YANMAR
SERVICE MANUAL

EXCAVATOR

MODEL ViO50-1

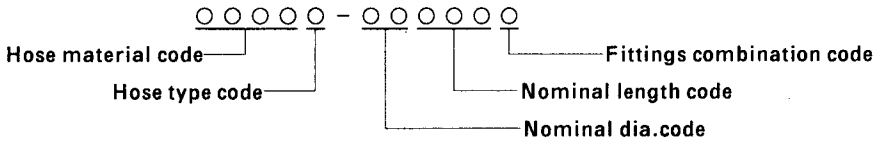
1. GENERAL CAUTIONS FOR MAINTENANCE WORK

1-9 Specifications of Hydraulic Hose

Two types of hydraulic hose are used in Yanmar Construction Machinery: the standard parts specified in the Yanmar Industrial Standards (YIS) and special parts for the respective models. Specifications of the hydraulic hoses can be known by the code number or part descriptions as explained below. (For the parts number, please refer to our Parts Catalog.)

(1) Yanmar Standard Type

The parts code consists of 11-digit numbers:



Description / Parts code No. / Hose material	Hose material	Type of hose		Hose dia.	Hose length	Combination of fittings
	○○○○	○		○○	○○○	○
Rubber hose (High pressure type)	2320	1	(SAE J517,100R1)	02	Unit : cm	1
						3
				03		4
		2	(SAE J517,100R2)			5
				04		6
Plastic hose (High pressure type)	2327	1	(SAE J517,100R7)	02	↑	1
				03		4
				04		5
		2	(SAE J517,100R7) Reinforced type	03		7
				04		
Rubber hose (Middle pressure type)	2325	1	(SAE J517,100R6)	02	↑	1
				03		
				04		
				05		4
				06		
				10		5
				12		
				14		

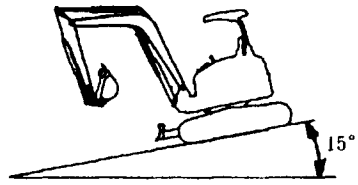
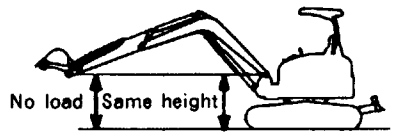
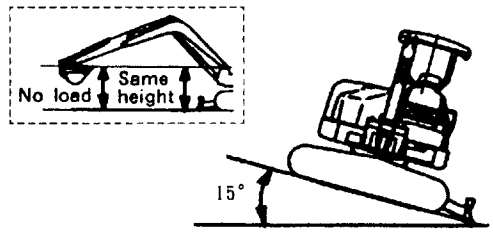
1) Type of hose (hose dia. & recommended working pressure)

Type of hose	Hose dia.	Inner dia. (mm)	Outer dia. (mm)	Working pressure (kgf/cm²)
1 (SAE J517, 100R1)	02	6.3	13.5	175
	03	9.5	17.5	140
	04	12.7	20.6	110
2 (SAE J517, 100R2)	02	6.3	15.1	300
	03	9.5	19.1	245
	04	12.7	22.2	210
3 (SAE J517, 100R7)	02	6.3	12.5	210
	03	9.5	16.6	175
	04	12.7	20.7	140

Type of hose	Hose dia.	Inner dia. (mm)	Outer dia. (mm)	Working pressure (kgf/cm²)
2 (SAE J517, 100R7)	03	9.5	17.2	210
	04	12.7	21.4	210
1 (SAE J517, 100R6)	02	6.3	12.7	30
	03	9.5	15.9	30
	04	12.7	19.8	30
	05	15.9	23.0	30
	06	19.0	31.8	30
	10	25.4	38.1	30
	12	31.8	44.5	30
	14	38.1	51.9	30

