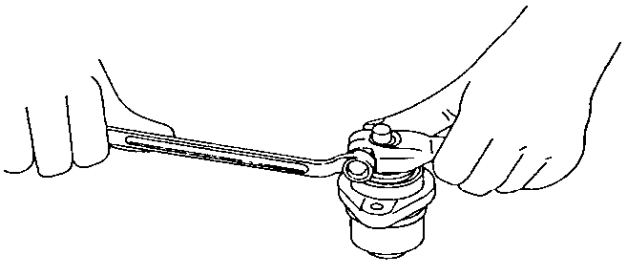
(1) Take out the shifter and shifter spring.



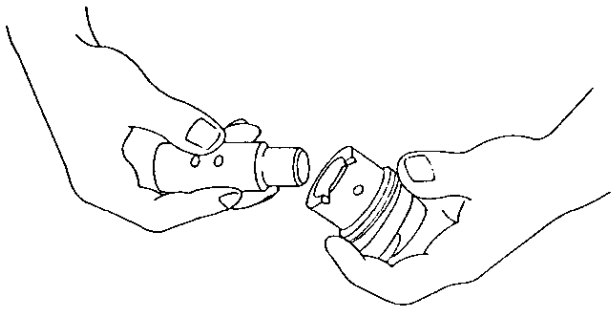
(2) Remove the stopper bolt of the shifter and shim.



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



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



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

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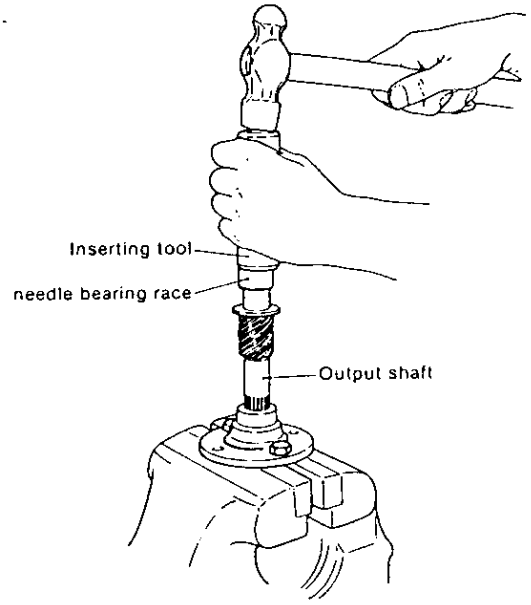
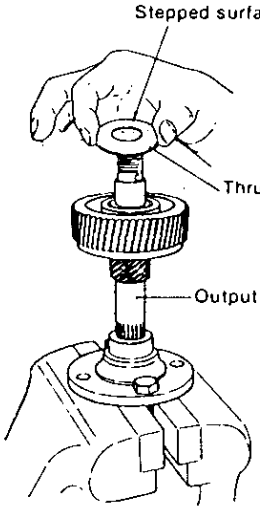
5. Reassembly

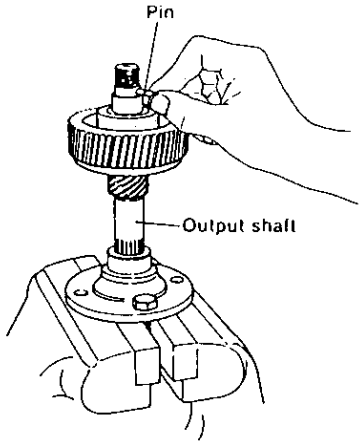
5-1 Reassembly of output shaft

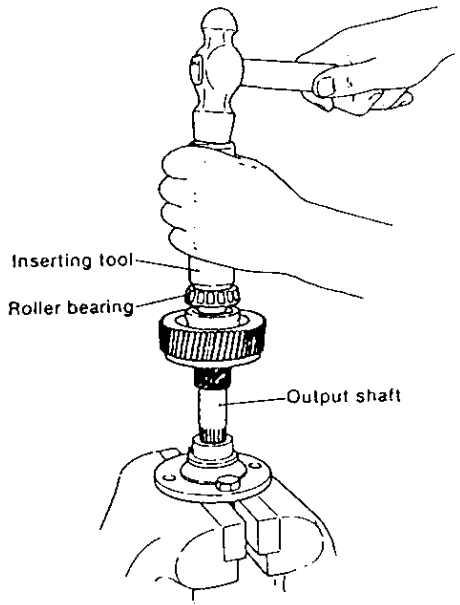
(1) Fit the forward side thrust collar B onto the shaft.
(2) Drive in the forward end inner needle bearing race using a jig.



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

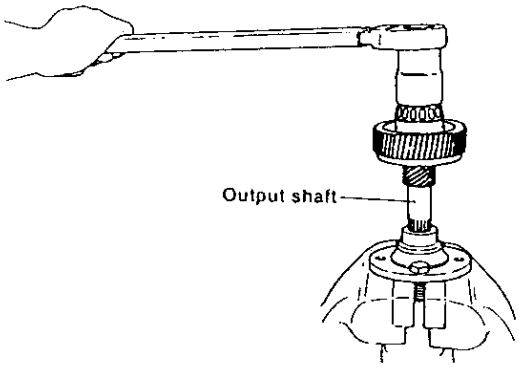






NOTE: 1) Drive in with a plastic headed hammer. Do not hit it hard.
2) When fitting the thrust collar A, note the fitting direction. Fit it keeping the stepped surface toward the roller bearing side.
3) Note that the pin cannot be fitted after the inner bearing race has been driven in.
4) Check that 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 kg-m (61.5 ~ 83.2 ft-lb)

(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 at the forward eng. This is to provide effective calking to the nut by changing the calking position.

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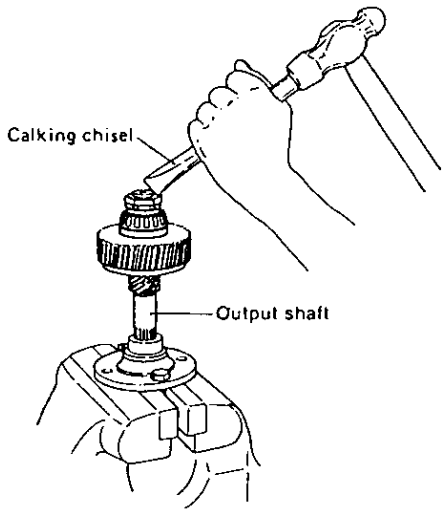
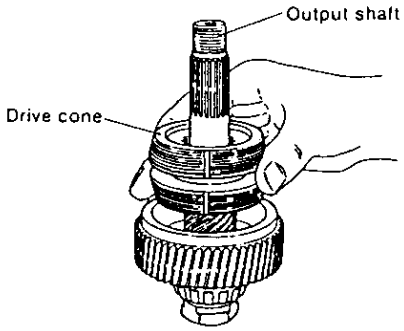
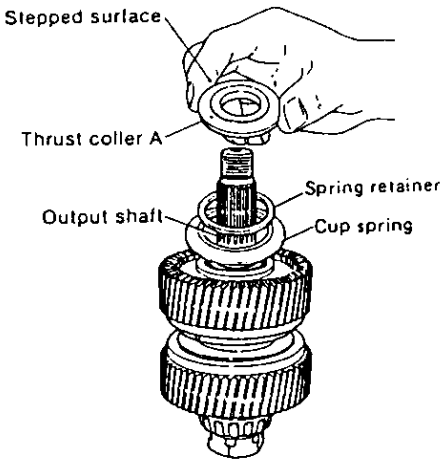


(7) Insert the drive cone while keeping the output shaft set for reverse.



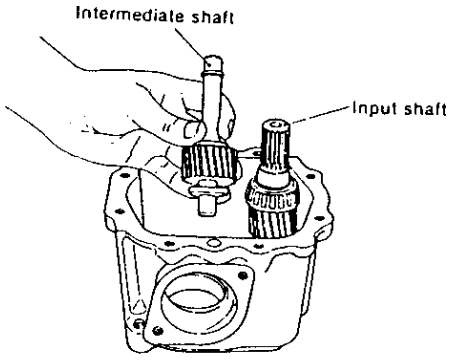
(8) Apply procedures 1 through 4 to the forward end.



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.

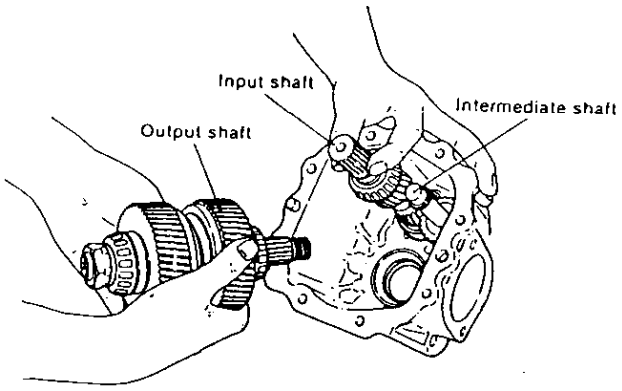
5-2 Reassembly of the clutch

(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.



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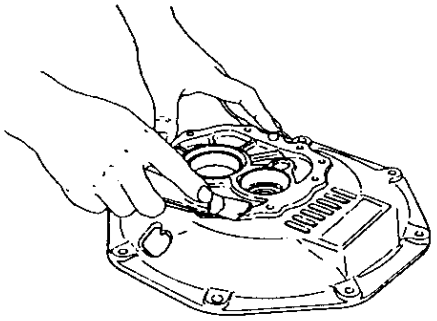
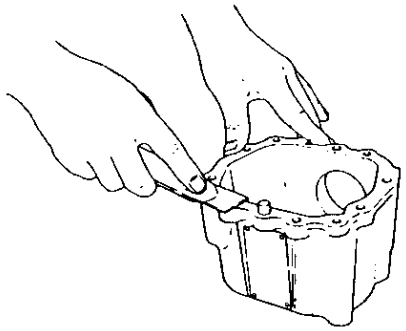
(5) Fit the adjusting plate to the mounting flange, and drive in the outer bearing race.

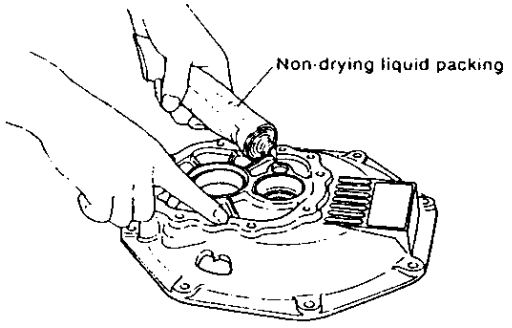
NOTE: The outer bearing race can be easily driven in by heating the mounting flange to about 100°C, or by cooling the outer race with liquid hydrogen.

(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.

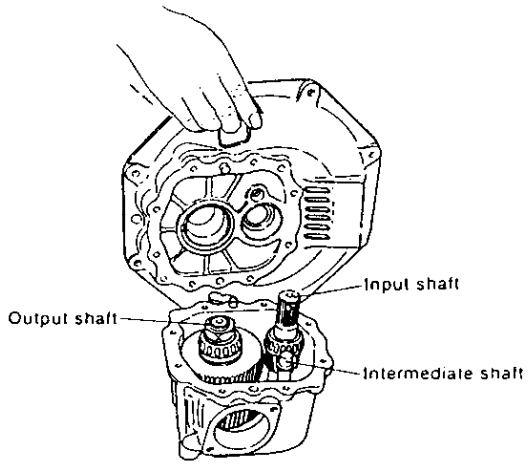
(7) Apply non-drying liquid packing to the matching surfaces of the mounting flange and the case body.







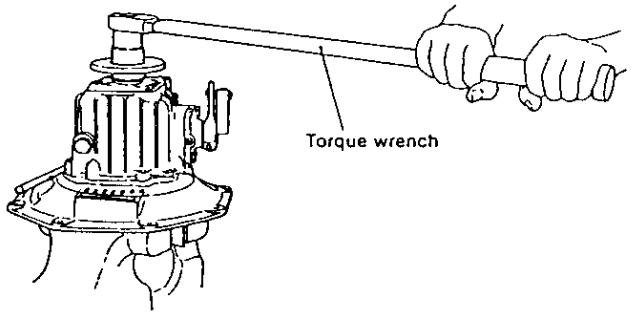
(8) Insert the input shaft and output shaft into the shaft holes of the mounting flange, assemble the mounting flange on the case body, and tighten the bolt.

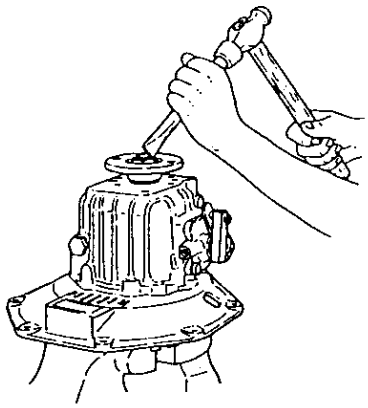


NOTE: Apply non-drying liquid packing to either the mounting flange or the case body.

(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 kg-m (61.5 ~ 83.2 ft-lb)

(The same torque applies to both models KM2P and KM3P).

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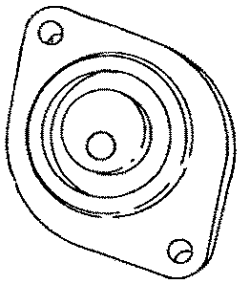
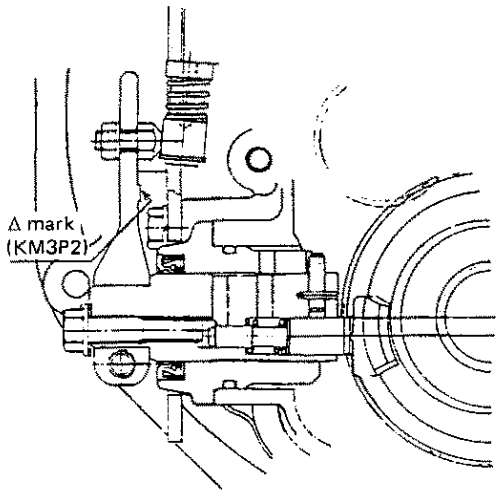
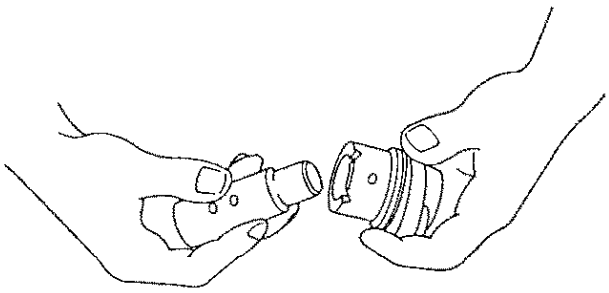
5-3 Reassembly of the shifting device

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



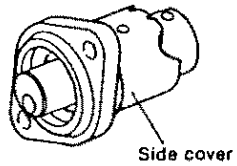


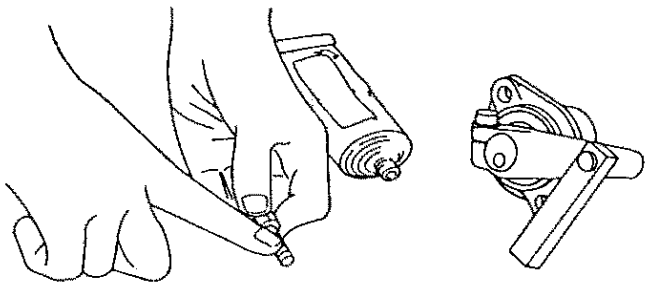
(2)Insert the shift lever shaft to the side cover.



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

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





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

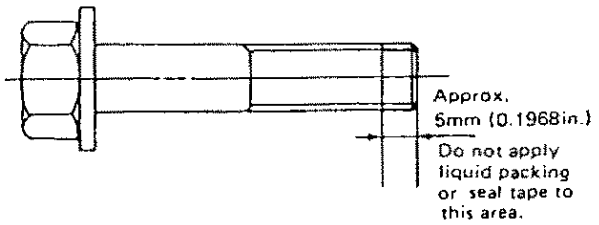
(5)Fit the side cover assembly to the clutch case.

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.



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

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CHAPTER 8

REMOTE CONTROL (OPTIONAL)

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1. Remote Control System

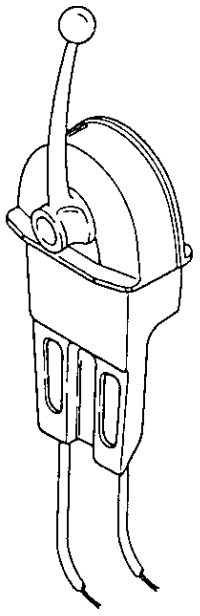
1-1 Construction of remote control system

The remote control permits one handed control of the engine speed, changing from forward to reverse, and stopping.
Fittings which allow for easy connection of the remote control cables with the fuel injection pump and transmission are provided with the remote control set.
The use of Morse remote control cables, clamps and a remote control head, are also provided for. The device to stop the engine is electric and will be explained under the section on electrical equipment.

1-2 Remote control device components

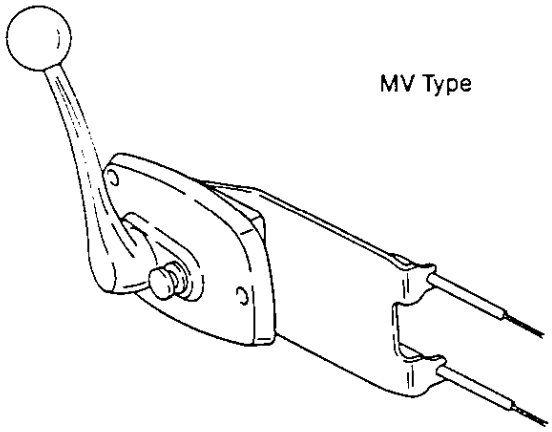
	Morse description	Yanmar Part No.
Remote control head	Morse MT2 top mounting single lever	41730-000680
	Morse MV side mounting single lever	128170-86500
Remote control cable	Morse 33C x 4m (13.12ft.)	41710-000360
	Morse 33C x 7m (23.00ft.)	129470-86500
Engine stop cable	Yanmar 4m (13.12ft)	129470-67550
	Yanmar 7m (22.96ft)	129470-67560

(1) Remote control handle



MT-2 Type

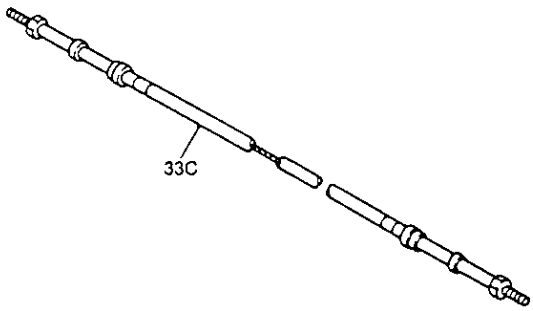
The model MT-2 remote control has been designed so that operation of the clutch (shift) and governor (throttle) can be effected with one lever.
Two cables are required for the MT-2 single, one for the clutch and the other for the governor.
When warming up the engine, to freely control the governor separately from the clutch put the lever in neutral, the central position, and pull the knob in the center of the control lever. When the lever is returned to the neutral position, the knob automatically returns to its original position, and the clutch is free. The governor can then be freely operated.



MV Type

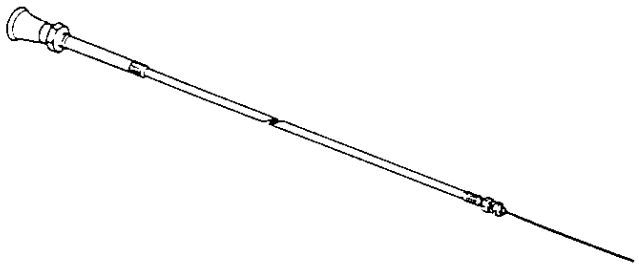
The MV type controller has been designed so that operation of the clutch and throttle can be effected with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the neutral position so that the throttle can be opened all the way and warm up the engine.
When the engine is warmed up, return the handle to the central position and push the button back in. Control of the clutch and throttle is thus effected with one handle.

(2) Remote control cable



Use only Super-Responsive Morse Control Cables.
These 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.

(3) Engine stop cable



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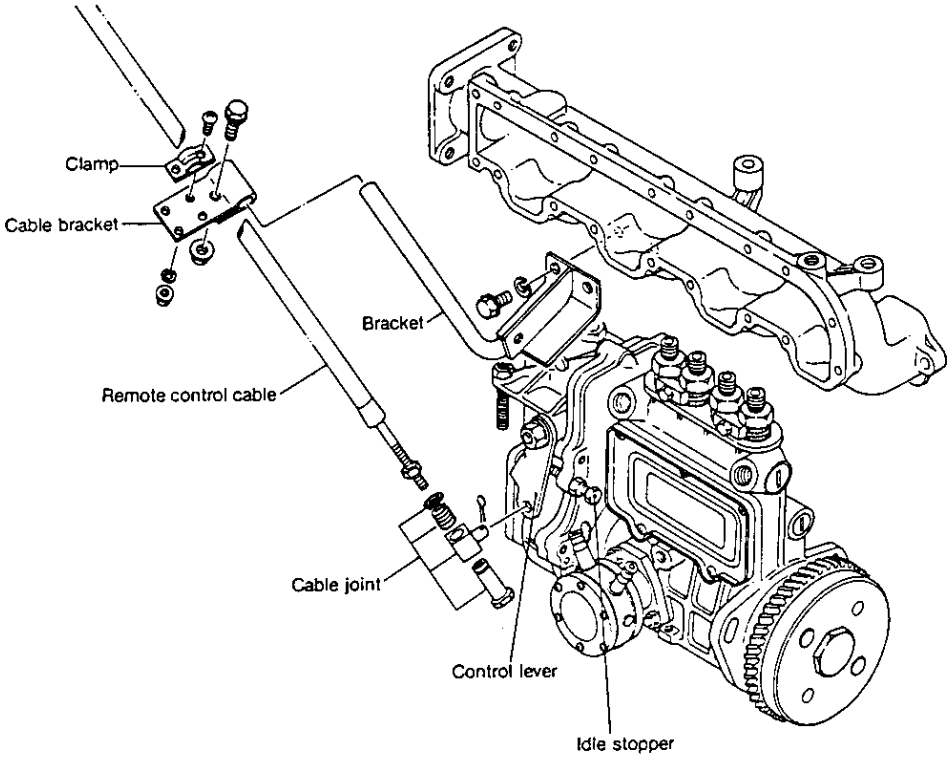
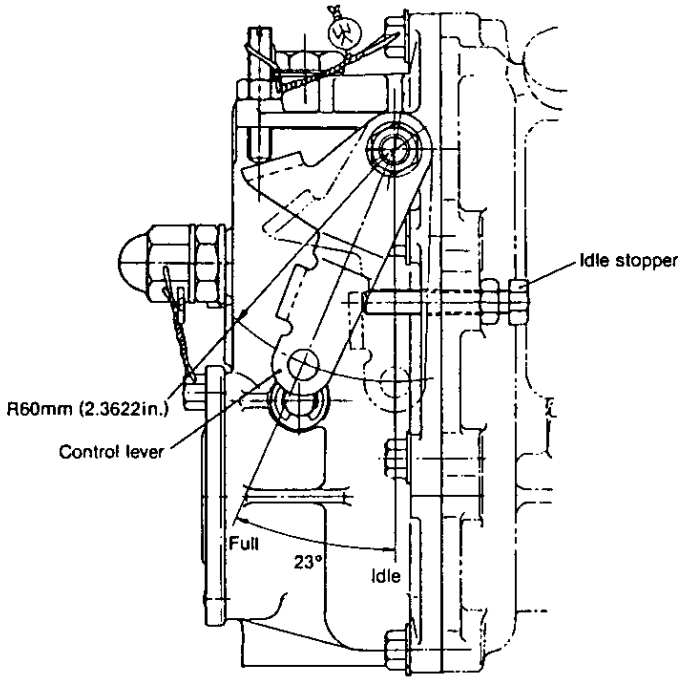
2. Remote Control Installation

2-1 Speed control





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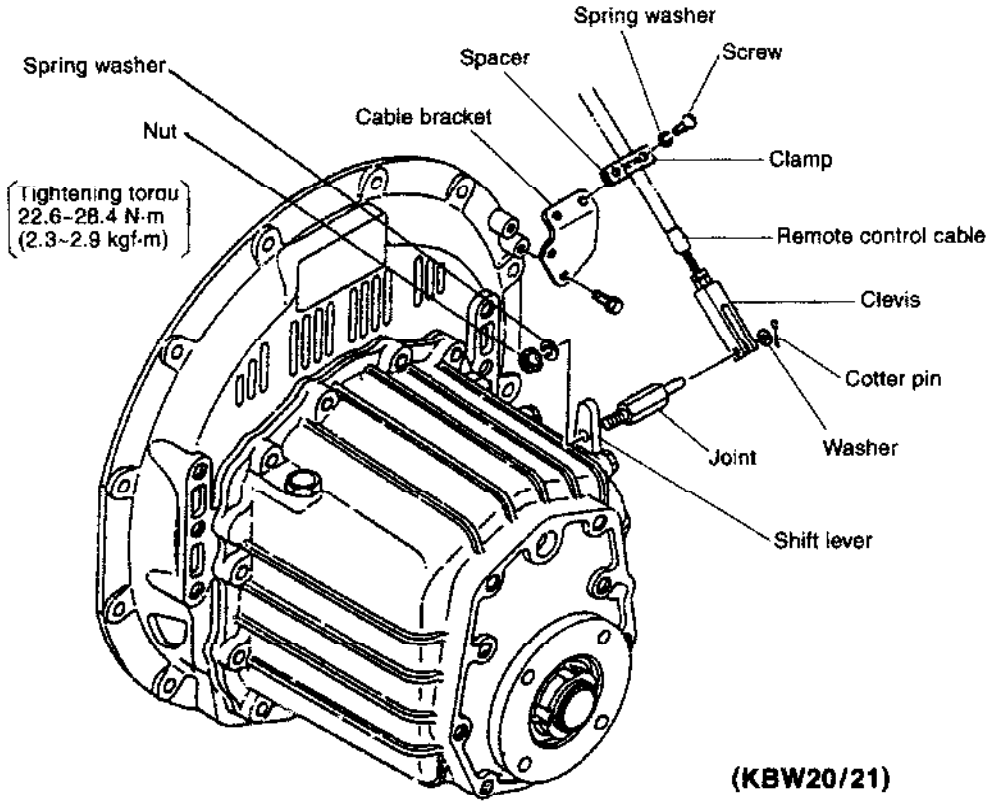
2-2 Clutch control



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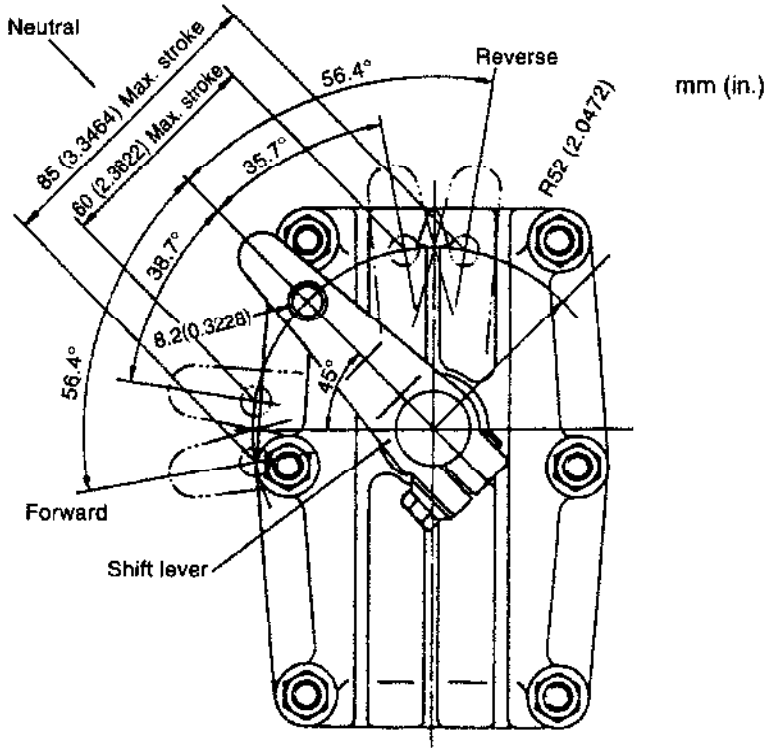
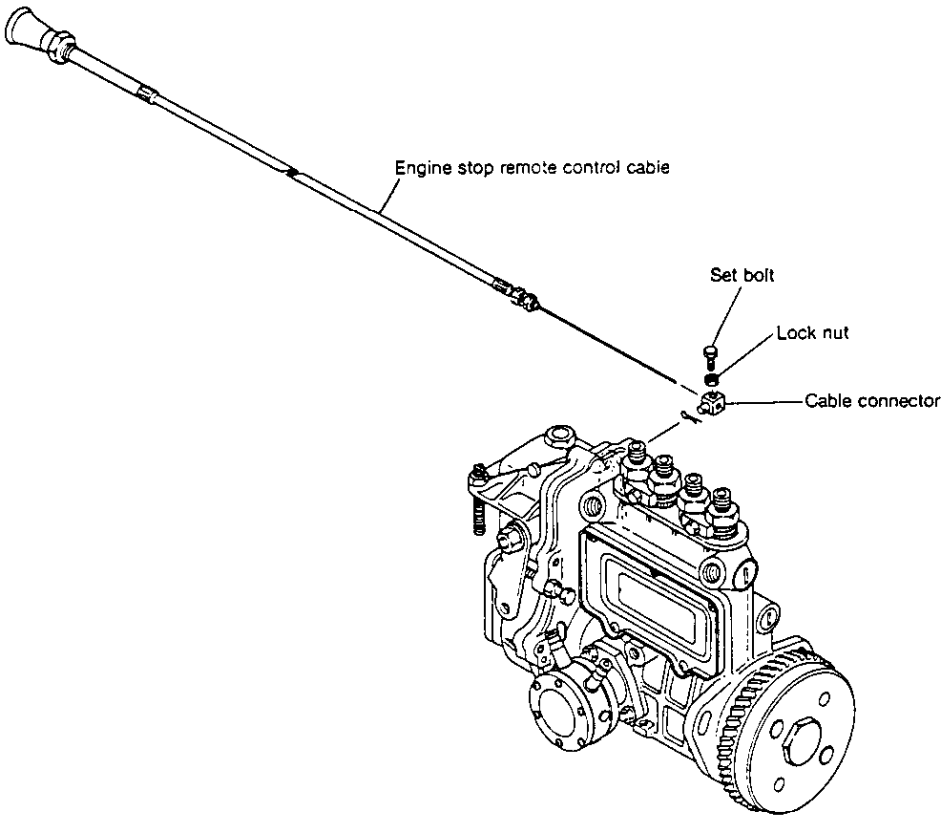
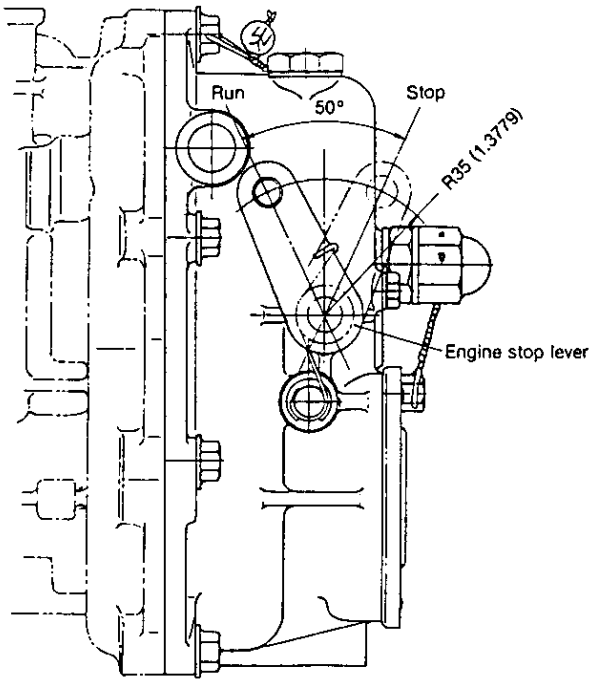


mm (in.)

2-3 Engine stop





mm (in.)

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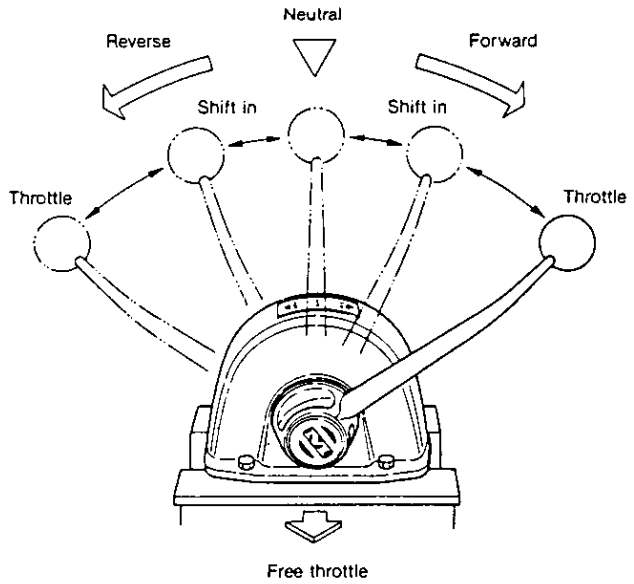
3. Remote Control Inspection

(1) When the control lever movement does not coincide with operation of the engine, check the cable end stop nut to see whether or not it is loose, and readjust/ retighten when necessary.



(2) Too many bends (turns) in the cable or bends at too extreme an angle will make it difficult to turn the handle. Reroute the cable to reduce the number of bends or enlarge the bending radius as much as possible (to 200mm or more).
(3) Check for loose cable bracket/clamp bolts or nuts and retighten as necessary.
(4) Check cable connection screwheads, cable sleeves and other metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

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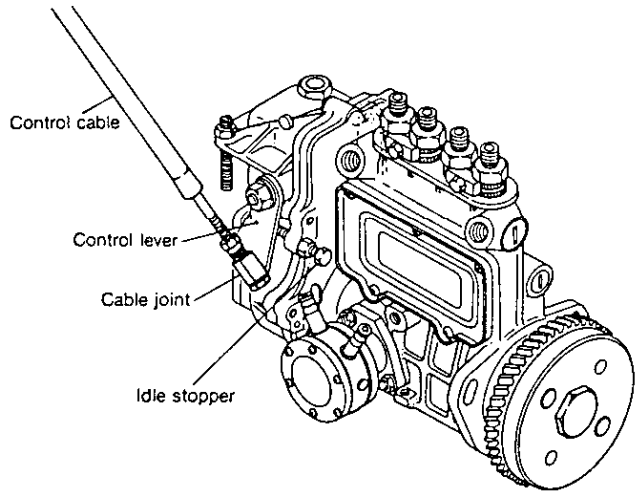
4. Remote Control Adjustment

(1) Shift lever adjustment
Move the lever several times—the movement of the clutch lever on the engine from forward, neutral and reverse must coincide with the forward, neutral and reverse on the control lever. If they do not coincide, adjust the fittings as necessary (first engine side, then controller side).

(2) Throttle lever adjustment
Move the control lever all the way to full throttle several times, and then return. The throttle lever on the engine must lightly push against the idle switch when it is returned. If it is properly adjusted, the knob can be easily pulled out when the lever is in the neutral position, and will automatically return when the control lever is brought back to the neutral position. If the control lever presses too hard against the knob, it may not return automatically, in which case the cable end must be adjusted as explained for the clutch. The knob cannot be pulled out when the lever is not in the neutral (central) position.



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CHAPTER 9

ELECTRICAL SYSTEM

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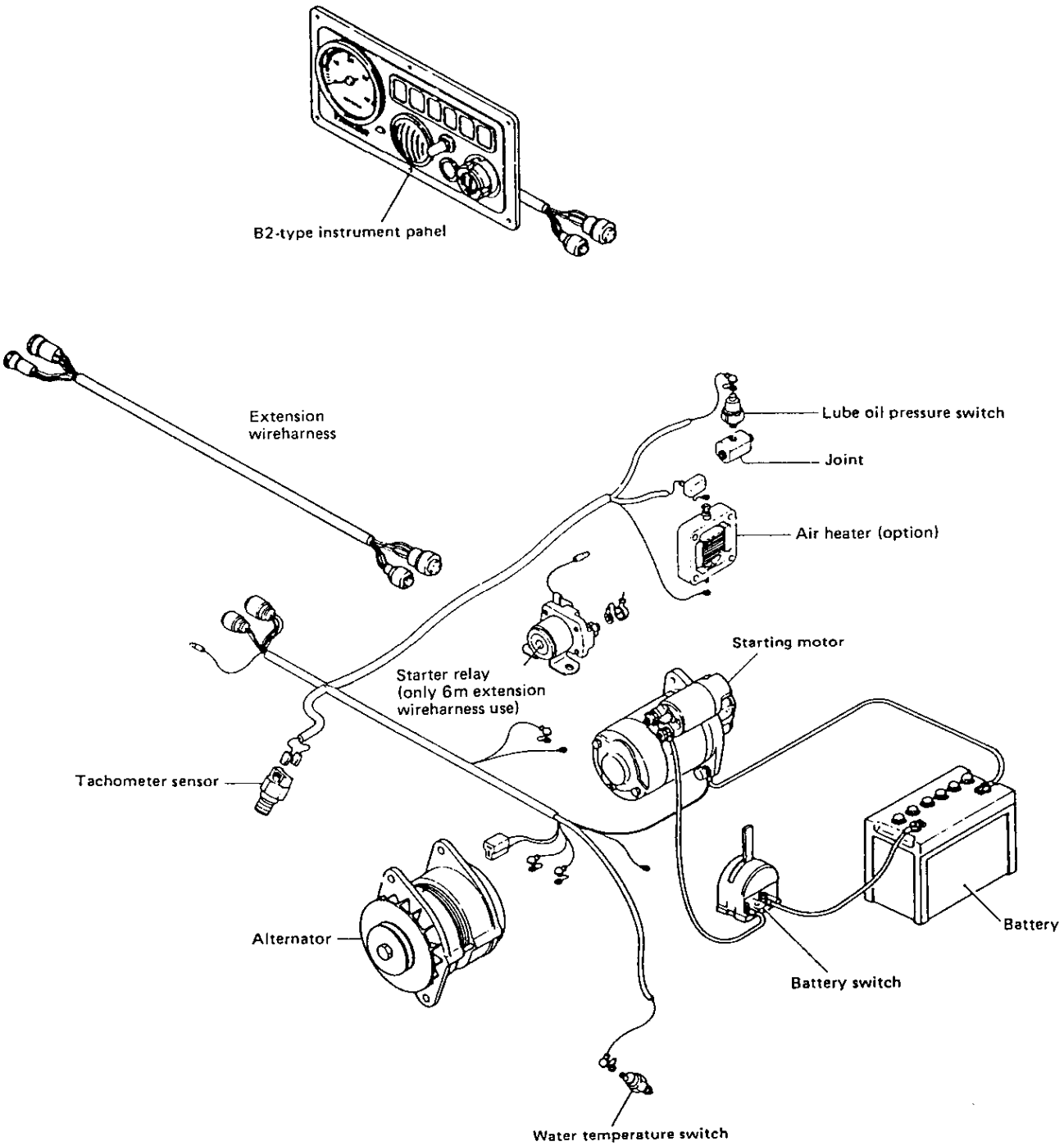
1. Electrical System

System diagram of electric parts (B2-type)



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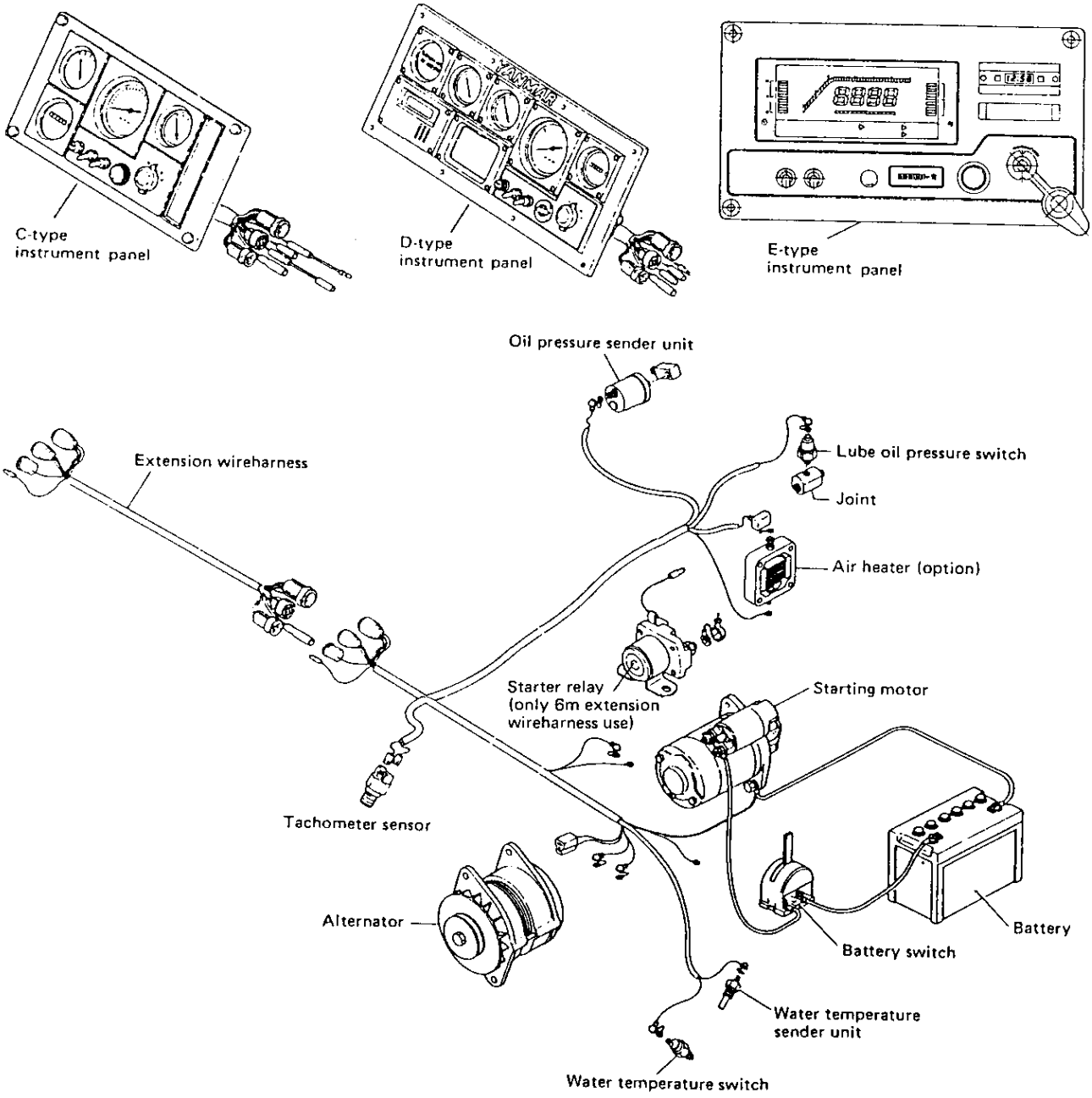
C-type, D-type and E-type



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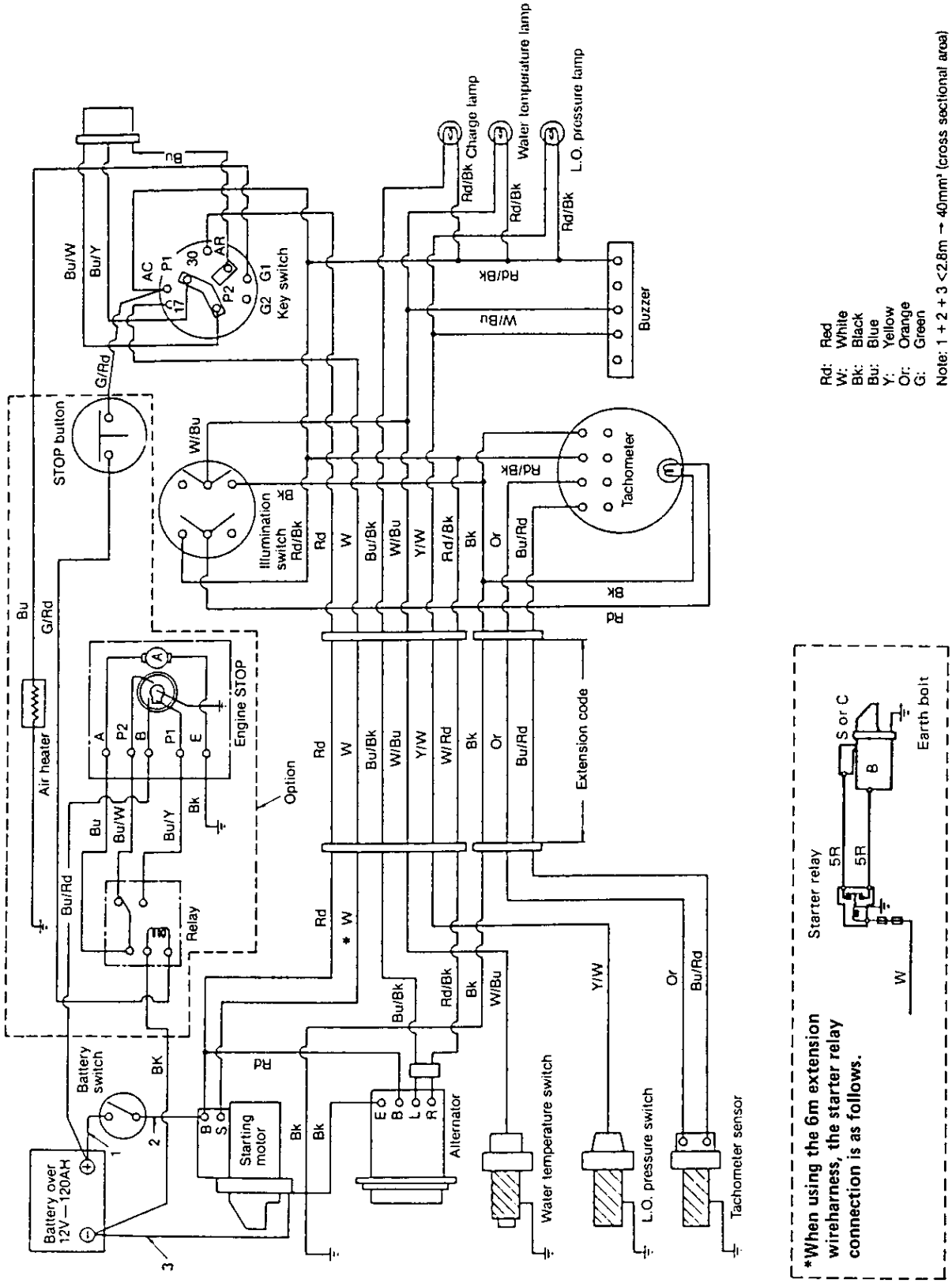
1-2 Wiring diagram