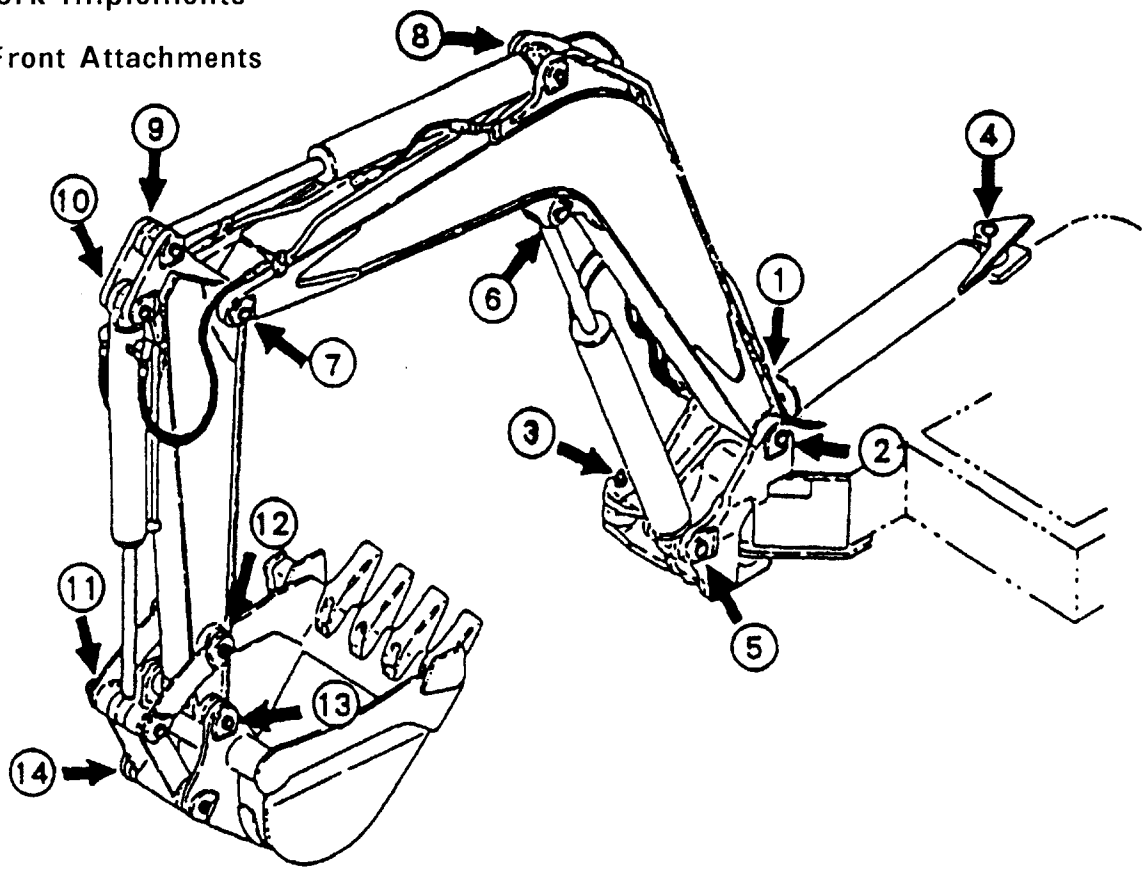
2. TECHNICAL DATA

Item		Unit	ViO50-1
Engine			
Main specifications			
Engine model			4TNE88-BVA
Type			Vertical water-cooled 4-cycle diesel engine
Combustion			Direct injection
No. of cylinders - Bore × Stroke		mm×mm	4-88×90
Total displacement		cc	2189
Rated output/revs.		PS/RPM	37/2200
Max. torque/revs.		kgf-m/RPM	13.7/1600
Specific fuel consumption		g/PSh	175
No load max. engine speed		RPM	2350 to 2400
No load min. engine speed		RPM	1125 to 1175 (Engine only)
Engine dry weight		kg	182 (excld. air-cleaner & silencer)
Lubrication			Forced lubrication by trochoid pump
Specific lube oil consumption		g/PSh	0.1 to 0.6
Compression pressure		kgf/cm^2	35 (at 300 RPM)
Cylinder head			
Intake valve	Open	deg. bTDC	10 to 20
	Close	deg. aBDC	40 to 50
Exhaust valve	Open	deg. bBDC	51 to 61
	Close	deg. aTDC	13 to 23
Intake valve clearance (Cold eng.)		mm	0.15 to 0.25
Exhaust valve clearance (Cold eng.)		mm	0.15 to 0.25
Intake valve seat angle		deg.	120
Exhaust valve seat angle		deg.	90
Piston			
1st compression ring	Ring shape		Barrel face (chrome plated)
	Ring quantity	pcs.	1
2nd compression ring	Ring shape		Taper face, inner cut
	Ring quantity	pcs.	1
Oil-ring	Ring shape		Bevel cutter with coil expander
	Ring quantity	pcs.	1
Governor			
Name			Mechanical all speed governor
Type			Centrifugal
Fuel feed system			
Fuel filter			Filtering paper with automatic air release device
Fuel filter filtration area		cm^2	900
Oil/water separator			Mesh filter
Feed pump			Mechanical, diaphragm type

Model				Vio50-1		
	Item		Measuring condition	Unit	Standard	Allowance
Machine performance	Traveling drift		Machine position  ● Engine : stopped ● Hydraulic oil temp. : 50 to 60 ℃ ● Drift of the machine after 5min. on a slope with an inclination of 15 degrees.	mm / 5 min.	200 or less	300
	Drift of cylinder	Boom drift (Cylinder rod retraction)	Machine position  ● Engine : stopped ● Hydraulic oil temp. : 50 to 60 ℃ ● Site : Firm, flat ground ● Make the boom and bucket pins the same height. ● Measure the retraction or extension of each cylinder rod after leaving the machine at the above position for 10 min. ● Lift the blade to the highest position, and measure the cylinder rod extension after 10 min.	mm / 10 min.	10 or less	15
		Arm drift (Cylinder rod extension)			10 or less	15
		Bucket drift (Cylinder rod extension)			6 or less	9
		Blade drift (Cylinder rod extension)			6 or less	9
		Boom swing drift (Cylinder rod extension)	Machine position  ● Engine : stopped ● Hydraulic oil temp. : 50 to 60 ℃ ● Make the boom and bucket pins the same height. ● Park machine on a slop with an inclination of 15 degrees and turn upperstructure 90 degrees to tracks and engage swing lock. ● Measure the cylinder rod extension after 10 min.	mm / 10 min.	6 or less	9

3-6 Work Implements

3-6-1 Front Attachments



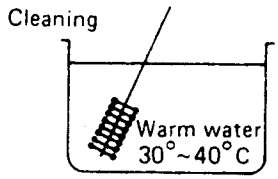
(Unit : mm)

No.	Measuring Point	Standard	Wear limit	
			Pin	Bore of bush or hole
①	Boom swing fulcrum	ϕ70	−0.5	+0.5
②	Boom fulcrum	ϕ50		
③	Boom swing cylinder, rod	ϕ40		
④	Boom swing cylinder, bottom			
⑤	Boom cylinder, bottom	ϕ50		
⑥	Boom cylinder, rod			
⑦	Arm fulcrum			
⑧	Arm cylinder, bottom			
⑨	Arm cylinder, rod			
⑩	Bucket cylinder, bottom	ϕ45		
⑪	Bucket cylinder, rod			
⑫	Link "A" arm			
⑬	Bucket fulcrum			
⑭	Bucket link "A"			

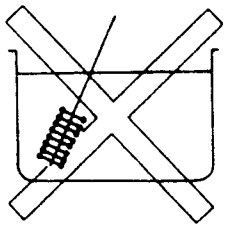
*[**Note**] Allowable clearance between pin and bore of bush or hole is 1.0mm.*

4. Handling of FLEX-HONE

- Use the Flex-Hone by mounting it on a motor-driven (step less variable speed,) drill.
- Use soluble type grinding fluid for grinding. Do not employ dry type grinding. Use neither emulsion type grinding fluid nor petroleum-base (wash oil) grinding fluid.
- After grinding, be sure to clean the grain ball in warm water of about 30° - 40°C using a bristled brush or the like. Do not store the grain ball with chipping powder or worn grain particles left deposited. Otherwise, grinding capacity decreases.
- The Flex-Hone is intended only for wet type grinding. Never use it for the dry type grinding purpose.



- Never keep the Flex-Hone immersed in thinner, gasoline, gas oil, etc. Be sure to keep it dry for storage. Otherwise, the binder of grain particles is inversely influenced.