1-2.1 For B-type instrument panel



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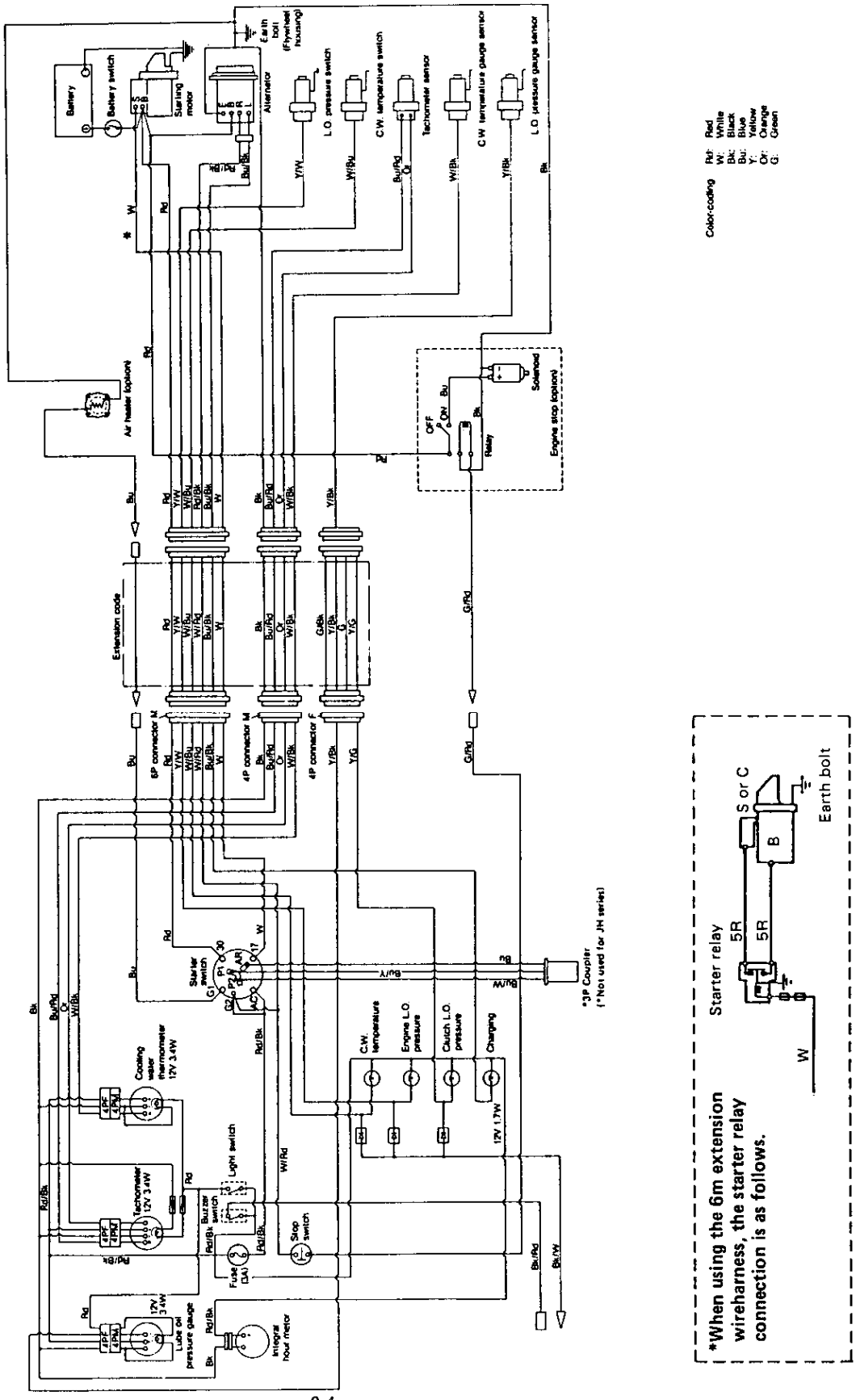
1-2.2 For C-type instrument panel



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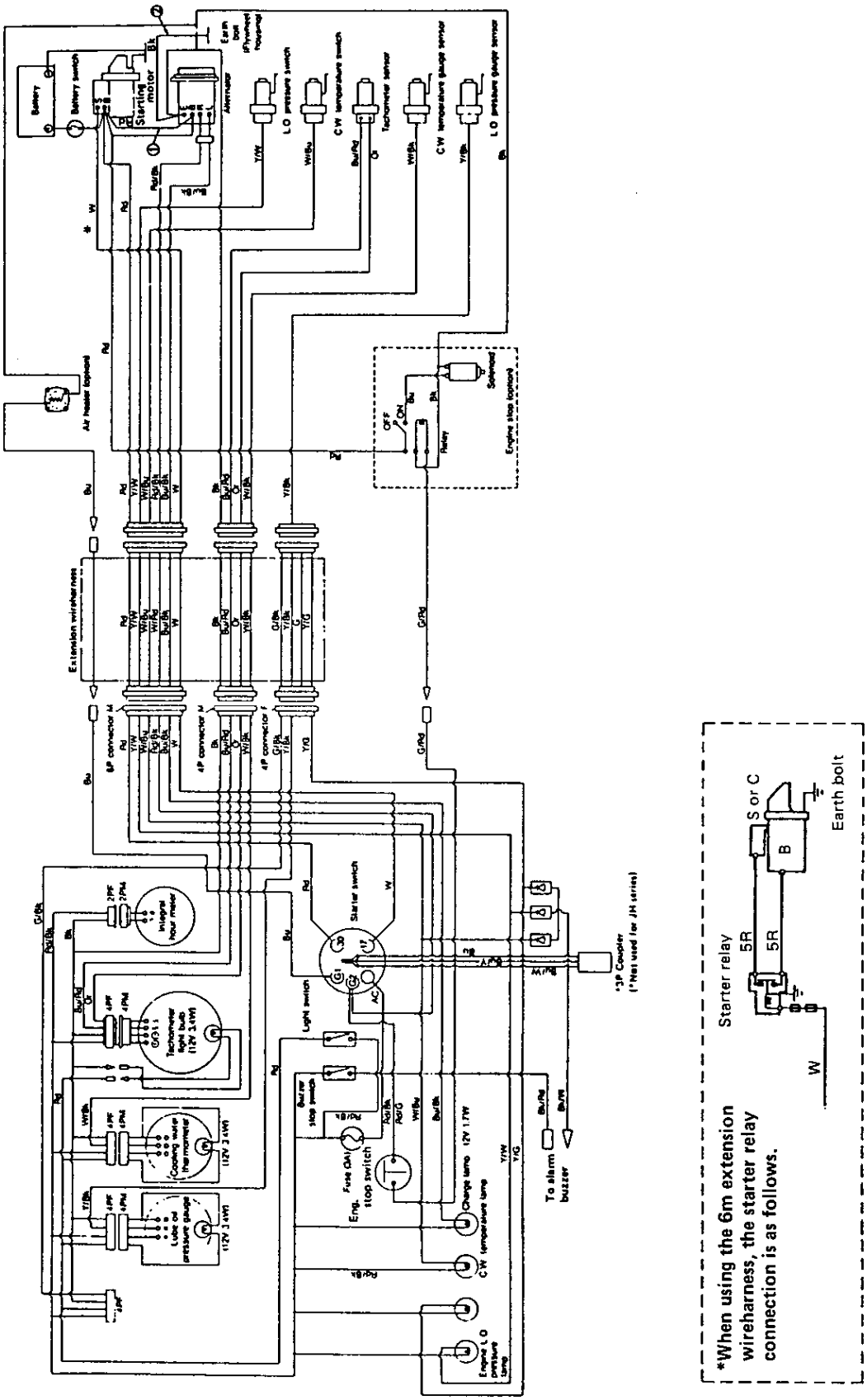
1-2.3 D-type instrument panel



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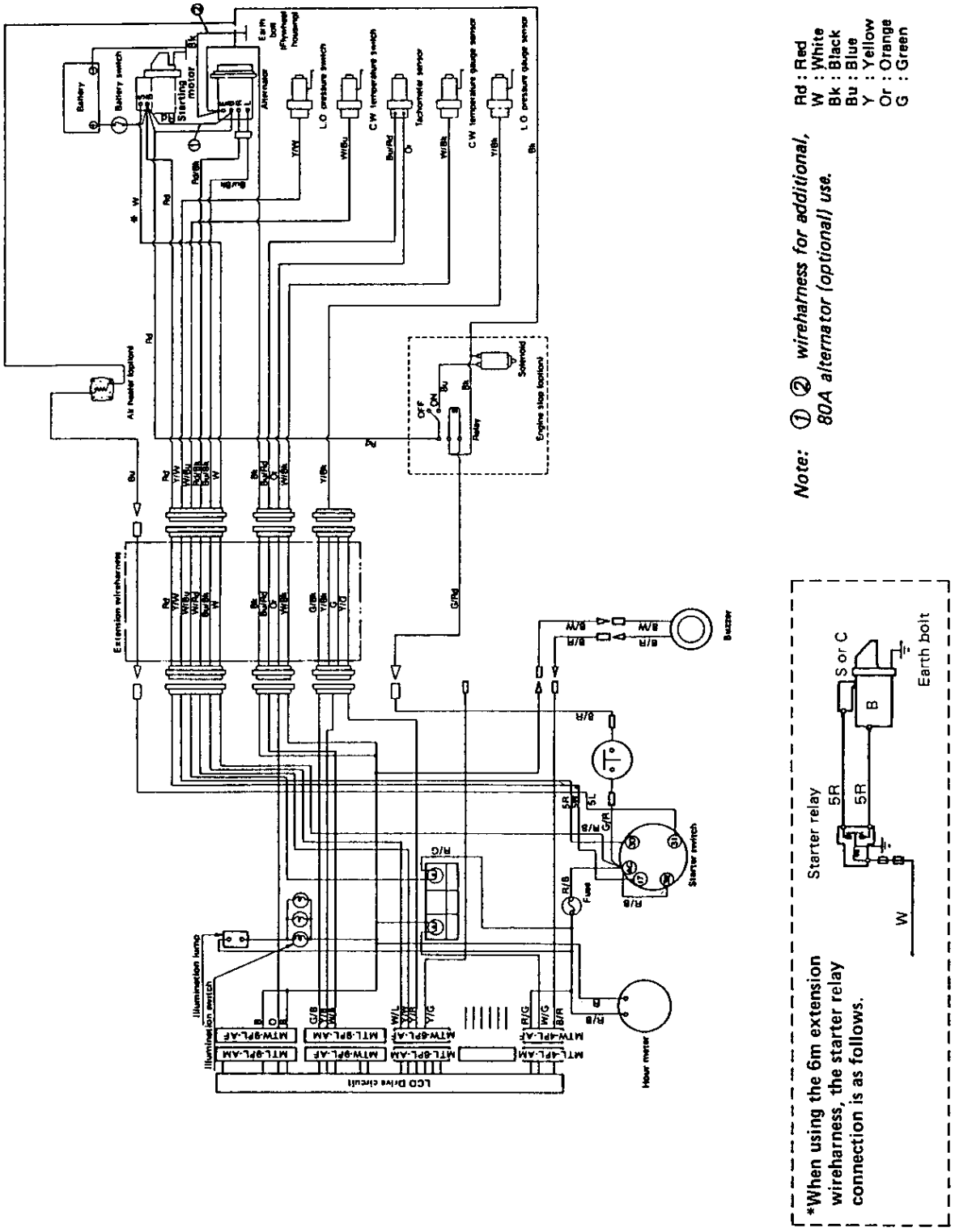
1-2.4 For E-type instrument panel



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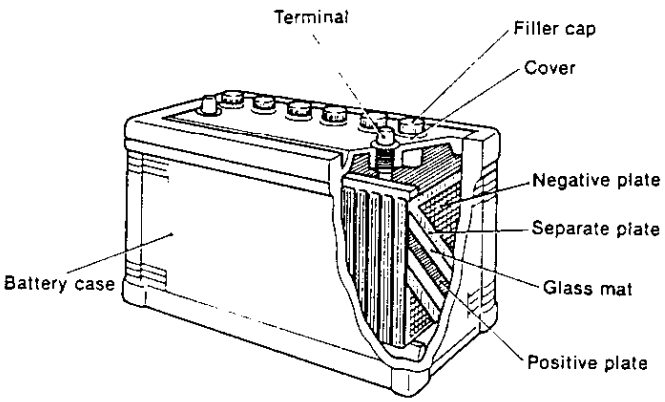
2. Battery

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

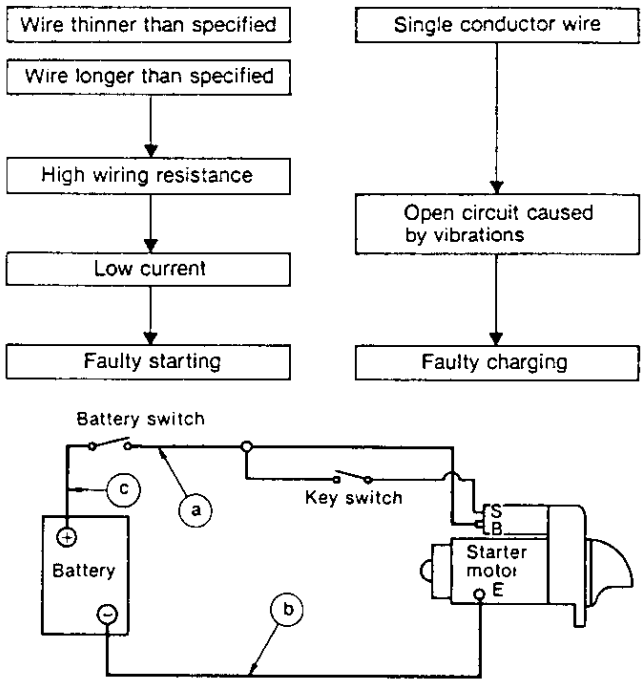
2-2.1 Battery capacity

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

Battery capacity	minimum	12V — 100AH
	standard	12V — 120AH
	cold weather	12V — 150AH
Full charged specific gravity		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 wire between the battery (+) terminal and the starter (B) terminal, and between the battery (–) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a + b + c allowable length
12V	0.2V or less/100A	20mm² (0.0311 in.²)	Up to 2.5m (98.43 in.)
		40mm² (0.062 in.²)	Up to 5m (196.87 in.)

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

2-3 Inspection

The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to ensure 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.

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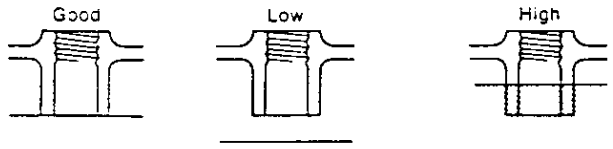
2-3.2 Checking the electrolyte

(1) Electrolyte level

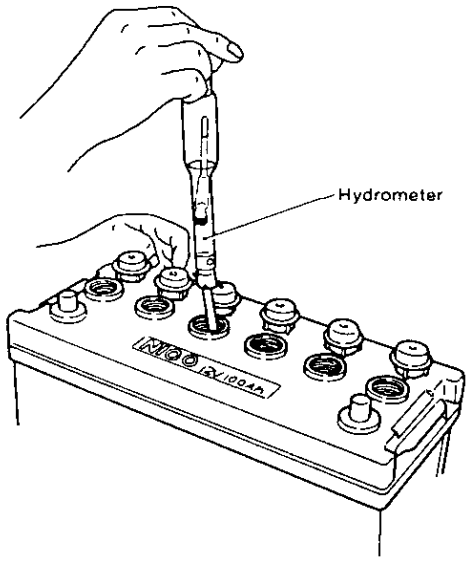


Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 ~ 20mm (0.3937 ~ 0.7874in.) over the top of the plates.

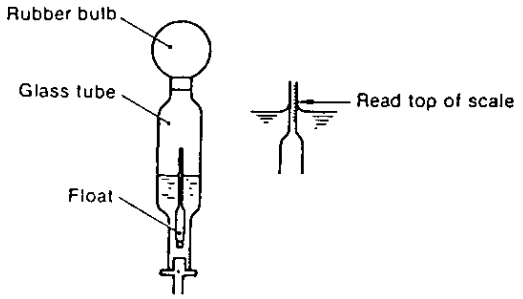
NOTES: 1. The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.
2. Always use distilled water to bring up the electrolyte level.
3. When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

(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.



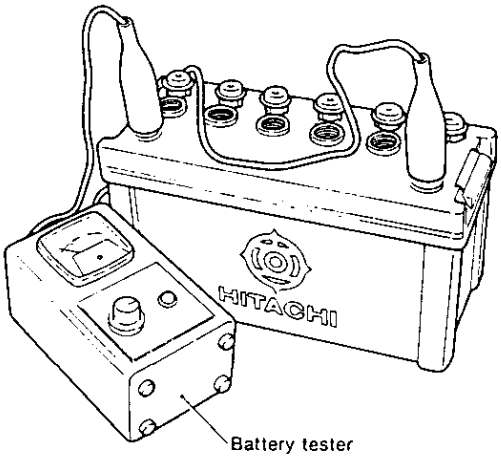
3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200 (50%). If the specific gravity is below 1.200, recharge the battery.

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
$S_{20} = St + 0.0007 (t - 20)$
S_{20}: Specific gravity at the standard temperature of 20°C
St: 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.

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2-4 Charging

2-4.1 Charging methods

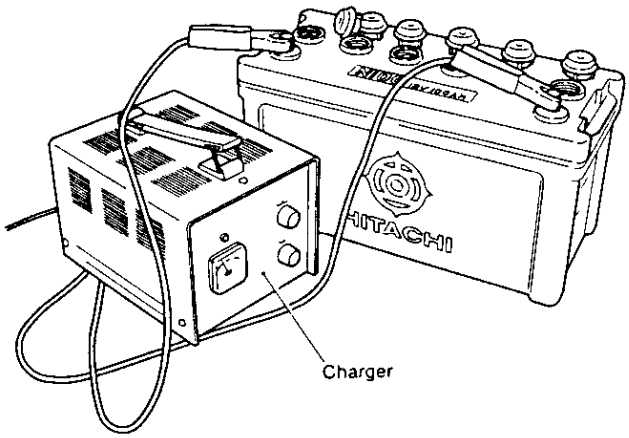
There are two methods of charging a battery: normal and rapid.

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

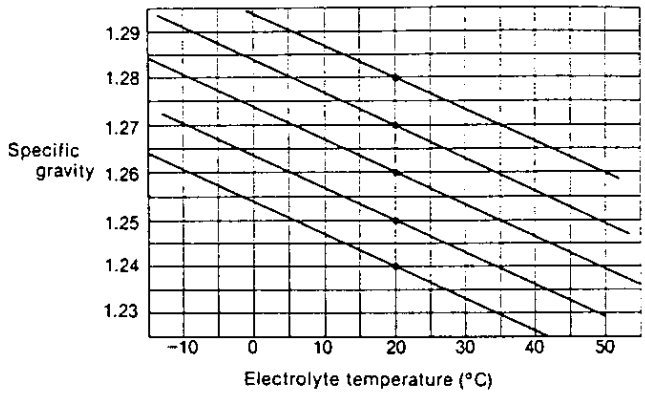
(1) Check the specific gravity and adjust the electrolyte level.
(2) Disconnect the battery cables.
(3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (−) terminal.



(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].)

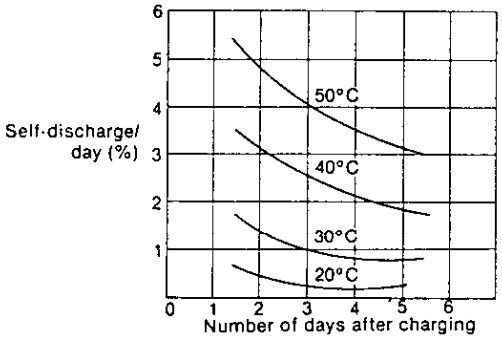


Electrolyte temperature and specific gravity

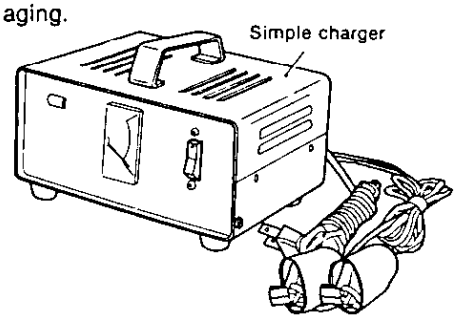
2-5 Battery storage precautions

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.



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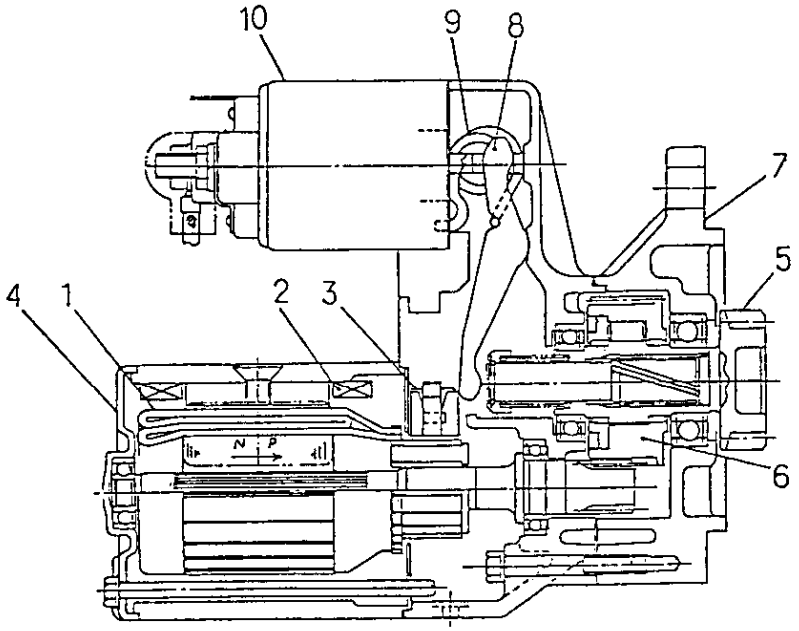
3. Starter Motor

1. The Reduction Starter System

1-1 The Reduction Starters

While these only had specialized applications in the past, they currently are being widely adopted because of their compact, lightweight design.
Although smaller than the direct-drive type starter with its armature and pinion driven at the same speed, the gear reduction starter actually reduces the motor speed to approximately 27% prior to driving the pinion.
It does this without reducing output, hence its name.
Furthermore, use of heat-resistant insulating materials and advanced production technology makes the compact, light weight design possible and improves its starting capabilities in cold regions.



1. Armature
2. Field Coil
3. Brush
4. Rear Cover
5. Pinion Shaft
6. Pinion Clutch
7. Gear Case
8. Shift Lever
9. Torsion Spring
10. Magnetic Switch

Fig.1 Reduction Starter Construction

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1-2 The Engagement Mechanism

This type utilizes the electromagnetic force. The pinion is engaged with the ring gear by means of the torsion spring and shift lever. The plunger is shifted by the attracting force and depresses the pinion. When the pinion does not strike the ring gear, smooth engagement occurs, then the contacts close to start the motor.

Also, when the pinion strikes the ring gear teeth, it compresses the torsion spring and loses the contacts. When the current flows through the motor and the armature starts rotating, the pinion is depressed strongly on the ring gear and rotated by means of torsion spring pressure and the helical spline's force. Then, the pinion teeth are arranged in engagement with the ring gear teeth. When the key start switch is turned OFF, the magnetic switch is demagnetized, and the pinion is returned by the torsion spring force. Simultaneously, the contacts open to stop motor operation. In Fig. 2. engagement between the pinion and ring gear is illustrated.

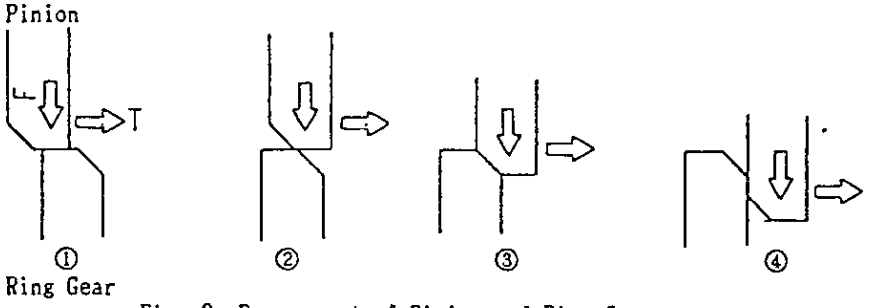
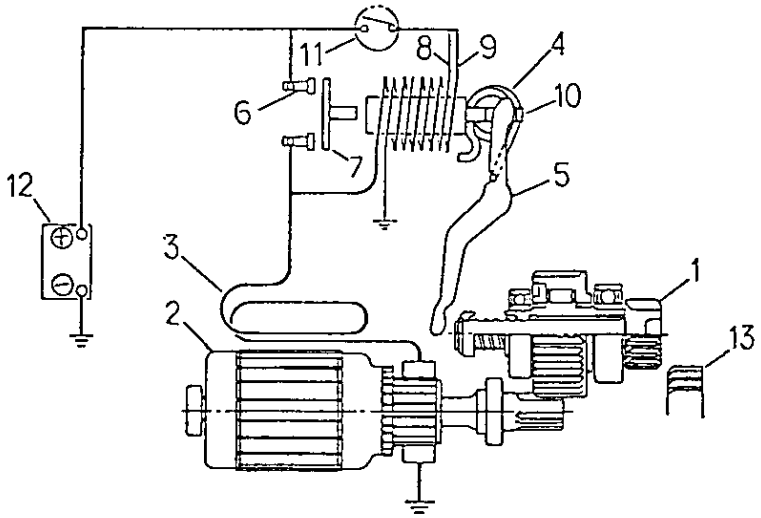


Fig. 2. Engagement of Pinion and Ring Gear



1. Pinion
2. Armature
3. Field Coil
4. Torsion Spring
5. Shift lever
6. Stationary contact
7. Movable Contactor
8. Shunt coil (Holding Coil)
9. Series Coil (Attracting Coil)
10. Plunger
11. Key Start Switch
12. Battery
13. Ring Gear

Fig. 3. Schematic Layout of Reduction Starter's Electrical Circuit

2. Removal

1) Disconnect the battery's negative or ⊖ side cable at the battery.
2) Disconnect the battery's posistive or ⊕ cable and the main harness' feed wire from the magnetic switch of the reduction starter.
3) Disconnect the battery's negative or ⊖ cable at the reduction starter.
4) Remove the reduction starter retaining bolts and lockwashers. Then withdraw the motor assembly.

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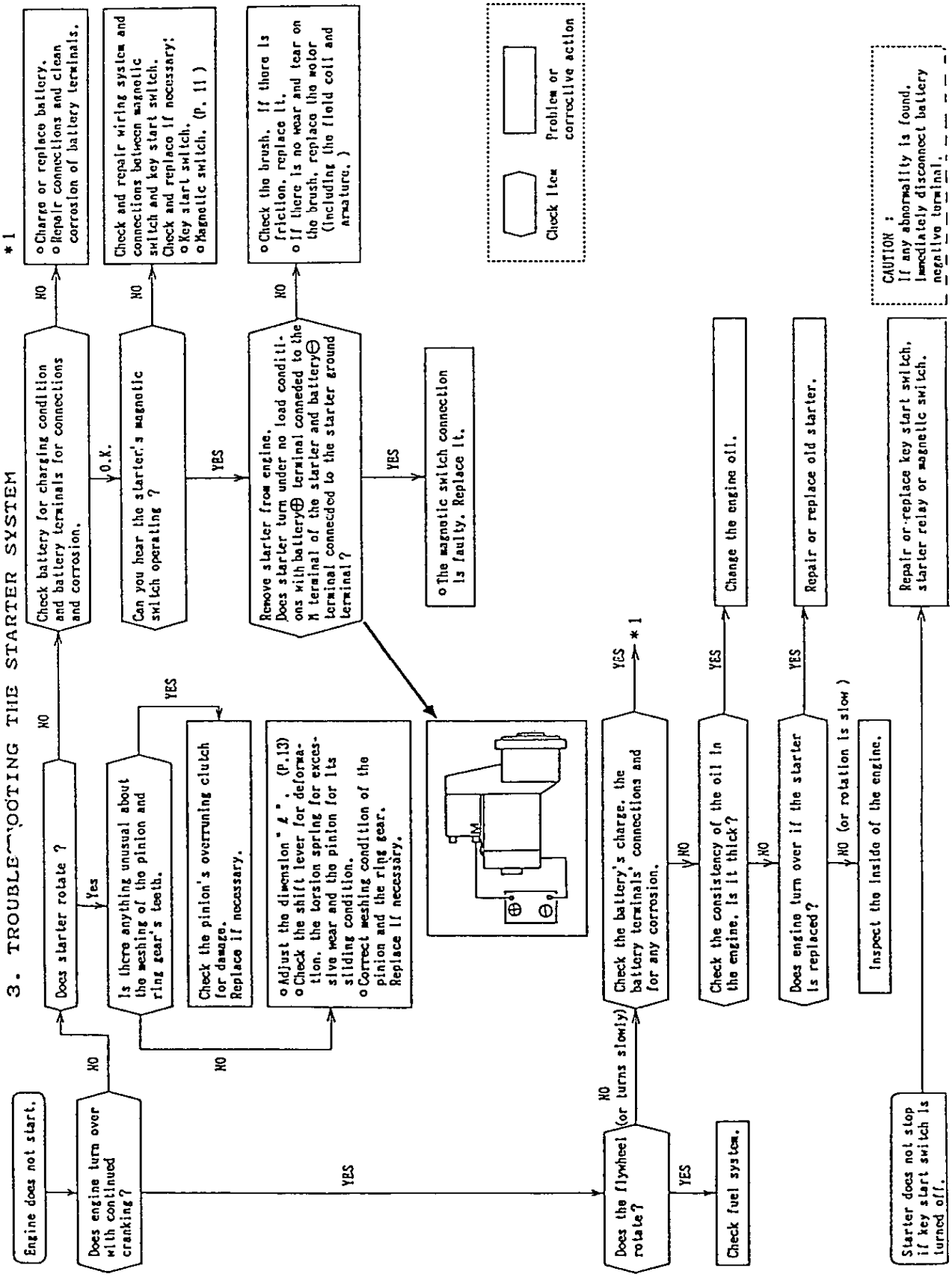

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4. Disassembly
- ▲ 1) The Magnetic Switch's 8 mm Nut
- 2) The 5 mm Through Bolts (2)
- ▲ 3) The Rear Cover
- ▲ 4) The Brush Holder
- 5) Yoke Assembly
- ▲ 6) Armature
- 7) The 6 mm Bolts (2)
- 8) Magnetic Switch
- ▲ 9) Torsion Spring
- 10) Dust Cover
- ▲11) Shift Lever
- 12) The 6 mm Bolts (3)
- 13) Gear Case
- ▲14) Center Housing
- ▲15) The Pinion Stopper Clip
- 16) Pinion Stopper
- 17) Retaining Spring
- 18) Pinion Shaft
- ▲19) Clutch Assembly

▲: Disassembly Reference Exhibit Is Provided

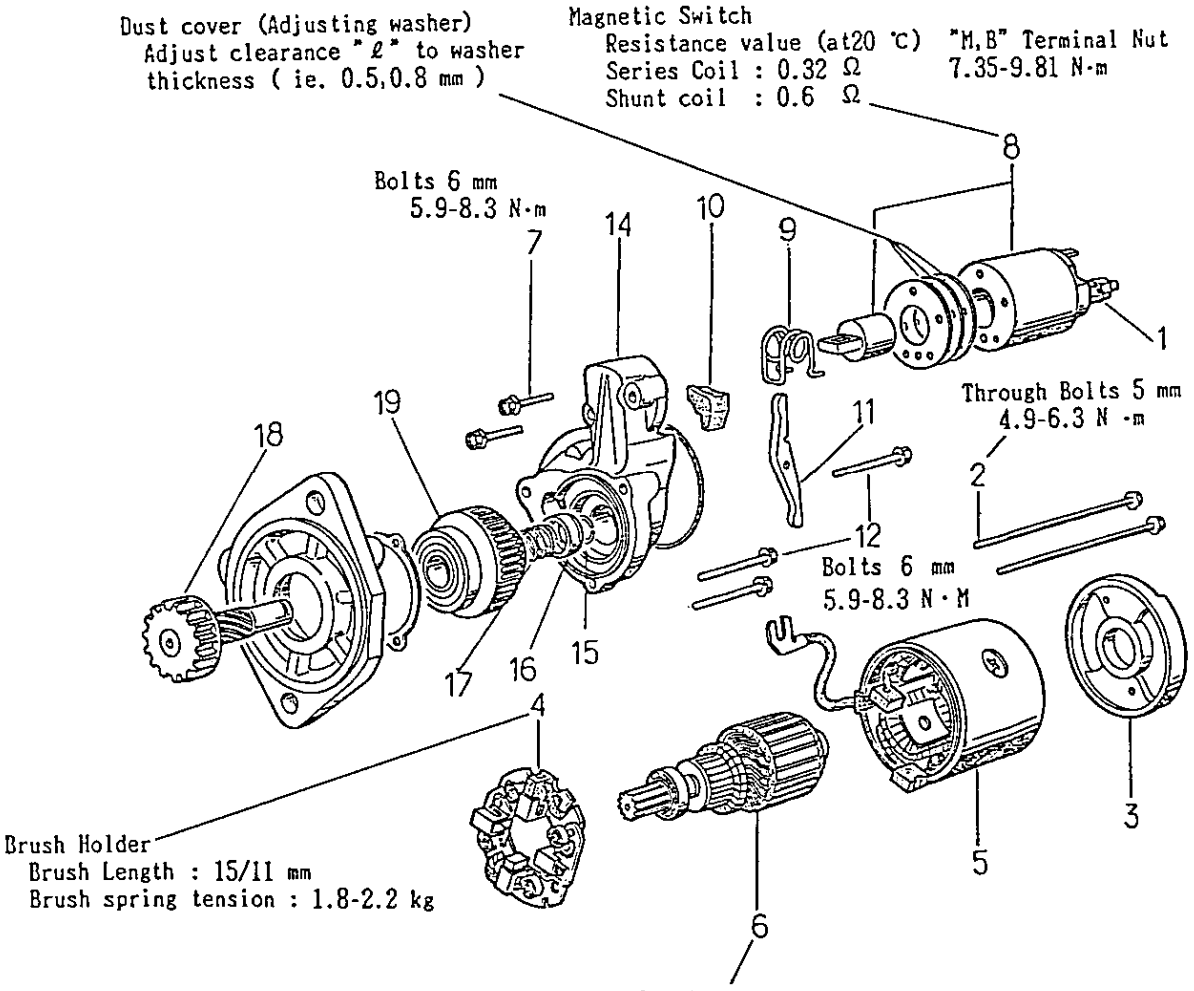

Fig. 4. Exhibit of Disassembled Parts

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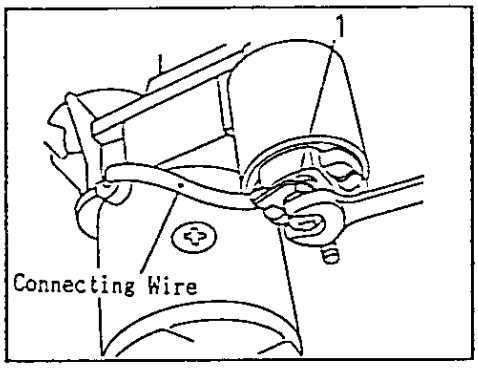

Fig. 5

1) The Magnetic Switch's 8 mm Nut

Remove the magnetic switch's 8 mm nut and disconnect the connecting wire.

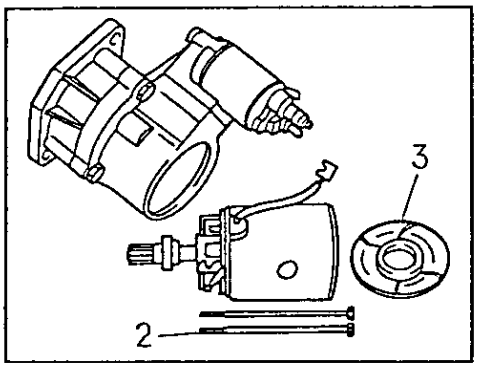

Fig. 6

2) The 5 mm Through Bolts (2)
3) The Rear Cover

The rear cover is disassembled by removing the 5 mm through bolts.

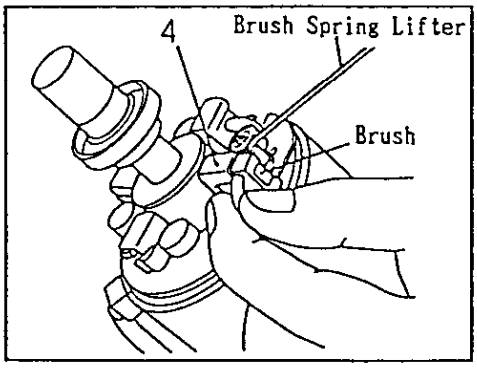

Fig. 7

4) The Brush Holder

Pull the brush spring up with a brush spring lifter tool so that the ⊖ side brush is separated from the surface of the commutator (otherwise, the brush holder keeps the brush in contact with the commutator). Remove the ⊕ side brush from the brush holder.

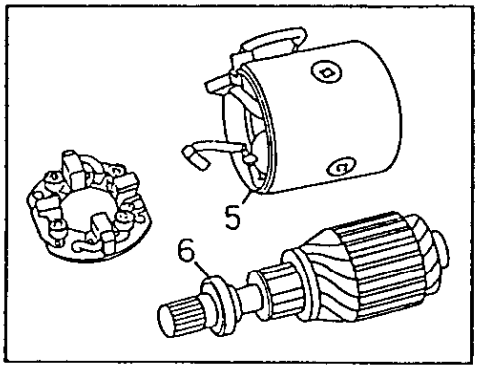

Fig. 8

5) Yoke Assembly
6) Armature

The armature and the yoke assembly can be disassembled once the brush holder is removed.

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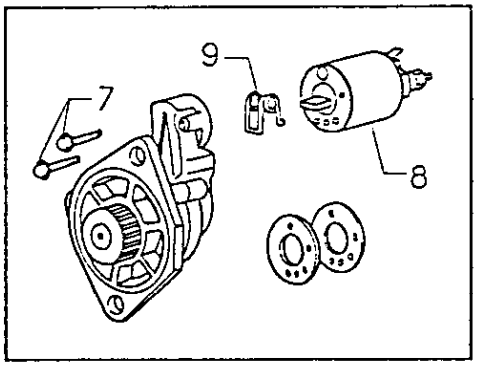

Fig. 9

7) The 6 mm Bolts (2)
8) Magnetic Switch
9) Torsion Spring

The magnetic switch can be disassembled once the 6 mm Bolts are removed. Next, the torsion spring is disassembled from the magnetic switch.

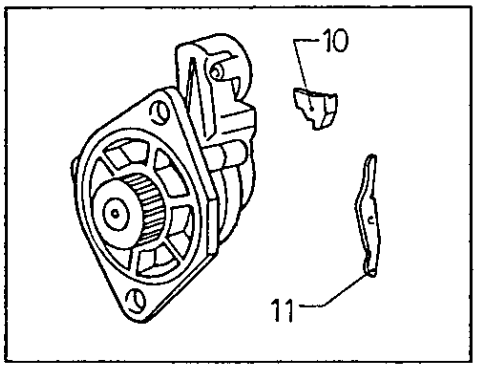

Fig. 10

10) Dust Cover
11) Shift lever

The shift lever can be removed once the dust cover is disassembled from the gear case.

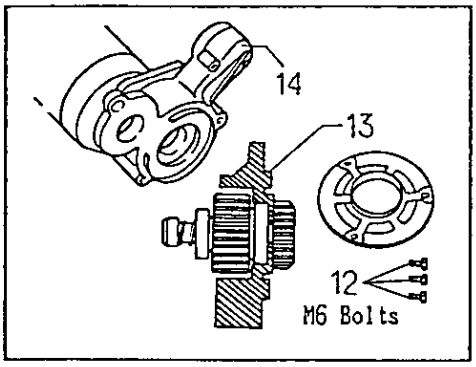

Fig. 11

12) The 6 mm Bolts (3)
13) Gear Case and Pinion Clutch ASSY.
14) Center Housing
20) Gasket

The gear case and the Center Housing can disasembled after the 6 mm Bolts have been removed.

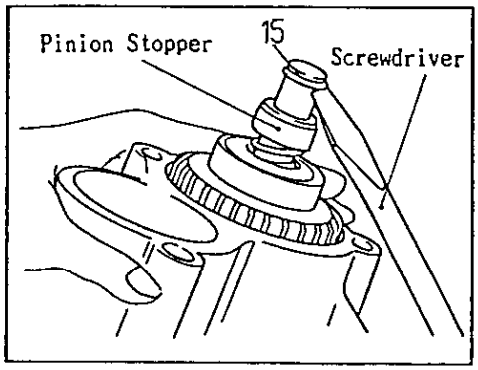

Fig. 12

15) The Pinion Stopper Clip

The pinion stopper clip is removed with a standard screwdriver while the pinion stopper is pushed toward the pinion.

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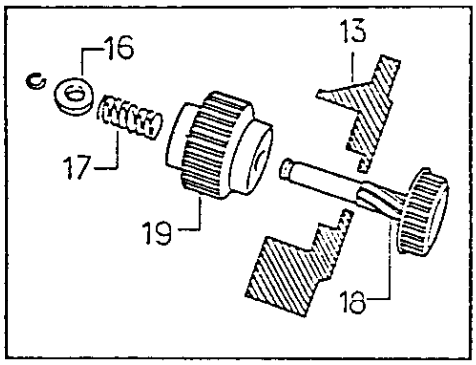

Fig. 13

13) Gear Case
16) Pinion Stopper
17) Retaining Spring
18) Pinion Shaft
19) Clutch Assembly

The pinion stopper, retaining spring, pinion shaft and the clutch assembly can be disassembled once the pinion stopper clip has been removed.

-End of Disassembly-

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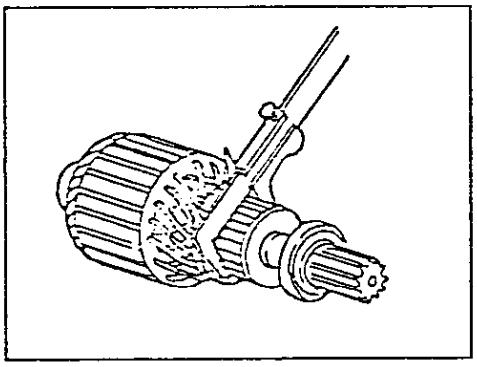

Fig. 14

5. Inspection and Repair

5-1 Armature

(1) Check the diameter of the Commutator

If the outside diameter of the commutator is below the minimum limit then replace it.

(mm)

Standard (New)	Limit (Used)
30	29

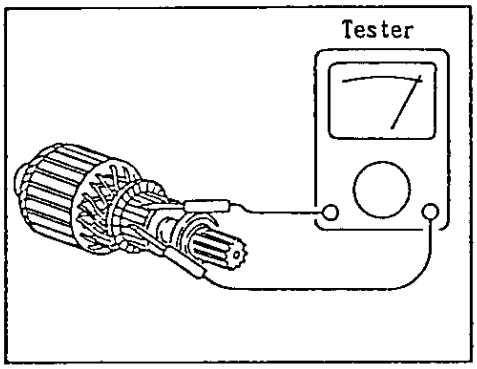

Fig. 15

(2) Continuity Test for the Armature Coil

Use a tester to check for continuity between parallel points on the commutator. If there is continuity, the armature is still good.

No continuity : (Disconnected coil)
Replace the armature.

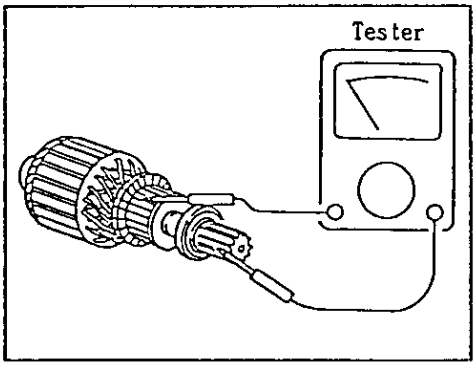

Fig. 16

(3) Insulation Test for the Armature Coil

Use a tester to check for continuity between a point on the commutator and the shaft or the core. If there is no continuity the armature is still good.

Continuity Exists : (Short circuited coil)
Replace the armature.

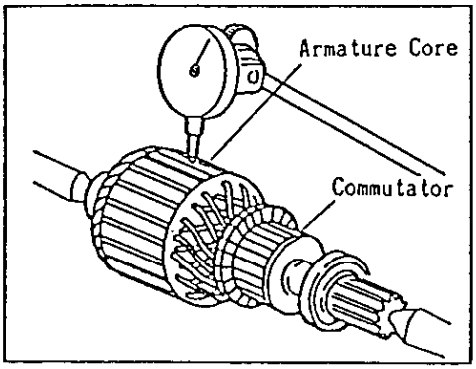

Fig. 17

(4) Check for Surface Distortion on the Armature and the Commutator

Use a dial gauge to measure the distortion of the outside surfaces of the armature core and the commutator. If it is above the limit, then repair or replace it.

(mm)

	Standard (New)	Limit (Used)
Armature	0.05 (MAX)	0.1
Commutator	0.05 (MAX)	0.1

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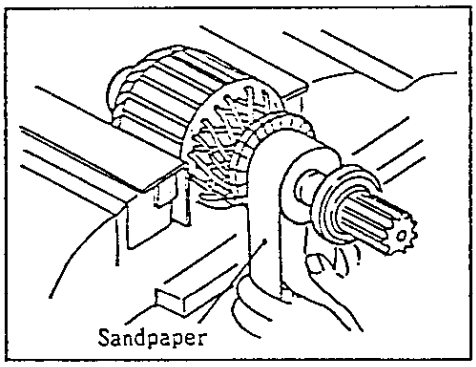

Fig. 18

(5) Check the Surface of the Commutator

If the commutator surface is rough, then please use No. 500-600 sandpaper to make it smooth.

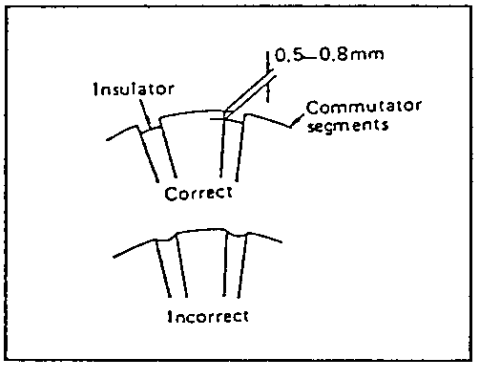

Fig. 19

(6) Check the Depth of Insulating Material from the Commutator Surface

If the depth of the insulating material from the commutator segments is less then the limit, than please repair it by filing it down.

(mm)

Standard (New)	Limit (Used)
0.5 ~ 0.8	0.2

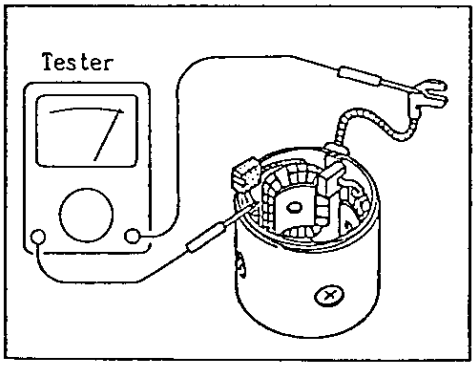

Fig. 20

5-2 The Field Coil

(1) Continuity Test for the Field Coil

Check for continuity between the field coils' terminals with a tester. If there is continuity, then it is still good.