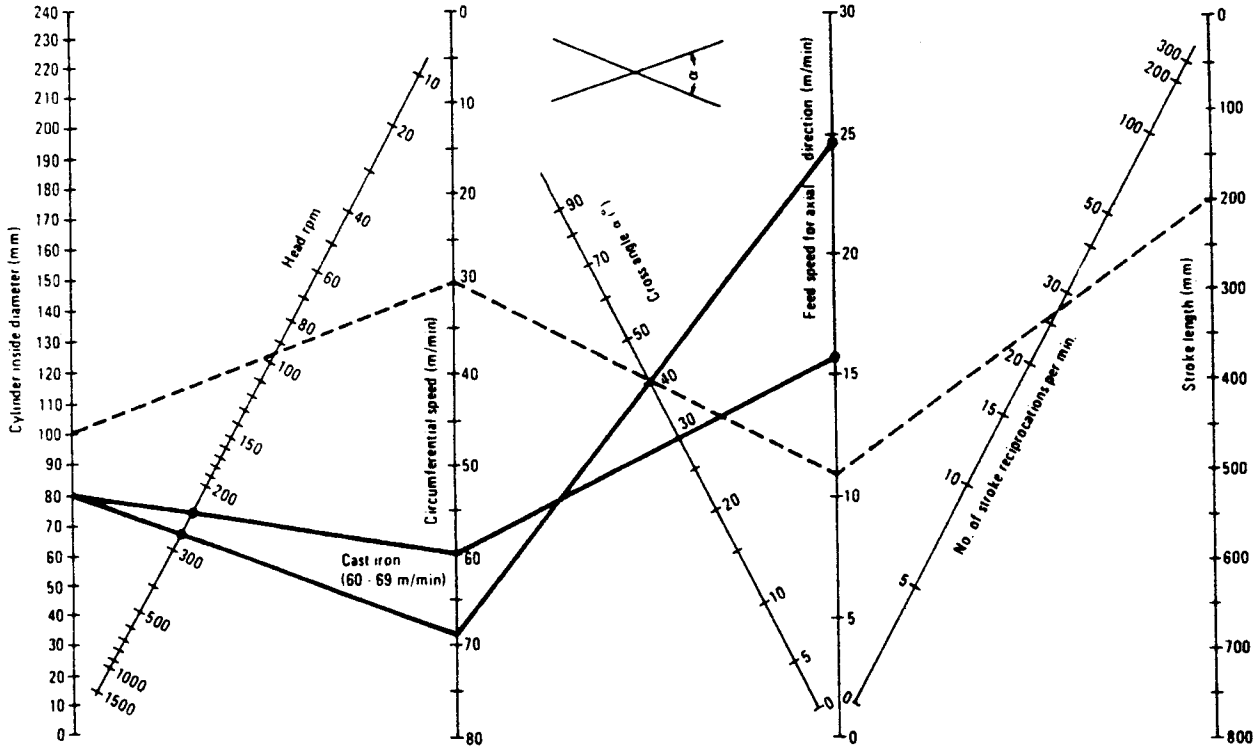
5. Calculation diagram for obtaining crosshatch angle

Calculation diagram for obtaining crosshatch angle crosshatching varies with circumferential speed and axial speed. The following diagram is a calculation diagram for obtaining a crosshatch angle.

[EXAMPLE] Where a work-piece is 100mm in inside diameter and is rotated at a head speed of 95 r.p.m., a broken line connecting the two extends to 29.8m/min on the circumferential speed axis.
Where a stroke is 200mm in length and number of stroke reciprocations is 27.5/min, an axial speed of 11.0m/min is obtained. When the point (29.8m/min at an axial speed), a crosshatch angle of 40? is obtained in the center.

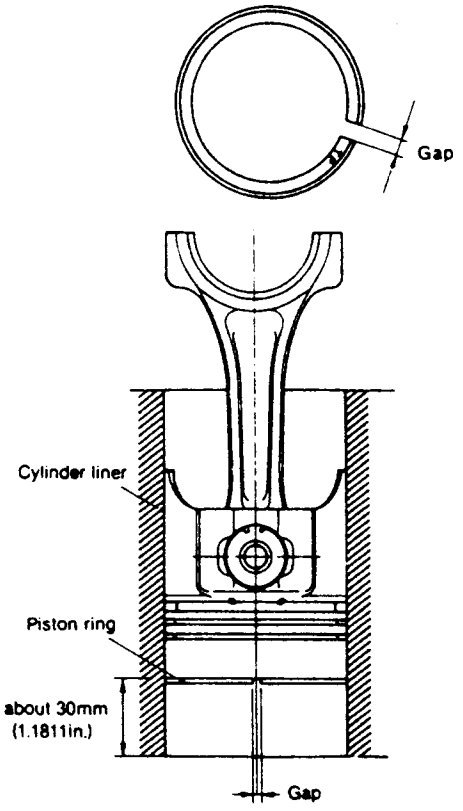
Parts list for oversize (0.25mm) piston and piston ring

- **Piston and rings : p/#129001-22900**
- **Piston rings : p/#129001-22950**



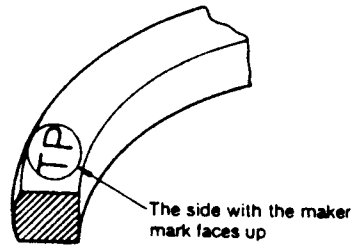
		Standard	Wear limit
First piston ring	Groove width	See separate service data (Page, 4-8-2)	
	Ring width		
	Groove and ring clearance		
Second piston ring	Groove width		
	Ring width		
	Groove and ring clearance		
Oil ring	Groove width		
	Ring width		
	Groove and ring clearance		

Press the piston ring onto a cylinder and measure the piston ring gap with a gauge.
Press on the ring about 30mm (1.1811 in.) from the bottom of the cylinder.

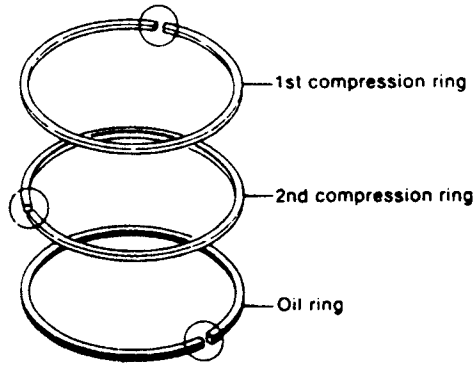


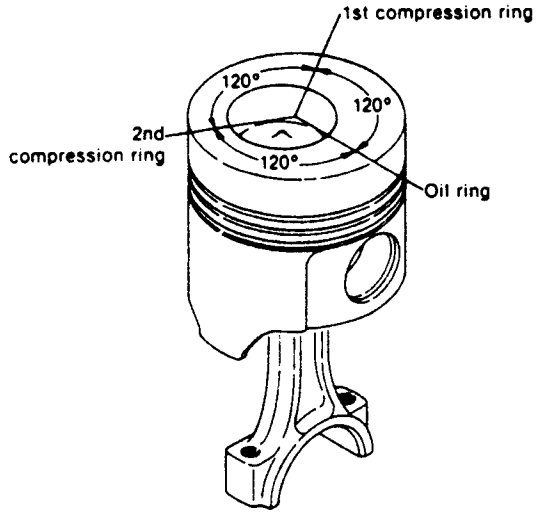
	Standard	Wear limit
First piston ring gap	See separate service data (Page, 4-8-2)	
Second piston ring gap		
Oil ring gap		

(1) Thoroughly clean the ring grooves when replacing piston rings.
(2) The side with the manufacturer's mark (near piston ring gap) should face up.

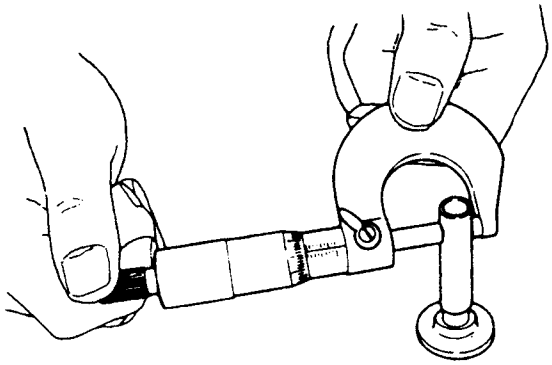


(3) After fitting the piston ring, make sure it moves easily and smoothly.
(4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.