No continuity : (Disconnected coil)
Replace the field coil.

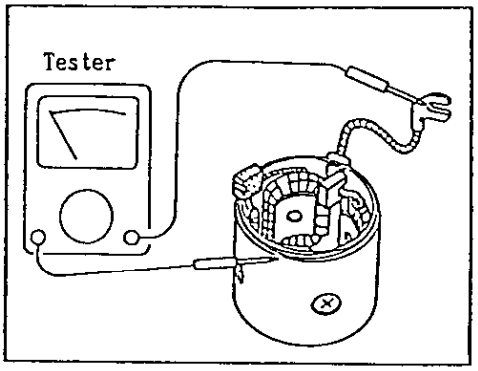

Fig. 21

(2) Insulation Test for the Field Coil

Check for continuity between the yoke and one terminals of each coil with a tester.
If there is no continuity the field coils are still good.

Continuity Exists : (Short circuited coil)
Replace the field coils.

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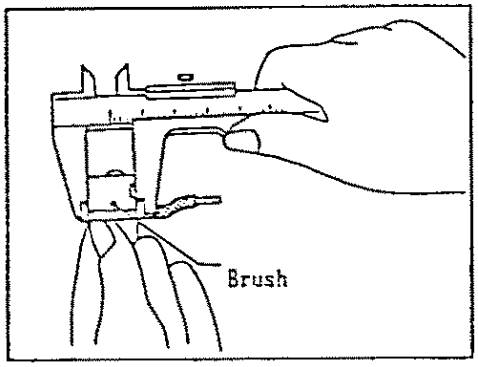

Fig. 22

5-3 Brushes

Measure the length of the brushes and if they are under the limit, replace them.

(mm)

Standard (New)	Limit (Used)
15	11

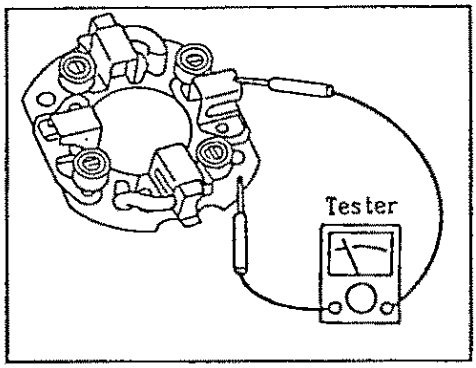

Fig. 23

5-4 Brush Holder

Insulation Test for the Brush Holder

Check for continuity between the brush holder's positive side and its base (negative side) with a tester. If there is no continuity the brush holder is still good.

Continuity Exists : (Unsatisfactory insulation)
Replace the brush holder.

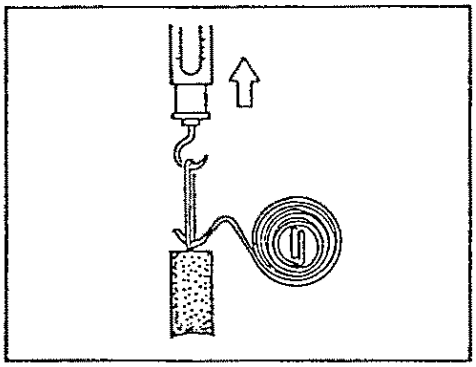

Fig. 24

(3) Inspection of the Brush Springs

Check the weight of the brush springs.

Standard Weight (Kg)
1.8 ~ 2.2

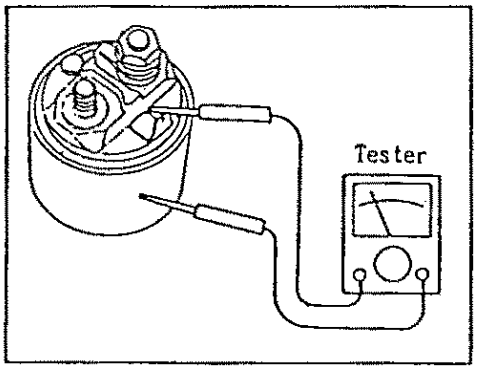

Fig. 25

5-5 Magnetic Switch

(1) Continuity Test for the Shunt Coil

Check for continuity between the "S" terminals and "M" (the switch body) with a tester. If there is continuity, then it is still good.

No continuity : (Disconnected coil)
Replace the magnetic switch.

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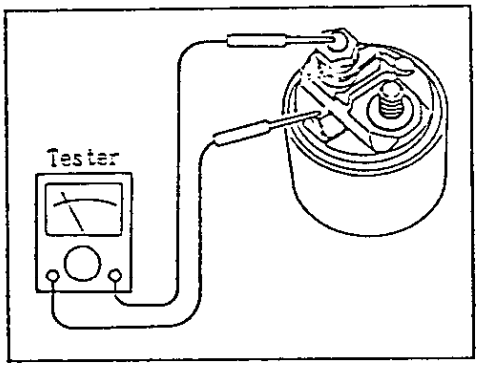

Fig. 26

(2) Continuity Test for the Series Coil

Check for continuity between the "S" and "M" terminals with a tester. If there is continuity, then it is still good.

No continuity : (Disconnected coil)
Replace the magnetic switch.

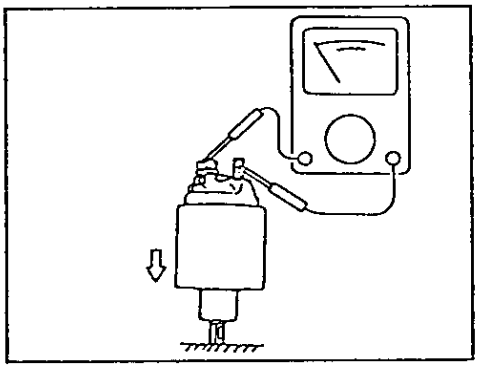

Fig. 27

(3) Continuity Test for Contact-Points

Put the plunger on the under side and then push the magnetic switch down. At this time, check for continuity between the "B" and "M" terminals with a tester. If there is continuity, then it is still good.

No continuity : (Insufficient Continuity)
Replace the magnetic switch.

5-6 Pinion Clutch

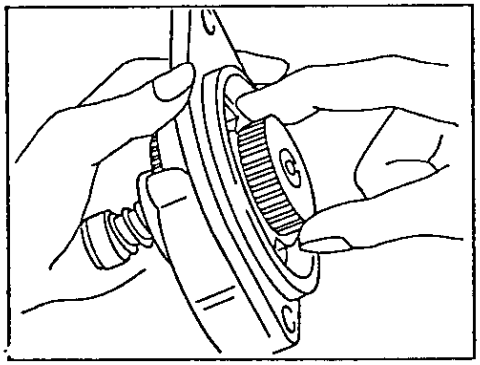

Fig. 28

(1) Inspection of the Pinion

Rotate the pinion manually. While rotating it in the direction of normal operation, smoothly reverse the direction of rotation to confirm that it locks. In the event of any irregularity, replace it.

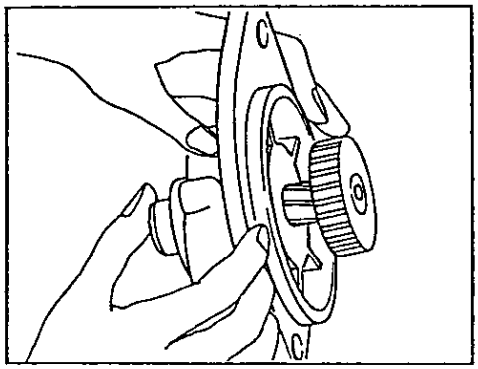

Fig. 29

(2) Pinion Sliding Test

Check to see if the pinion slides up smoothly when the end is pushed. If there are scratches, rust or if the required force seems too strong, please repair it. If too much grease is applied to the pinion shaft, Then it will seem hard to slide.

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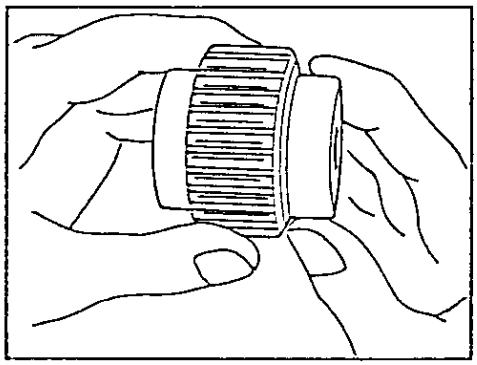

Fig. 30

(2) Inspection of the Ball Bearings

Rotate the ball bearings outer ring surface with your finger tips and check to see if it rocks perpendicularly to the direction of rotation.

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6. Reassembly

Reassembly is in the reverse order of disassembly. However, note the following points.

1. Tightening Torques : Refer to page 5 of the reference materials for the tightening torques of particular screws.

2. The Places to Apply Grease :
   ①····· The moving parts of shift lever.
   ②·····┬··· The sliding surface of magnetic switch plunger.
   　　└··· The surface of pinion.
   ③····· The toothed wheel inside the gear case.

Part		①	②	③
Item ＼ Grease		Shell Alvania Grease No. 2	Aero Shell Grease No. 7	Epnoc Grease No. 2
Worked Penetration 60 Times at 25℃		280	272	282
Dropping Point		182	260	200
Viscosity	at 37.8 ℃	145	———	———
	at 98.7 ℃	———	32	13. 9
Starting Torque /Running Torque (Ball Bearing Dia. 47 mm) g-cm	at-30 ℃	2890／800	———	———
	at-40 ℃	———	520／140	———

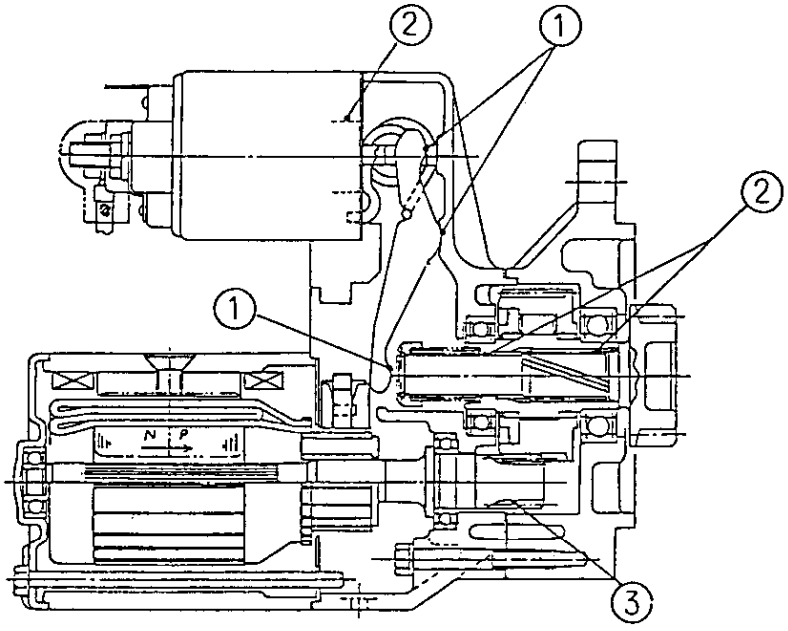

Fig. 31 Kind of Grease

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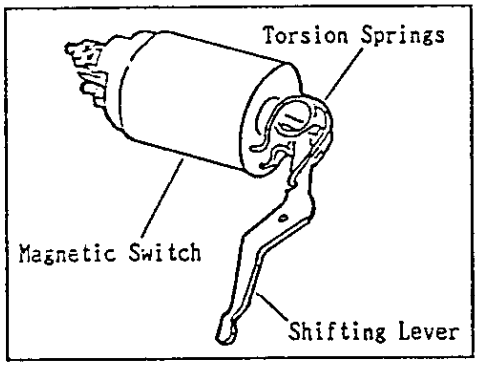

Fig. 32

3. Reassembly of the Magnetic Switch

(1) Introduce the torsion springs into the magnetic switch and connect the shifting lever.

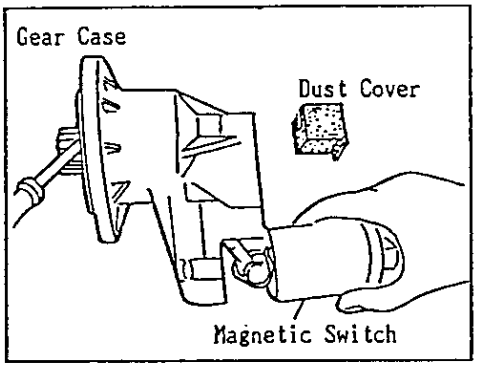

Fig. 33

(2) To connect and stabilize the magnetic switch to the gear case, pull out the pinion and connect the shift lever (connected to the magnetic switch) to the gear case with a 6 mm bolt.
Do not forget to reconnect the dust cover.

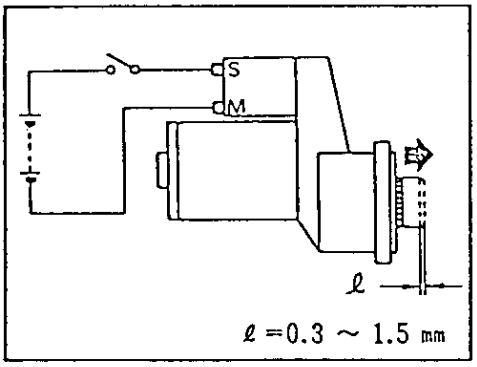

Fig. 34

(4) Measurement of the Pinion's Motion

After connecting the positive ⊕ side of the battery to the "S" terminal and the negative ⊖ side to the "M" terminal and turning the switch on, measure the amount of movement " ℓ " in the direction of the pinion's thrust.

Standard length " ℓ "
0.3 ~ 1.5 mm

Note : When taking the measurement, do so by pushing the pinion softly in the direction of the large arrow.

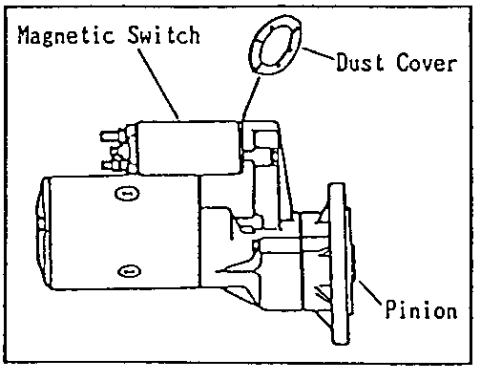

Fig. 35

(5) When the measurement " ℓ " is outside the standard range, adjust the dust cover by inserting it further or loosening it.

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7. Operation Specifications Check

Perform the no-load test as instructed because this provides an easy way to confirm the specifications.
Note: The rating is 30 seconds, so perform the test quickly.

(1) The No-load Test

Set the starter securely on a test bench and lay the lines as shown in fig. 36. When the switch is turned off, the electric current flows into the starter in no-load operating conditions. With the electric current flowing, measure the voltage and the r.p.m. and see whether they satisfy the specifications.

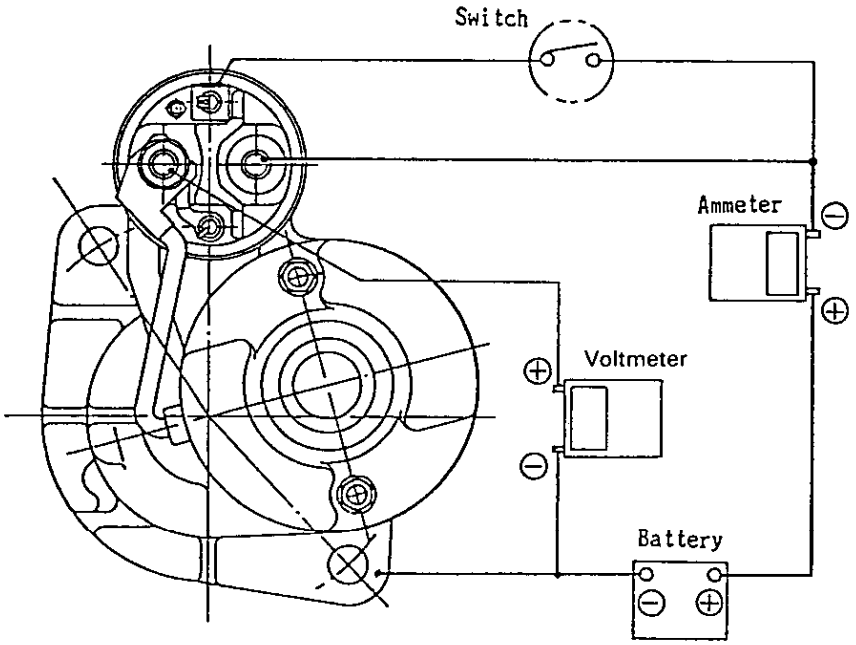

Fig. 36 The No-load Test

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8. Appendix

(1) Specifications

Hitachi Model No.		S114-483
YANMAR Part No.		171008-77010
Yoke Diameter	(mm)	80
Nominal power	(kw)	1.4
Nominal voltage	(V)	12
Rating	(sec)	30
Direction of Rotation (Looking from the pinion side)		Clockwise
Number of Pinion Teeth		15
Weigt	(kg)	5.0
No load — Terminal voltage	(V)	12
No load — Electric Current	(A)	100 (MAX)
No load — Revolutions	(rpm)	4300 (MIN)
Load — Terminal voltage	(V)	9.8
Load — Electric Current	(A)	200
Load — Torque	(N·m)	4.5 (MIN)
Load — Revolutions	(rpm)	1900 (MIN)

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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

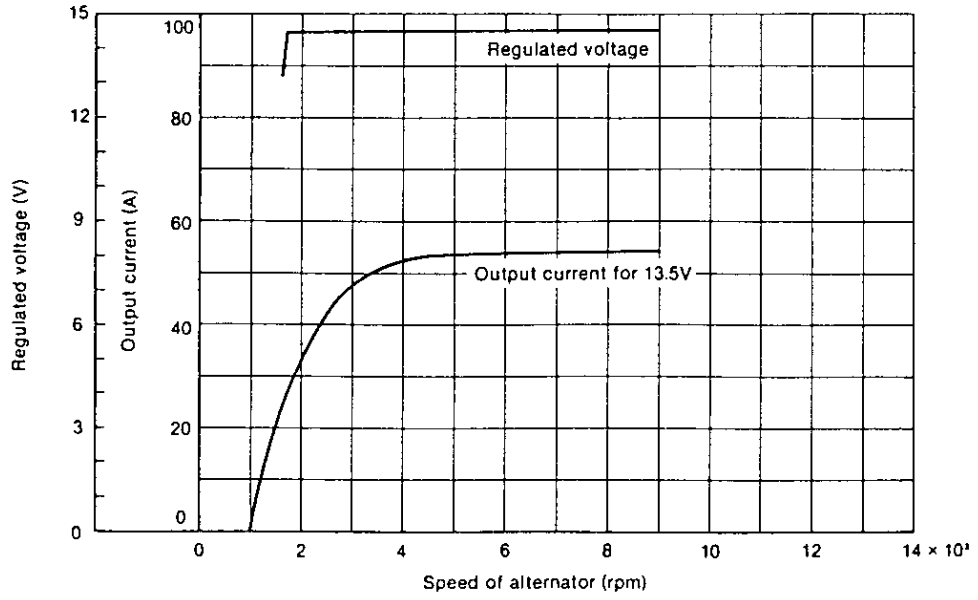
The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). 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) It is an alternator 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.

4-2 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 (⊖)
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)

4-3 Characteristics



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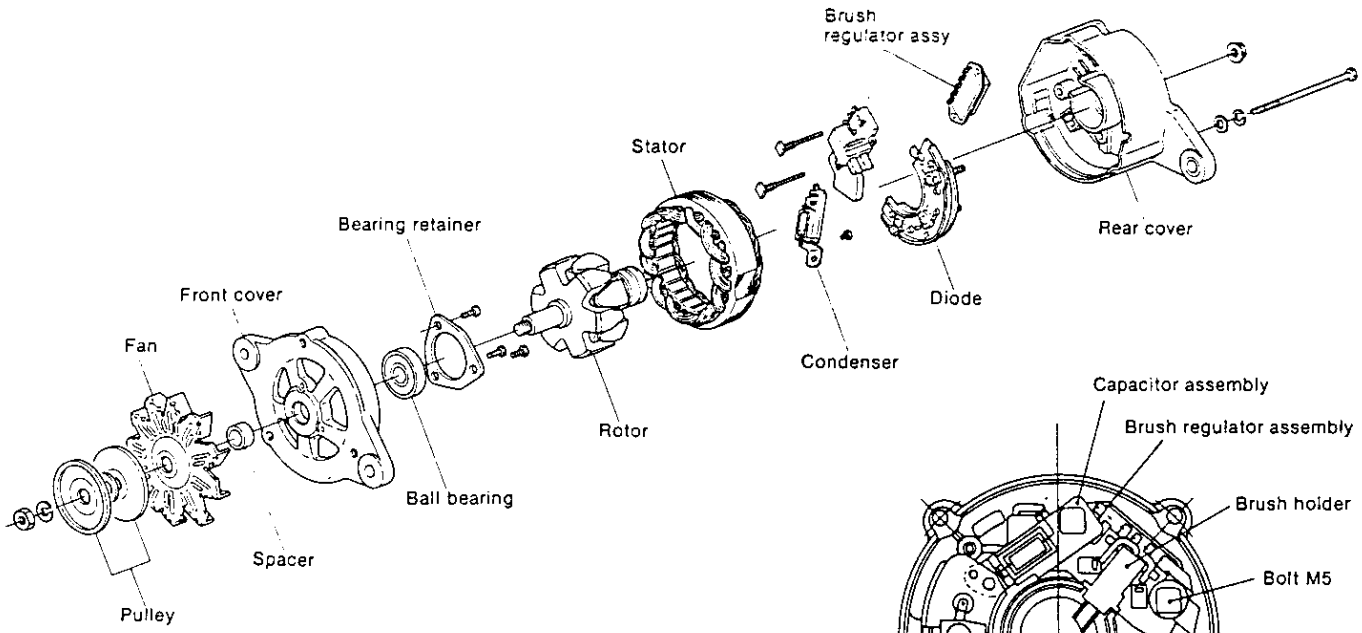
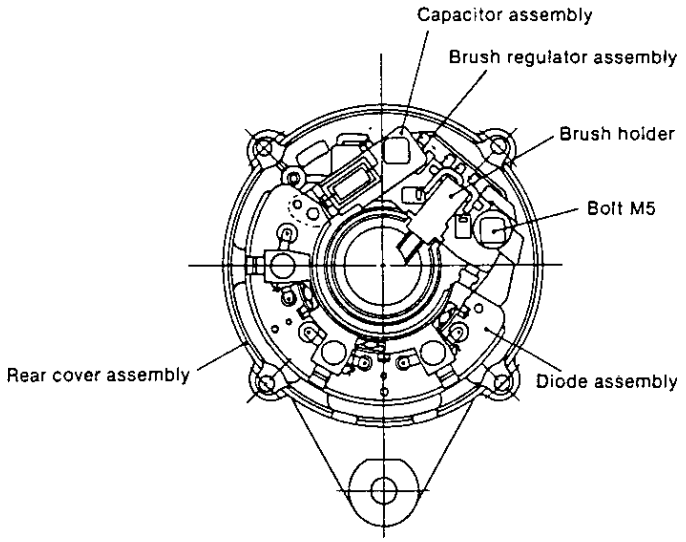
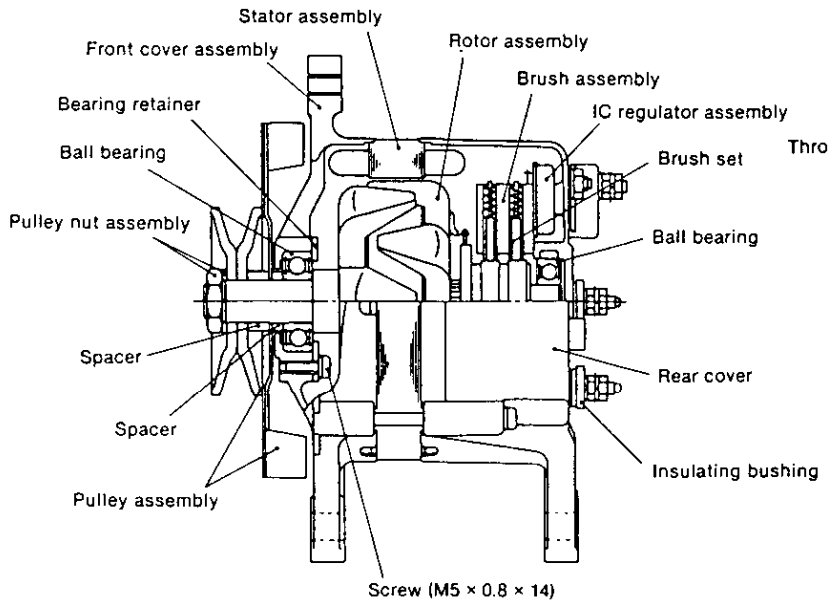
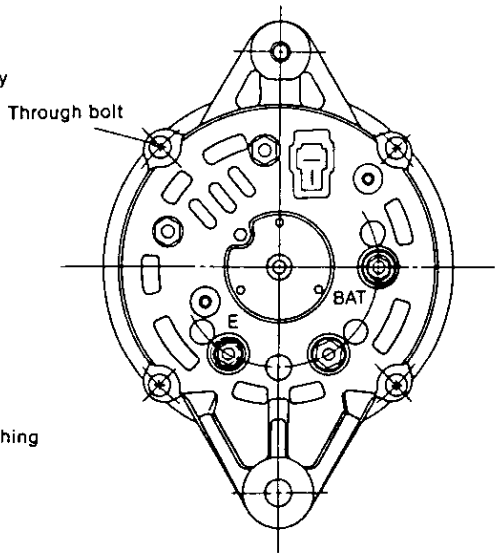
4-4 Construction

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.









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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_4 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

4-6 Handling precautions

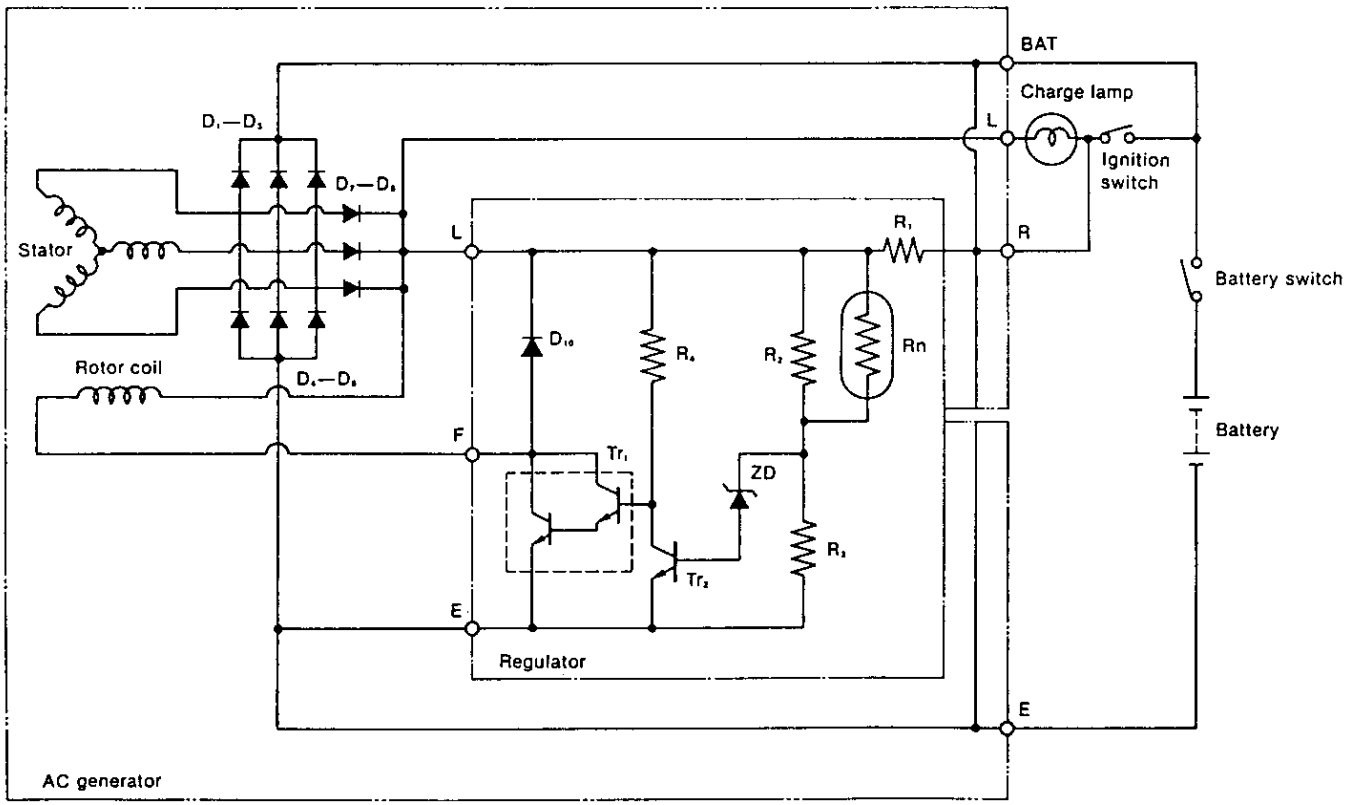
(1) Be careful of the battery's polarity (+, – terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

(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.)



BAT:	Generator output terminal	D_1—D_6:	Output commutation diode
D_{10}:	IC protecting diode	R_1—R_4:	Resistor
L:	Charge lamp terminal	D_7—D_9:	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	Rn:	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2:	Transistor		

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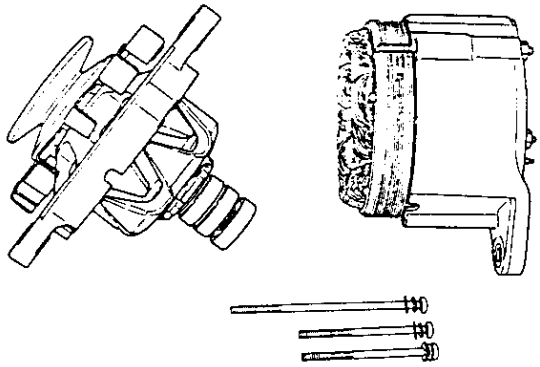
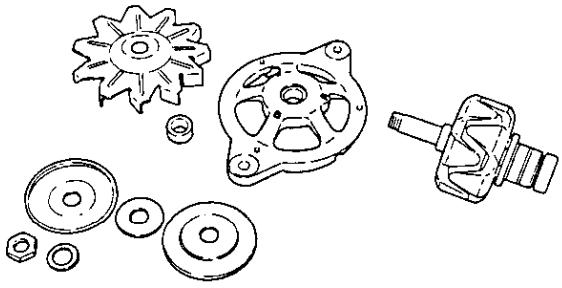
4-7 Disassembling the alternator

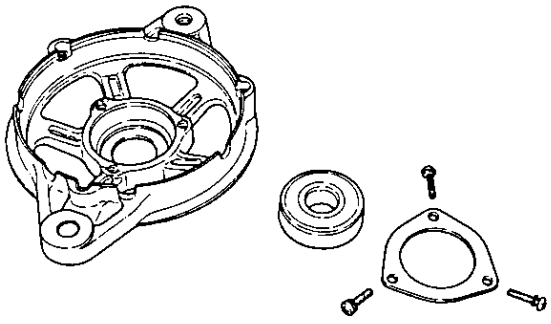
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



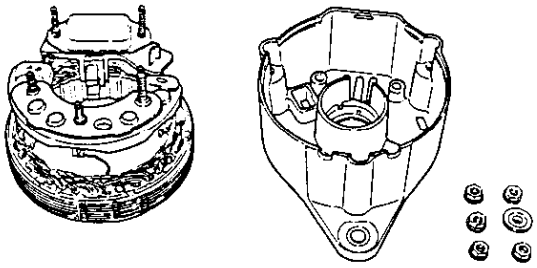
(2) Remove the pulley nut, and pull out the rotor from the front cover.



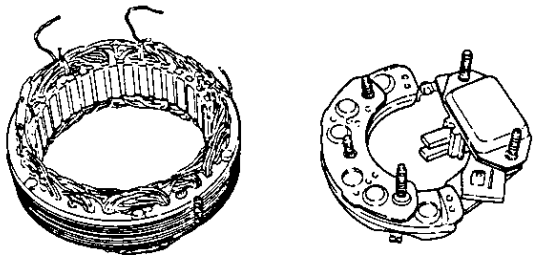
(3) Remove the ø5mm (ø0.1969in.) screw from the front cover, and then remove the ball bearing.



(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).

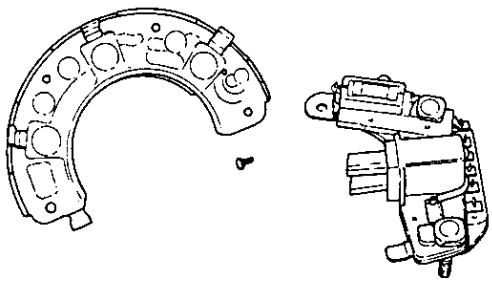


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



(6) Separating the regulator

1) To separate the regulator, remove the ø3mm (ø0.1181in.) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



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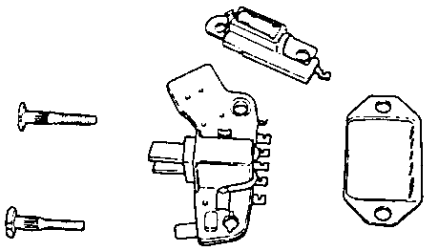
2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.

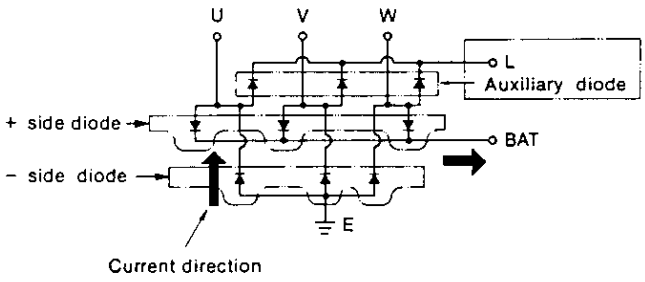


4-8 Inspection and adjustment

(1) Diode

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

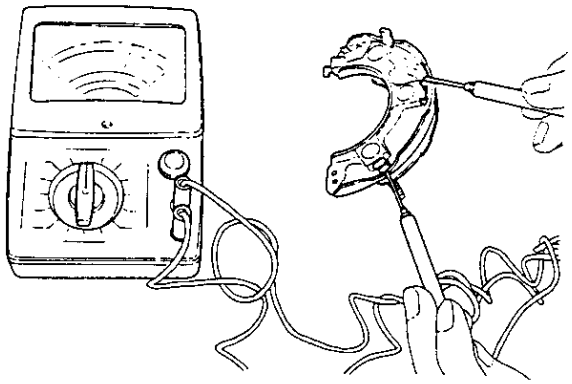
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



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.

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.



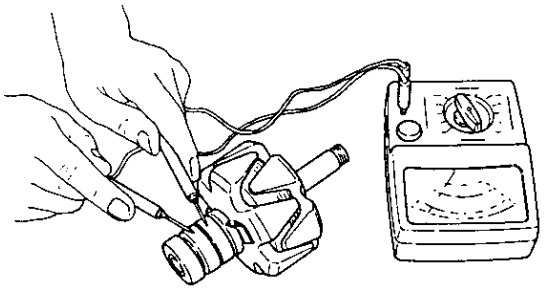
CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(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.

	Standard	Wear limit
Slip ring outer dia.	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.



Resistance value	Approx. 3.34Ω at 20°C

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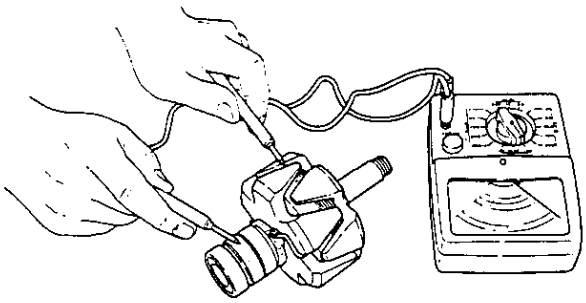
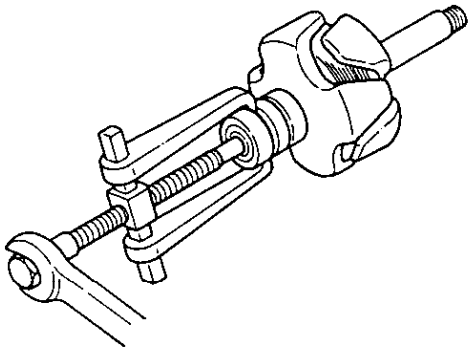
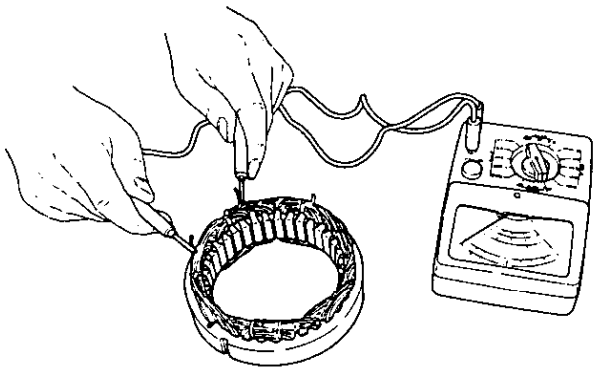
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



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

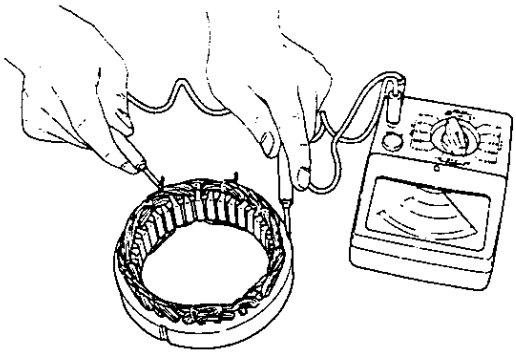


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

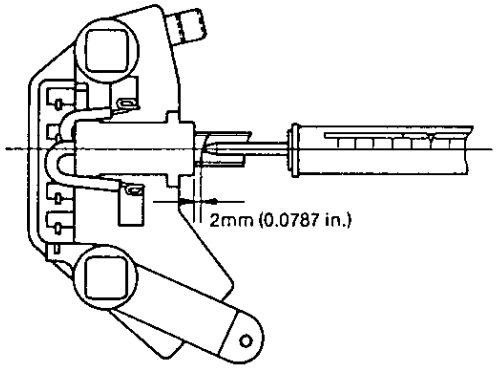


Resistance value	Approx. 0.077Ω at 20°C 1-phase resistance

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.

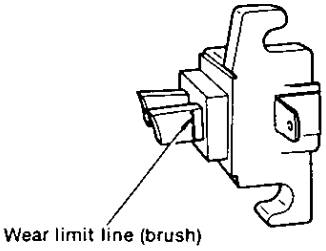


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.
To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



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)

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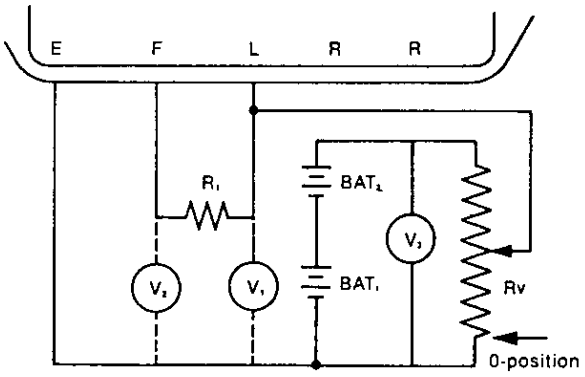
(6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

Resistor (R.)	100Ω, 2W, 1pc.
Variable resistor (Rv)	0—300Ω, 12W, 1pc.
Battery (BAT_1, BAT_2)	12V, 2pcs.
DC voltmeter	0—30V, 0.5 class 1pc. (measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.
   a) Check V_3 (BAT_1 + BAT_2 voltage). If the voltage is 20—26V, both BAT_1 and BAT_2 are normal.
   b) While measuring V_2 (F-E terminal voltage), move Rv gradually from the 0-position. Check if there is a point where the V_2 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 Rv to the 0-position, and connect the voltmeter to the V_1 position.
   c) While measuring V_1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V_1 rises sharply by 2—6V. Measure the voltage of V_1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V_1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

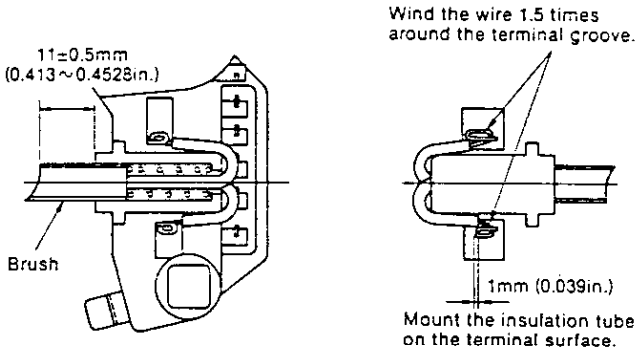


4-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4—7 disassembling alternator).

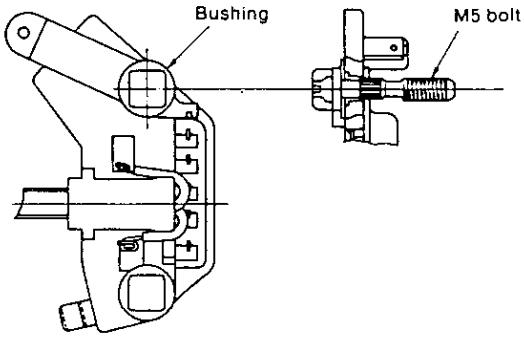
(1) Assembling the brush regulator

1) Solder the brush.
   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).



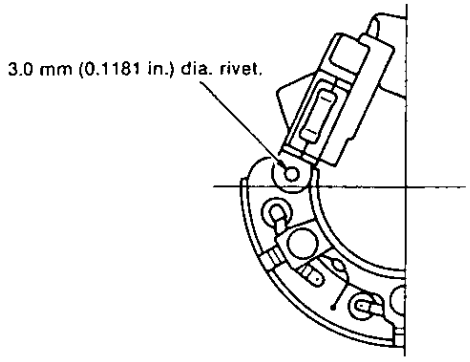
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(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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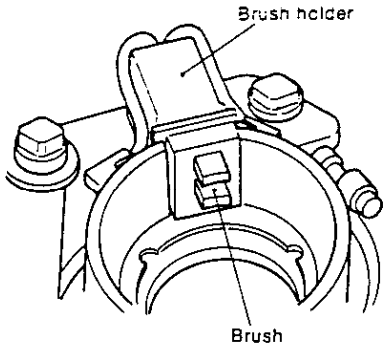
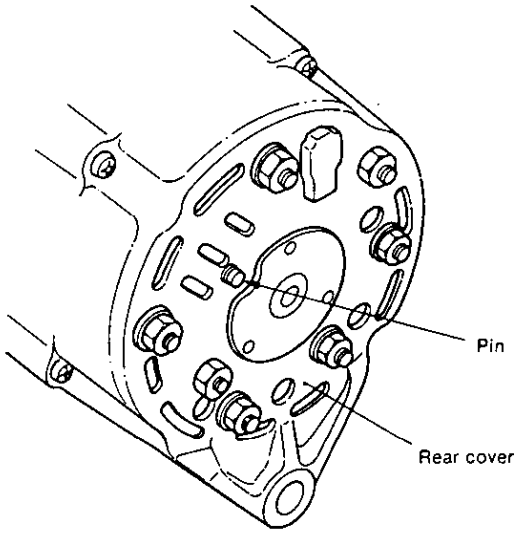
(3) Assembling the rear cover
Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.



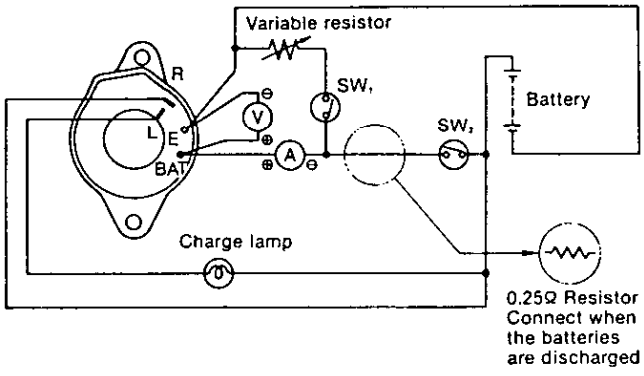


(4) Tightening torques

Positions	Tightening torque kg-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 SW_2 while keeping SW_1 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 SW_1 open for measurement.

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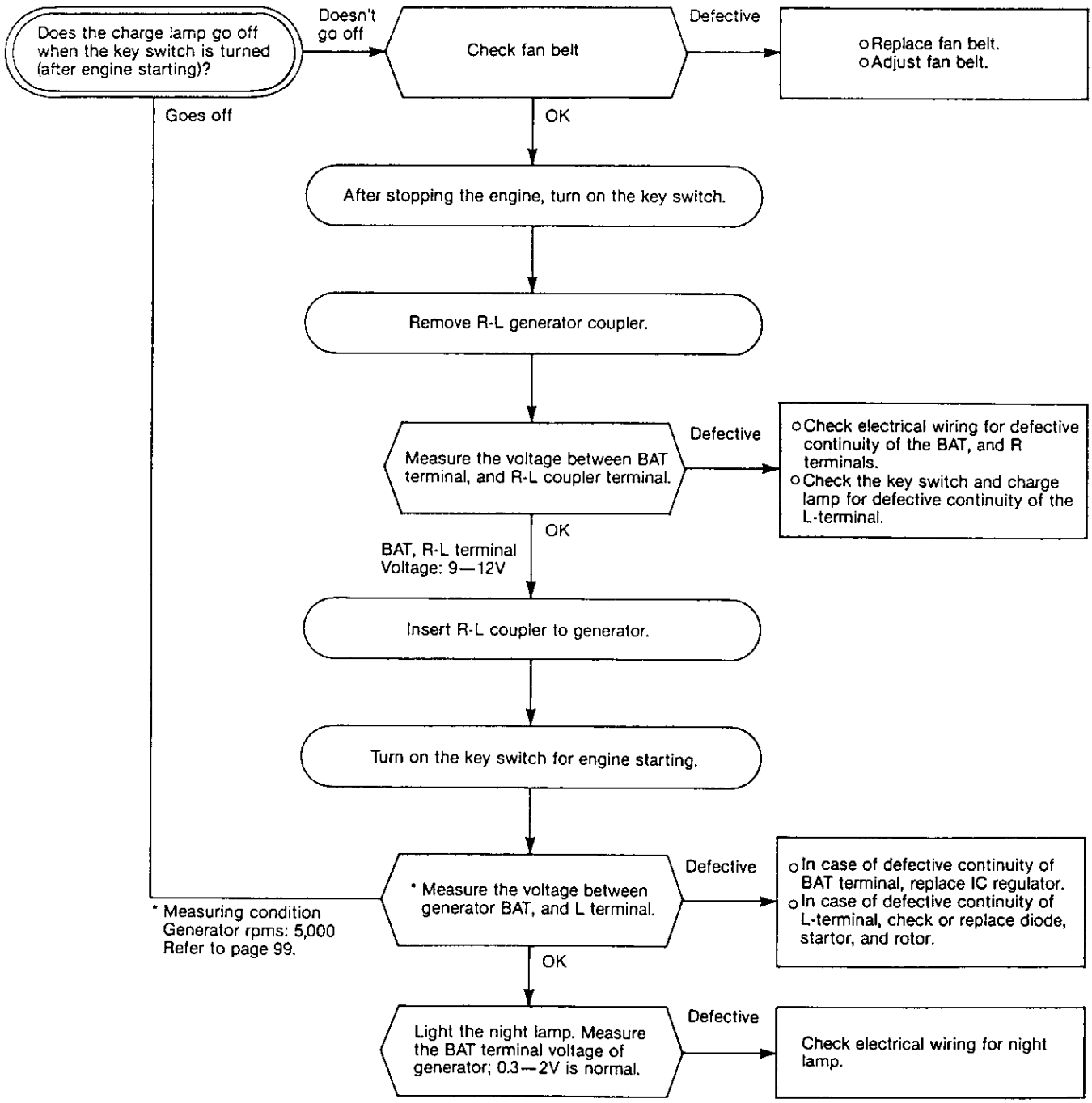
4-11 Troubleshooting

(1) Charging failure



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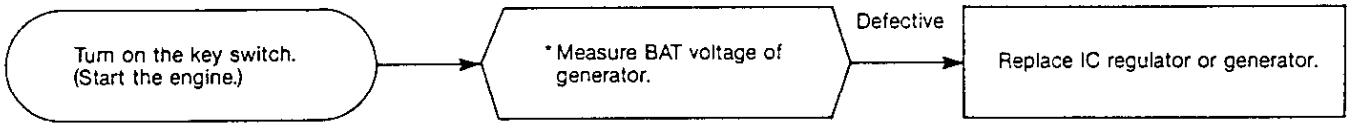
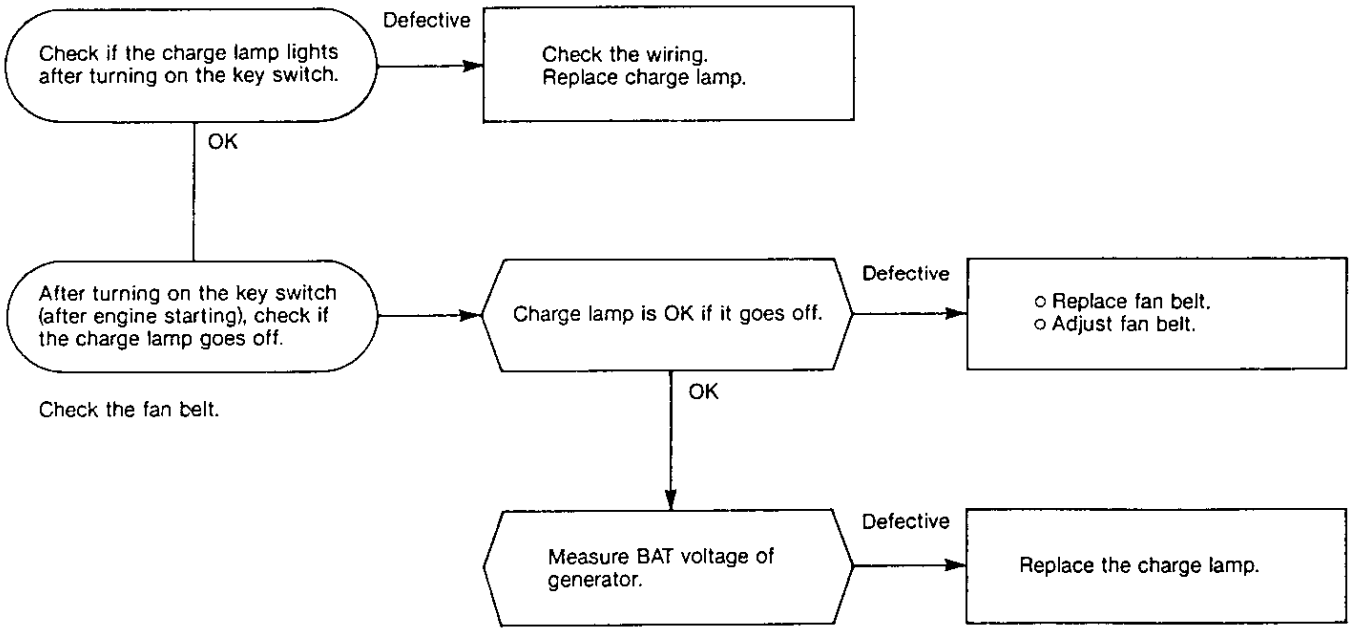
(2) Overcharging



(3) Charge lamp failure



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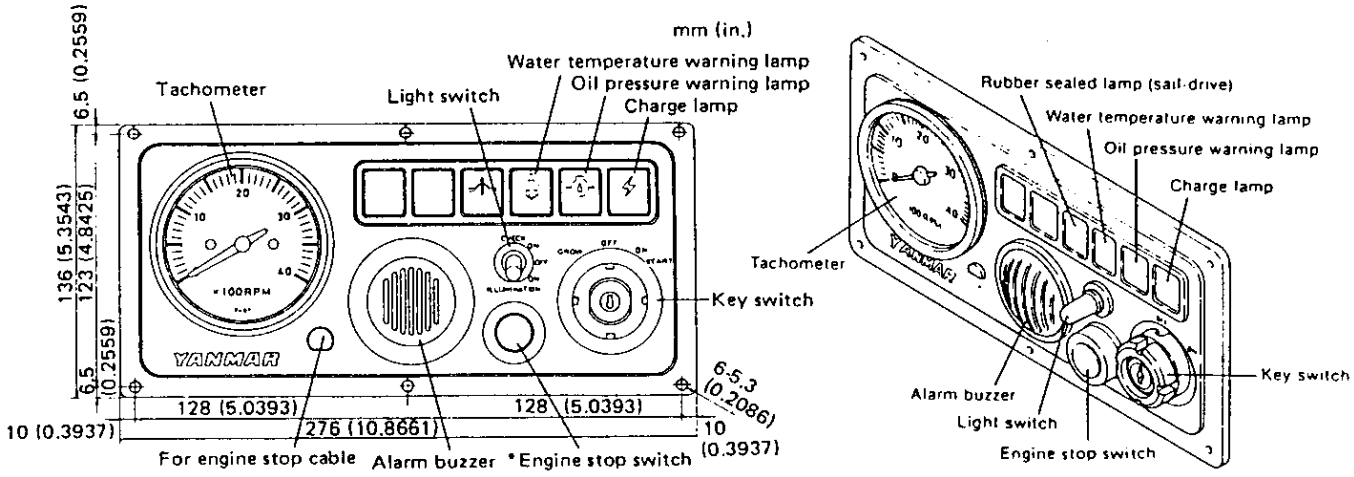
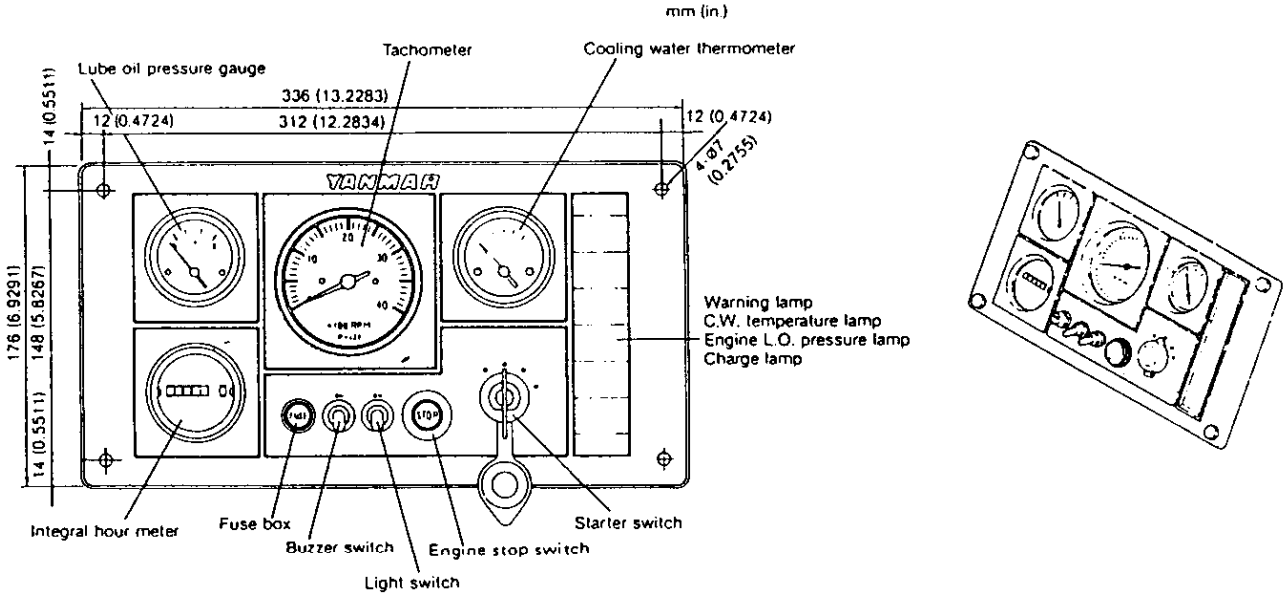
5. Instrument Panel

5-1 B2-type instrument panel with wiring



5-2 C-type instrument panel



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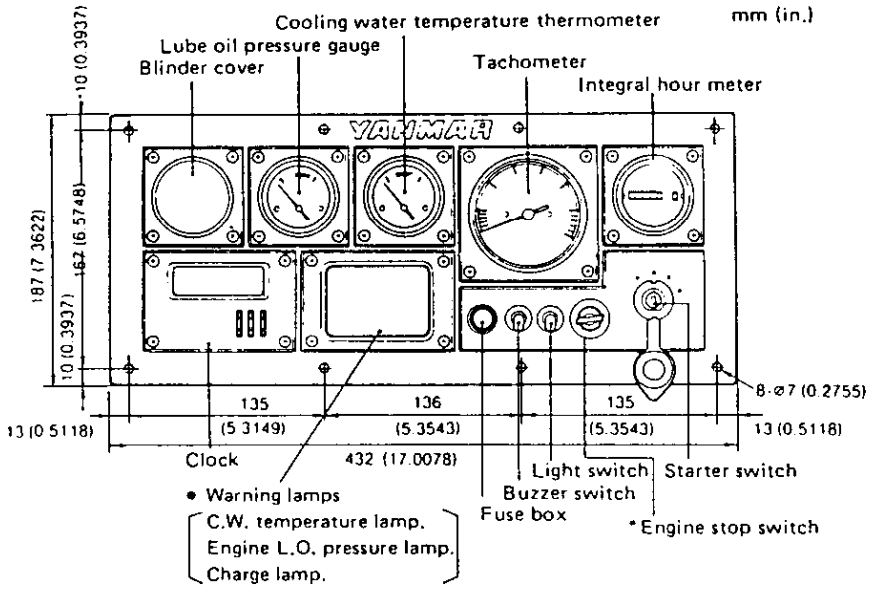
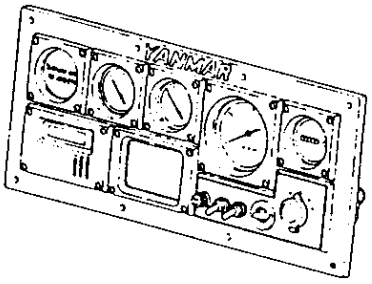
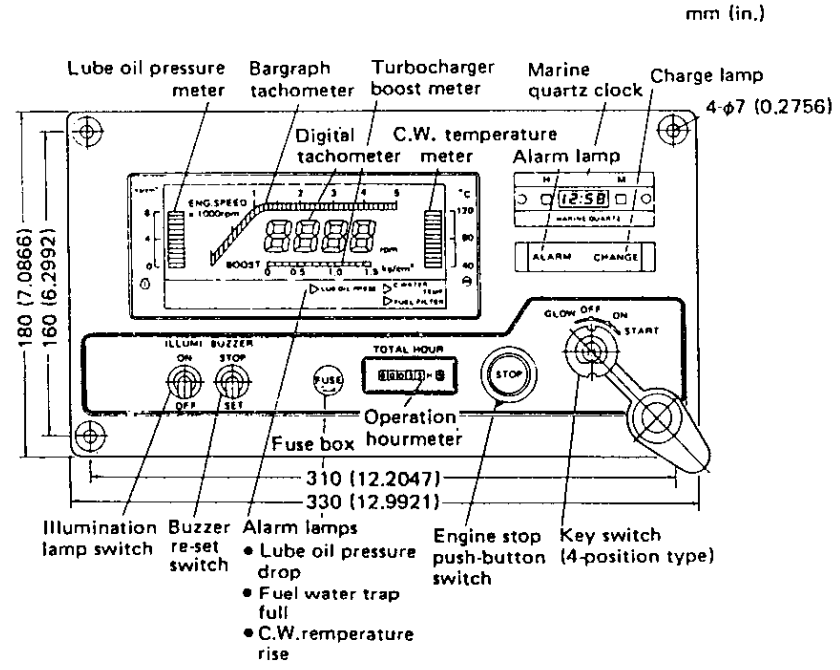
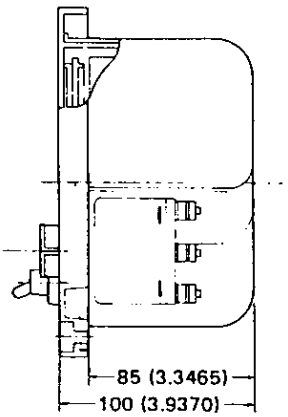
5-3 D-type instrument panel





5-4 E-type instrument panel





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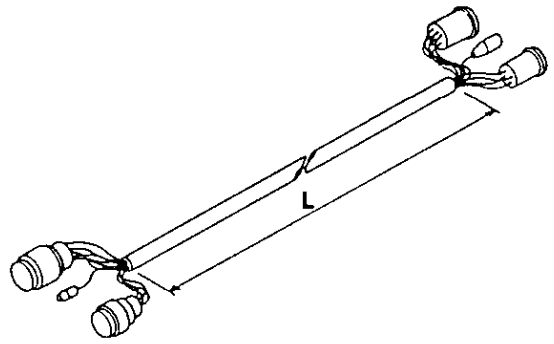
5-5 Extension codes

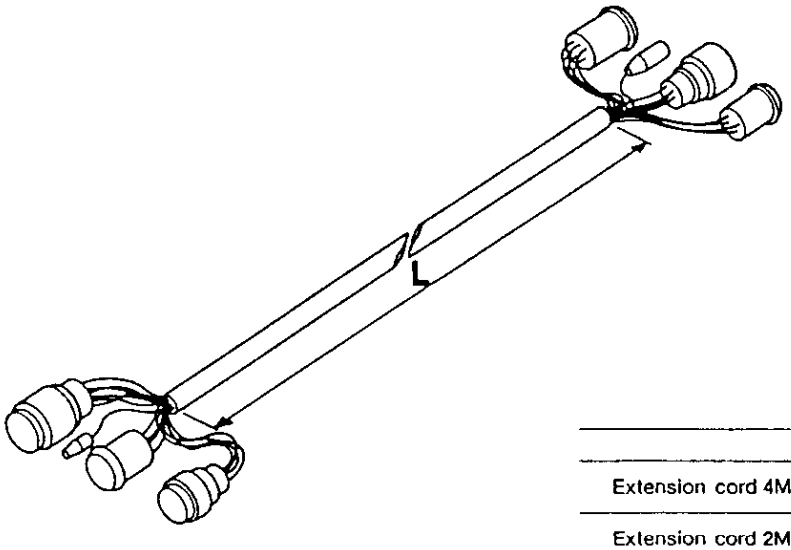
Extension cord for B2-type instrument panel



mm (in.)

	Part code No.	L
Extension cord 4M	129772-77500	3750 ~ 3850 (147.63 ~ 151.57)
Extension cord 2M	129470-77510	1750 ~ 1850 (68.89 ~ 72.83)
Extension cord 6M	129470-77530	5750 ~ 5850 (226.38 ~ 230.31)

Extension cord for C-type and D-type, E-type instrument panel



mm (in.)

	Part code No.	L
Extension cord 4M	129470-77930	3750 ~ 3850 (147.63 ~ 151.57)
Extension cord 2M	129470-77520	1750 ~ 1850 (68.89 ~ 72.83)
Extension cord 6M	129470-77540	5750 ~ 5850 (226.38 ~ 230.31)

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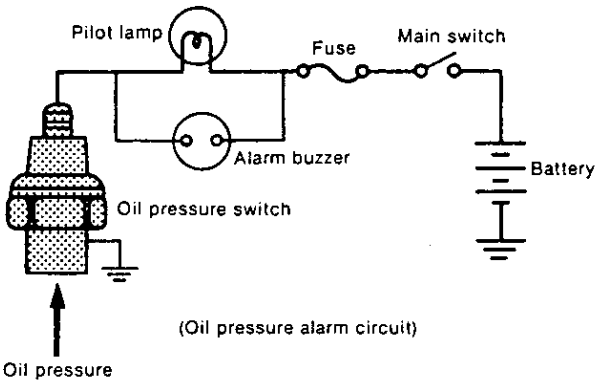
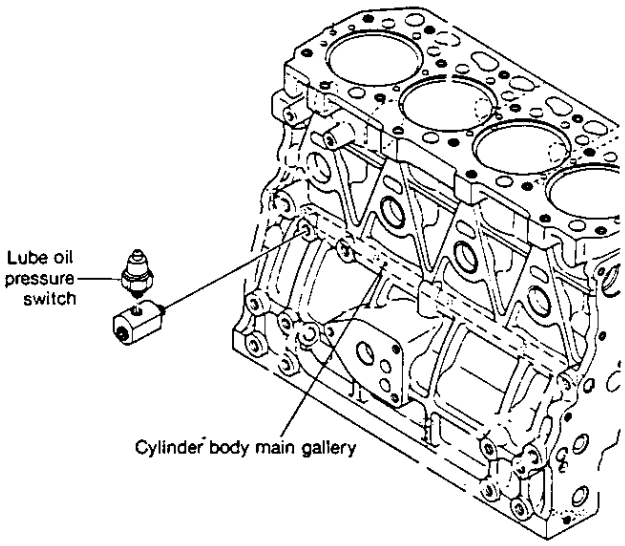
6. Warning Devices

6-1 Oil pressure alarm

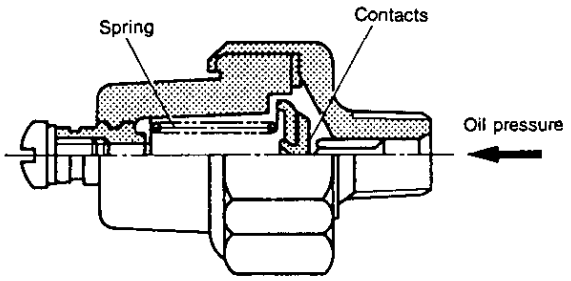
If the engine oil pressure is below 0.1 ~ 0.3 kg/cm² (1.42 ~ 4.26 lb/in.²), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring, and the lamp is illuminated through the lamp → oil pressure switch → ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.



(Oil pressure alarm circuit)



Oil pressure switch



Part No.	124060-39451
Rated voltage	12V
Operation pressure	0.1 ~ 0.3kg/cm² (1.422 ~ 4.266lb/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

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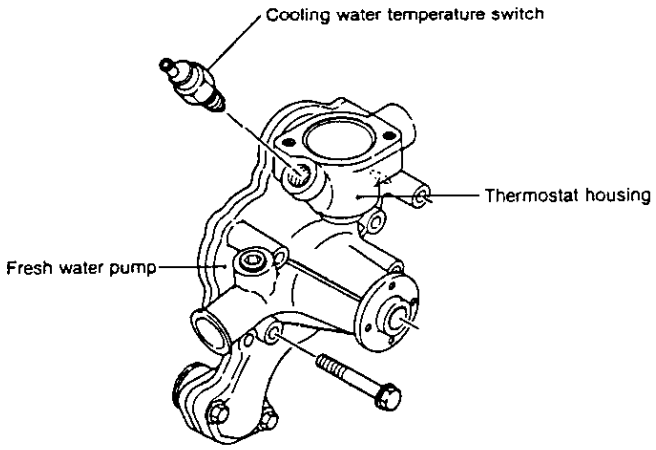
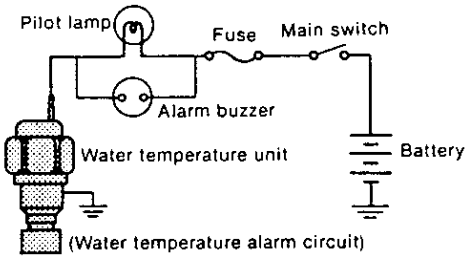
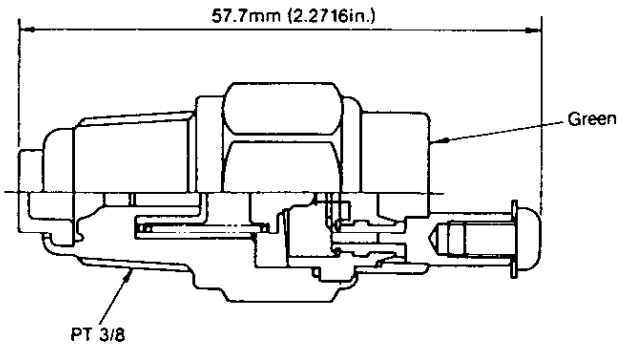
6-2 Cooling water temperature alarm

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.

Operating temperature	ON	93 ~ 97°C (199 ~ 206°F)
	OFF	88°C (190°F) or high
Electric capacity		DC 12V, 1A
Response time		with in 60 sec.
Indication color		Green
Part code No.		127610-91350
Tightening torque		2.40 ~ 3.20kg-m (17.35 ~ 23.14ft-lb)

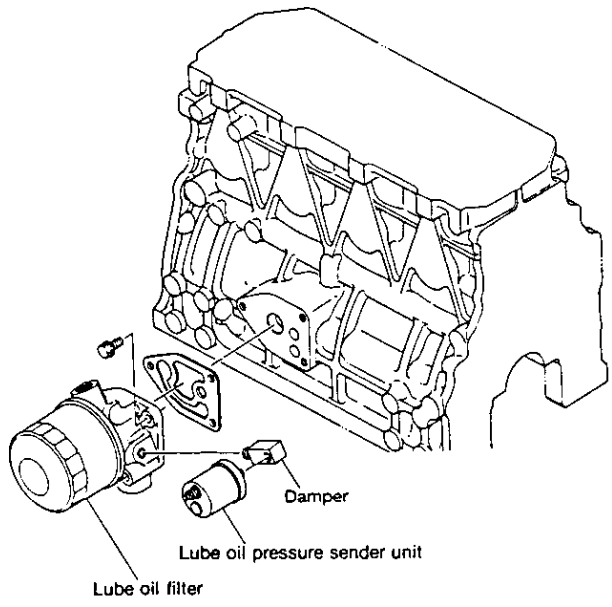






6-3 Sender unit for lube oil pressure gauge

The sender unit for the lube oil pressure gauge has a mounting seat for mounting on the lube oil filter bracket. Oil pressure is measured when the oil enters into the main gallery after being fed from the lube oil cooler and passing through the oil pressure control valve. Be sure to mount a vibration damper when mounting the oil pressure sender unit.



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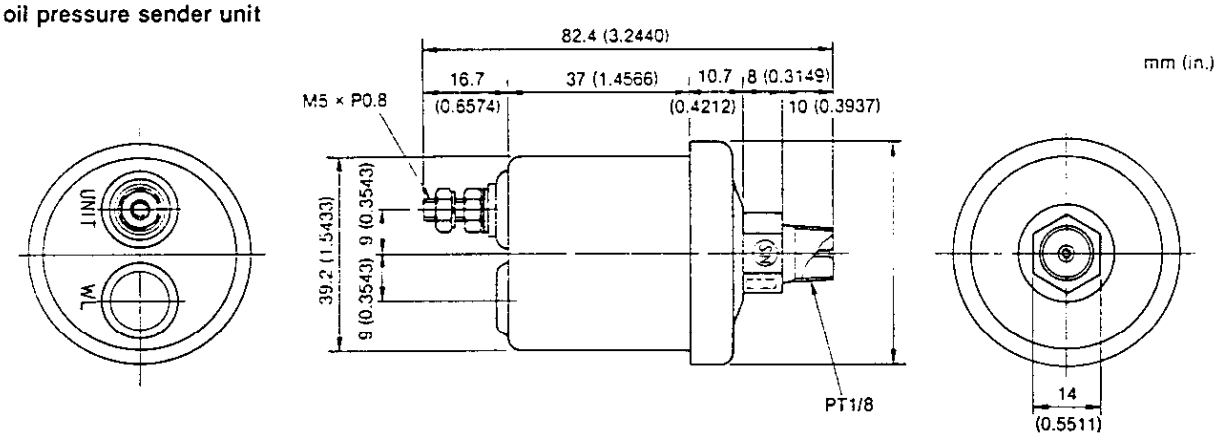
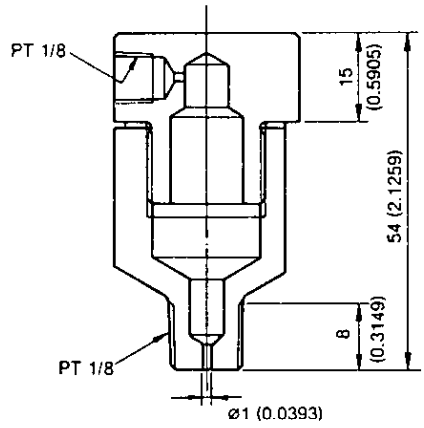
Lube oil pressure sender unit



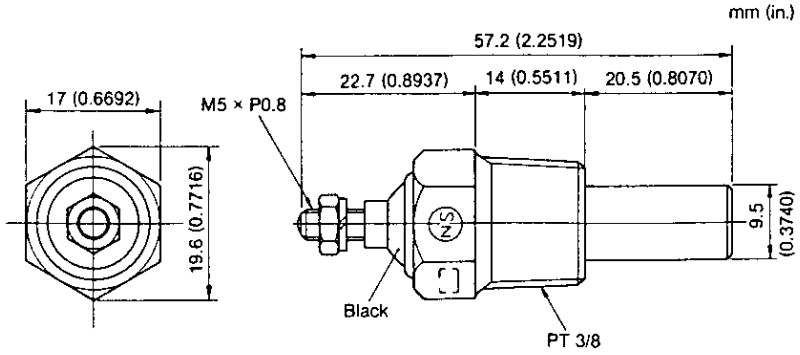
Damper

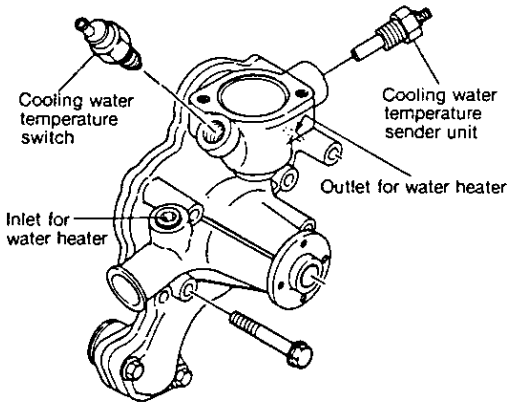


Type	Resistance switch
Rated voltage	DC 12/DC 24
Max. operating pressure	8kg/cm² (113.76 lb/in.²)
Part code No.	144626-31560

6-4 Sender unit for the cooling water temperature gauge

The water temperature sender unit has a mounting seat for mounting on the fresh water pump unit. Water temperature is measured when the cooling water flows into the thermostat housing after leaving the cylinder head.





Type	Thermistor switch
Rated voltage	12V/24V
Part code No.	144626-91570

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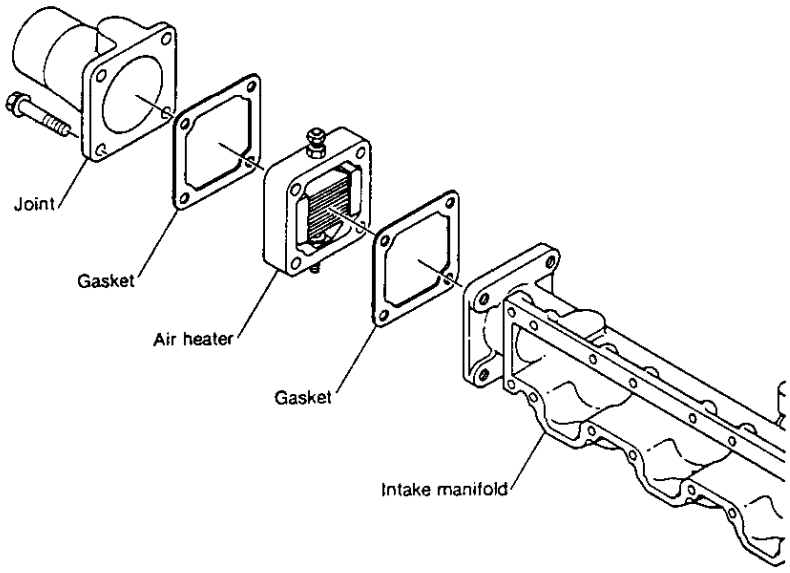
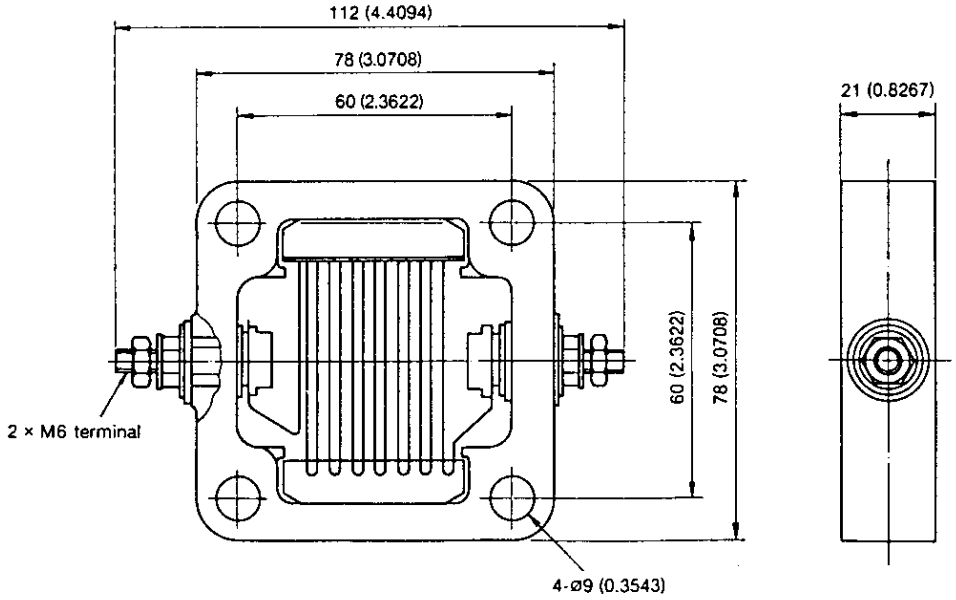
7. Air Heater (Optional)

An air heater is available for warming intake air when starting in cold areas in winter. The air heater is mounted between the intake manifold and intake manifold coupling. The device is operated by the glow switch on the instrument panel.





Rated output	400W
Rated current	33.3A
Rated voltage	DC 12V
Rated operating time	Engine operation: 60 sec. Engine stop: 30 sec.
Range of operating temperature	+50°C ~ 30°C (122°F ~ -22°F)
Part code No.	129400-77500

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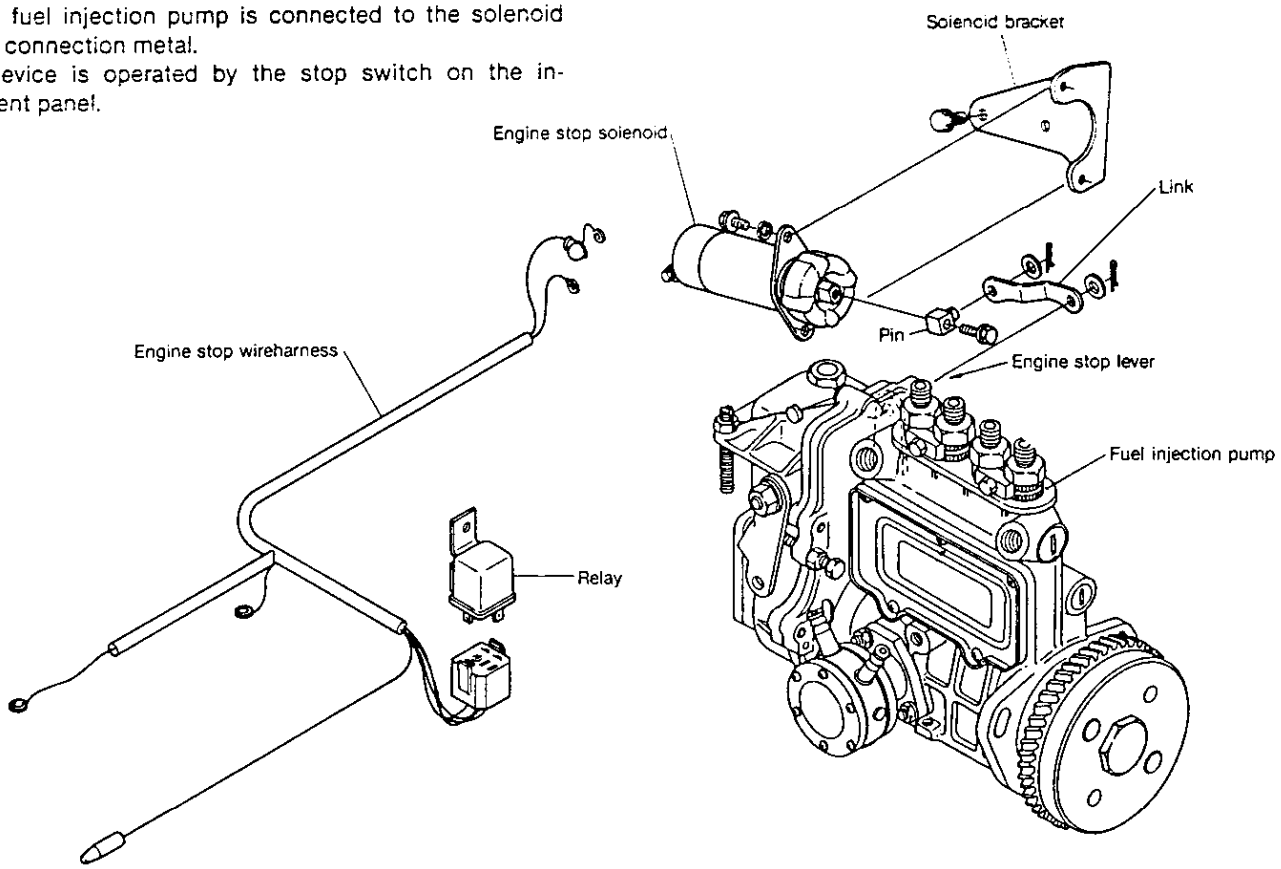
8. Electric type Engine Stopping Device (Optional)

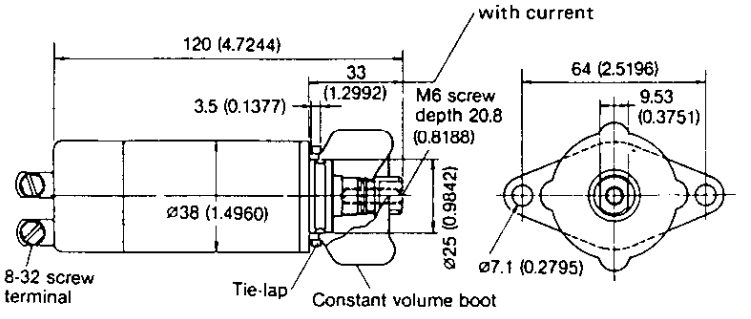
To employ the electric engine stop device, the stop lever of the fuel injection pump is connected to the solenoid with a connection metal.
The device is operated by the stop switch on the instrument panel.

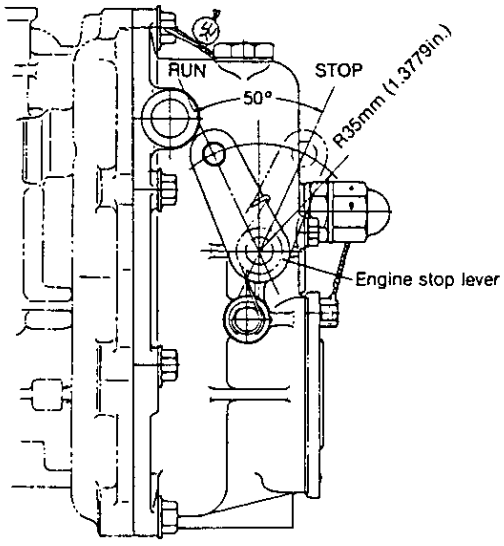


8-1 Solenoid

Solenoid model	1502-12A7U1B
Rated voltage	12V
Loaded current	30A
Loaded force	9kg (19.84lb)
No-load current	0.7A
No-load force	4kg (8.82lb)

mm (in.)





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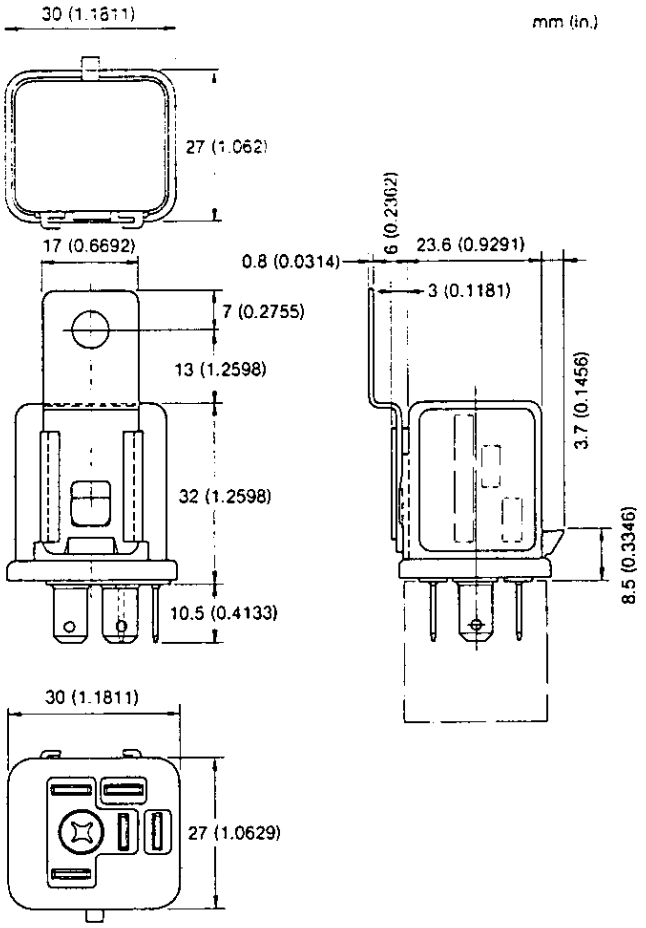
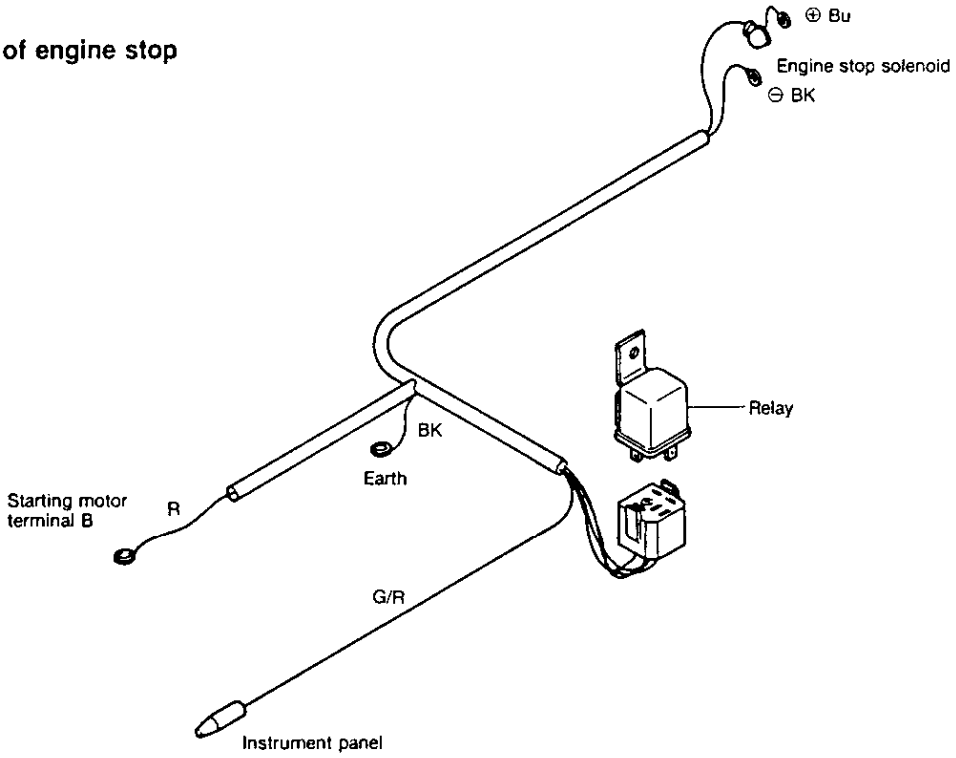
8-2 Relay



Rated voltage	12V
Contact current	Lamp: 20A, extra-lamp: 25A
Range of operation	−30°C ∼ +90°C (−22°F ∼ 194°F)
Part code No.	124617-91850

8-3 Wire harness of engine stop



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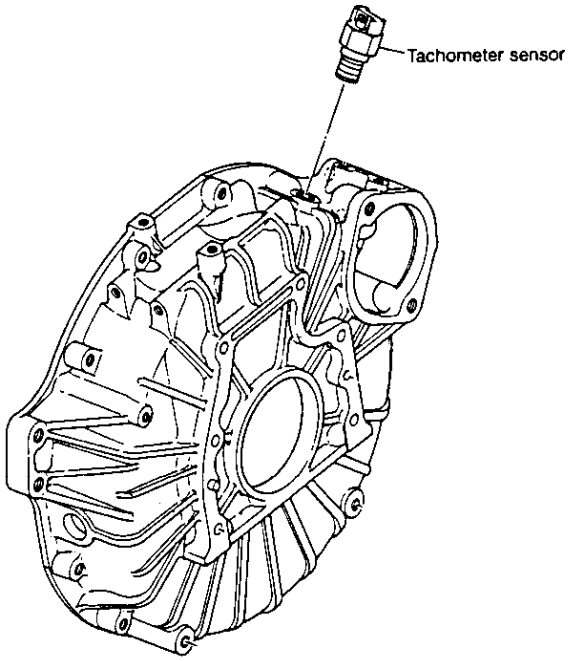
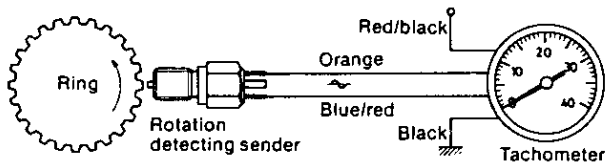
9. Tachometer

9-1 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 counting the number of teeth of the ring gear connecting with the flywheel housing.



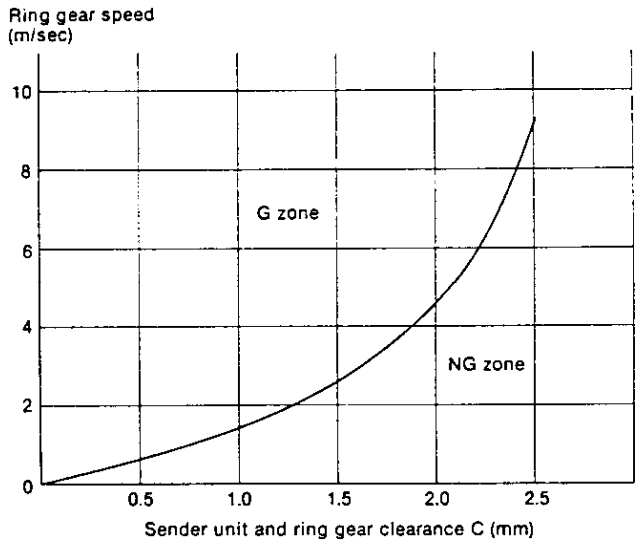


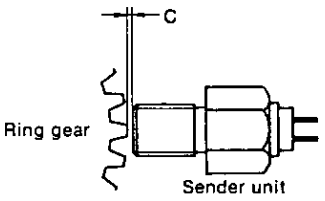
9-2 Specifications and dimensions of tachometer

(1) Specifications

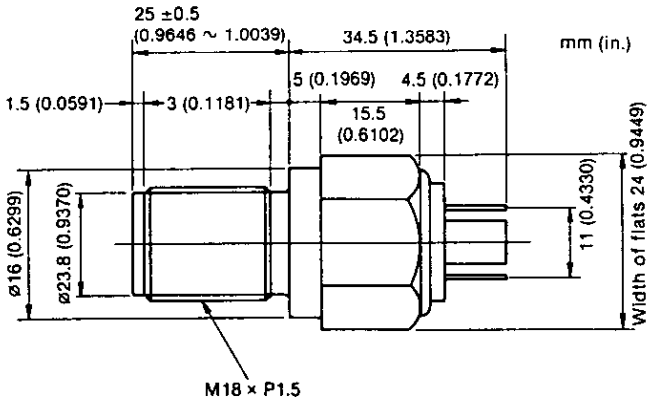
Rated voltage		DC 12V
Range of operating voltage		10 ~ 15V
Illumination		3.4W/12V
Ring gear	No. of teeth	127
	Module	2.54
Part No. of tachometer		120130-91200 (128696-91100)
Part No. of sender unit		128170-91160

(2) Sensitivity limit of sender unit

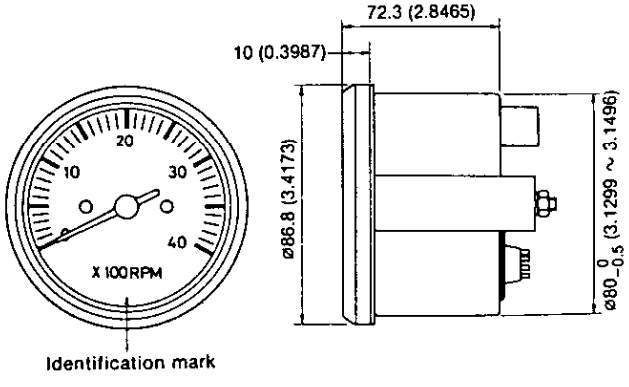




(3) Dimensions of sender unit



(4) Dimensions and shape of tachometer



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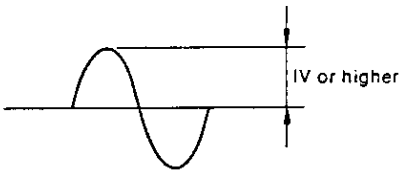
9-3 Measurement of sensor unit characteristics

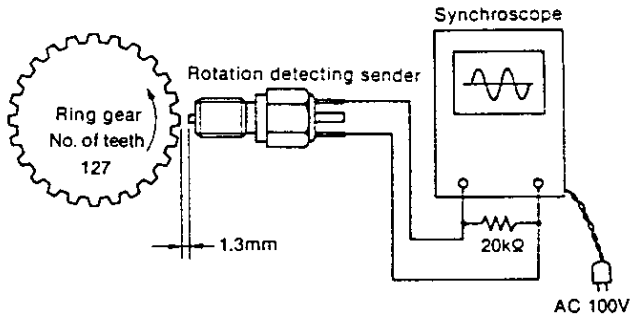
(1) Measurement of output voltage

Output voltage	1.0V or higher



Measuring conditions

Number of teeth of ring gear	127
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 (68°F)
Measuring instrument	Synchroscope

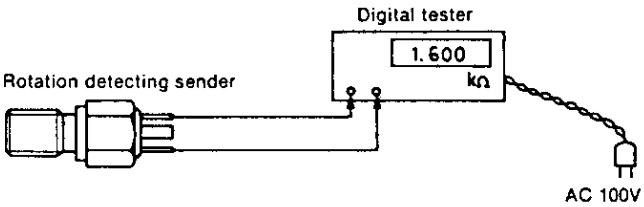


* Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

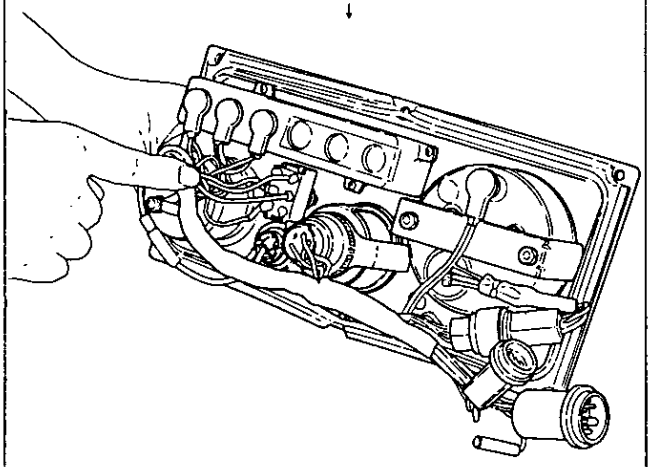
(2) Measurement of internal resistance

Measuring conditions

Measuring temperature	20°C (68°F)
Measuring instrument	Digital tester



9-4

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.)