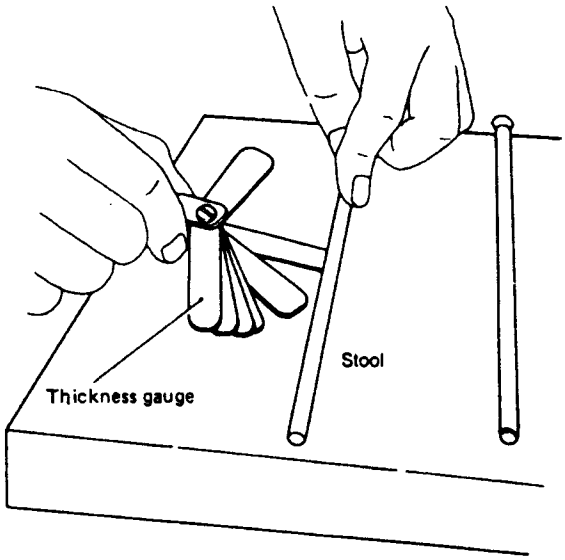


(2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



	Standard	Wear limit
Tappet stem outside dia.	See separate service data (Page, 4-8-3)	
Tappet guide hole inside dia. (cylinder block)		
Tappet stem and guide hole oil clearance		

(3) Measuring push rods.
Measure the length and bending of the push rods.

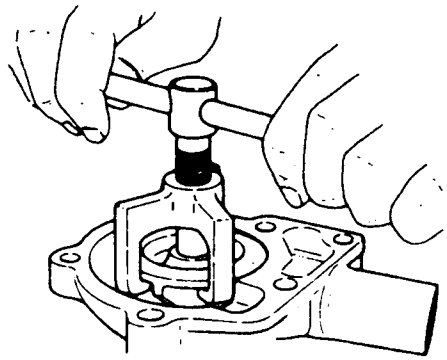


	Standard	Wear limit
Push rod length	See separate service data (Page, 4-8-3)	
Push rod bend		
Push rod dia.		

2. Water pump disassembly

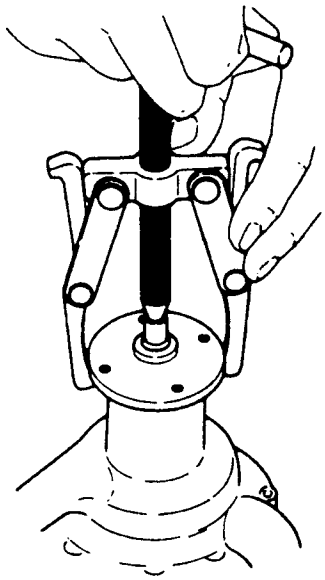
(1) Remove the water pump.
(2) Remove the impeller using a gear puller.

Removing impeller



(3) Remove the mechanical seal.
(4) Remove the fan pulley flange using a gear puller.

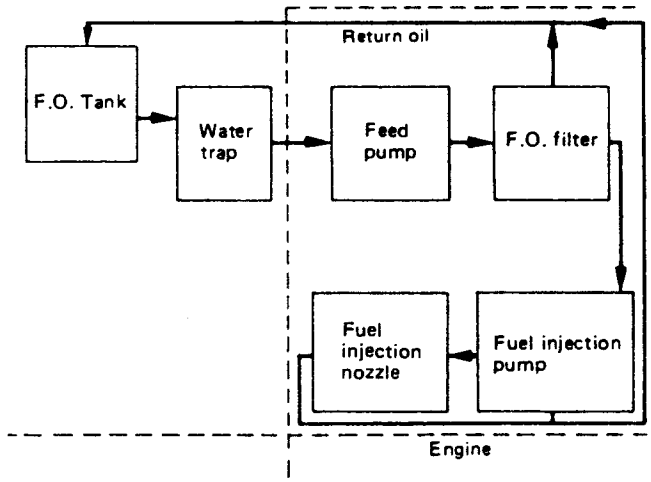
Removing pulley flange



(5) Remove the snap ring.
(6) Press the pump shaft and bearing assembly out from the impeller end to the fan pulley end.
(7) Reassemble in the reverse order of disassembly.
(8) Install the water pump.

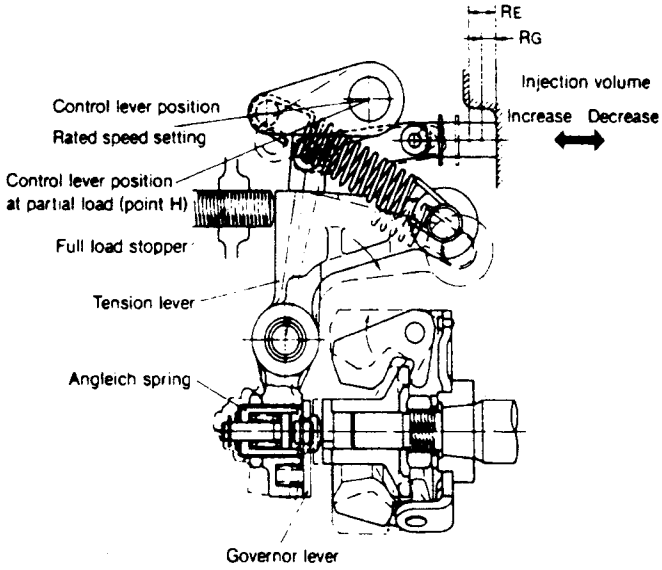
4-11 Fuel Supply System

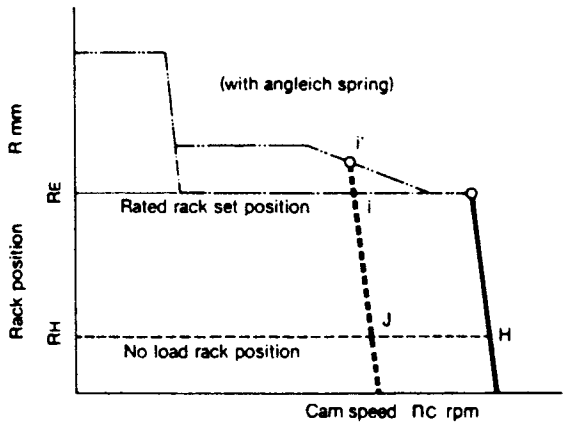
The Yanmar injection pump is Bosch in-line type with the camshaft driven by engine gears via the timing gears. The feed pump is driven by the camshaft of the fuel injection pump. The filtered fuel is fed to the reservoir in the pump housing. The plunger increases the pressure, and fuel passes through the injection pipe to be injected into each cylinder by the fuel injection nozzle.