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	Check if the sender is loosely fitted. ↓ No	Yes	Fix the sender securely.
	Measure the internal resistance of the sender. (To be 1.6 ±0.1kΩ at 20°C) ↓	No	Replace the sender.
	Measure the output voltage of the sender. (To be 1V or higher at 20°C)	No	Replace the sender.

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10. Alternator 12V/80A (OPTIONAL)

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.

10-1 Features

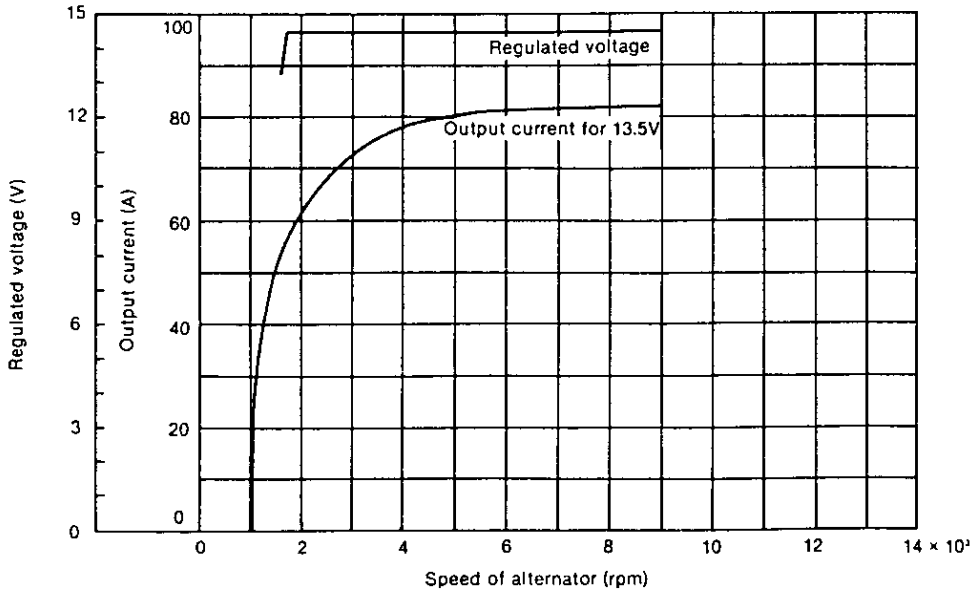
The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). 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) It is an alternator 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.

10-2 Specifications

Model of alternator	LR180-03 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth (⊖)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	5.8kg (12.8lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 78A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, −0.01/°C)

10-3 Characteristics



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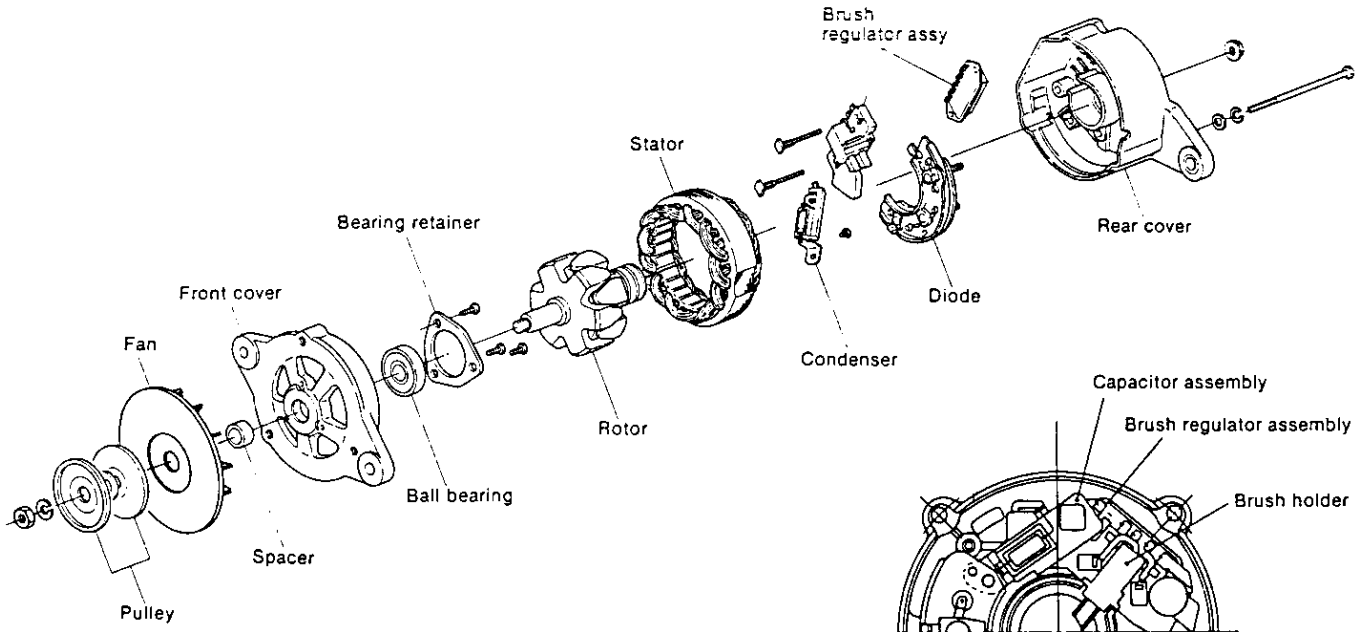
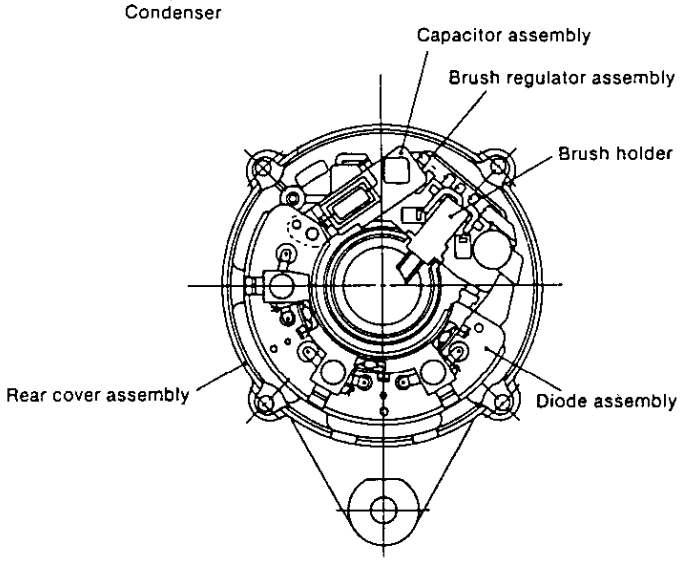
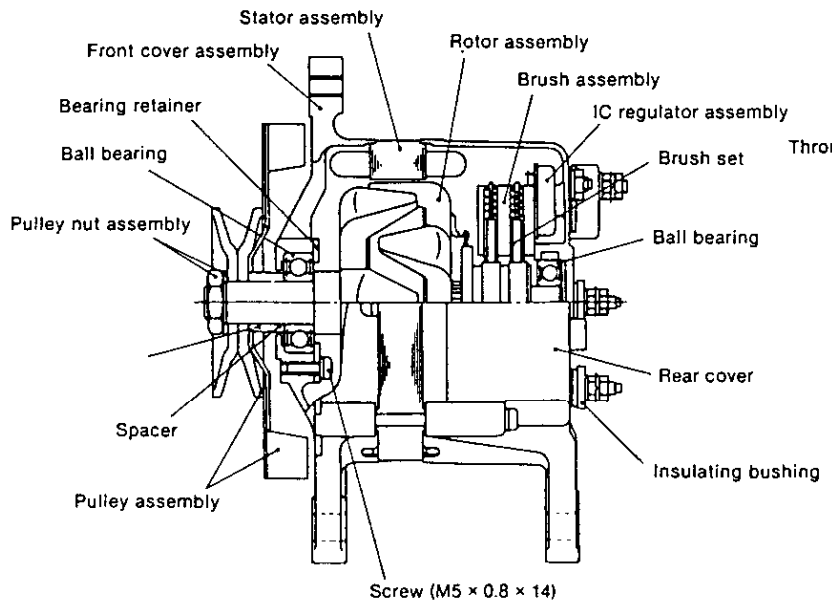
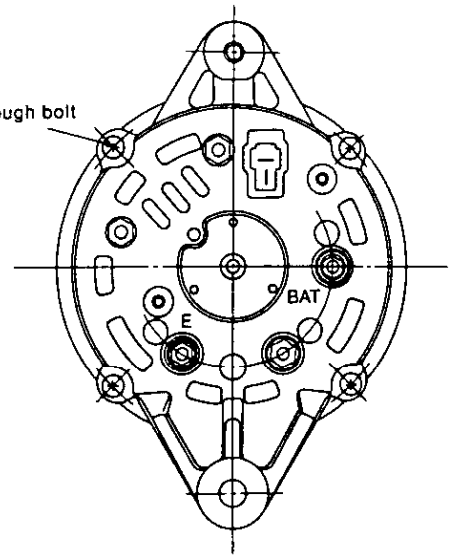
10-4 Construction

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.









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10-5 Alternator functioning

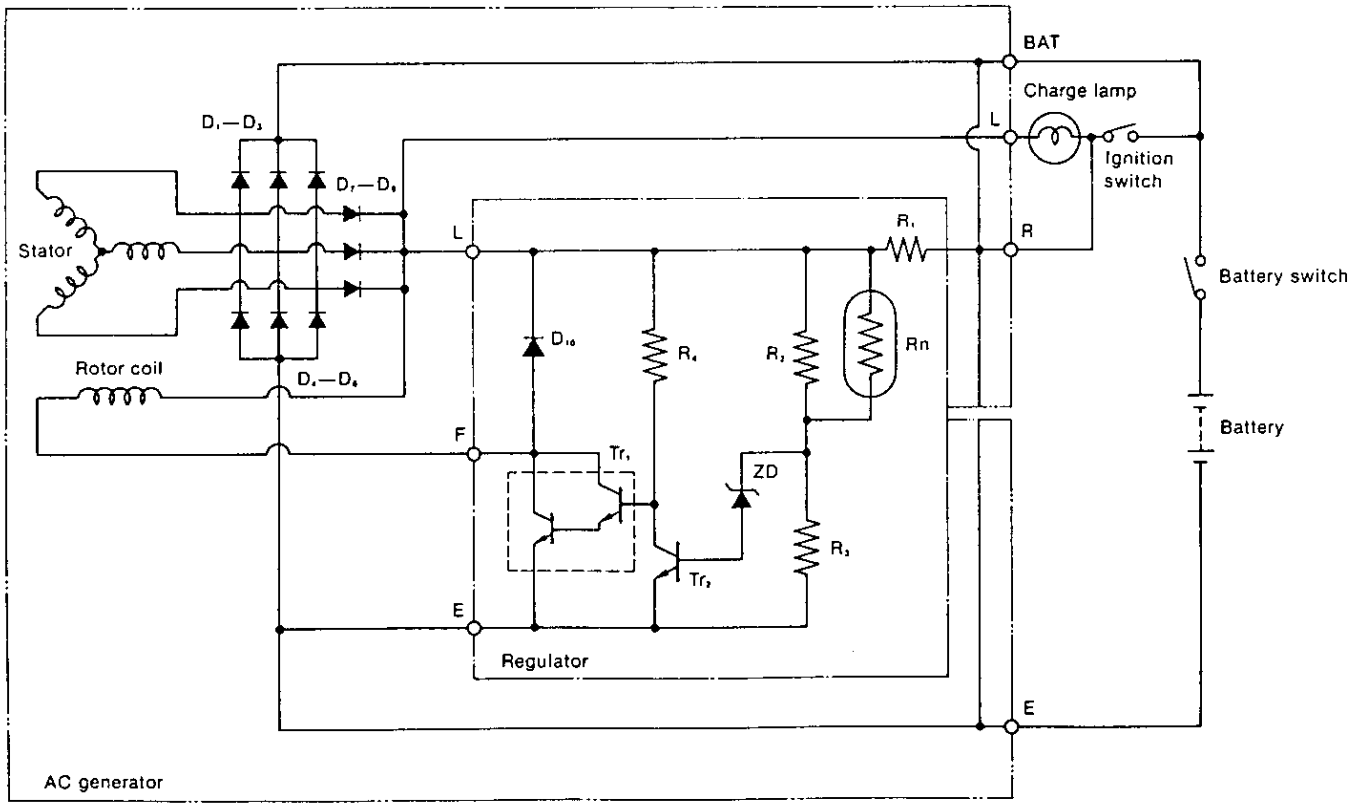
(1) IC regulator
The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.
When the output voltage of the generator is within the standard value, the transistor (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_4 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

10-6 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.)



BAT:	Generator output terminal	$D_1—D_6$:	Output commutation diode
D_{10}:	IC protecting diode	$R_1—R_4$:	Resistor
L:	Charge lamp terminal	$D_7—D_9$:	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	Rn:	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2:	Transistor		

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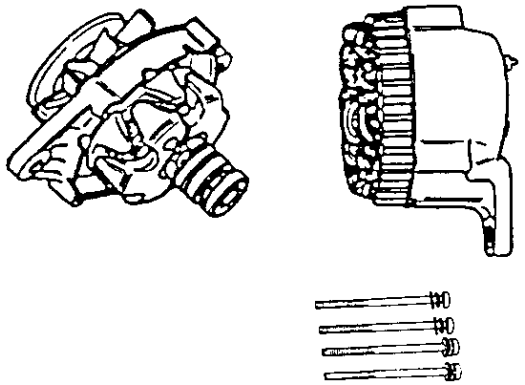
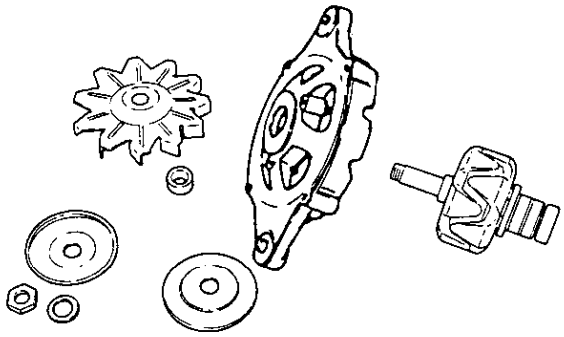
10-7 Disassembling the alternator

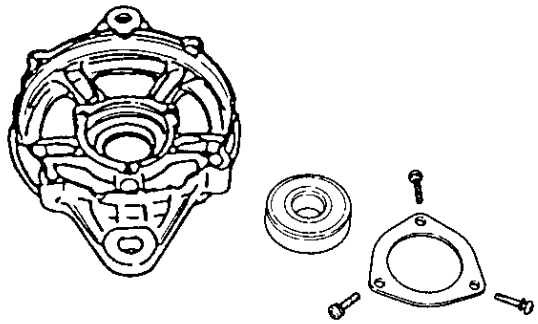
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



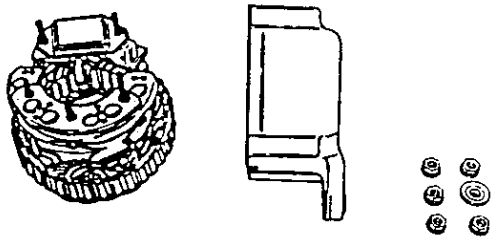
(2) Remove the pulley nut, and pull out the rotor from the front cover.



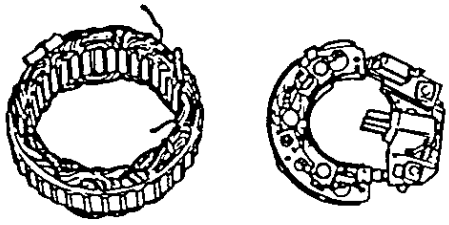
(3) Remove the ø5mm (ø0.1969in.) screw from the front cover, and then remove the ball bearing.



(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).

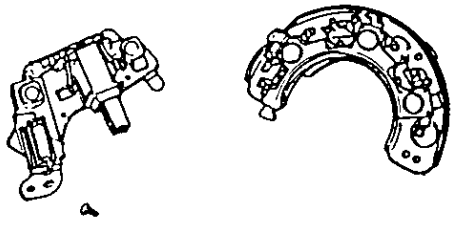


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



(6) Separating the regulator

1) To separate the regulator, remove the ø3mm (ø0.1181in.) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



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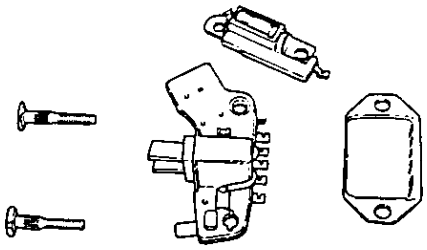
2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.

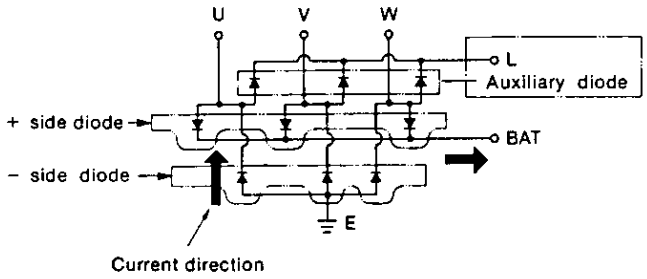


10-8 Inspection and adjustment

(1) Diode

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

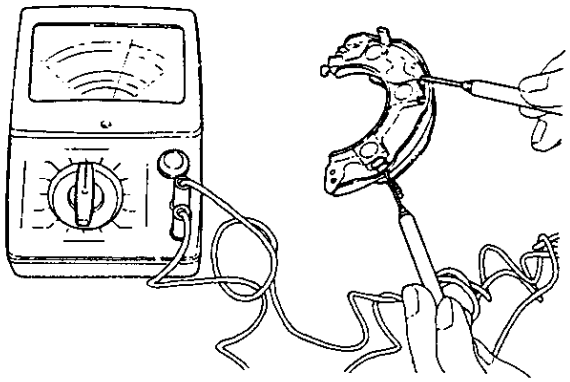
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



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. 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.

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.



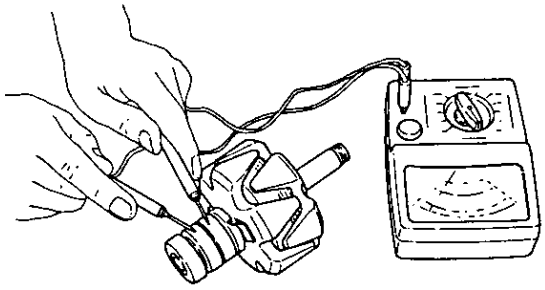
CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(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.

	Standard	Wear limit
Slip ring outer dia.	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.



Resistance value	Approx. 2.58Ω at 20°C

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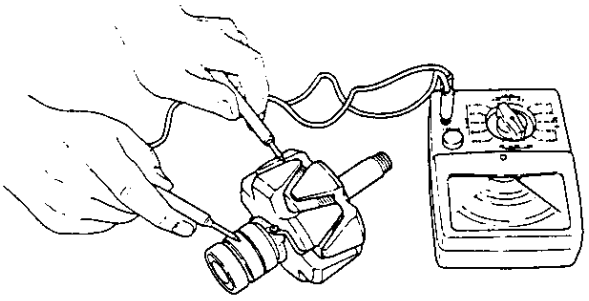
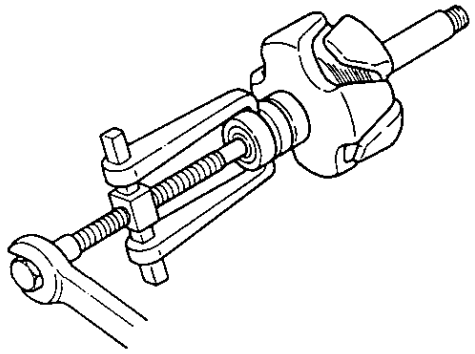
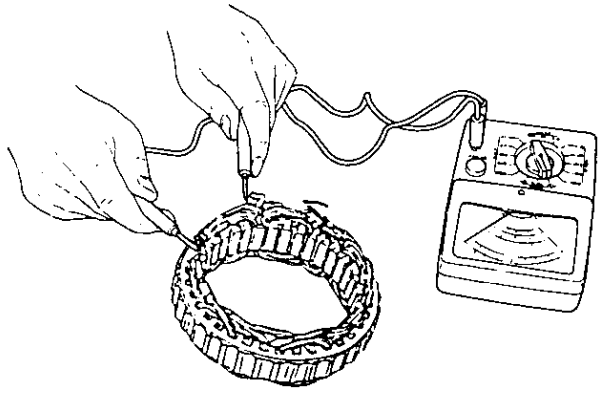
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



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

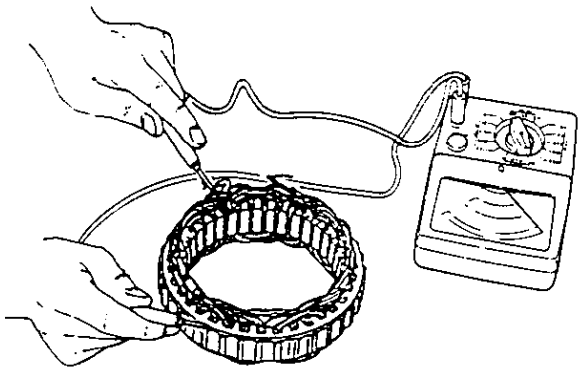


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

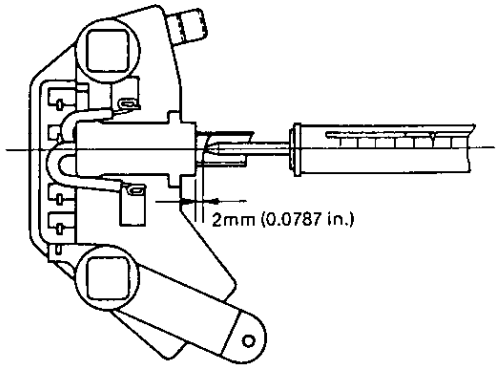


Resistance value	Approx. 0.041Ω at 20° C u, v-phase resistance
	Approx. 0.036Ω at 20° C w-phase resistance

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.

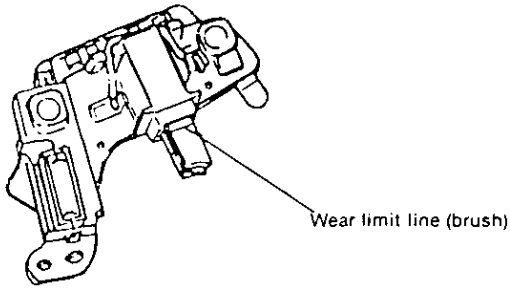


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring. To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



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)

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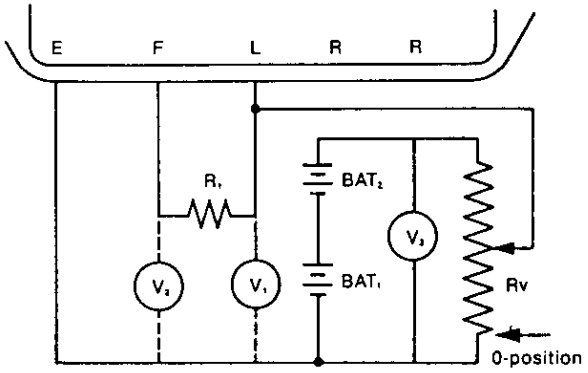
(6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

Resistor (R_1)	100Ω, 2W, 1pc.
Variable resistor (Rv)	0—300Ω, 12W, 1pc.
Battery (BAT_1, BAT_2)	12V, 2pcs.
DC voltmeter	0—30V, 0.5 class 1pc. (measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.
   a) Check V_3 (BAT_1 + BAT_2 voltage). If the voltage is 20—26V, both BAT_1 and BAT_2 are normal.
   b) While measuring V_2 (F-E terminal voltage), move Rv gradually from the 0-position. Check if there is a point where the V_2 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 Rv to the 0-position, and connect the voltmeter to the V_1 position.
   c) While measuring V_1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V_1 rises sharply by 2—6V. Measure the voltage of V_1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V_1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

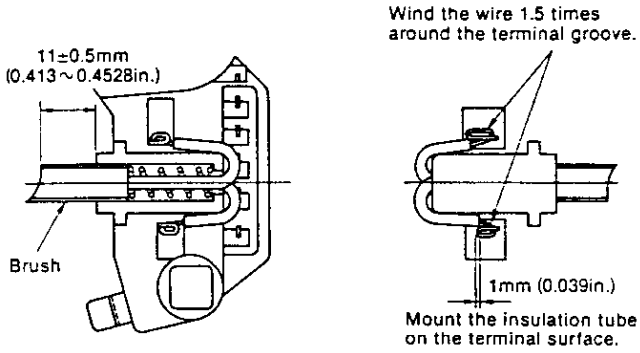


10-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4—7 disassembling alternator).

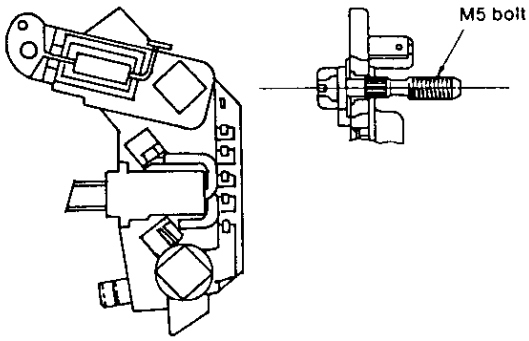
(1) Assembling the brush regulator

1) Solder the brush.
   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).



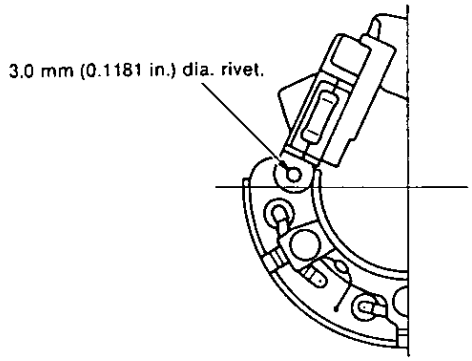
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(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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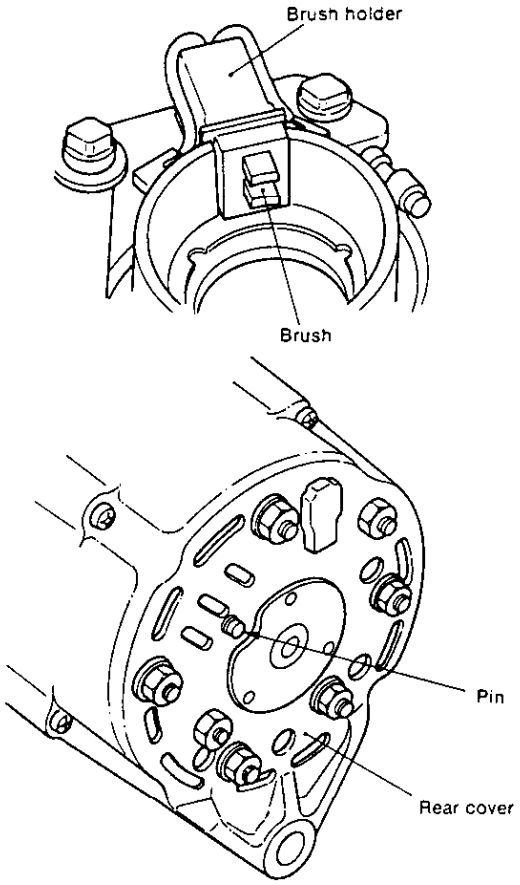
(3) Assembling the rear cover
Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.

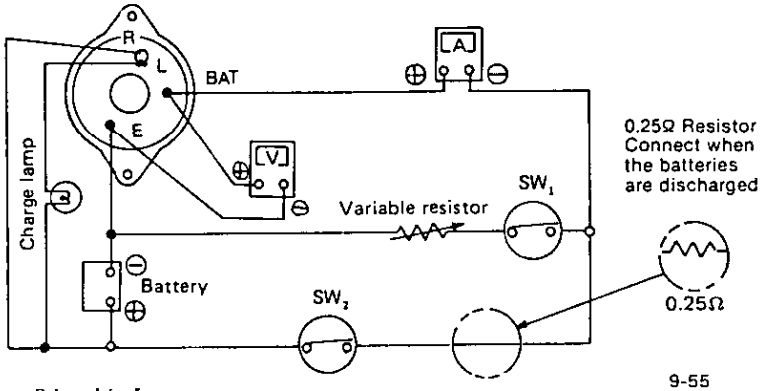


(4) Tightening torques

Positions	Tightening torque kg-cm (ft-lb)
Brush holder fixing	32–40 (2.31~2.89)
Diode fixing	60–70 (4.33~5.05)
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)

10-10 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 SW_2 while keeping SW_1 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 SW_1 open for measurement.

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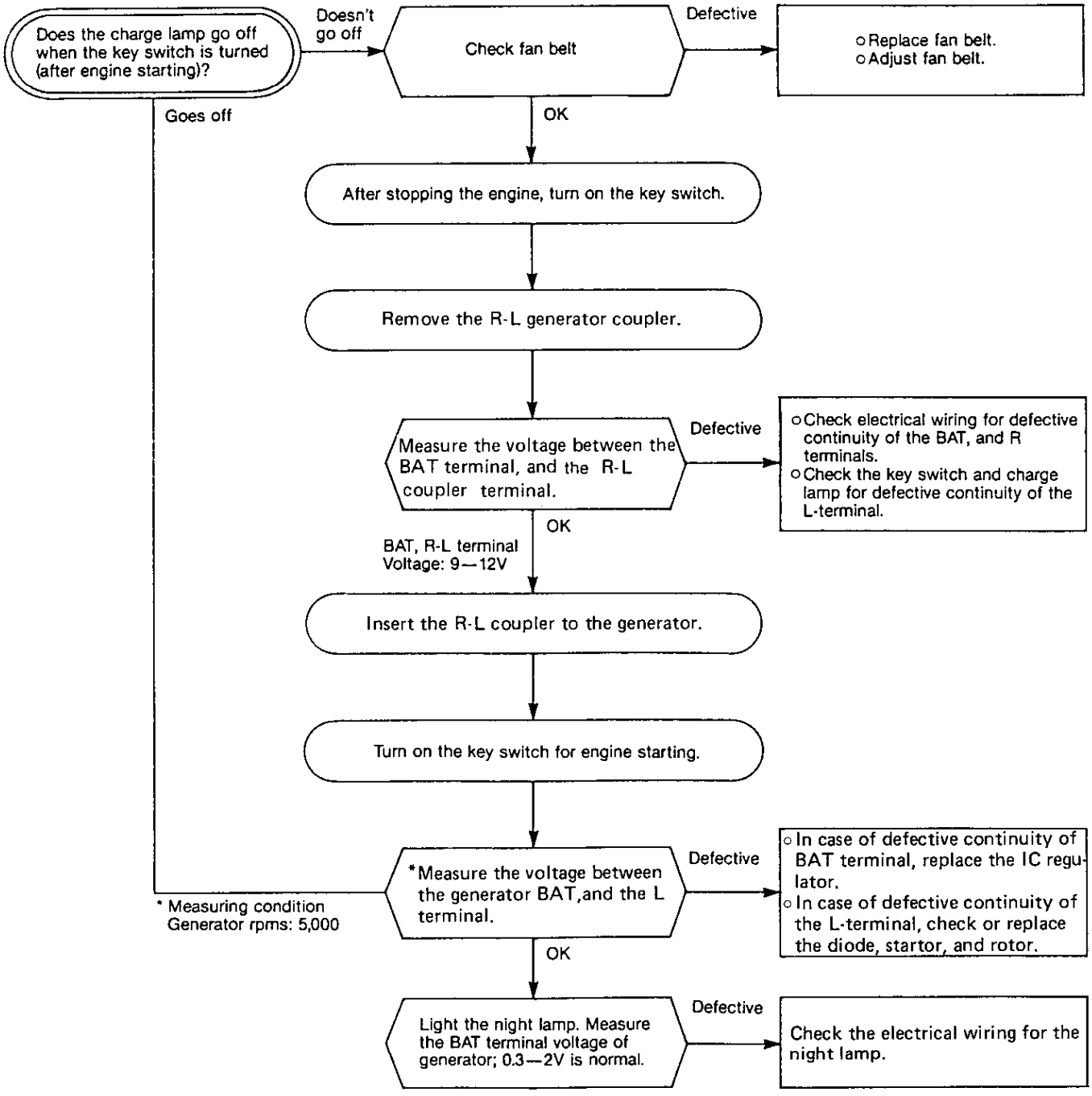
10-11 Troubleshooting

(1) Charging failure



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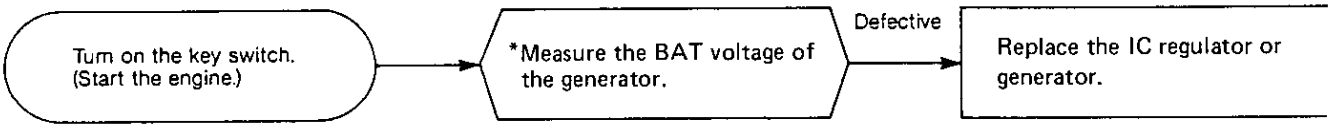
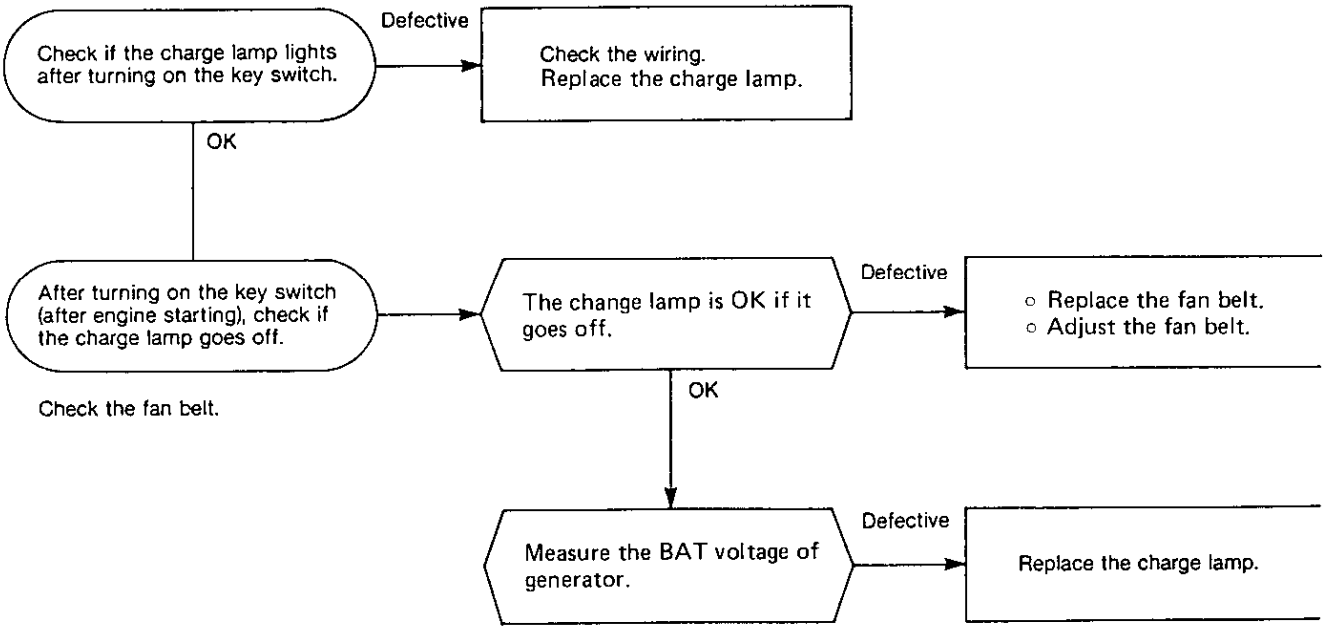
(2) Overcharging



(3) Charge lamp failure



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CHAPTER 10

DISASSEMBLY AND REASSEMBLY

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1. Disassembly and Reassembly Precautions

(1) Disassembly
- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.
- Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare a container(s).
- Drain cooling water (sea water, fresh water) and lube oil.
- Close the Kingston cock.

(2) Reassembly
- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check the oil and thrust clearances, etc. of parts when assembling.
- Make sure you use the correct bolt/nut/washer. Tighten main bolts/nuts to the specified torque. Be especially careful not to overtighten the aluminum alloy part mounting bolts.
- Align match marks (if any) when assembling. Make sure that the correct sets of parts are used for bearings, pistons, and other parts where required.

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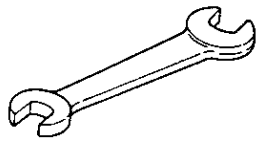
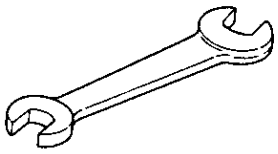
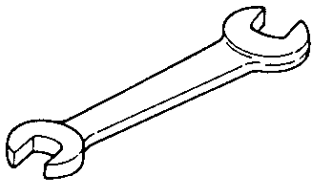
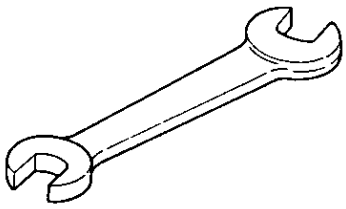
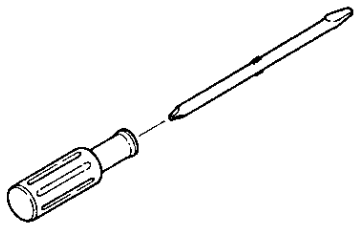
2. Disassembly and Reassembly Tools

The following tools are required when disassembling and reassembling the engine.
Please use them as instructed.

2-1. General Handtools

Name of tool	Illustration	Remarks
Wrench		Size: 10 × 13
Wrench		Size: 12 × 14
Wrench		Size: 17 × 19
Wrench		Size: 22 × 24
Screwdriver		
Steel hammer		Local supply

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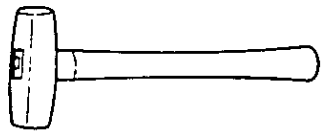
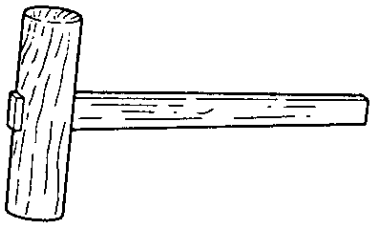
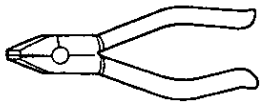
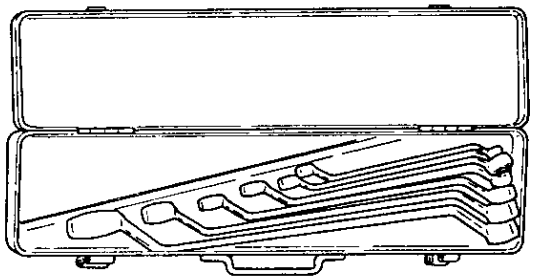
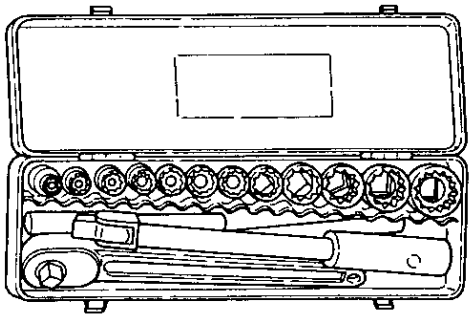
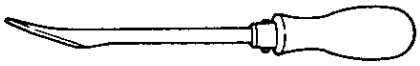
Name of tool	Illustration	Remarks
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set
Scraper		Local supply

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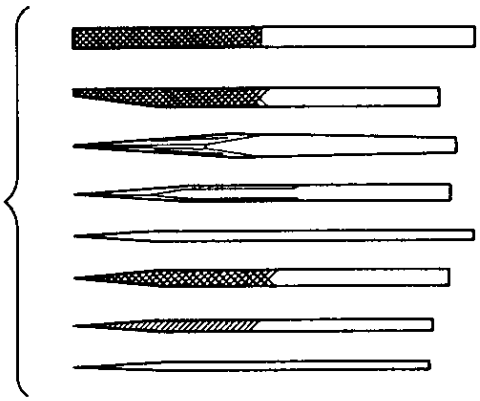
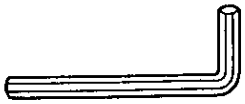
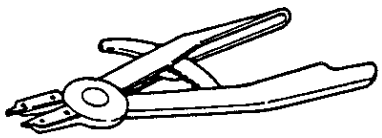
Name of tool	Illustration	Remarks
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size: 6mm (0.2362in.) 8mm (0.3150in.) 10mm (0.3937in.)
Starling Pliers Hole type Shaft type	 S—0  H4 ~ H8 S = Hole type H = Shaft type	Local supply

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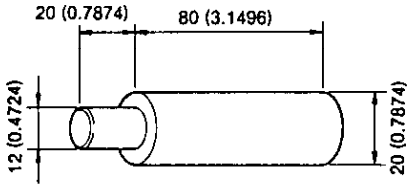
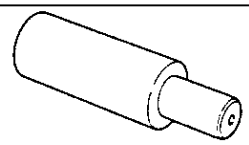
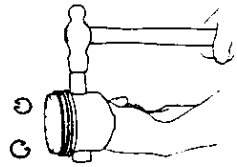
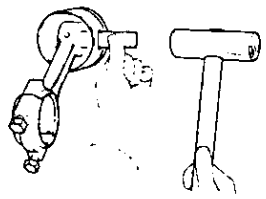
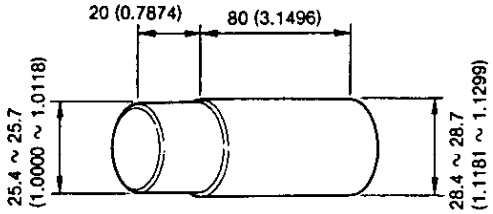
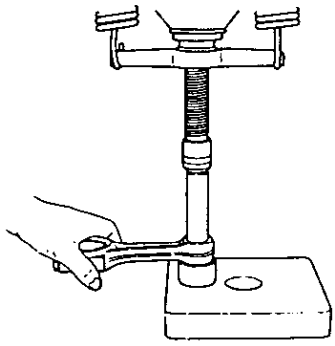
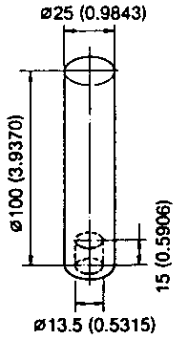
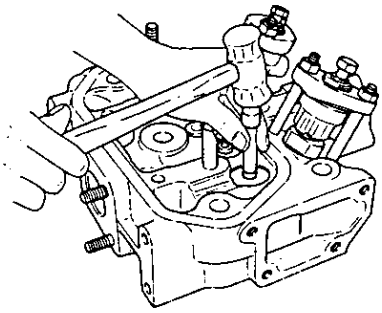
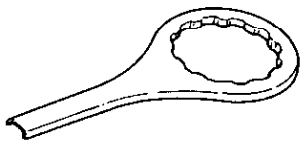
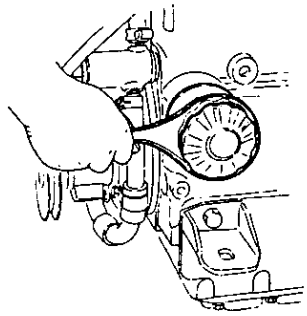
2-2 Special Handtools

Name of tool	Shape and size	Application
Piston pin insertion/ extraction tool	mm (in.)  Part No. 128670-92260	 Piston pin extractor  Extraction of piston pin  Insertion of piston pin
Connecting rod small end bushing insertion/ extraction tool	mm (in.) 	 Extraction
Intake and exhaust valve insertion/ extraction tool	mm (in.) 	
Lubricating oil No.2 filter case remover		

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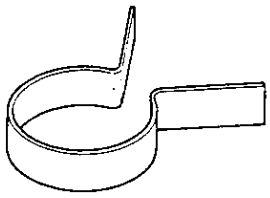
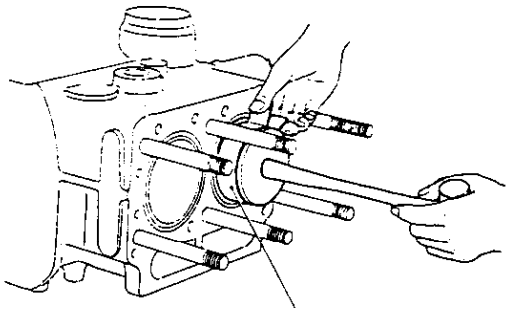
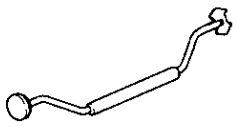
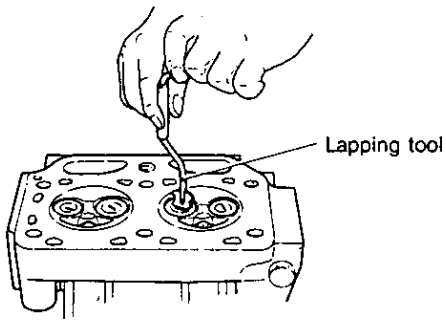
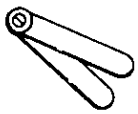
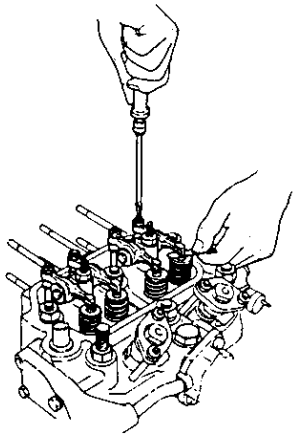
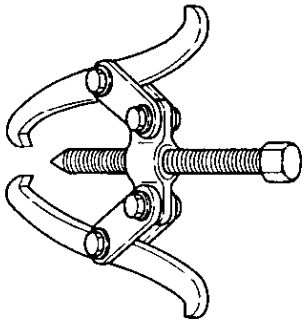
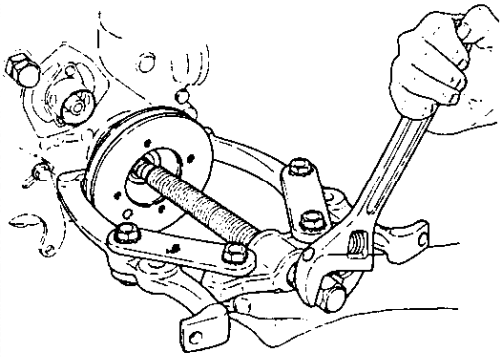
Name of tool	Shape and size	Application
Piston ring compressor		 Piston insertion guide
Valve lapping handle		 Lapping tool
Valve lapping powder		
Feeler gauge		
Pulley puller	 Local supply	 Removing the coupling

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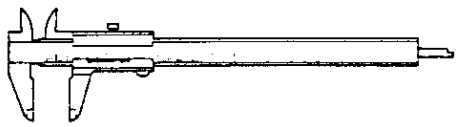
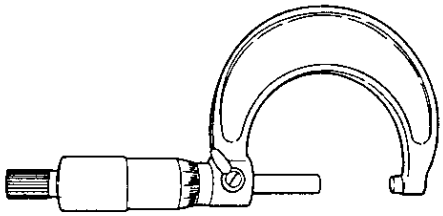
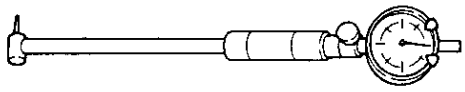
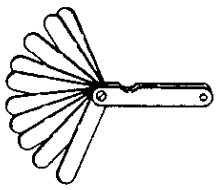
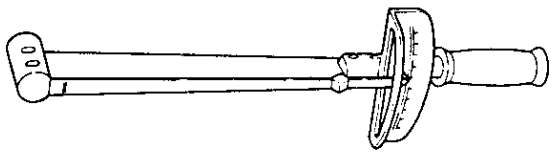
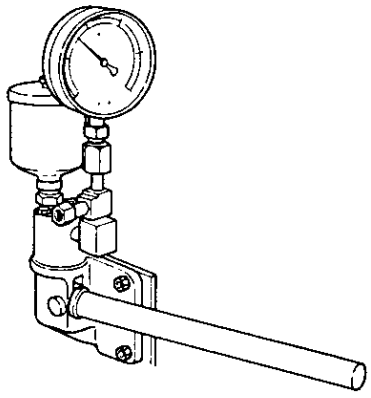
2-3 Measuring Instruments

Name of tool	Shape and size	Application
Vernier calipers		0.05mm (0.0020in.), 0 ~ 150mm (0 ~ 5.9055in.)
Micrometer		0.01mm (0.0004in.) 0 ~ 25mm (0 ~ 0.9843in.), 25 ~ 50mm (0.9843 ~ 1.9685in.), 50 ~ 75mm (1.9685 ~ 2.9528in.), 75 ~ 100mm (2.9528 ~ 3.9370in.), 100 ~ 125mm (3.9730 ~ 4.9213in.). 125 ~ 150mm (4.9213 ~ 5.9055in.).
Cylinder gauge		0.01mm (0.0004in.), 18 ~ 35mm (0.7087 ~ 1.3780in.), 35 ~ 60mm (1.3780 ~ 2.3622in.), 50 ~ 100mm (1.9685 ~ 3.9370in.).
Thickiness gauge		0.05 ~ 2mm (0.0020 ~ 0.0787in.)
Torque wrench		0 ~ 13kg-m. (0 ~ 94ft-lb)
Nozzle tester		0 ~ 500kg/cm² (0 ~ 7111.7lb/in.²)

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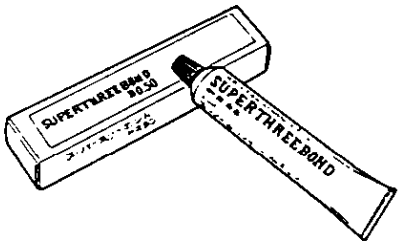
2-4 Other

Supplementary packing agent

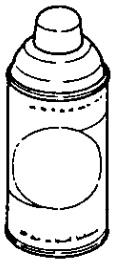


Type	Use
"Three Bond 3B8-005"	White. Since "Three Bond 3B8-005" is a nonorganic solvent, it does not penetrate asbestos sheets made principally or completely of asbestos. Always use it with grey asbestos sheet packing for complete oil tightness. When "Three Bond 3B8-005" is difficult to obtain, use silicon nonsolvent type "Three Bond No. 50."
"Three Bond No. 50"	Grey. Silicon 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

Only Metallic Ecole Silver is used on this engine.

Wipe 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.

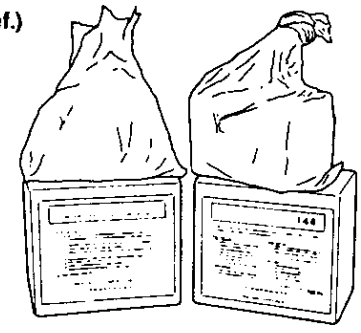
Paint

Type
White paint
(Mixed oil paint)

Usage point
Cylinder liner
insertion hole

Use
Paint parts that contact with the cylinder body when inserting the cylinder liner to prevent rusting and water leakage.

Yanmar cleaner (Ref.)



Cooling passage cleaner is mixed 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, refill 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 them 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.

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3. Disassembly and Reassembly

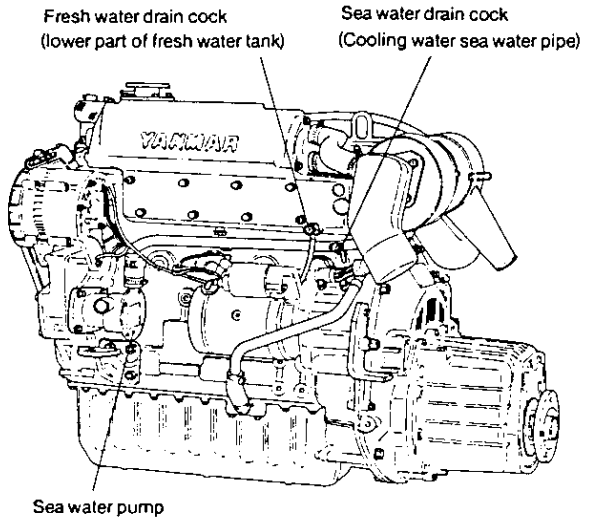
3-1 Disassembly

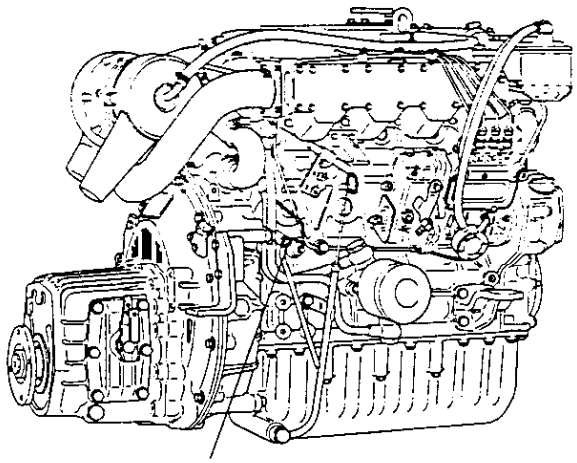
For engines mounted in an engine room, remove the piping and wiring connecting them to the ship.

(1) Remove the remote control cable (from engine and marine gearbox).
(2) Unplug the extension cord for the instrument panel from the engine.
(3) Remove the wiring between the starting motor and the battery.
(4) Remove the exhaust rubber hose from the mixing elbow.
(5) Remove the fresh water sub-tank rubber hose from the filler cap.
(6) Remove the cooling water (sea water) pump sea water intake hose (after making sure the Kingston cock is closed).
(7) Remove the fuel oil intake rubber hose from the fuel feed pump.
(8) Remove the body fit (reamer) bolts and disassemble the propeller shaft coupling and thrust shaft coupling.
(9) If a driven coupling is mounted to the front drive coupling, disassemble.
(10) Remove the flexible mount nut, lift the engine, and remove it from the engine base.
(Leave the flexible mount attached to the engine base.)

3-1.1 Drain cooling water

(1) Open the sea water drain cock between the sea water pump and lube oil cooler to drain the sea water.
(2) Open the cylinder body drain cock to drain the fresh water from the cylinder head and cylinder body.
(3) Open the fresh water drain cock on the lower part of the fresh water tank to drain the fresh water.





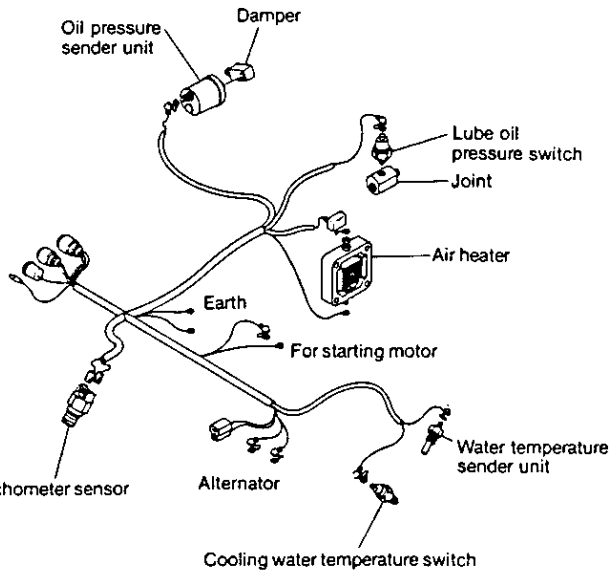
3-1.2 Drain lube oil

(1) Remove the pipe coupling bolt which holds the lube oil dip stick guide, and drain the lube oil from the engine.
(2) Remove the drain plug on the lower part of the crank case control side, and drain the lube oil from the marine gearbox.

NOTE: If a lube oil supply/discharge pump is used for the engine, the intake hose is placed in the dip stick guide, and for the clutch side (gearbox) it is placed in the oil hole on top of the case.

3-1.3 Removing (electrical) wiring

Remove the wiring from the engine.



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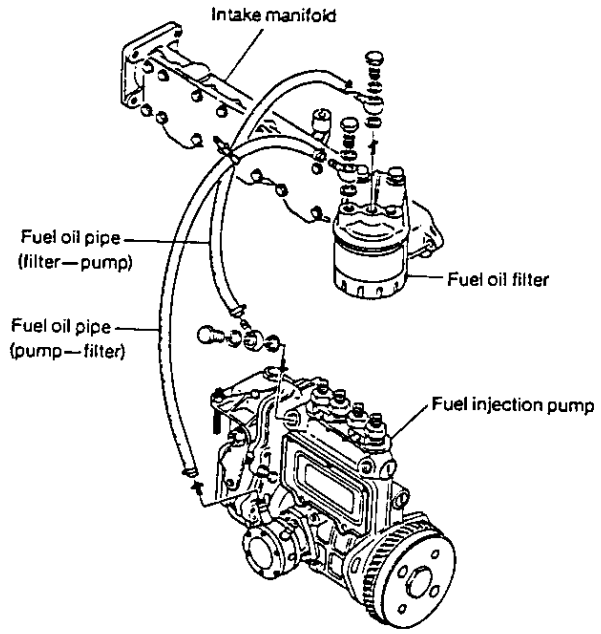
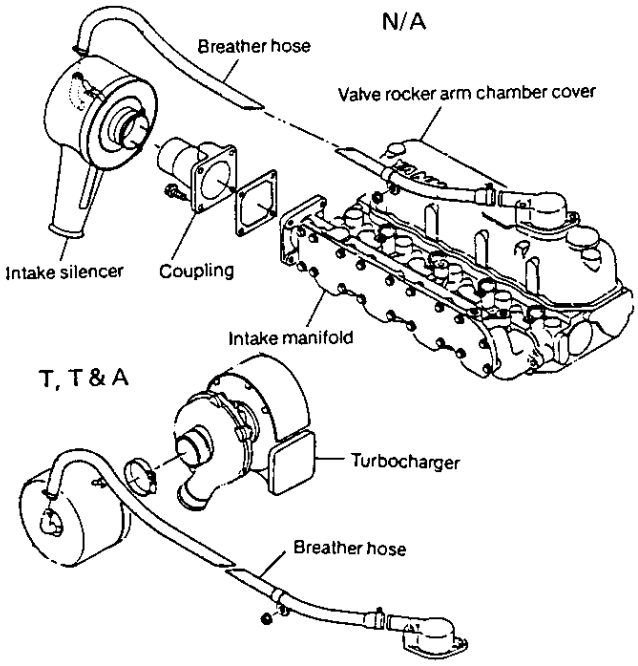
3-1.4 Removing the fuel oil filter & fuel oil pipe

(1) Remove the fuel oil pipe (fuel oil filter—fuel feed pump, fuel oil filter—fuel injection pump).
(2) Remove the fuel oil filter (with bracket) from the intake manifold.



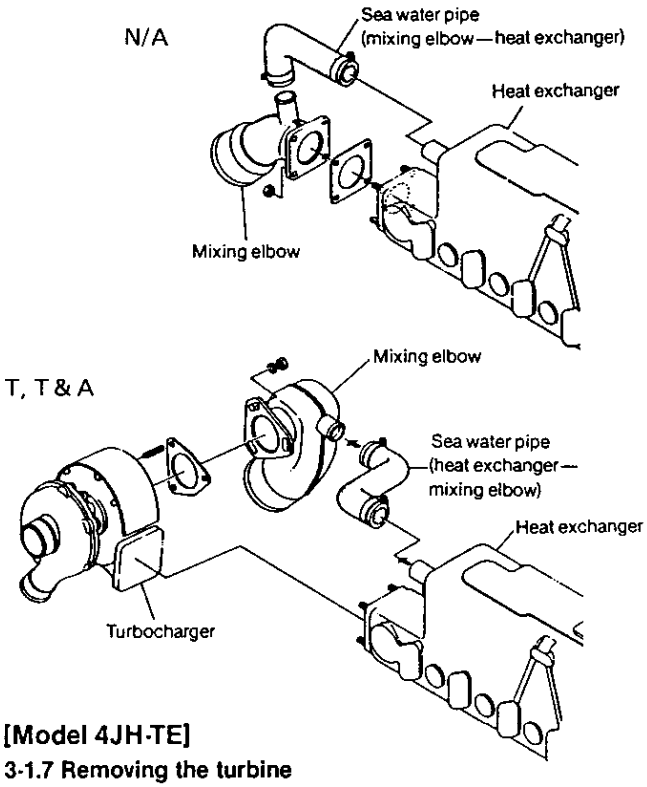
3-1.5 Removing the intake silencer

(1) Remove the breather hose attached to the intake silencer—valve rocker arm chamber cover.
(2) Remove the intake silencer
N/A: from exhaust manifold outlet
T, T & A: from turbocharger outlet



3-1.6 Removing the mixing elbow

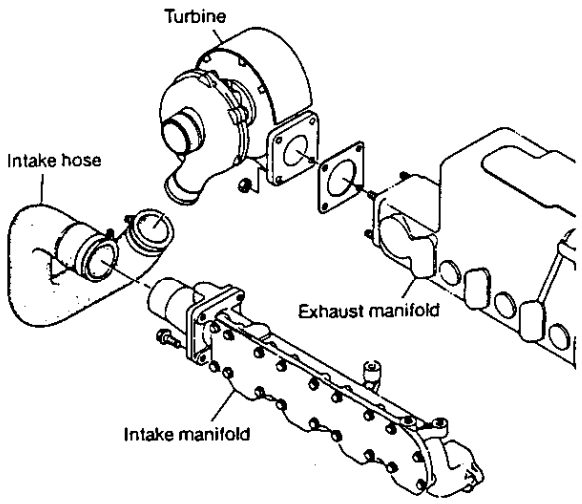
(1) Remove cooling water (sea water) pipe rubber (heat exchanger—mixing elbow).
(2) Remove the mixing elbow
N/A: from the intake manifold intake coupling
T, T & A: from the blower side of the turbocharger



[Model 4JH-TE]

3-1.7 Removing the turbine

(1) Remove the intake rubber hose (turbine—intake manifold).
(2) Remove the oil pan side rubber hose for the turbine lube oil return pipe from the oil pan, and the vibration stop from the flywheel housing.
(3) Remove the turbine lube oil pipe (lube oil cooler—turbine).
(4) Remove the turbine from the exhaust manifold.



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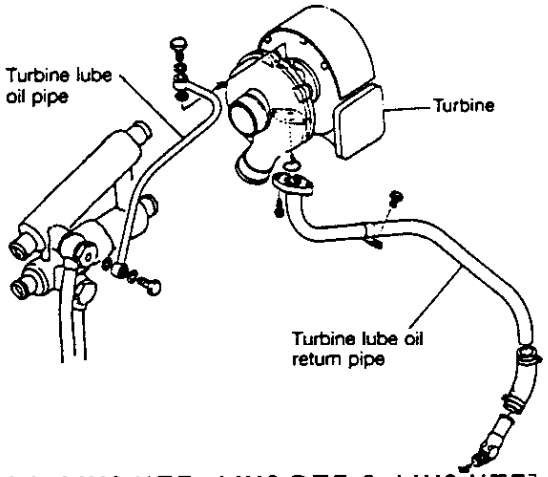
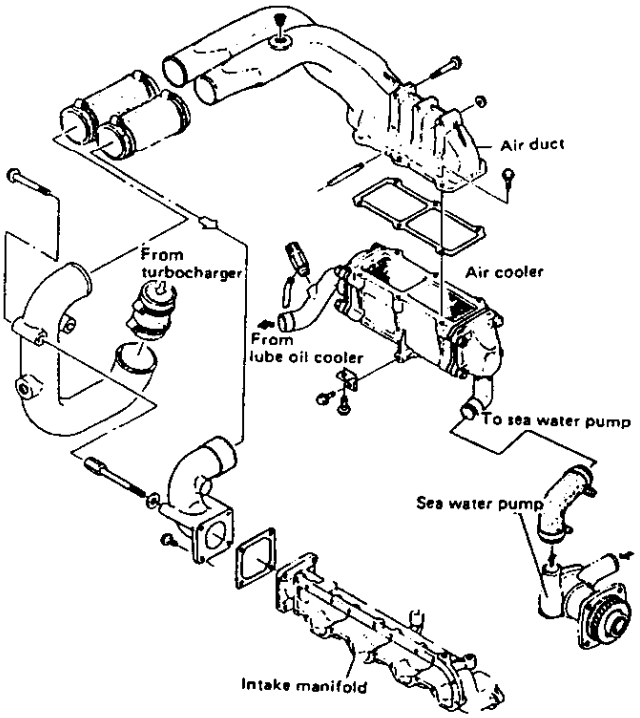


[Model: 4JH2-HTE, 4JH2-DTE & 4JH2-UTE]

Removing the air cooler

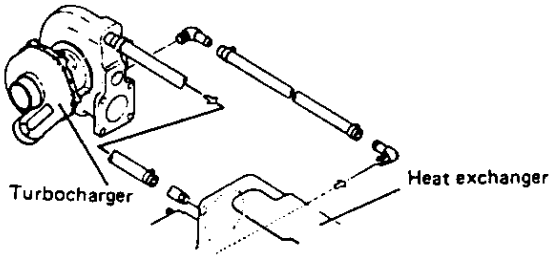
(1) Remove the intake rubber hoses.
(Air duct-intake manifold, and turbocharger)
(2) Remove the sea-water rubber hoses.
(Sea water pump — Air cooler — Lube oil cooler)
(3) Remove the air cooler from the heat exchanger, and cylinder block.

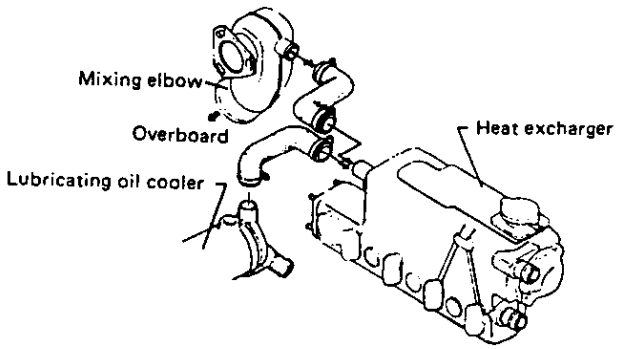
MODEL: 4JH2-HTE & 4JH2-DTE

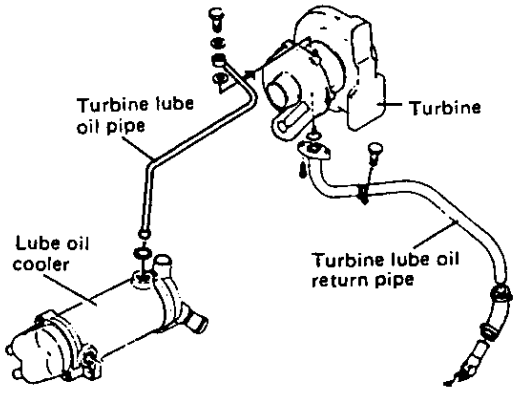


Removing the mixing elbow and the turbocharger.

(1) Remove the fresh water hoses.
(Turbocharger — heat exchanger)
(2) Remove the lube oil pipes.
(Lube oil cooler—Turbocharger—Lube oil pump)
(3) Remove the sea water hose.
(Mixing elbow — heat exchanger)
(4) Remove the mixing elbow from turbocharger.
(5) Remove the air duct rubber hose.
(Air duct — Turbocharger)
(6) Remove the turbocharger from exhaust manifold.







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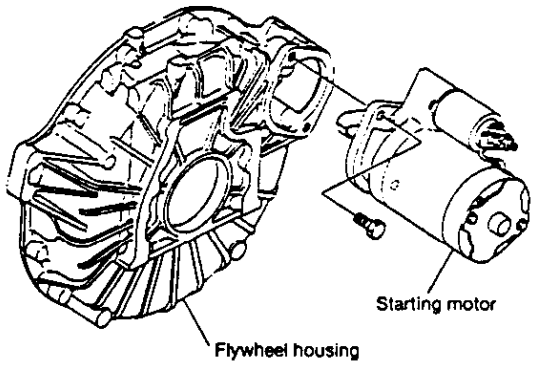
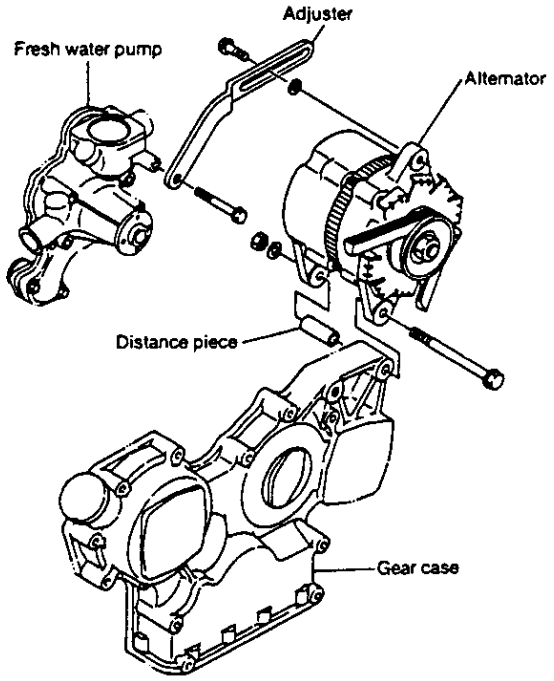
3-1.8 Removing the starting motor

Remove the starting motor from the flywheel housing.



3-1.9 Removing the alternator

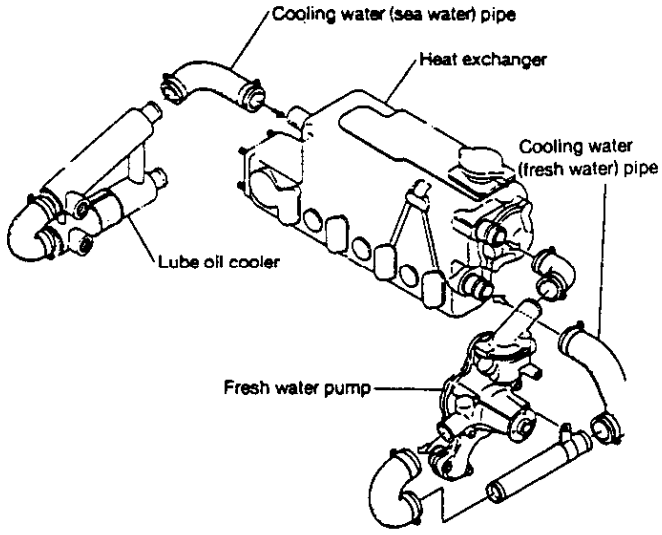
(1) Loosen the alternator adjuster bolt and remove the V-belt.
(2) Remove the adjuster from the fresh water pump, and remove the alternator from the gear case (with distance piece).



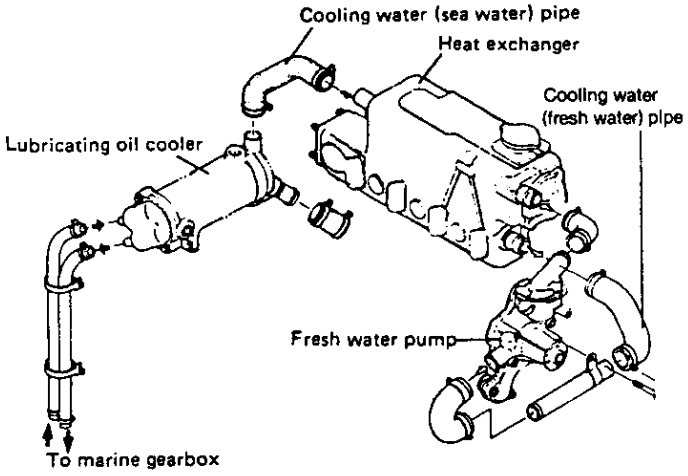
3-1.10 Removing the cooling water pipe

(1) Remove the cooling water (sea water) pipe (lube oil cooler — heat exchanger).
(2) Remove the cooling water (fresh water) pipe (heat exchanger — fresh water pump, fresh water pump — fresh water tank).
(3) Remove the cooling water pipe (lube oil cooler — marine gearbox)

[Model: 4JH2E 4JH2-TE]

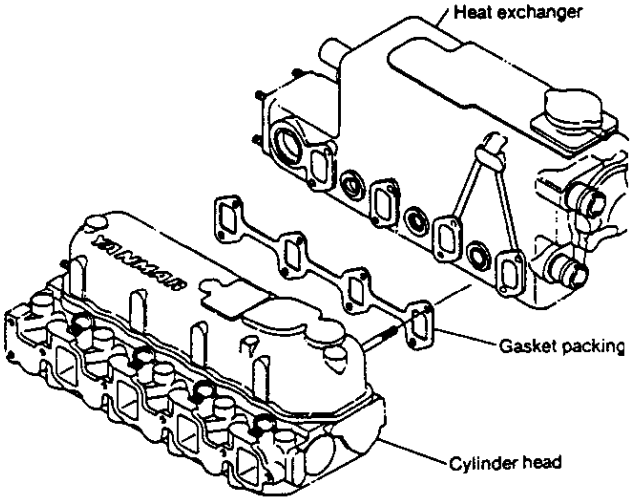


[Model: 4JH2-HTE, 4JH2-DTE, 4JH2-UTE]



3-1.11 Removing the heat exchanger (exhaust manifold, fresh water tank unit)

Remove the heat exchanger and gasket packing.



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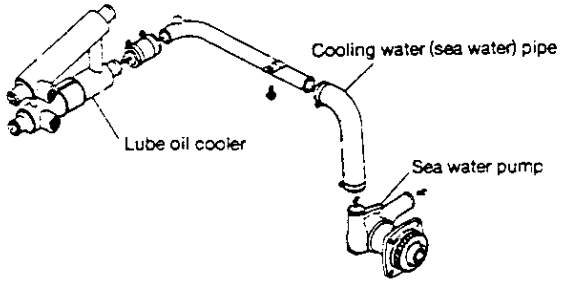
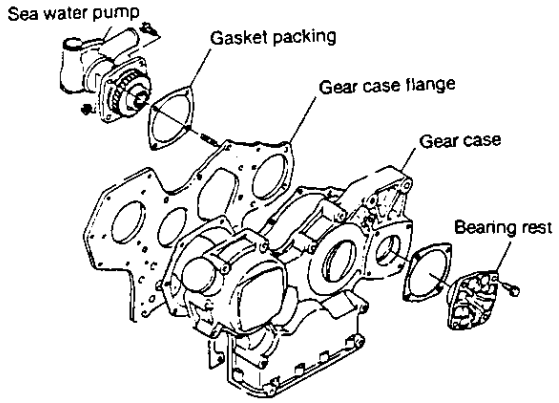
3-1.12 Removing the cooling water (sea water) pipe (sea water pump—lube oil cooler).



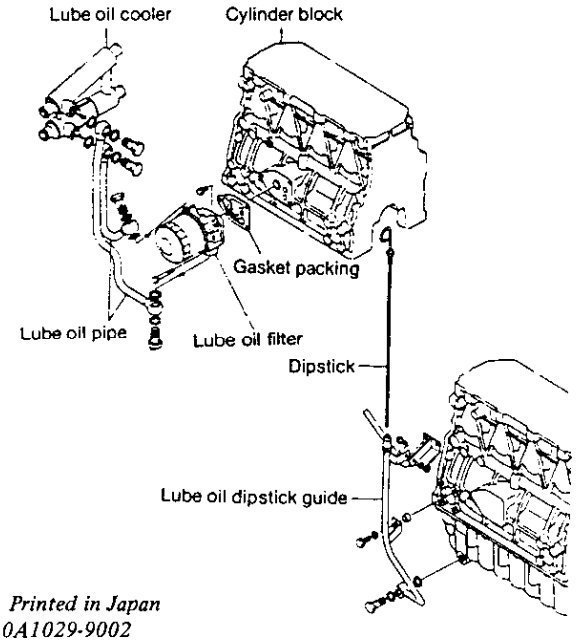
3-1.13 Removing the sea water pump

(1) Pull out the bearing mounts, receptacles from the sea water pump mounting side and from the opposite side of the gear case.
(2) Remove the sea water pump.



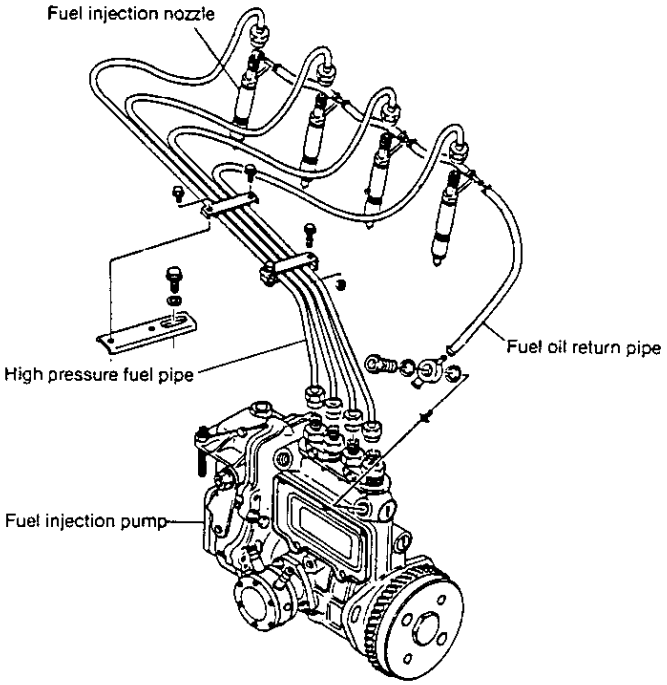
3-1.14 Removing the lube oil filter

(1) Remove the lube oil pipe (lube oil cooler—filter bracket, filter bracket—lube oil cooler).
(2) Remove the filter bracket (with lube oil filter element) from the cylinder block.
(3) Remove the lube oil pipe (cylinder block—fuel injection pump).
(4) Remove the lube oil dipstick and guide.



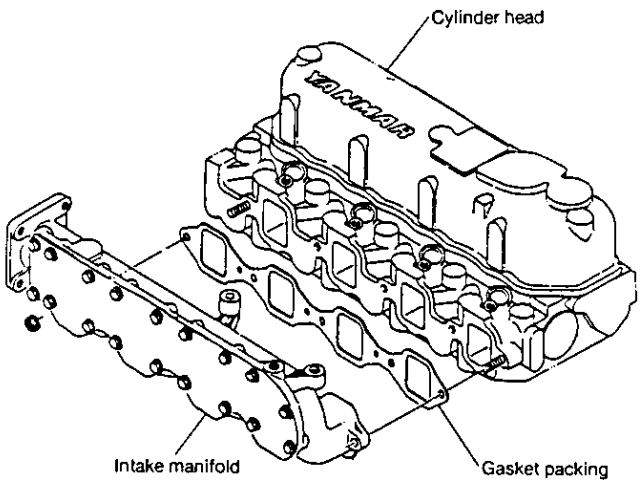
3-1.15 Removing the high pressure fuel pipe

(1) Remove the high pressure fuel pipe vibration stop from the intake manifold.
(2) Loosen the box nuts on both ends of the high pressure fuel pipe and remove the high pressure fuel pipe.
(3) Remove the fuel oil return pipe (fuel injection nozzle—fuel injection pump).



3-1.16 Removing the intake manifold

(1) Remove the governor speed remote control bracket.
(2) Remove the intake manifold and gasket packing.



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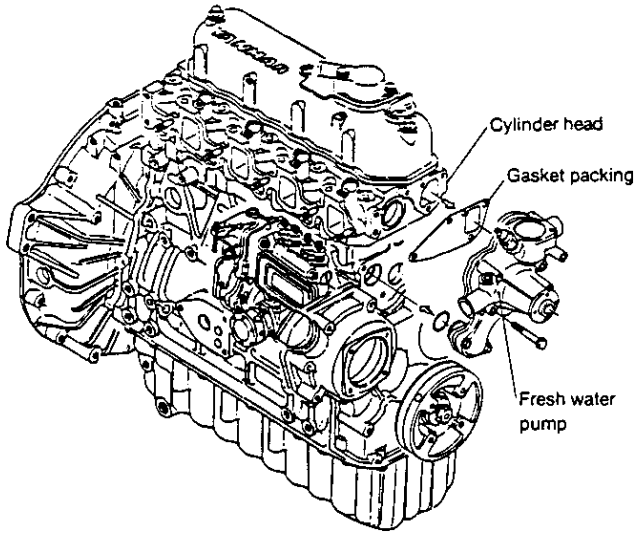
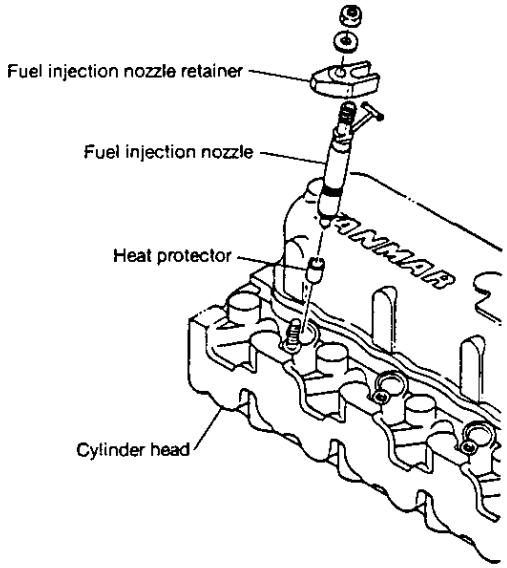
3-1.17 Removing the fresh water pump

Remove the fresh water pump, gasket packing and O-ring.



3-1.18 Removing the fuel injection nozzles

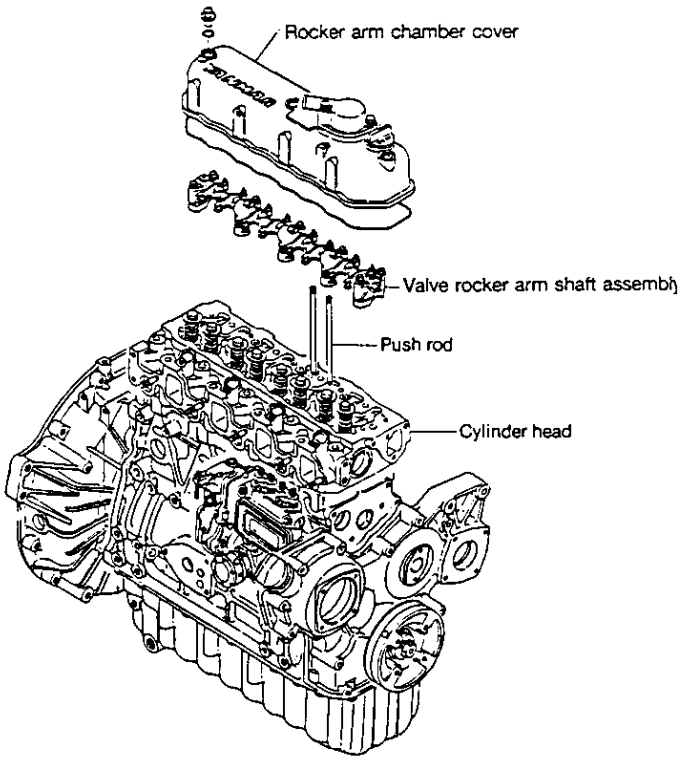
Remove the fuel injection nozzle retainer nut, and pull out the fuel injection nozzle retainer and fuel injection nozzle.



NOTE: If the heat protector stays in the cylinder head, make a note of the cylinder no. and be sure to remove it when you disassemble the cylinder head.

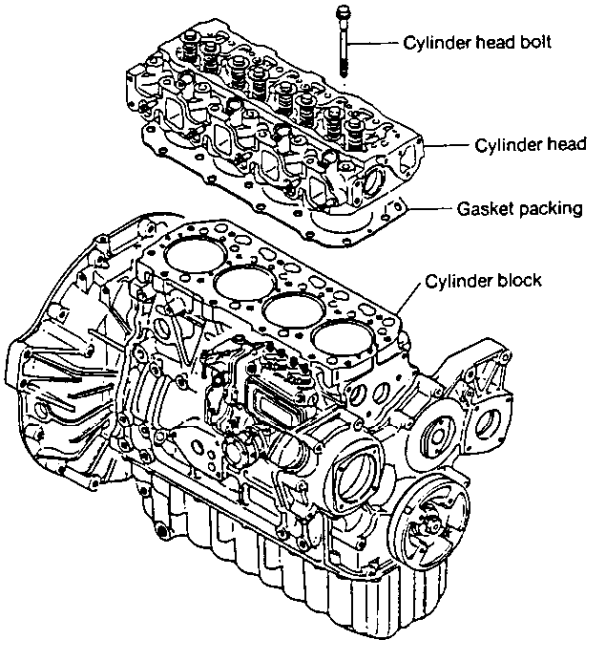
3-1.19 Removing the valve elbow shaft assembly

(1) Remove the valve elbow chamber cover.
(2) Remove the valve elbow shaft support mounting bolts(s), and remove the entire valve elbow shaft assembly.
(3) Pull out the push rods.



3-1.20 Remvoing the cylinder head

(1) Remove the cylinder head bolts with a torque wrench, and remove the cylinder head.
(2) Remove the cylinder gasket packing.



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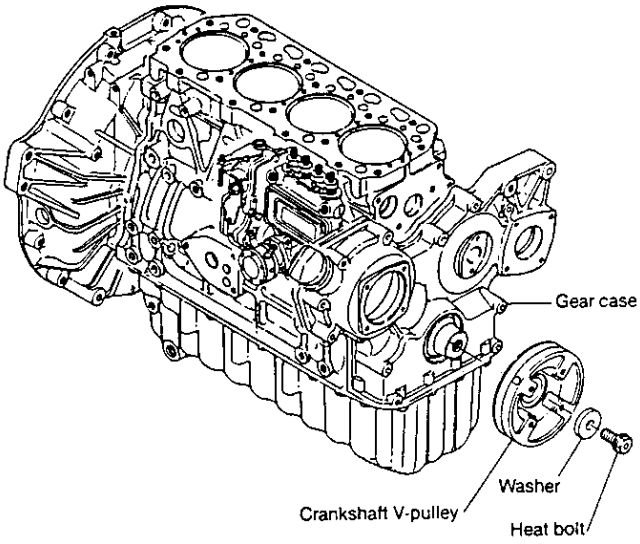
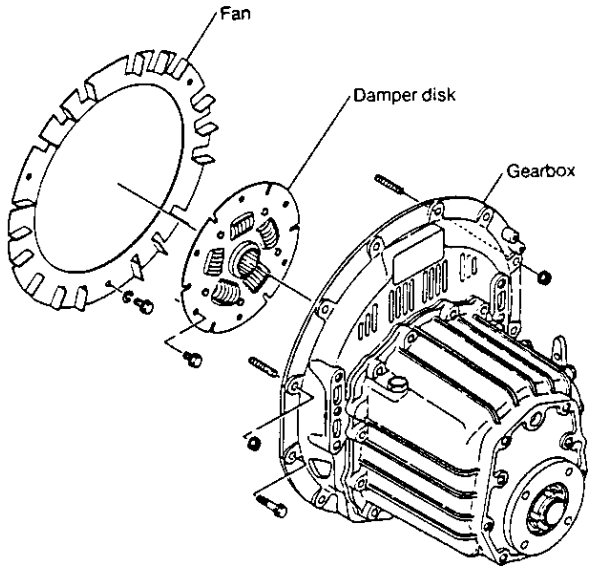
3-1.21 Removing the crankshaft V-pulley

Remove the hex bolts holding the crankshaft V-pulley, and remove the crankshaft V-pulley with an extraction tool.



3-1.22 Removing the marine gearbox

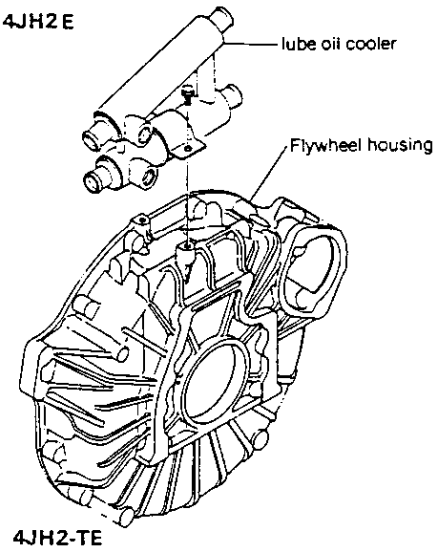
(1) Remove the hex bolts from the clutch case flange, and remove the gearbox assembly.
(2) Remove the damper disk from the flywheel.
(3) Remove the fan from the flywheel.



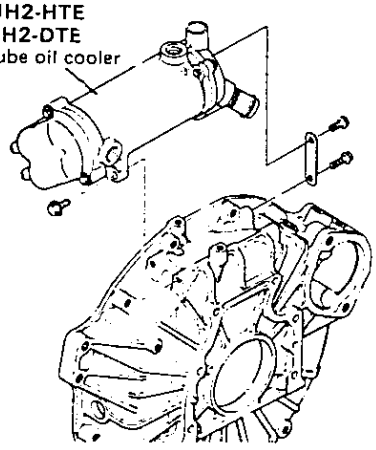
3-1.23 Removing the lube oil cooler

Remove the lube oil cooler from the upper part of the flywheel housing.

MODEL: **4JH2E**

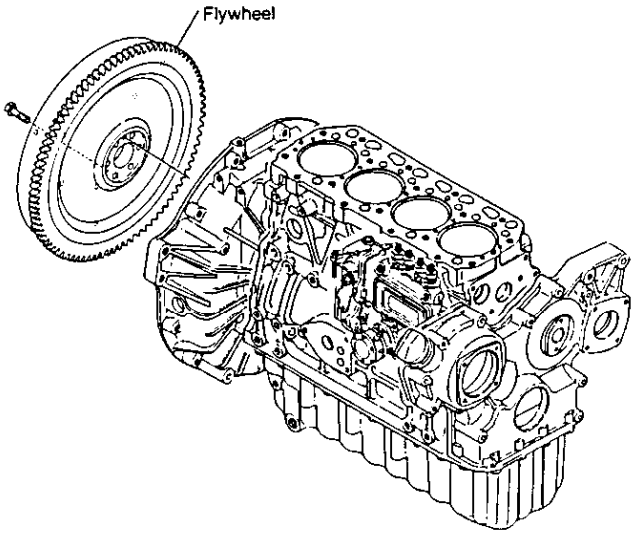


MODEL: **4JH2-TE**
4JH2-HTE
4JH2-DTE



3-1.24 Removing the flywheel

Remove the flywheel mounting bolts and then the flywheel.



NOTE: Be careful not to scratch the ring gear.

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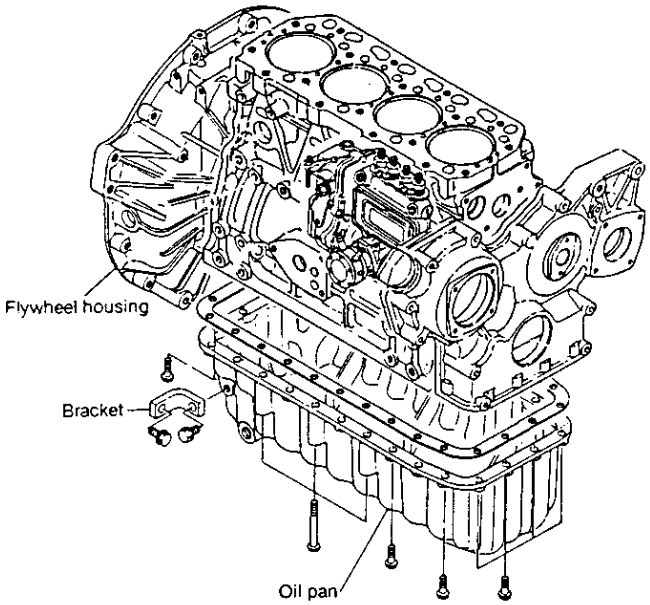
3-1.25 Turning the engine over

(1) Place a wood block of appropriate size on the floor, and stand up the engine on the flywheel housing.
(2) Remove the engine mounting feet.