(6) No-load maximum speed

When the load decreases from full load max. speed and engine speed increases, the increased thrust load of the governor weight acting on the governor spring through the tension lever exceeds the set load of the spring, the tension lever and governor lever
descend clockwise; the control rack is pushed to the no-load injection volume position (R_H), and the engine is operated at no-load max. speed.
When the engine is being used at a partial load, the governor spring functions in the same way at a lower speed (i, i' - J) as for full load max. speed, as the governor spring set load is smaller.



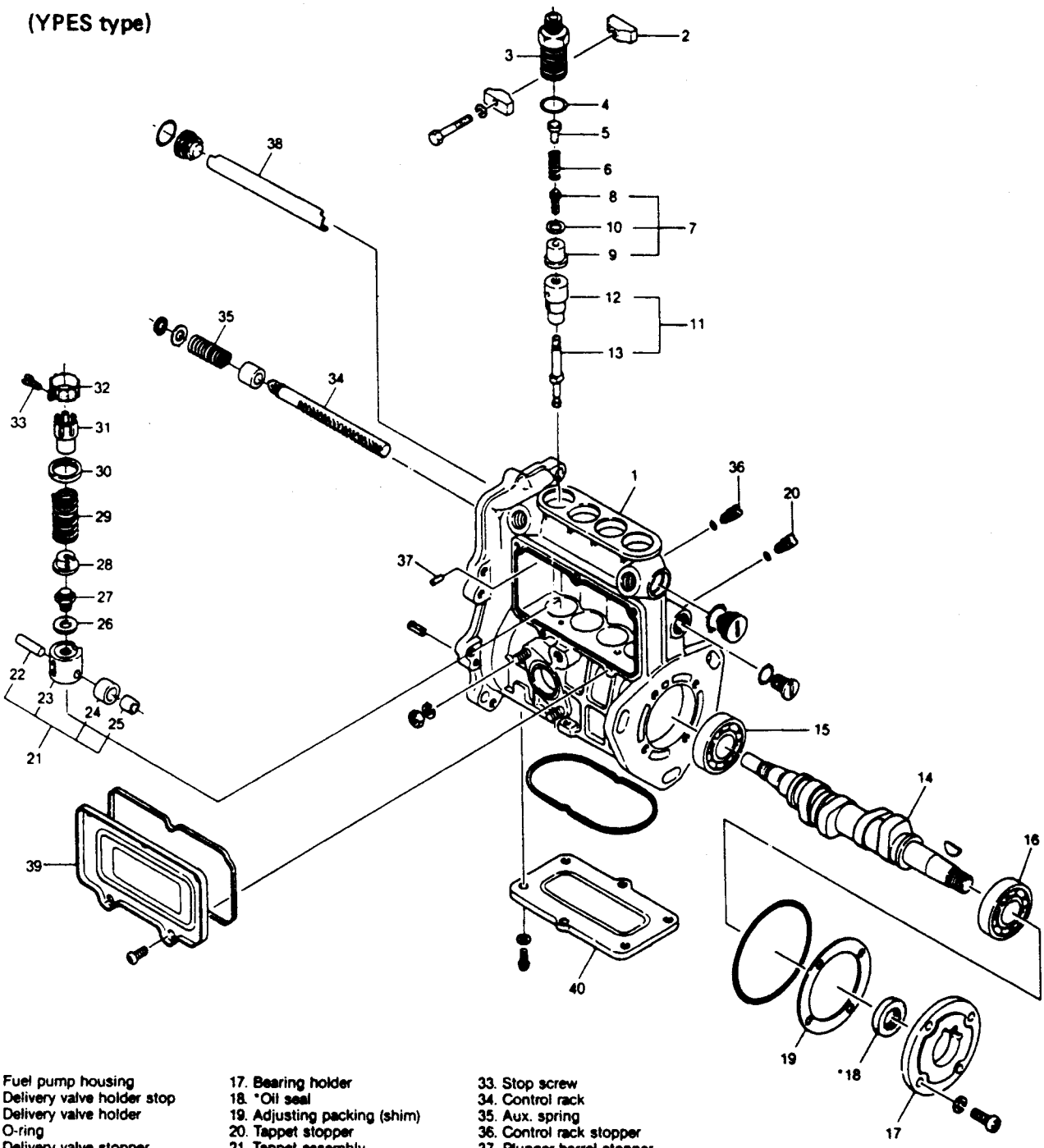


(7) Stopping engine

The engine stops when you turn the governor control lever all the way towards stop.
On engines equipped with a stop device, the engine can be stopped by moving the control rack to the stop position, regardless of the control lever position.

4-11-2 Disassembly, Reassembly and Inspection of Fuel Injection Pump

(YPES type)



1. Fuel pump housing
2. Delivery valve holder stop
3. Delivery valve holder
4. O-ring
5. Delivery valve stopper
6. Delivery valve spring
7. Delivery valve assembly
8. Delivery valve
9. Delivery valve seat
10. Delivery packing
11. Plunger assembly
12. Plunger barrel
13. Plunger
14. Fuel pump camshaft
15. Bearing
16. Bearing
17. Bearing holder
18. *Oil seal
19. Adjusting packing (shim)
20. Tappet stopper
21. Tappet assembly
22. Pin
23. Roller guide
24. Roller (outer)
25. Roller (inner)
26. Adjusting shim
27. Adjusting bolt
28. Plunger spring seat B
29. Plunger spring
30. Plunger spring seat A
31. Control sleeve
32. Control pinion B
33. Stop screw
34. Control rack
35. Aux. spring
36. Control rack stopper
37. Plunger barrel stopper
38. Deflector
39. Pump side cover
40. Pump bottom cover

Note: *1. Some models are equipped with ball bearings and some with taper roller bearings.*
*2. *Oil seal: Some models are equipped with oil seals and some are not. The shape of the bearing holder differs for models with and without seals.*

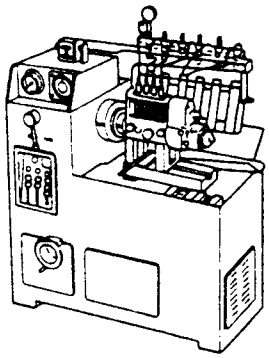
4-11-3 Adjustment of Fuel Injection Pump and Governor

Adjust the fuel injection pump after you have completed reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, roller guide assembly, fuel camshaft, etc. Procure a pump tester like the one illustrated below.