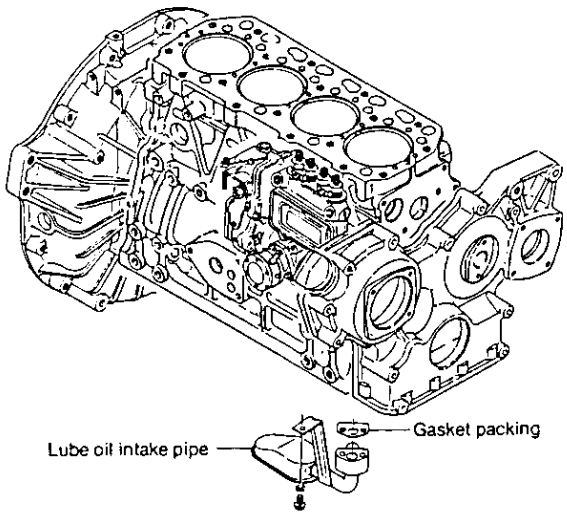
3-1.26 Removing the oil pan

(1) Remove the bracket holding the oil pan and clutch housing.
(2) Remove the oil pan and gasket packing.



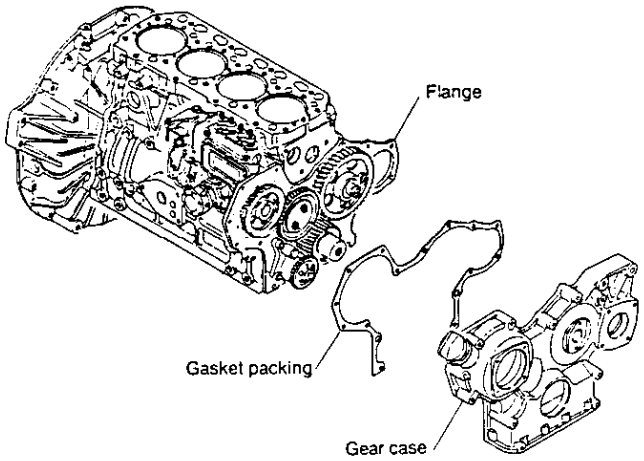
3-1.27 Removing the lube oil intake pipe

Remove the lube oil intake pipe and gasket packing.



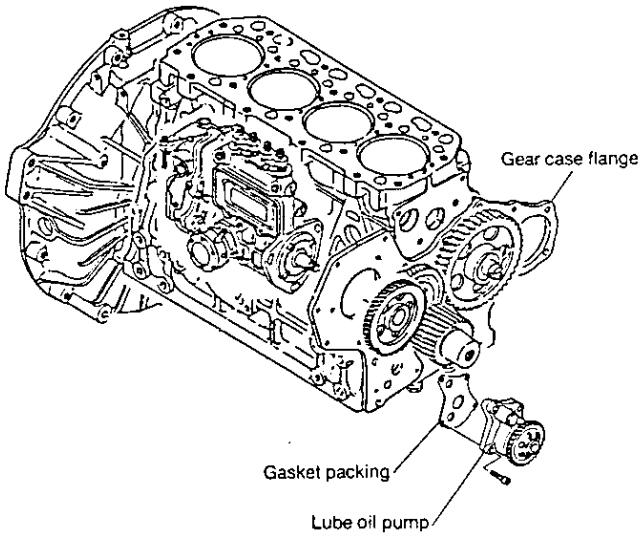
3-1.28 Removing the gear case

Remove the gear case mounting bolts, and remove the gear case from the cylinder block.



3-1.29 Removing the lube oil pump

Remove the lube oil pump and gasket packing from the gear case flange.



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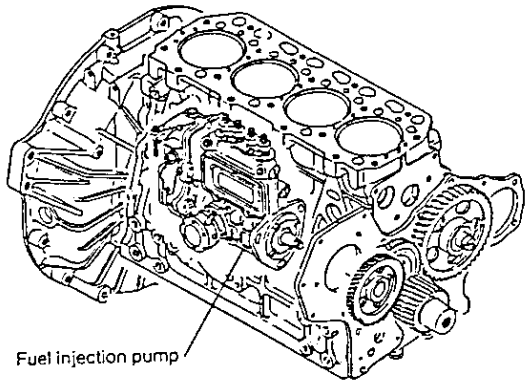
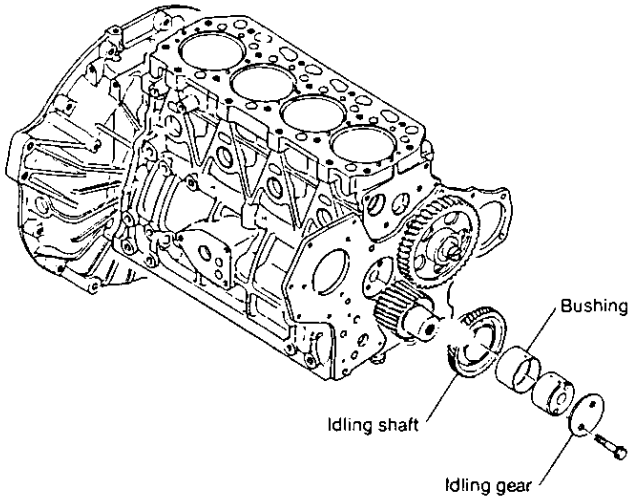
3-1.30 Remove the fuel injection pump

(1) Remove the blind plug mounted to the hub of the automatic advancing timer.
(2) Remove the box nut, and pull out the fuel oil pump drive gear/automatic advancing timer assembly with an extraction tool.
(3) Remove the fuel injection pump and O-ring from the gear case flange.



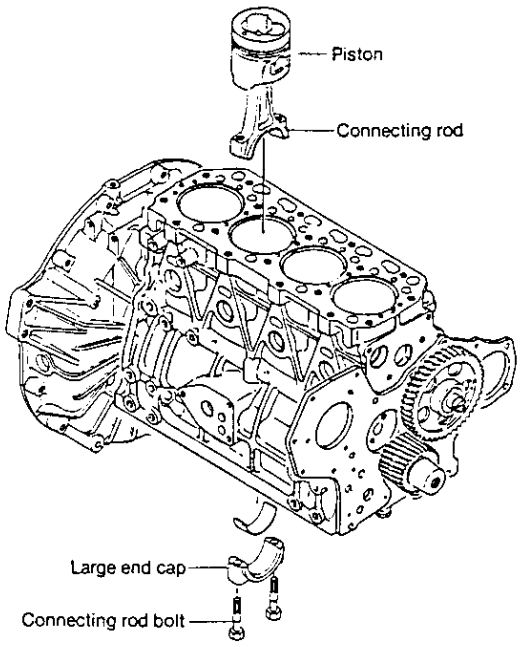
3-1.31 Removing the idling gear

Remove the two hex bolts holding the idling shaft, and pull out the idling gear and idling shaft.



3-1.32 Removing the pistons and connecting rods

(1) Remove the connecting rod bolt and the large end cap.
(2) Push the connecting rod from the bottom and pull out the piston connecting rod assembly.



NOTE: Place a tool against the piston cooling nozzle to make sure the nozzle position does not change and it does not get scratches.

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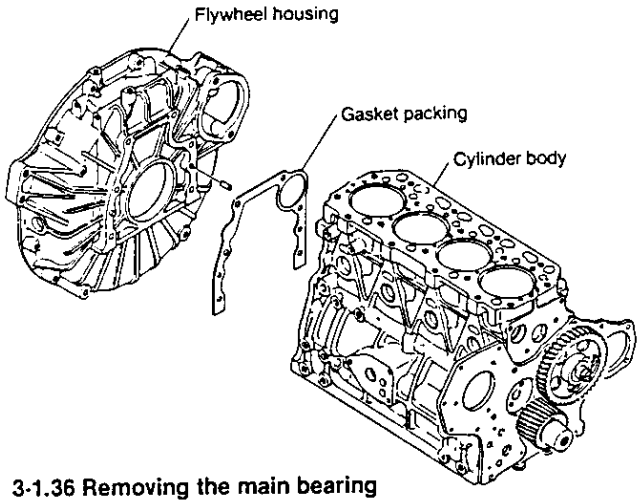
3-1.34 Turning the engine over

Place a wood block of suitable size on the floor and turn the engine over, with the cylinder head mounting surface facing down.

NOTE: Make sure that the cylinder head positioning pins on the cylinder block do not come in contact with the wood block.

3-1.35 Removing the flywheel housing

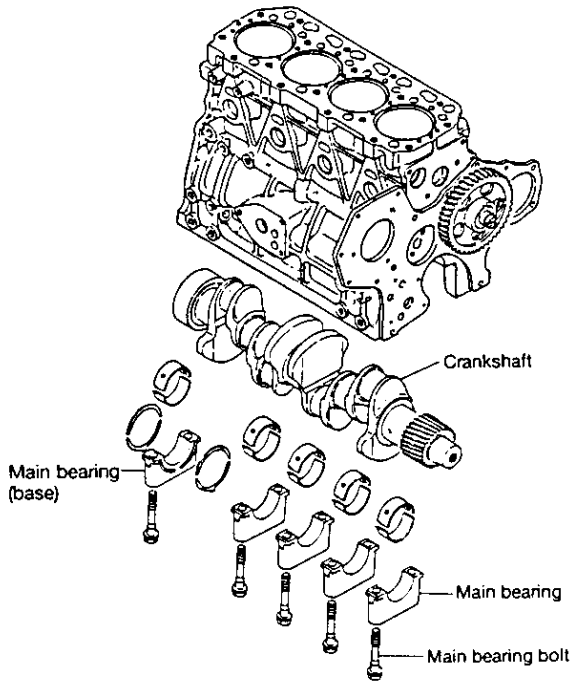
Remove the flywheel housing from the cylinder block.



3-1.36 Removing the main bearing

(1) Remove the main bearing bolts.
(2) Remove the main bearing cap and lower main bearing metal.

NOTE: The thrust metal (lower) is mounted to the standard main bearing cap. Be sure to differentiate between mounting surfaces.



3-1.37 Removing the crankshaft

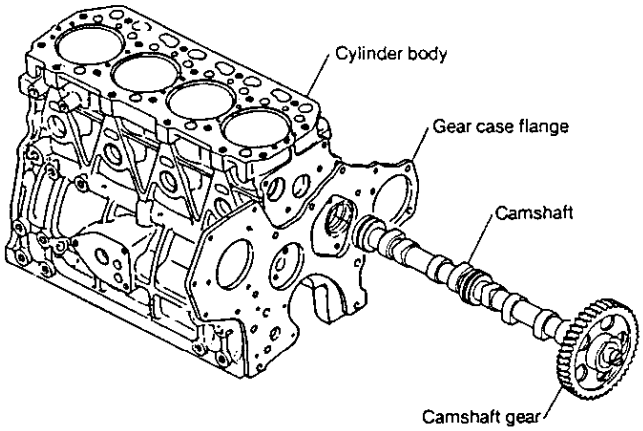
(1) Remove the crankshaft

NOTE: 1. The thrust metal (upper) is mounted to the standard main bearing. However, in some cases the thrust metal (upper) may be mounted to the crankshaft.
2. Remove the main bearing metal (upper) from the cylinder block.

3-1.38 Removing the camshaft

(1) Loosen the thrust rest mounting bolts out of the holes in the camshaft gear, and remove.
(2) Pull out the camshaft gear and camshaft assembly from the cylinder block.

NOTE: The camshaft gear and camshaft are shrunk fit. They must be heated to 180—200°C to disassemble.

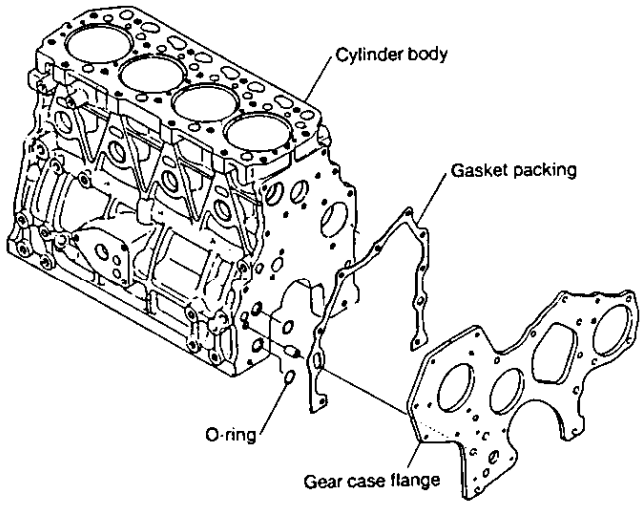


3-1.39 Removing the tappets

Remove the tappets from the tappet holes in the cylinder block.

3-1.40 Removing the gear case flange

(1) Remove the gear case flange from the cylinder block.
(2) Remove the two O-rings from the lube oil passage.



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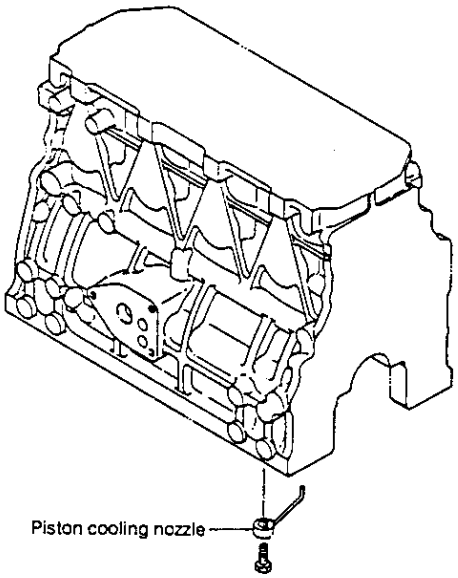
3-1.41 Removing the piston cooling nozzle

Remove the piston cooling nozzle mounting nut and then the piston cooling nozzle from the cylinder block.

3-2 Reassembly

3-2.1 Mounting the piston cooling nozzle

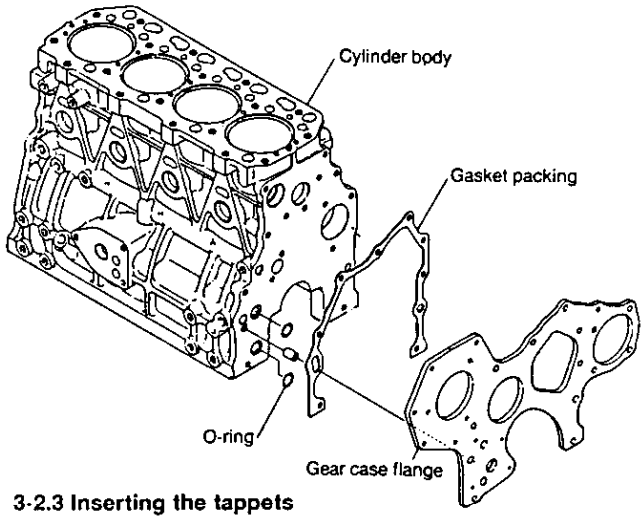
Turn the cylinder block upside down and place it on appropriate wood blocks. Mount the piston cooling nozzles.



3-2.2 Mounting the gear case flange

Mount the gear case flange, gasket packing and lube oil line O-ring onto the cylinder block.

NOTE: 1. When mounting the gear case flange, match up the two cylinder block pipe knock pins.
2. Be sure to coat the cylinder block lube oil line O-ring with grease when assembling, so that it does not get out of place.



3-2.3 Inserting the tappets

Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, and insert the tappets in the cylinder block.

NOTE: Separate the tappets to make sure that they are reassembled in the same cylinder, intake/exhaust manifold as they came from.

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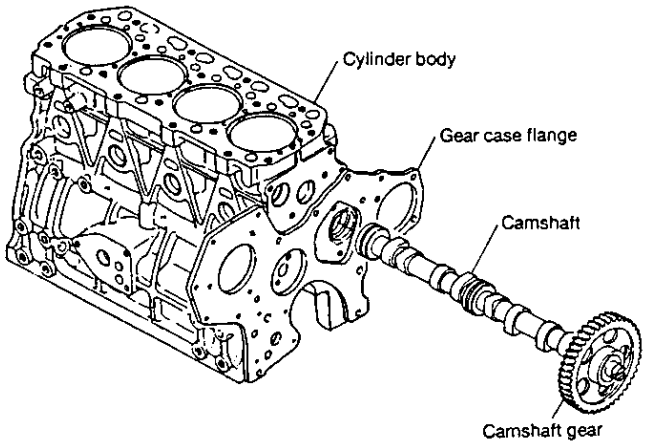
3-2.4 Mounting the camshaft

(1) If the camshaft and camshaft gear have been disassembled, shrink fit the camshaft and camshaft gear [heat the camshaft gear to 180—200°C (356—392°F) in the hot oil and press fit].

NOTE: When mounting the camshaft and camshaft gear, be sure not to forget assembly of the thrust rest. Also make sure they are assembled with the correct orientation.

(2) Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block, and mount the thrust rest with the bolt.



(3) Measure the camshaft side gap.

mm (in.)

Camshaft side gap	0.05 ~ 0.25 (0.0020 ~ 0.0098in.)

(4) Make sure that the camshaft rotates smoothly.

3-2.5 Mounting the crankshaft

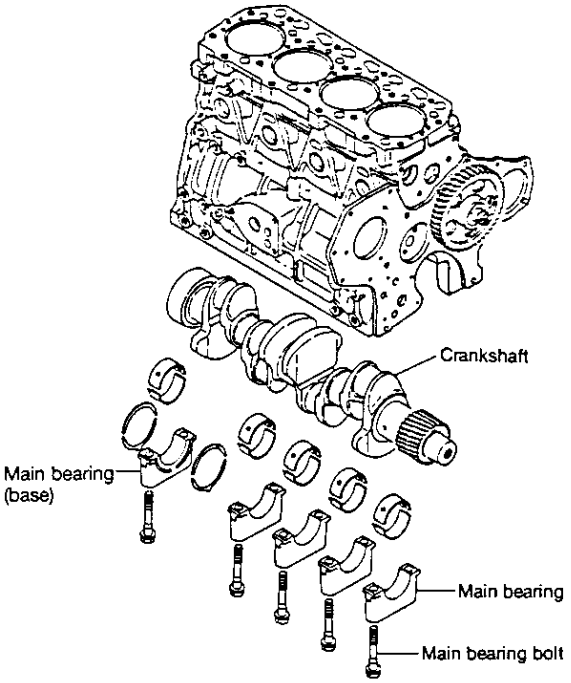
(1) The crankshaft and crankshaft gear are shrink fitted. If the crankshaft and crankshaft gear have been disassembled, they have to be shrink fitted [heat the crank shaft gear to 180°—200°C (356—392°F) in the hot oil and press fit].

(2) Coat the cylinder block crank journal holes and upper part of the main bearing metal with oil and fit the upper main bearing metal onto the cylinder block.

NOTE: 1. Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.
2. When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, (crankshaft side).

(3) Coat the crank pin and crank journal with engine oil and place them on top of the main bearing metal.

NOTE: 1. Align the crankshaft gear and camshaft gear with the "A" match mark.
2 Position so that the crankshaft gear is on the gear case side.
3. Be careful not to let the thrust metal drop.



3-2.6 Mounting the main bearing metal with engine oil, and mounting the main bearing cap.

NOTE: 1. The lower main bearing metal does not have an oil groove.
2. The standard bearing thrust metal is fitted with the oil groove slit facing outwards.

(2) Coat the main bearing cap bolt washer contact surface and threads with engine oil, place them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.

kg-m (ft-lb)

Main bearing bolt tightening torque	9.5 ~ 10.5 (68.7 ~ 75.9)

NOTE: 1. The main bearing cap should be fitted with the arrow near the embossed letters "FW" on the cap pointing towards the flywheel.
2. Make sure you have the correct cylinder alignment no.

(3) Measure the crankshaft side clearance.

mm (in.

Crankshaft side clearance	0.090 ~ 0.271 (0.0035 ~ 0.0107)

(4) Make sure that the crankshaft rotates smoothly and easily.

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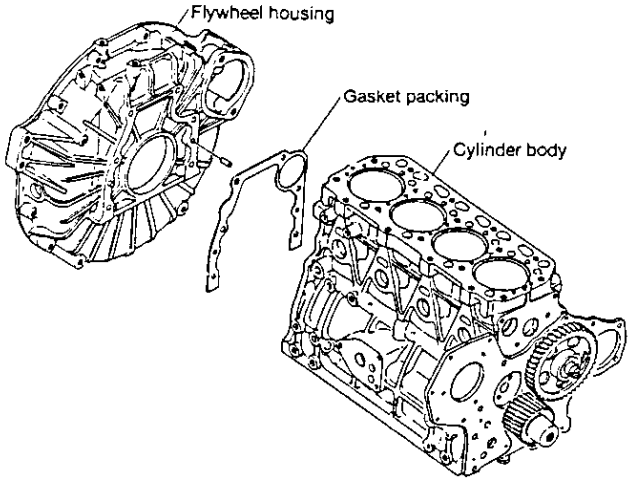
3-2.7 Mounting the flywheel housing

(1) Press fit the oil seal in the flywheel housing, and coat the lip of the oil seal with engine oil.
(2) Mount the flywheel housing and gasket packing, matching them up with the cylinder block positioning pins.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.



3-2.8 Stand up the cylinder block

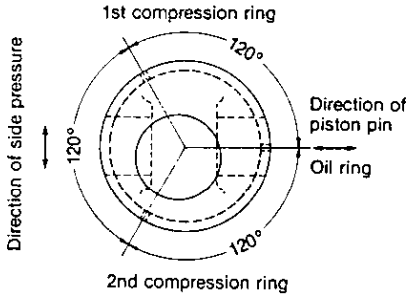
On wood blocks, with the flywheel housing facing down. Take care that the gearbox mounting surface does not get scratched.

3-2.10 Mounting the piston and connecting rod

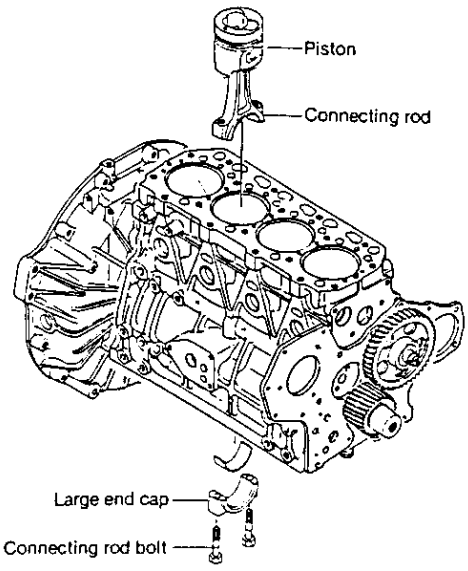
(1) Reassemble the piston and connecting rod.

NOTE: When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.

(2) Each ring opening (piston/oil rings) should be staggered at gaps of 120°.



(3) Coat the outside of the piston and the inside of the connecting rod crank pin metal with engine oil and insert the piston with the piston insertion tool.



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NOTE: 1. Insert the piston so that the match mark on the large end of the connecting rod faces the fuel feed pump, and the manufactuer's mark on the stem points toward the flywheel.
2. After inserting the piston, make sure the combustion chamber hollow is facing the fuel feed pump, looking from the top of the piston.

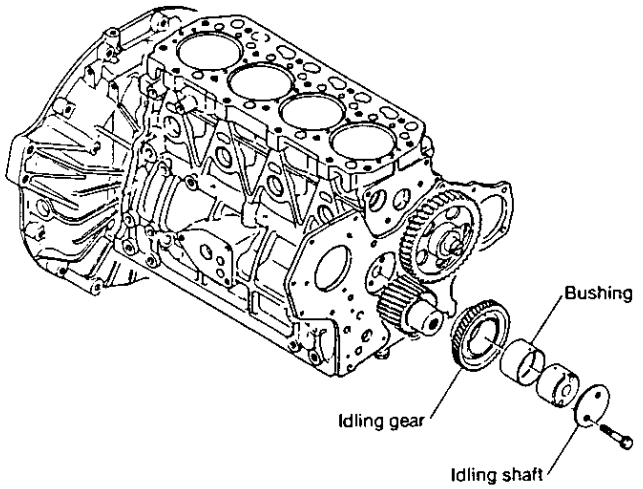
(4) Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

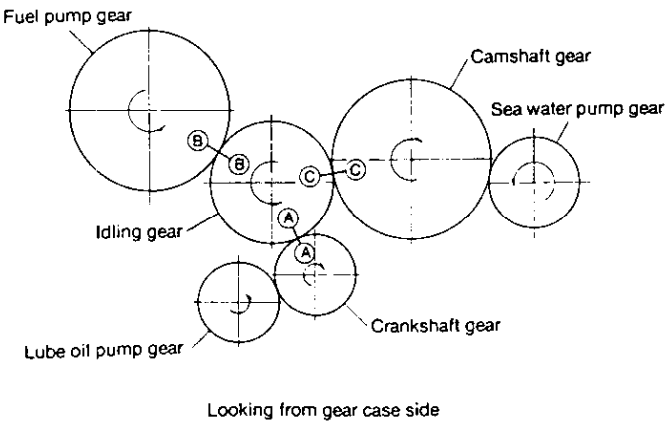
	kg-m (ft-lb)
Connecting rod bolt tightening torque	4.5 ~ 5.0 (32.5 ~ 36.2)

NOTE: If a torque wrench is not available, match up with the mark made before disassembly.

3-2.11 Mounting the idling gear

(1) Fit the idling gear so that the side of the idling shaft with two oil holes faces up.
(2) Align the "A" and "C" camshaft gear and crankshaft gear match marks, match up with idling shaft retaining plate, and tighten the bolts.
(3) Measure the idling gear, camshaft gear and crankshaft gear backlash.



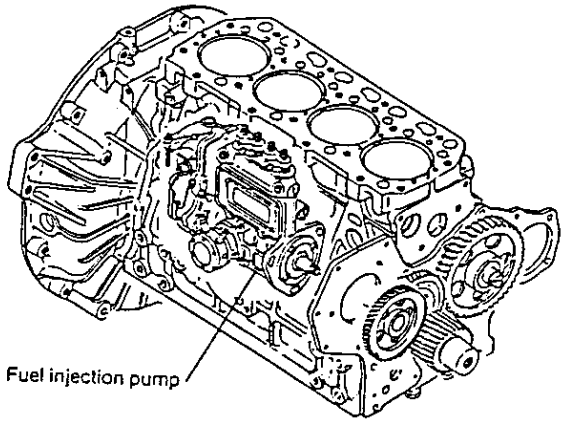


Looking from gear case side

3-2.12 Mounting the fuel injection pump

Lightly fit the fuel injection pump on the gear case.

NOTE: 1. Be careful not to scratch the O-ring between the fuel injection pump and gear case flange.
2. Tighten the fuel injection pump all the way after adjusting injection timing.



3-2.13 Mounting the fuel feed pump drive gear and automatic advancing timer.

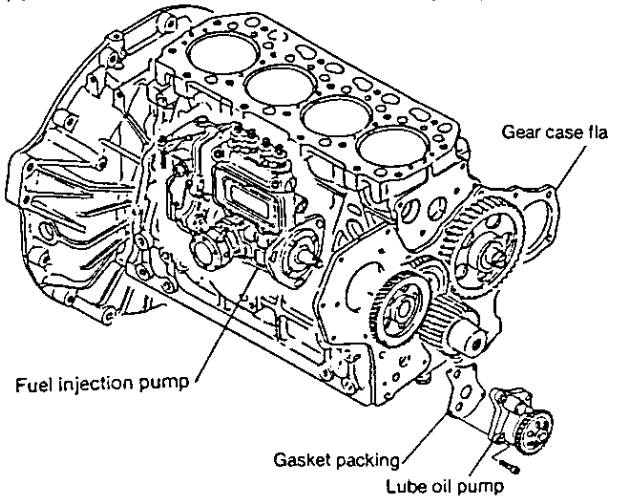
(1) When the drive gear and automatic advancing time have been disassembled, coat all sliding parts in bot assemblies with grease.
(2) Align the "B" match marks on the fuel pump drive gea and idling gear.
(3) Tighten all box nuts holding the fuel feed pump to th specified torque.

	kg-m (ft-l
Box nut tightening torque	6 ~ 7 (43.4 ~ 50.6)

(4) Grease parts around the box nuts (lithium grease) ar tighten the blind plug.
(5) Measure the backlash of the fuel feed pump drive gea

3-2.14 Mounting the lube oil pump

(1) Mount the lube oil pump on the gear case flange.
(2) Measure the backlash of the lube oil pump drive gear.



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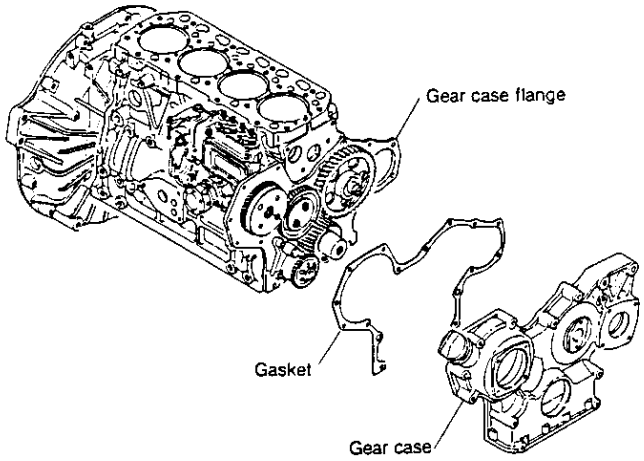
3-2.15 Mounting the gear case

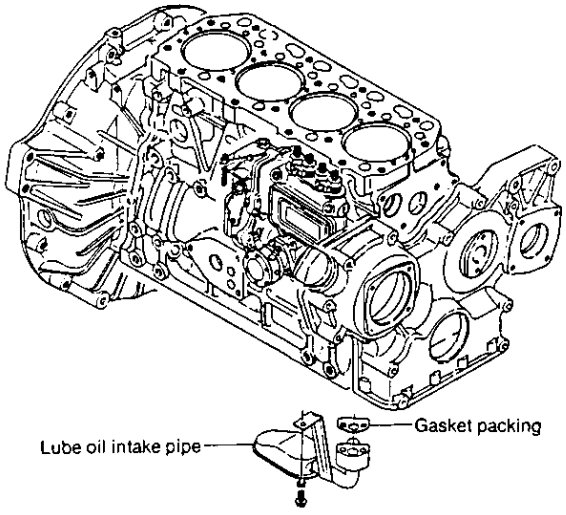
(1) Coat the inside and outside of the oil seals with engine oil, and press fit them into the gear case.
(2) Position the two pipe knock pins, and tighten the bolts holding the gear case and gasket packing.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.



3-2.16 Mounting the lube oil intake pipe

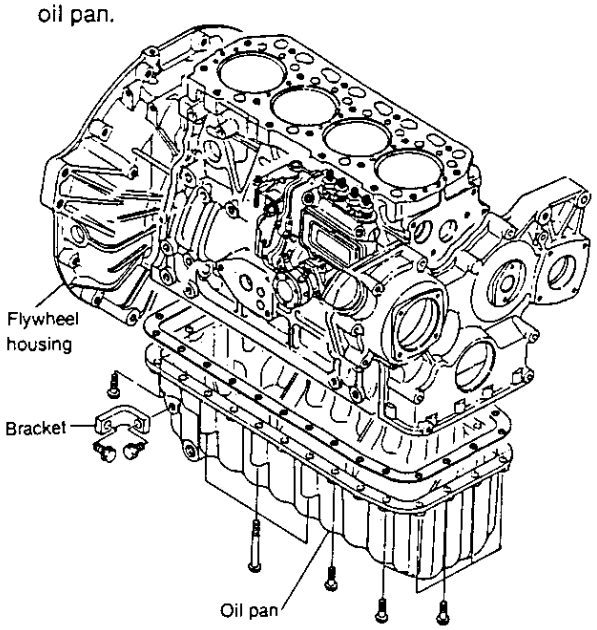
Mount the lube oil intake pipe on the bottom of the cylinder block, using new packing.



	kg-m (ft-lb)
lube oil intake pipe tightening torque	2.6 (18.8)

3-2.17 Mounting the oil pan

(1) Coat with three bond (3B-1114) the surfaces of the gear case, gear case flange and flywheel that contact with the cylinder block.
(2) Tighten the gasket packing/oil pan bolts.
(3) Mount the bracket that connects the flywheel with the oil pan.

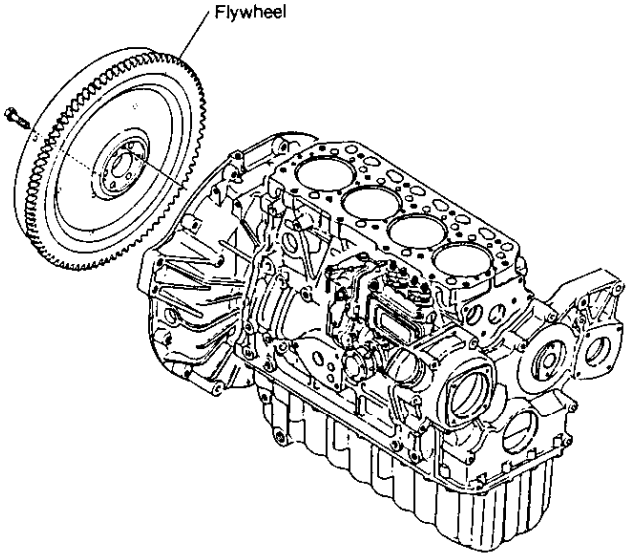


3-2.18 Mounting the engine mounting feet and turning the engine upright.

Place suitable wood blocks below the oil pan and turn the engine upright.

3-2.19 Mounting the flywheel

(1) Coat the flywheel mounting bolt threads with engine oil.
(2) Align the positioning pins, and tighten the flywheel bolts to the specified torque.



	kg-m (ft-lb)
Flywheel mounting bolt tightening torque	7.0 ~ 8.0 (50.6 ~ 57.9)

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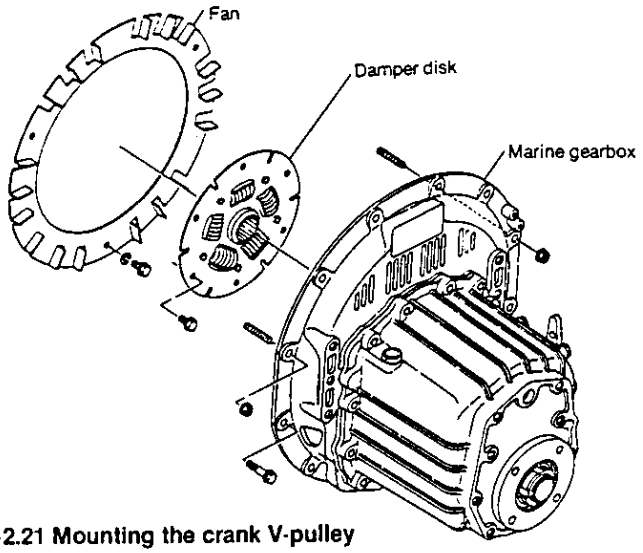
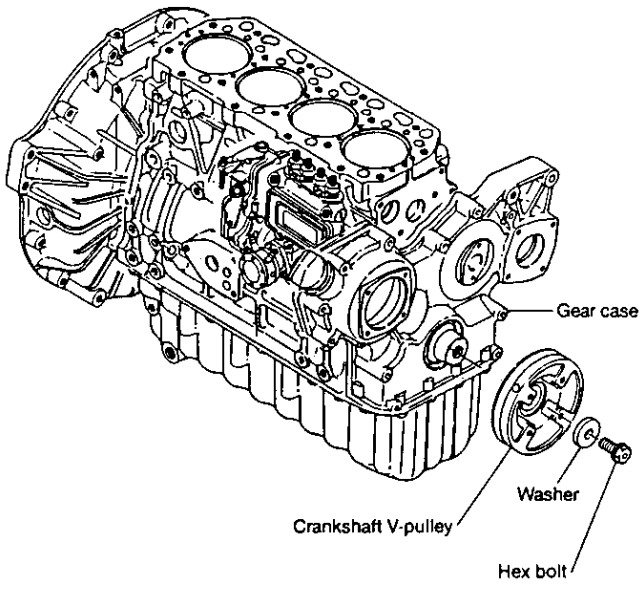
3-2.20 Mounting the marine gearbox

(1) Mount the fan and damper disk to the flywheel.
(2) Align the damper disk with the input shaft spline and insert. Tighten the flywheel housing and flange.



3-2.21 Mounting the crank V-pulley

(1) Coat the oil seal and the section of the shaft with which it comes in contact with oil.
(2) Tighten to the specfied torque.



kg-m (ft-lb)

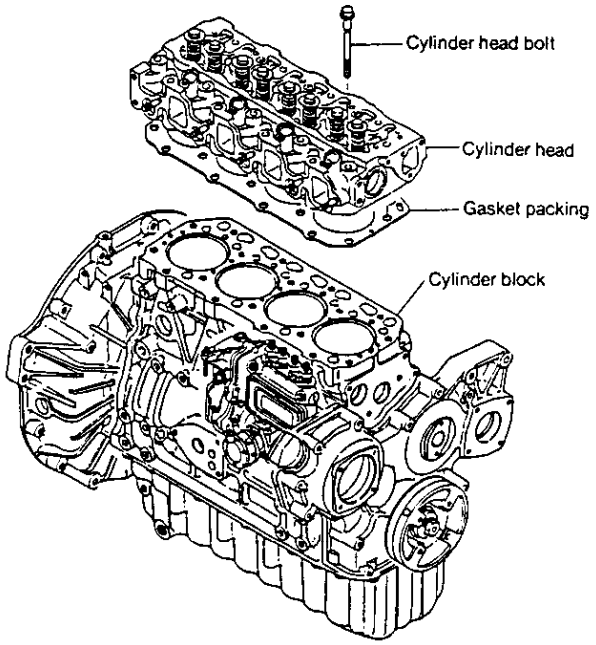
V-pulley tightening torque	11.5 ~ 12.5 (83.2 ~ 90.4)

3-2.22 Mounting the cylinder head

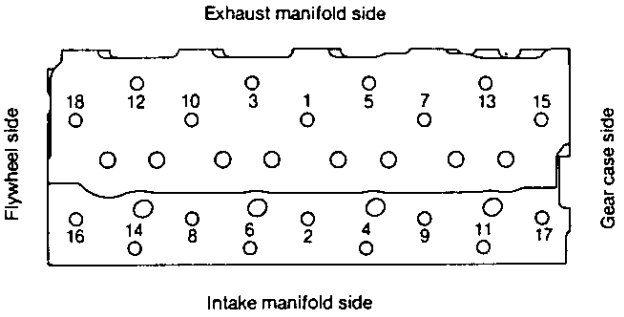
(1) Fit the gasket packing against the cylinder block, aligning it with the cylinder block positioning pins.

NOTE: The side on which the engine model is inscribed should face up (cylinder head side).

(2) Lift the cylinder head horizontally and mount, aligning with the cylinder head gasket.
(3) Coat the mounting bolt washers and threads with engine oil, and lightly tighten the bolts in the specified order. Then tighten completely, in the same order.



Tightening order



kg-m (ft-l

	Partial	Complete
Cylinder bolt tightening torque	3.5 ~ 4.5 (25.3 ~ 32.5)	7.5 ~ 8.5 (54.2 ~ 61.5)

(4) Measure the top clearance.

mm (i

Top clearance	0.71 ~ 0.89 (0.0279 ~ 0.0350)

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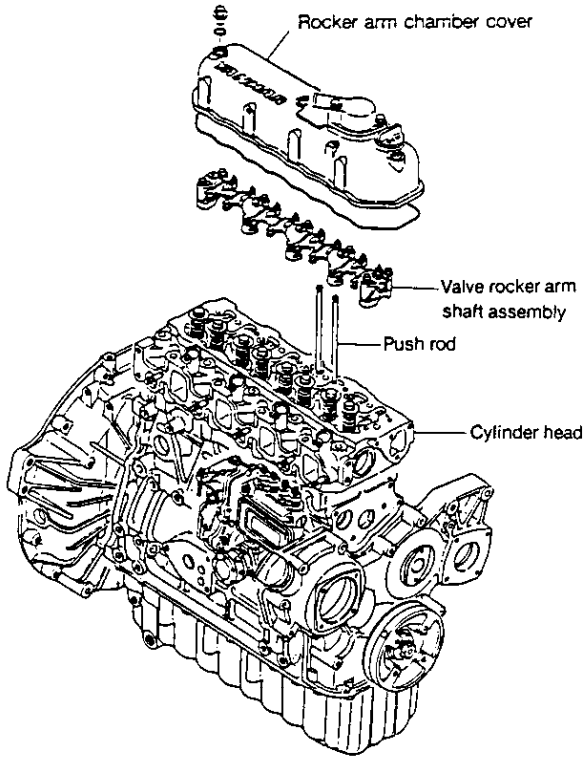
3-2.23 Mounting the valve rocker arm shaft assembly pushrod

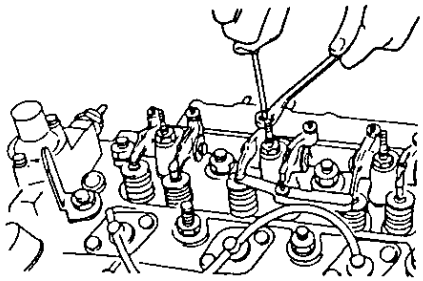
(1) Fit the pushrod to the tappet.
(2) Mount the valve rocker arm shaft assembly.

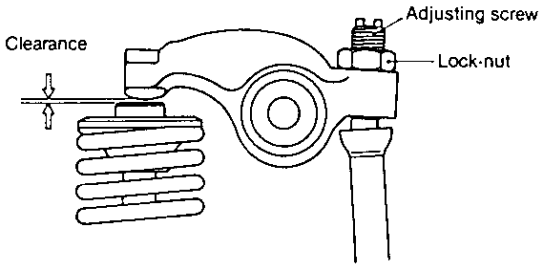
kg-m (ft-lb)

Valve rocker arm shaft support tightening torque	2.4 ~ 2.8 (17.4 ~ 20.4)

(3) Adjust valve clearance.







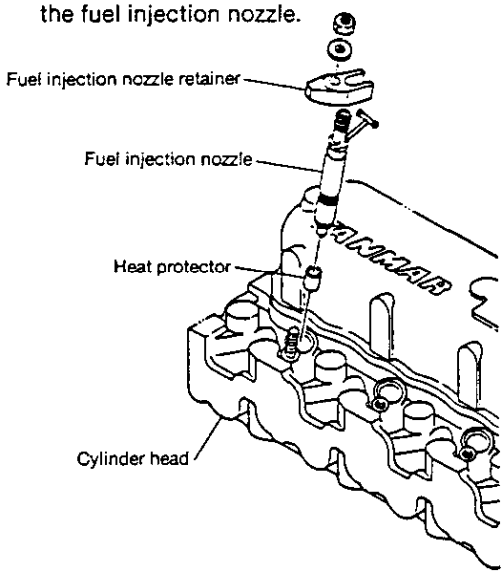
mm (in.)

Intake/discharge valve clearance	0.2 (0.0079)

(4) Coat the valve rocker arm and valve spring with engine oil, and mount the valve rocker arm chamber cover.

3-2.24 Mounting the fuel injection nozzle

(1) Mount the injection nozzle tip heat protector, and then the fuel injection nozzle.



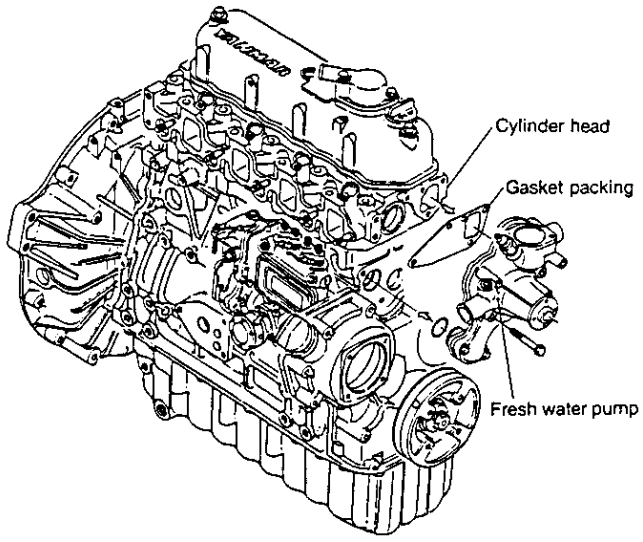
(2) Tighten the fuel injection nozzle retainer nut to the specified torque.

kg-m (ft-lb)

Fuel injection nozzle retainer tightening torque	2.0 ~ 3.0 (14.5 ~ 21.7)

3-2.25 Mounting the fresh water pump

(1) Thoroughly coat both sides of the packing with adhesive.
(2) Replace the O-ring for the connecting pipe which is inserted in the cylinder block, and tighten the fresh water pump to the specified torque.



kg-m (ft-lb)

Fresh water pump tightening torque	0.7 ~ 1.1 (5.0 ~ 8.0)

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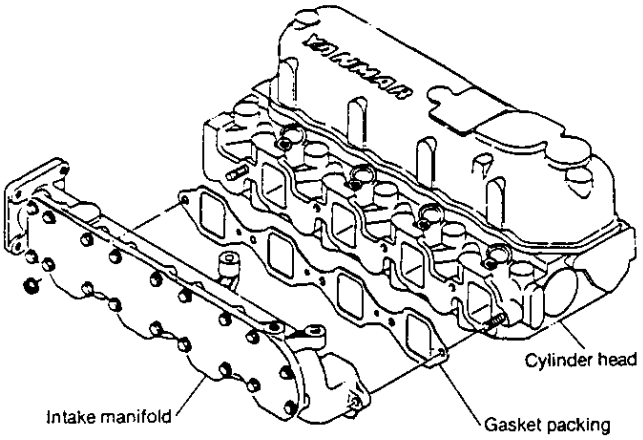
3-2.26 Mounting the intake manifold

(1) Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.
(2) Mount the governor remote control bracket.

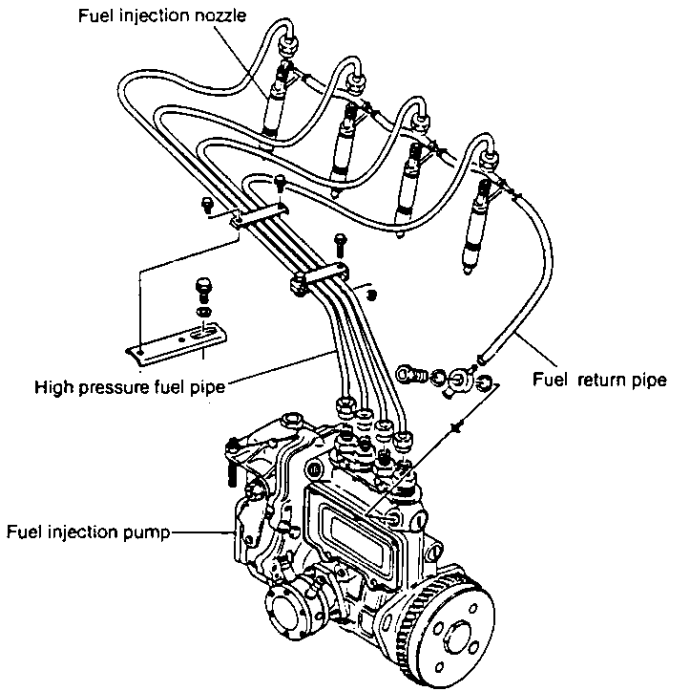


3-2.27 Mounting the high pressure fuel pipe and fuel oil return pipe

(1) Mount the high pressure fuel pipe and then the high pressure fuel pipe vibration stop.