1. Preparations (YPES type)

Prepare for adjustment of the fuel injection pump as follows:

(1) Adjusting nozzle assembly and inspection of injection starting pressure.



kgf/cm²

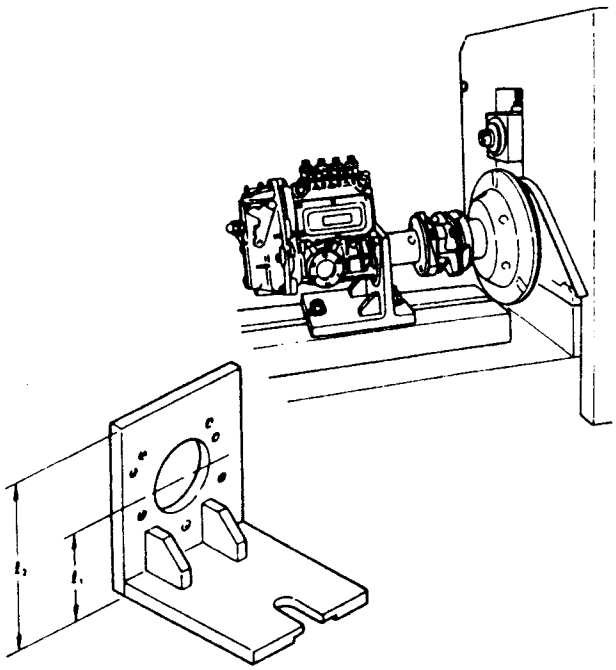
Adjusting nozzle type	YDN-12SD12
Injection starting pressure	165~175

(2) Adjusting injection pipe.

mm

Inner dia./outer dia. × length	2.0/6.0 × 600
Minimum bending radius	25

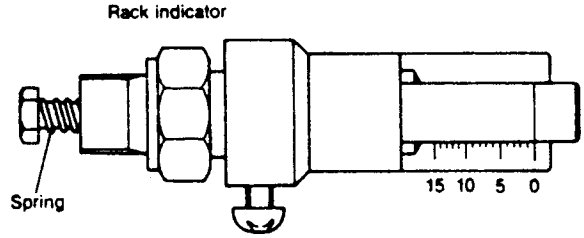
(3) Mount the fuel injection pump on the pump tester platform.

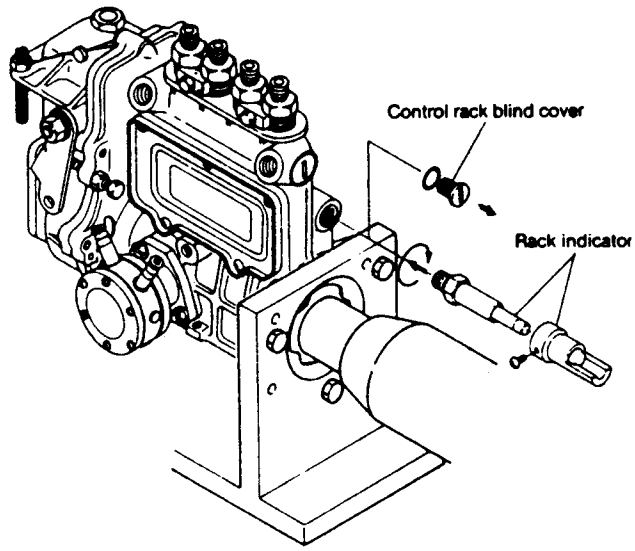


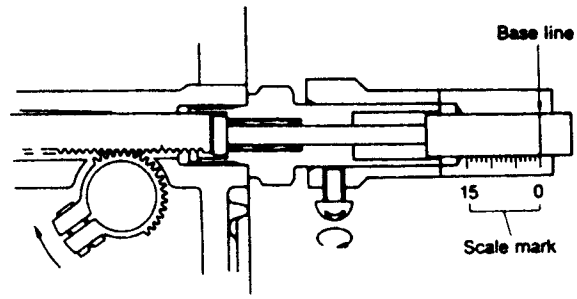
mm

Tester used	ℓ_1	ℓ_2	Part code number
Yanmar	110	150	158090-51010
Robert Bosch	125	165	158090-51020

(4) Remove the control rack blind cover and fit the rack indicator.
Next, turn the pinion from the side of the pump until the control rack is at the maximum drive of the side position, and set it to the rack indicator scale standard position. Then make sure that the control rack and rack indicator slide smoothly.







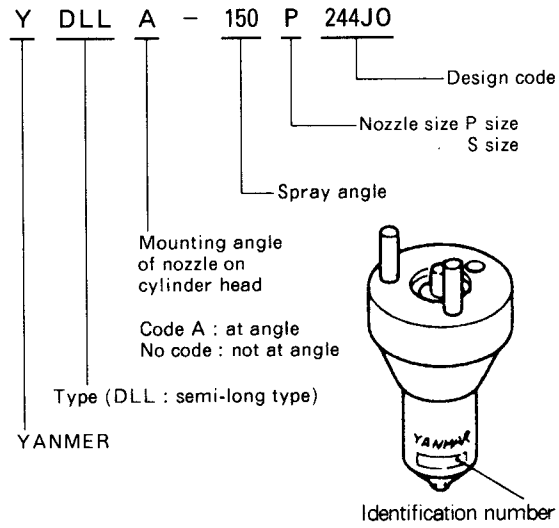
Part code number	158090-51500

2. Nozzle body identification number

The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

1) Hole type injection nozzles

(Sample)

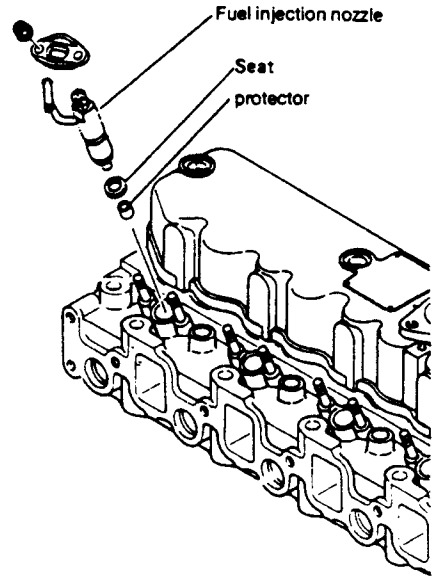


3. Fuel injection nozzle disassembly

Note: *1. Disassemble fuel injection nozzle in a clean area as for fuel injection pump.*

2. When disassembling more than one fuel injection nozzle, keep the parts for each injection nozzle separate for each cylinder (i.e. the nozzle for cylinder 1 must be remounted in cylinder 1).

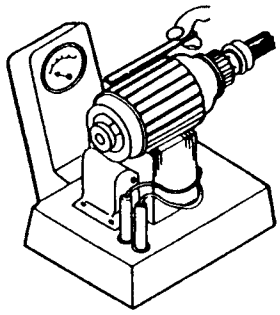
(1) When removing the injection nozzle from the cylinder pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.



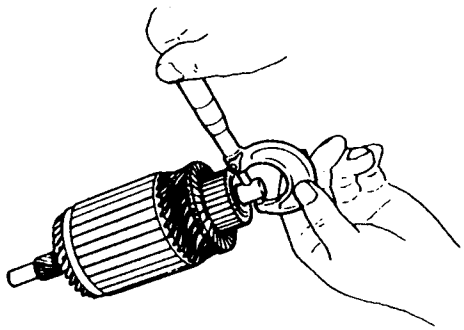
(2) Service data of fuel injection pump

Engine Model				4TNE88L-RBV
Part Ass'y No.				729430-51360
Adjustment specification				Engine spec
Nozzle type				150P234HAC
Injection start pressure			kg/cm	190~210
Fuel injection pipe D/d × L			mm	6/1.6 × 400
Top clearance (pre-stroke)			mm	1.0 (2.5)
Rated load	Pump speed : N1		rpm	1100
	Rack position (indicator scale) : R1		mm	15
	Measuring stroke		st	——
	Injection volume : Q1		cc	29±0.75
	Variation of cyl. to cyl.		%	±3
High idle speed	Pump speed : N2		rpm	1175
	Rack position (indicator scale) : R2		mm	——
Idling or at rack position b-2	Pump speed : N3 or N1		rpm	500
	Measuring stroke		st	——
	Injection volume : Q3		cc	——
	Variation at (R1-2 mm) rack position (between cylinder)		%	——
Starting	Pump speed : N4		rpm	200
	Rack position (indicator scale) : R4		mm	19
	Measuring stroke		st	——
	Injection volume : Q4		cc	45±5
Torque rise	Angleich spring	Pump speed : N5	rpm	800
		Screw-in angle : θ	mm	——
		Measuring stroke	st	——
		Injection volume : Q5	cc	33.5±1.5
	Torque spring	Pump speed : N5	rpm	——
		Torque rise stroke	mm	——
		Measuring stroke	st	——
		Injection volume : Q5	cc	——

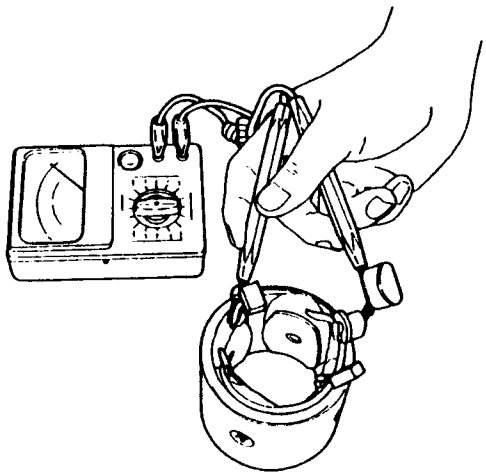
Armature coil short test
Place the iron piece on the armature fitted to the layer short tester and turn the armature.
If the iron piece vibrates, there is a short circuit and the armature should be replaced.



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

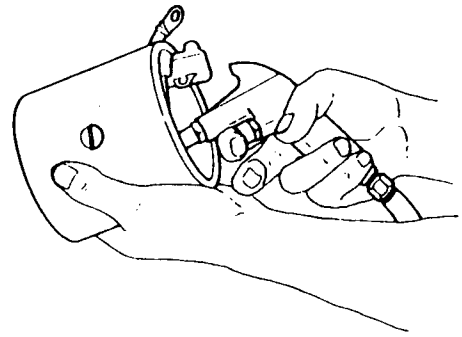


2. Field coil
(1) Open test
Check for continuity between the terminals of the field coil. If there is continuity, the coil is open and must be replaced.



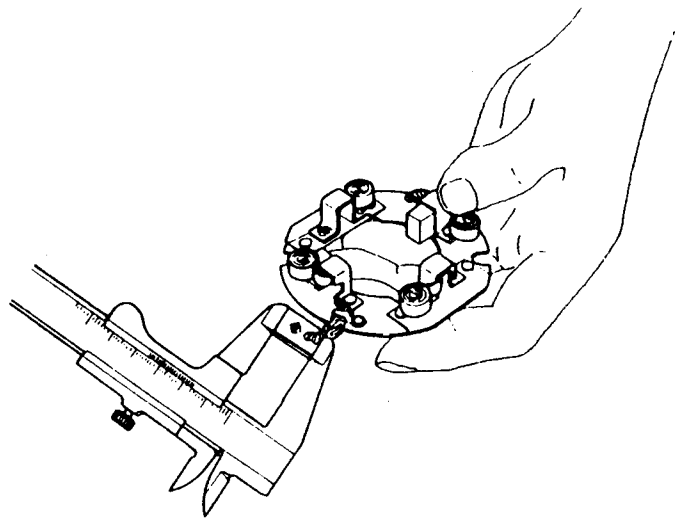
(2) Short test
Check for continuity between the yoke and any field coil terminal. If there is continuity, the coil is shorted and it must be replaced.

(3) Cleaning the inside of the yoke
If any carbon powder or rust has collected on the inside of the yoke, blow the yoke out with dry compressed air.
Do not remove the field coil from the yoke.

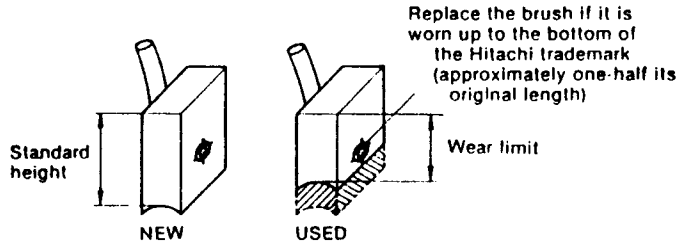


3. Brush

The brushes are quickly worn down the motor will drop.



(1) Brush dimensions
Replace brushes which have been worn beyond the specified wear limit.



mm (in.)

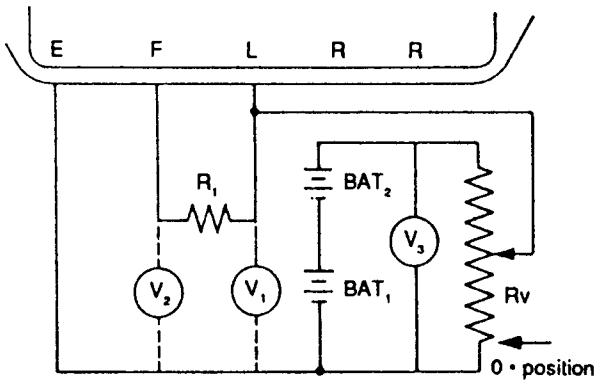
Bush standard height	See separate service data (Page, 4–12–11)
Wear limit	

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" (F-E terminal voltage), move Rv gradually from the 0-position. Check if there is a point where the V" 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 V1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V2 rises sharply by 2 - 6V. Measure the voltage of V1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

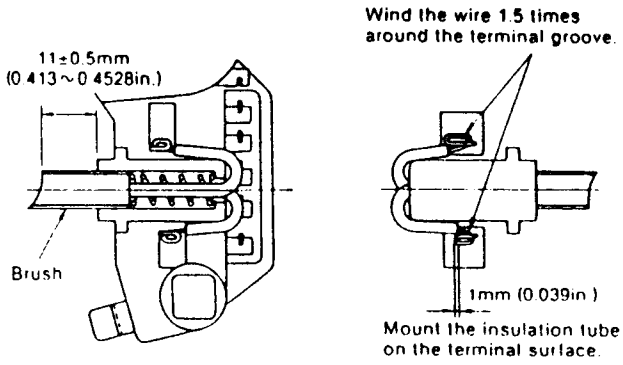


4-13-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4-13-7 Disassembling alternator).