NOTE: Lightly tighten the box nuts on both ends of the high pressure fuel pipe. Completely tighten after adjusting the injection timing.

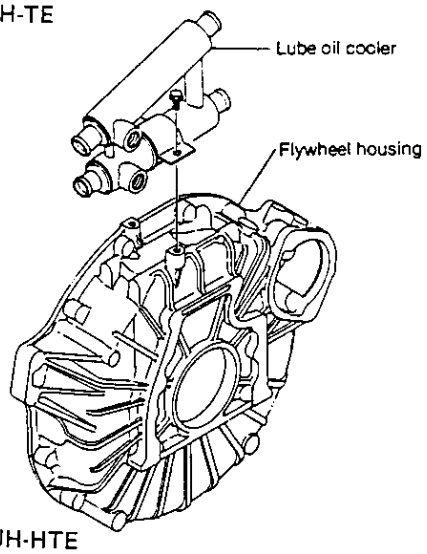
(2) Mount the fuel oil return pipe with the hose clamp (fuel injection nozzle—fuel injection pump)



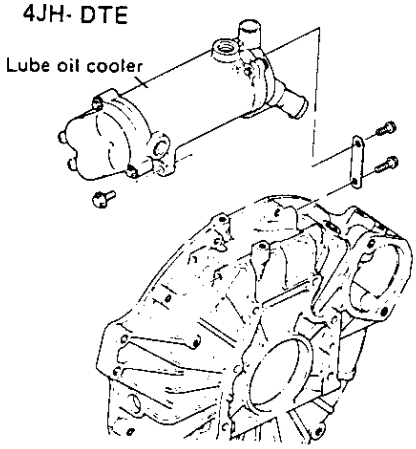
3-2.28 Mounting the lube oil cooler

Mount the lube oil cooler to the top of the flywheel housing with the bracket.

MODEL: 4JHE
4JH-TE

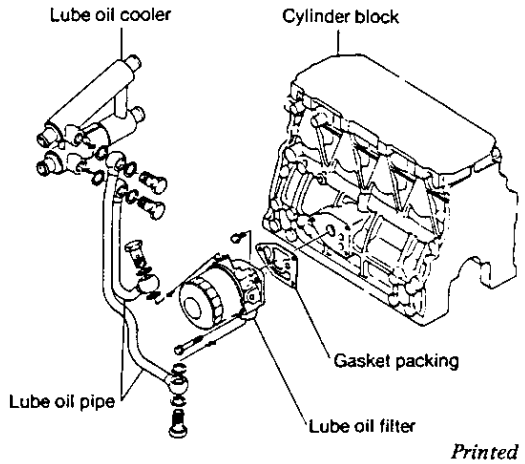


MODEL: 4JH-HTE
4JH- DTE



3-2.29 Mounting the lube oil filter

(1) Mount the filter bracket and packing on the cylinder block.
(2) Mount the filter element with the filter remover mounting tool.



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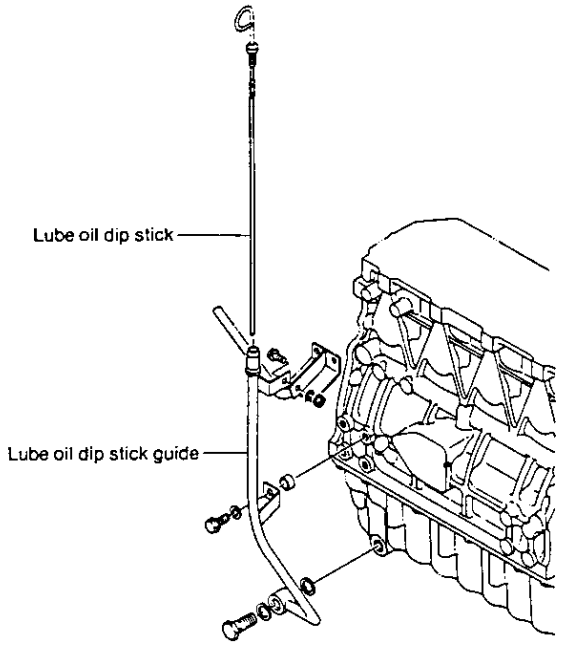
3-2.30 Mounting the lube oil pipe

(1) Mount the lube oil pipe (filter—lube oil cooler, lube oil cooler—filter).
(2) Mount the lube oil pipe (cylinder block—fuel injection pump).

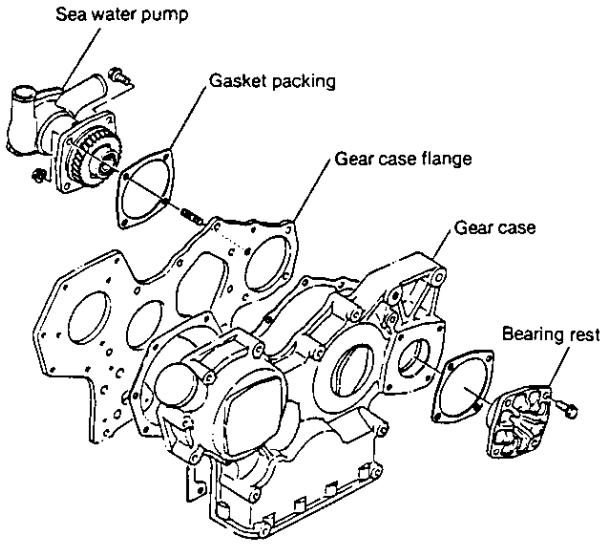
3-2.31 Mounting the dipstic guide

Mount the dipstick and dipstick guide.



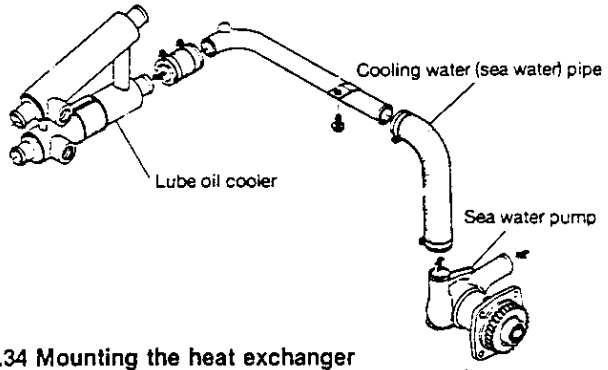
3-2.32 Mounting the sea water pump

(1) Mount the sea water pump assembly to the gear case flange.
(2) Lightly tap the gear case side bearing rest with a wood hammer, and tighten the mounting bolts.



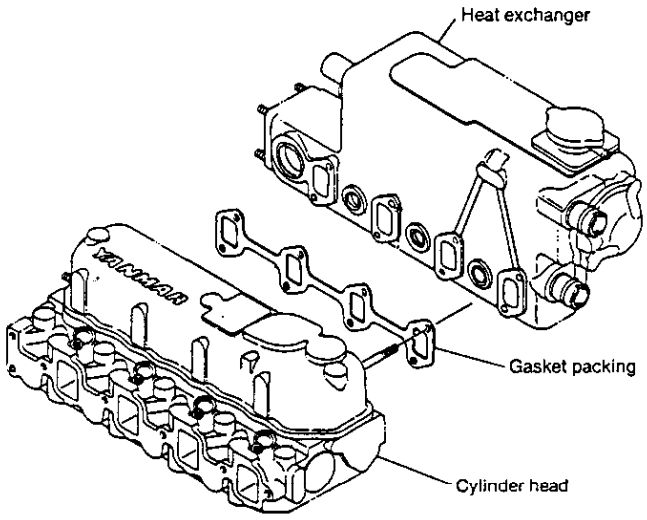
3-2.33 Mounting the cooling sea water pipe

Mount the cooling water pipe with the hose clamp (sea water pump—lube oil cooler).



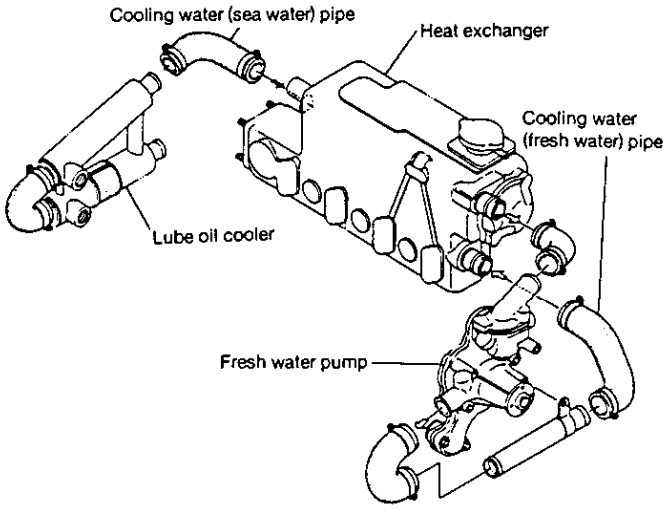
3-2.34 Mounting the heat exchanger (exhaust manifold, fresh water tank unit).

Mount the gasket packing and exhaust manifold.



3-2.35 Mounting the cooling water pipe

(1) Mount the cooling fresh water pipe with the hose clamp (fresh water tank — fresh water pump, fresh water pump—heat exchanger).
(2) Mount the cooling sea water pipe with the hose clamp (lube oil cooler —heat exchanger).
(3) Mount the cooling sea water pipe with the hose clamp (lube oil cooler —marine gearbox).



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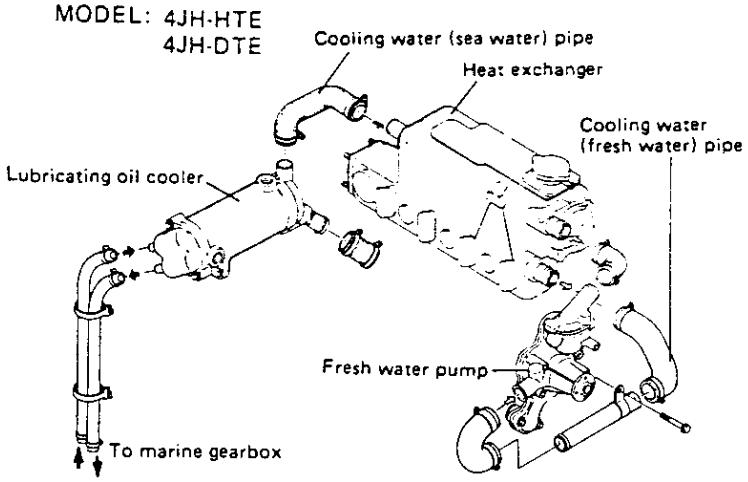
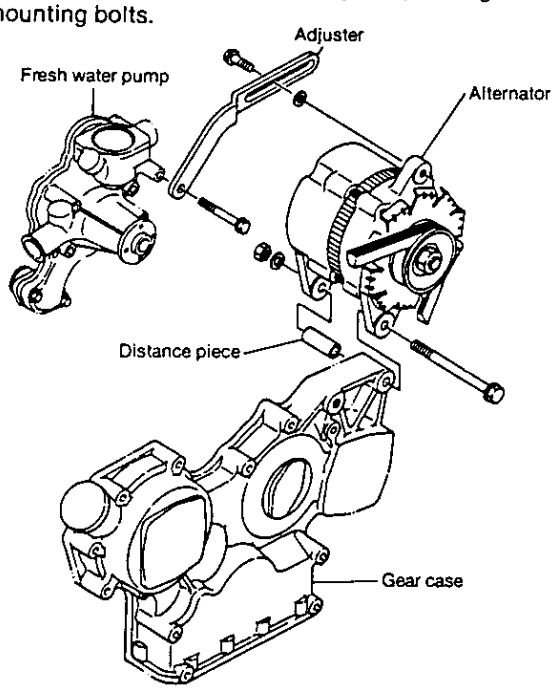
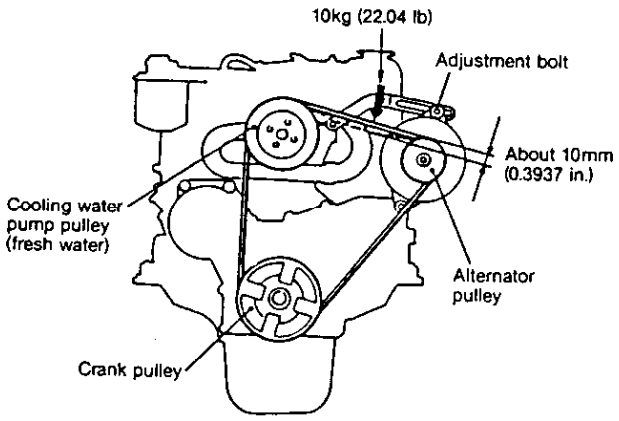
MODEL: 4JH-HTE
4JH-DTE



3-2.36 Mounting the alternator

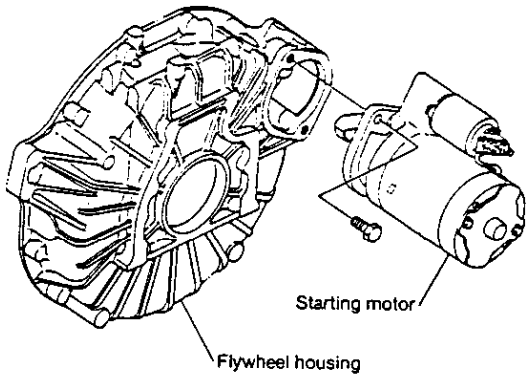
(1) Mount the adjuster on the fresh water pump, the distance piece on the gear case, and then the alternator.
(2) Adjust V-belt tension with the adjuster, and tighten the mounting bolts.





3-2.37 Mounting the starting motor

Fit the starting motor in the flywheel housing.



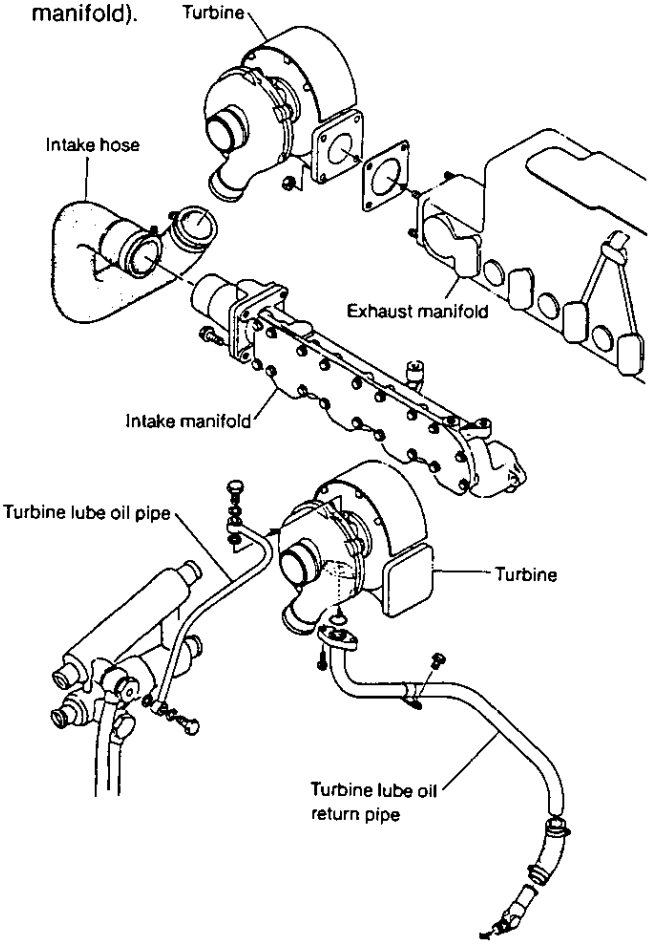
[Model 4JH-TE]

3-2.38 Mounting the turbine

(1) Mount the turbine on the exhaust manifold.

NOTE: First make sure to tighten the turbine lube oil return pipe.

(2) Mount the lube oil pipe (lube oil cooler—turbine).
(3) Insert the rubber hose at the end of the lube oil return pipe (turbine—oil pan) into the elbow on the oil pan, and mount with the hose grip.
(4) Mount the intake rubber hose (turbine—intake manifold).



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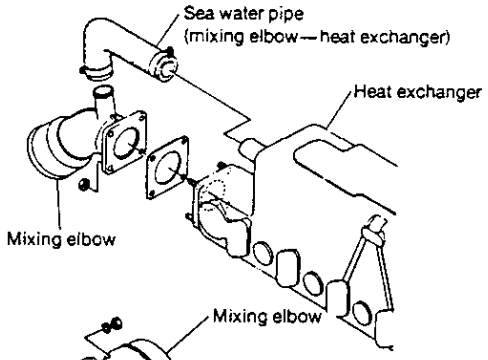
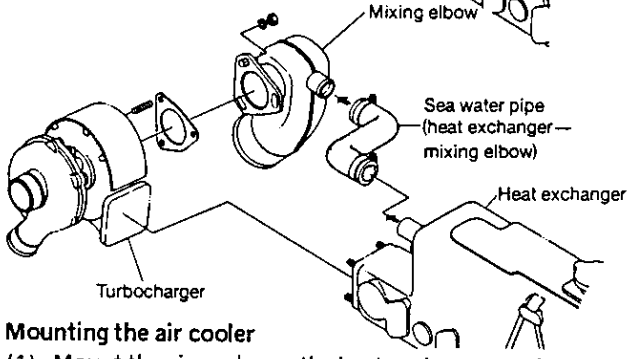
3-2.39 Mounting the mixing elbow

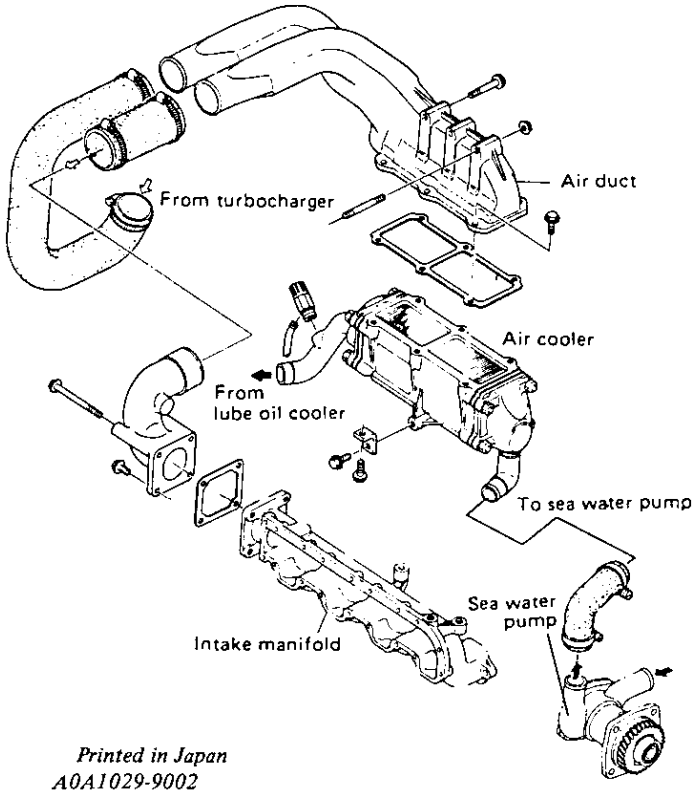
(1) Mount the mixing elbow on the exhaust manifold outlet for model 4JHE, and on the turbocharger outlet for model 4JE-TE.
(2) Mount the cooling sea water pipe rubber hose with the hose grip (heat exchanger—mixing elbow).





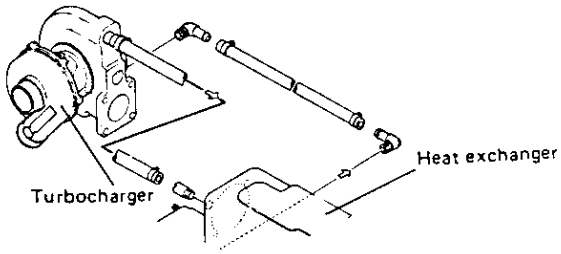
Mounting the air cooler

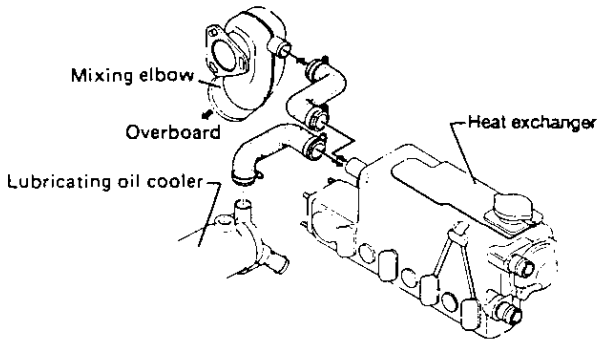
(1) Mount the air cooler on the heat excharger, and cylinder block.
(2) Mount the sea-water rubber hoses.
(Lube oil cooler — Air cooler — Sea water pump)
(3) Mount the intake rubber hoses
(Intake manifold, and turbocharger — Air duct)

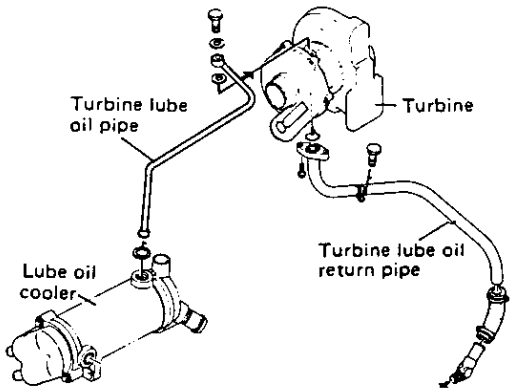


Mounting the mixing elbow and the turbocharger

(1) Mount the turbocharger on the exhaust mainfold.
(2) Mount the air duct rubber hose.
(Turbocharger — Air duct)
(3) Mount the mixing elbow on the turbocharger.
(4) Mount the sea water hose.
(Heat exchanger — Mixing elbow)
(5) Mount the lube oil pipes.
(Lube oil pump — Turbocharger — Lube oil cooler)
(6) Mount the fresh water hoses.
(Heat exchanger — Turbocharger)







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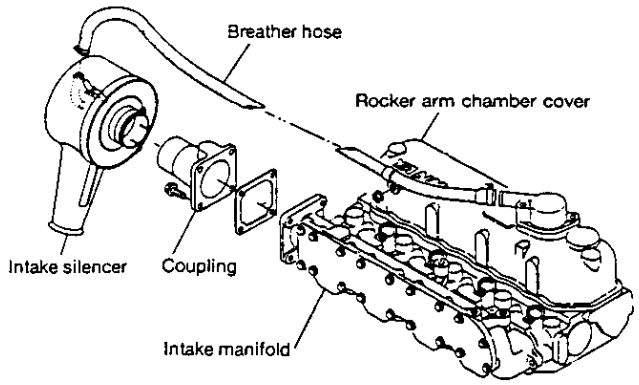
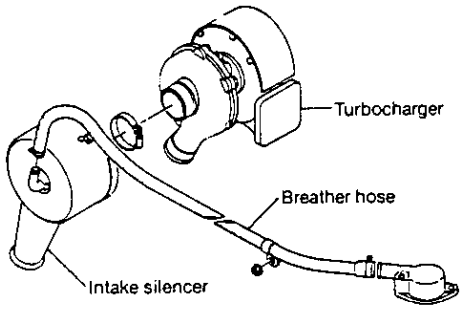
3-2.40 Mounting the intake silencer

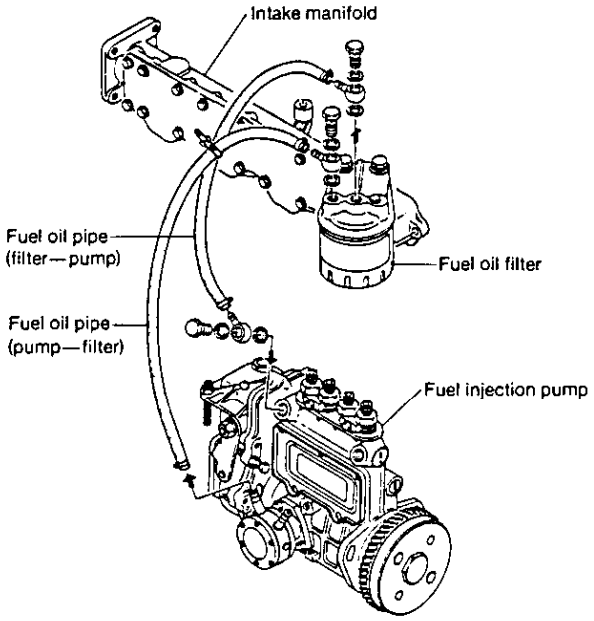
(1) Mount the intake silencer on the intake manifold inlet coupling for model 4JHE, and on the turbocharger blower side for model 4JH-TE.
(2) Mount the breather hose with the hoe clamp (intake silencer—valve rocker arm chamber cover).





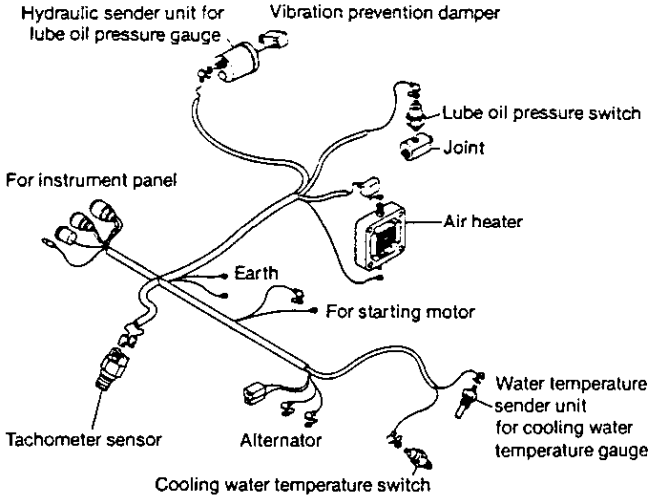
3-2.41 Mounting the fuel filter and fuel oil pipe

(1) Mount the fuel filter.
(2) Mount the fuel oil pipe (fuel feed pump—fuel filter, fuel filter—fuel injection pump).



3-2.42 Electrical Wiring

Connect the wiring to the proper terminals, observing the color coding to make sure the connections are correct.



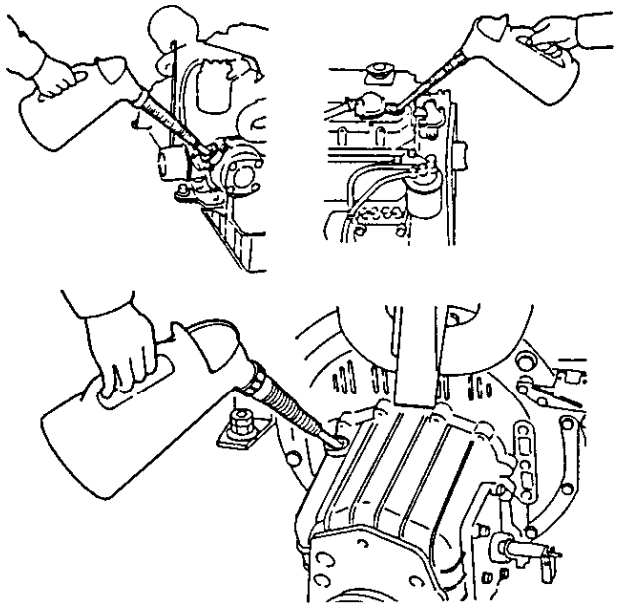
3-2.43 Installation in the ship and completion of the piping and wiring

Mount the engine in the ship after all engine assembly has been completed. Connect the cooling water, fuel oil and other piping on the ship and the exhaust hoses. Connect the battery, instrument panel, remote control and other wiring.

3-2.44 Filling with lube oil

Fill the engine with lube oil from the supply port on top of the gear case and the marine gearbox supply port on top of the clutch case.

		ℓ (in.³)
Lube oil capacity	Engine	6.5 (396.63)
	Gearbox	1.2 (73.22)



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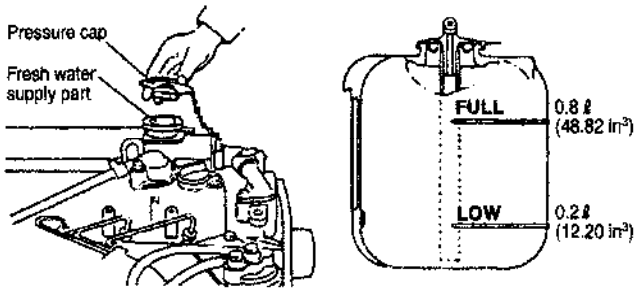
3-2.45 Filling with cooling water

(1) Open the frssh water tank cap and fill with water.

	ℓ (in.³)
Fresh water tank capacity	6.7 (408.83)

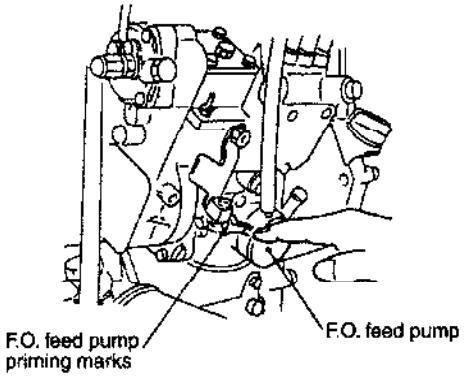
(2) Fill with water until the level in the sub-tank is between the full and low marks.

	ℓ (in.³)	
Sub-tank capacity	Full	Low
	0.8 (48.82)	0.2 (12.20)

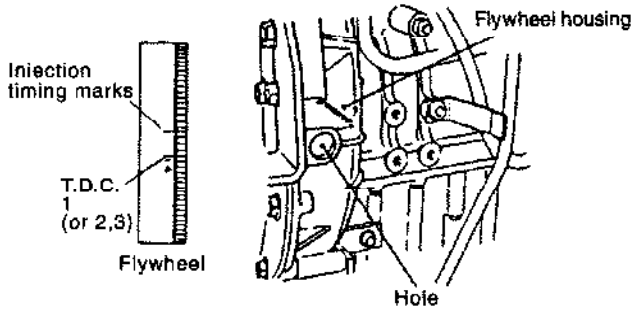


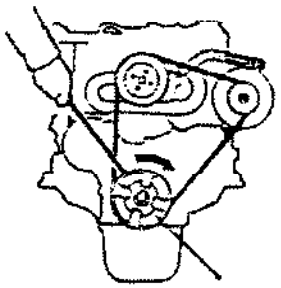
3-2.46 Check fuel iniection timing

(1) Open the fuel tank cock and shift the fuel feed pump priming lever for air bleeding.



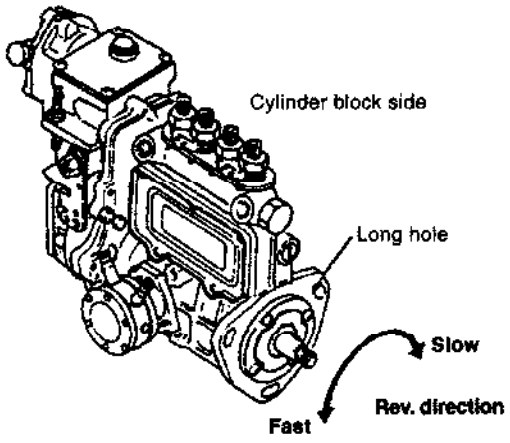
(2) Check injection timing by turning the flywheel and looking through the inspection hole in the flywheel housing.





(3) If injection timing is off, change the mounting position using the long hole in the injection pump mounting flange. Turning the fuel feed pump towards the cylinder block slows timing down, while movement in the other direction makes it faster.

		ℓ (in.³)
Fuel injection timing (FID)	4JH2E	b.TDC 10°
	4JH2-TE	b.TDC 12°
	4JH2-HTE	b.TDC 14°
	4JH2-DTE	b.TDC 10°
	4JH2-UTE	b.TDC 12°



4. Bolt/nut tightening torque

Engine

Description	Thread dia. x pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in)
Cylinder head bolts	M10 x 1.25	7.5 ~ 8.5 (52.24 ~ 61.47)	14 (0.5512)
Connecting rod bolts	M9 x 1.0	5.0 ~ 5.5 (36.16 ~ 39.78)	13 (0.5118)
Flywheel bolts	M10 x 1.25	7.0 ~ 8.0 (50.63 ~ 57.86)	17 (0.6693)
Crankshaft V-pulley bolts	M14 x 1.5	11.5 ~ 12.5* (83.17 ~ 90.41) 8.5 ~ 9.5** (61.47 ~ 68.70)	19 (0.7480)
Main bearing bolts	M12 x 1.5	10.5 ~ 11.5 (75.94 ~ 83.17)	17 (0.6693)
Fuel pump gear nut	M12 x 1.75	6.0 ~ 7.0 (43.39 ~ 50.63)	17 (0.6693)

* For P.T.O. V-pulley (optional) (material: steel)
** For standard V-pulley (material: casting iron)

Turbocharger (RHB52)

Description	Thread dia. x pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in)
Turbine chamber bolts	M6	10.0 ~ 11.0 (72.33 ~ 79.56)	10 (0.3937)
Blower chamber bolts	M5	3.5 ~ 4.5 (25.31 ~ 32.54)	8 (0.3150)
Thrust metal bolts	M3	0.7 ~ 0.9 (5.06 ~ 6.50)	—
Seal plate screws	M3	0.7 ~ 0.8 (5.06 ~ 5.78)	—
Blower blade nuts	M5	1.8 ~ 2.2 (13.01 ~ 15.91)	8 (0.3150)

Tightening torque of the standard bolts & nuts for general use.

[NOTICE]

- ● Apply the following tightening torque to bolts having "7" on the head. (JIS strength classification : 7T)
- ○ Tighten bolts with no "7" mark to 60% tightening torque.
- ○ If the parts to be tightened are made from aluminum alloy, tighten the bolts to 80% tightening torque.

Bolt dia. x pitch mm		M6x1.0	M8x1.25	M10x1.5	M12x1.75	M14x1.5	M16x1.5
Tightening torque	N·m (Kgf-m)	10.8±1.0 (1.1±0.1)	25.5±2.9 (2.6±0.3)	49.0±4.9 (5.0±0.5)	88.3±9.8 (9.0±1.0)	137±9.8 (14.0±1.0)	226±9.8 (23.0±1.0)

Name	Thread diameter	Tightening torque N·m (kgf-m)
PT plug	1/8	9.80 (1.0)
	1/4	19.61 (2.0)
	3/8	29.42 (3.0)
	1/2	58.83 (6.0)
Ball joint bolt	M8	14.70 (1.5)
	M12	29.42 (3.0)
	M14	44.12 (4.5)
	M16	53.93 (5.5)

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5. Test running

5-1. Preliminary Precautions

Before making a test run, make sure of the following points.

(1) Warm the engine up.
(2) Remove any precipitation from the F.O. filter, water separator, and F.O. tank.
(3) Use only lube oil recommended by Yanmar.
(4) Be sure to add Yanmar anti-rust agent to fresh cooling water.
(5) During cold weather, add Yanmar anti-freeze to the cooling water.
(6) Provide good ventilation in the engine room

5-2 Check Points and Precautions During Running

Step	Item	Instructions	Precautions
1	Checks before operation	1) Make sure that the Kingston Cock is open. 2) Make sure there is enough lube oil and (fresh) cooling water. 3) Operate the remote control handle and check if the devices connected to the engine side work properly.	 3) Lamp should go off when engine is running.
2	No load operation; warm up operation	1) Glow plug is provided to aid engine starts. When the lube oil temperature is raised to allow the engine to start, the pilot lamp goes off. 2) When the engine is started, check the following: • there is no water and no oil leakage. • gas does not leak when the engine is started. • there are no abnormal indications on the instrument panel. • there is no abnormality in cooling water discharge, engine vibrations, or engine sounds. 3) To warm up the engine, operate at low revolutions for about 5 minutes, then raise the revolutions to the rated rpms and then to max. rpms.	1) Even if one glow plug should break, the remaining plug works. 2) • Fix leaks if any. • Check the intake/exhaust valves, F.O. injection valve, and cylinder head. 3) Do not raise the engine revolutions abruptly.
3	Cruising (load) operation	1) Do not operate the engine at full load yet, but raise the rpms gradually for about 10 minutes until they reach rated rpms. 2) Make sure that exhaust color and temperature are normal. 3) Check the instrument panel and see if the water temperature and oil pressure are normal.	
4	Stopping the engine	1) Before stopping the engine, operate it at 650—700 rpms for about 5 minutes. 2) Raise engine rpms to 1,800 just before stopping the engine and idle the engine for about 3—4 seconds.	1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts. 2) This procedure prevents carbon from being deposited on the valve seats, etc.
5	Checks after stopping the engine	1) Check again for water and oil leaks. 2) Make sure that no nuts and bolts are loose. 3) Close the Kingston and fuel cocks. 4) When the temperature is expected to fall below freezing, drain the cooling water (sea water). 5) Turn off the battery switch.	1) Check the oil seal area. 2) Especially the engine installation bolts. 4) Drain from the sea water pump.

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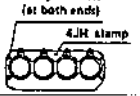
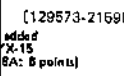
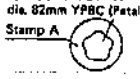
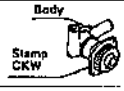
4JHE/4JH2E PARTS DIFFERING IN SHAPE

No.	Part		Specification: Current 4JH-DTE	4JH2E Series: 4JH2E	4JH2-TE	4JH2-HTE	4JH2-DTE	4JH2-UTE	Reason for Difference	Remarks
1	Output	Cont rating	70HP/3500rpm	46/3400	57/3400	69/3400	80/3400			
		Max.	Clutch output 77HP/3600rpm	Clutch output 48/3600 Flywheel output 50/3600	Clutch output 60/3600 Flywheel output 62/3600	Clutch output 72/3600 Flywheel output 75/3600	Clutch output 85/3600 Flywheel output 88/3600	Clutch output 96/3600 Flywheel output 100/3600		Indication in nameplate is for flywheel output.
2	Cylinder block CMP		129472-01000 for cyl. w/sleeve	→	→	→	129573-01000 for sleeveless cyl. Cyl. block: 129402-01010	←	Bore enlargement by sleeveless structure	Design change in corner of main bearing(2→2.5)
3	Cylinder sleeve		(129472-01100)	→	→	→	None	←	Bore enlargement by sleeveless structure	
4	Cyl. head gasket		φ78mm bore, for cyl. w/sleeve No grommets (at both ends) 4JH stamp 	→	→	Grommets (at both ends) 4JH2 stamp 	(129573-01340 (1.3t) -01350 (1.4t) -01360 (1.5t)) standard φ82mm for sleeveless cyl.	←	Bore enlargement by sleeveless structure	
5	Engine name plate		(129473-07010) -07020 Model: 4JH-DTBE 4JH-DTE	(129570-07010) Model: 4JH2E	(129571-07010) Model: 4JH2-TE	(129572-07010) Model: 4JH2-HTE	(129573-07010) Model: 4JH2-DTE	(129574-07010) Model: 4JH2-UTE		
6	Metal cap tightening torque		10±0.5 kg-m	→	→	→	11±0.5 kg-m	←	P max. increase	JH2 mass-produced. As for JH, the torque will be changed to 11 kg-m.
7	Rocker arm support		(129150-11260) -11270 Made of FCD	→	→	→	(129155-11260) -11270 Made of ACD	←		Rocker arm support of current 4JH is to be changed also to of ADC.
8	Supercharger		(129474-18001) 9000 [VHP12NF BRL3511E "MY60"	None	(129571-18000) 5200 II HP12NW BRL3511E "MY67"	(129474-18001) Same as current 4JH-DTE "MY60"	(129473-18000) 5200 II HP15NW BRL3511E (Old type of 4JH-DTE) Abbreviation: "MY34"	←	Combustion performance	RHB52 (Water cooling) MY60 MY34
9	Crankshaft		(129474-21010) SCM440 Discrimination Stamp: C (on No.4 arm)	← (Same as left)	→	→	(129573-21010) SCM440 Resintered Discrimination: (on No.4 arm)	←	P max. increase	
10	Flywheel CMP		(129472-21590) 6-M8 FCD170 	→	→	Seat added for YX-15 (5-M8A: 5 points) FCD350 FCD170 	(129573-21590) 	←	To make it applicable to Bob tail	
11	Piston		(129474-22010) dia.78mm Toroidal	(129570-22010) dia. 82mm YPBC (Petal) Stamp A 	→	(129572-22010) dia. 82mm YPBC (Petal) Stamp C 	(129573-22010) dia. 82mm YPBC (Petal) Stamp D 	←	Bore enlarging. Combustion performance	4JH2-HTE & 4JH2-DTE differ in combustion chamber only.
12	Piston ring (Top)		(129550-22100) Chrome-plating on 3 faces	→	→	→	(129573-22100) Chrome-plating on 3 faces	←	Bore enlargement	Differ in material
	Piston ring(2nd)		(129785-22120)	→	→	→	(129351-22100)	←	Bore enlargement	
	Oil ring		(129785-22200)	→	→	→	(129573-23010)	←	Bore enlargement	Differ in material
13	Conn. rod		(129150-23010) • Small end: Straight • Small end: Hole dia. = 29mm • Tightening torque: 4.5~5.0 kg-m	→	→	→	(129573-23010) • Small end: Taper • Small end: Hole dia. = 31mm • Tightening torque: 5.0~5.5 kg-m	←	P max. increase	
14	Piston pin		(129150-22300) dia.26× ℓ 66mm	→	→	→	(129573-22300) dia.28× ℓ 69mm	←	P max. increase	
15	Piston pin metal		(129100-23100) dia. 66mm Straight	→	→	→	(129573-23100) dia. 28mm Taper	←	P max. increase	
16	Piston pin snap ring		(121100-22400) Coil(Round) For dia. 26mm hole	→	→	→	(22252-000280) Circlip(Flat) For dia. 28mm hole	←		
17	Seawater pump		(129470-42500) Discharge capacity: 3250 ℓ/hr Cam lift: 4.5mm	→	→	Body Stamp CKW 	(129573-42500) Discharge capacity: 3750 ℓ/hr (Cam lift increased)5mm	←	Increase in heat exchanged calorie	That for 4JH2 is changed in design and applied to current 4JH.
18	Fresh water cooler (Body)		(129470-44010) Cooler inset dia. 76.5mm Length: 451mm	←	←	→	(129573-44010) Cooler inset dia. 83mm Length: 481mm	←	Increase in heat exchanged calorie	

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A0A1029-9109S2

4JHE/4JH2E PARTS DIFFERING IN SHAPE

No.	Part	Specification: Current 4JH-DTE	4JH2E Series: 4JH2E	4JH2-TE	4JH2-HTE	4JH2-DTE	4JH2-UTE	Reason for Difference	Remarks
19	Freshwater cooler (Cooler core)	(129473-44111) Core dia. 76.5 mm A=0.328 ㎡	←	←	Stamp C	(129573-44111) Core dia. 83 mm A=0.416 ㎡	←	Increase in heat exchanged calories	
20	Freshwater cooler (Side cover)	(129470-44450) -44440) Cooler inset dia. 76.5 mm	←	←	Side cover; Emboss mark	(129573-44440) -44450) Cooler inset dia. 83 mm	←		
21	Fuel injection pump governor	Retraction volume 30 mm³/st Cut amt.: 0.05 mm W/O Boost compensator (729473-51300) (B364)	(729570-51300) (B471)	Retraction volume 23.6 mm³/st Cut amt.: W/Boost compensator (729572-51300) (B445)	Same as right, differs in injection amount at B point only) (729572-51300) (B438)	Retraction volume 36 mm³/st Cut amt.: 0.13 mm W/Boost compensator (729573-51300) (B434)		Combustion performance Standization at acceleration	
22	Fuel injection nozzle	(729595-51300) 5-0.25φ × 140° 140P255Z0	5-0.23φ × 155° 155P235J20	→	(729595-51300) 5-0.25φ × 145° 140P255Z0	5-0.26φ × 140° 140P265J20	5-0.25φ × 150°	Combustion performance	
23	Push rod	(129150-14200) dia. 8 mm Material=5TKH12C	→	→	→	(119171-14400) dia. 8.5 mm Material=5TKM16C; yellow paint	←	Stress relieving	
24	Cyl. head packing	Asbestos used	→	→	→	Non-asbestos (Material: SF7000)	←		Non-asbestos is also to be applied to current 4JH
25	Oil pan	E: Deep type BE: Shallow type	→	→	→ Shallow Type	(1) Hole added for front P.T.O bracket (2) Screw hole (M16 × 1.5) for dipstick Added also to non-control side	←	To make it applicable to twin installation	Oil pan for current 4JH is changed in design (Applied also to current 4JHE Series)
26	Cover (Thermostat)	(129470-49540)	←	←	→	(129573-49540)	←	Following elongation of fresh water cooler (No. 19, 20)	
27	Marine gear Model: KM4A	Input shaft Oil seal: Nitril	→	→	→	Input shaft Oil seal: Acryl Shaft. case: oil supply amt increased Length: 7 mm increased	←	Measure for oil leak. Measure for wear out of friction plate. To make it applicable to the clutchless engines	
	Cooling fan	None	None	None	None	Added	←	Oil temp. reduced	
28	Intercooler	(129473-18101) Corrugated type	None	None	(129474-18100) plate-fin type used also for 4JH-HT(E)	(129473-18101) Used also for 4JH-DT(B)(E)	←		
29	Air intake duct	Bent rubber hose	None	Aluminum pipe and rubber joint.	→	Aluminum pipe and rubber joint.	←	Prevention of hose slipping off	A1 pipe is also to be applied to current 4JH-HTE/DTE
30	Starter	Conventional type (124250-77012)	→	→	→	Reduction type (129573-77010)	←	Unification of parts	
31	Wireharness Extension cord	Without relay (for all 2, 4, 6 m)	→	→	→	2 & 4 m: Without relay 6 m: with/relay	←	Following change of starter	Optional
32	Marine gear Model: KBW	KBW21 (S) (G) (GG) Input shaft length	KBW20 (S) (G) (GG) Input shaft length: 7 mm up	← (S) (G)	KBW21 (S) (G) Input shaft length: 7 mm up	← (S)	←	Flywheel changed for application to Bobtail	
	Cooling fan	None	Added Same as KM4A 177073-63190	←	None	None	←	Same as above	
33	Head bolt tightening torque	T=8±0.5 kg-m	→	→	→	T=9±0.5 kg-m at shop assembly (T=8±0.5 kg-m at site reassembly)	←	P. max. increase	Applied also to current 4JHE Series

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Printed in Japan
A0A1029-0104

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0000A0A102S-9004