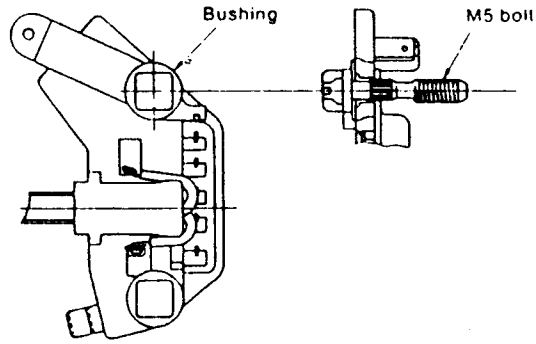
(1) Assembling the brush regulator

1) Solder the brush
Polish 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℃.

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 (220.5lbs.)*
2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

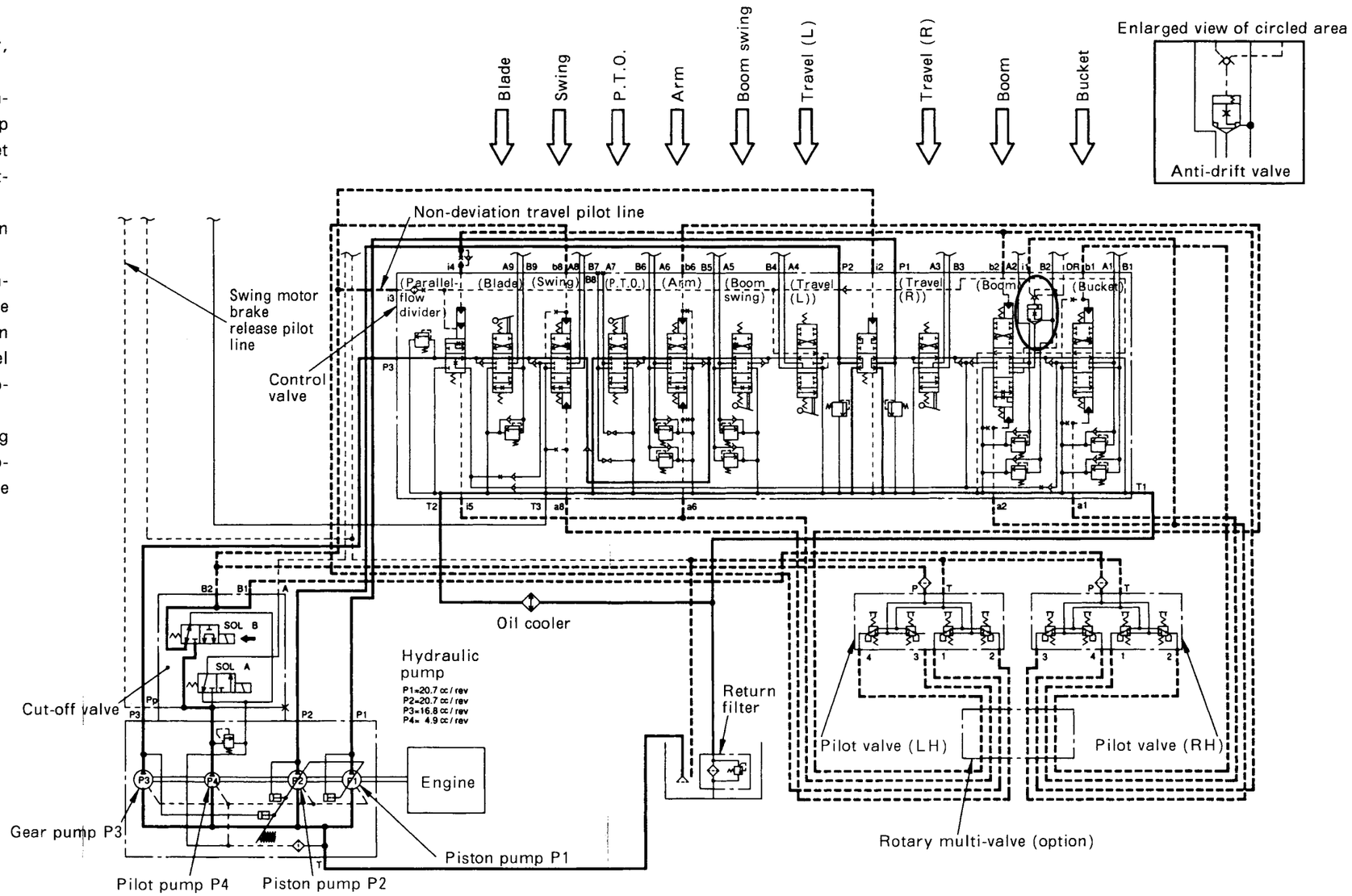
1) Check the rivets.
Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500 kgf (1102 lbs.)

5. HYDRAULIC SYSTEM

5-1-1 Control Valve Operation

The oil from the piston pump P1 is fed to the right travel motor and the boom and bucket cylinders.
The oil from the piston pump P2 is fed to the left travel motor, the boom swing and arm cylinders and the P.T.O..
The oil from the gear pump P3 is fed to the blade cylinder, the swing motor, the arm cylinder and the P.T.O..
The arm cylinder and the P.T.O. are actuated by the combined oil flow which consists of the oil from the piston pump P2 and that from the gear pump P3. The boom and bucket cylinders have parallel passages so that they can be actuated simultaneously.
An anti-drift valve is installed in the boom cylinder section to prevent the boom from drifting.
In addition, a swing motor brake release pilot line is installed to release the brake of the swing motor with the pressure oil from the pilot pump P4, and a non-deviation travel pilot line is installed to allow the machine to travel without deviation while any of the work implements are operating.
The inlet section is added in order not to allow the traveling of the machine when the lock lever is set to the "Lock" position. For the details, refer to the section "Track Drive Lock" on page 5-1-6.



5-3-4 Swing

• Mechanical brake operation

a. During the engine stop, no pressure oil flows to the brake release port P of the swing motor. Therefore, the mechanical brake installed in the swing motor works and the pinion gear of the swing motor is locked so as not to turn the upperstructure.

b. When the engine is started, the pressure oil from the pilot pump P4 flows to the brake release port P to release the brake, so that the pinion gear of the swing motor is released.

c. For the details, refer to the section of the theory of operation for the swing motor.

When the swing control lever is moved to the right, the oil from the pilot pump P4 flows through the cut-off valve and the port 2 of the pilot valve (LH) to the port a8 of the control valve to move the swing spool.

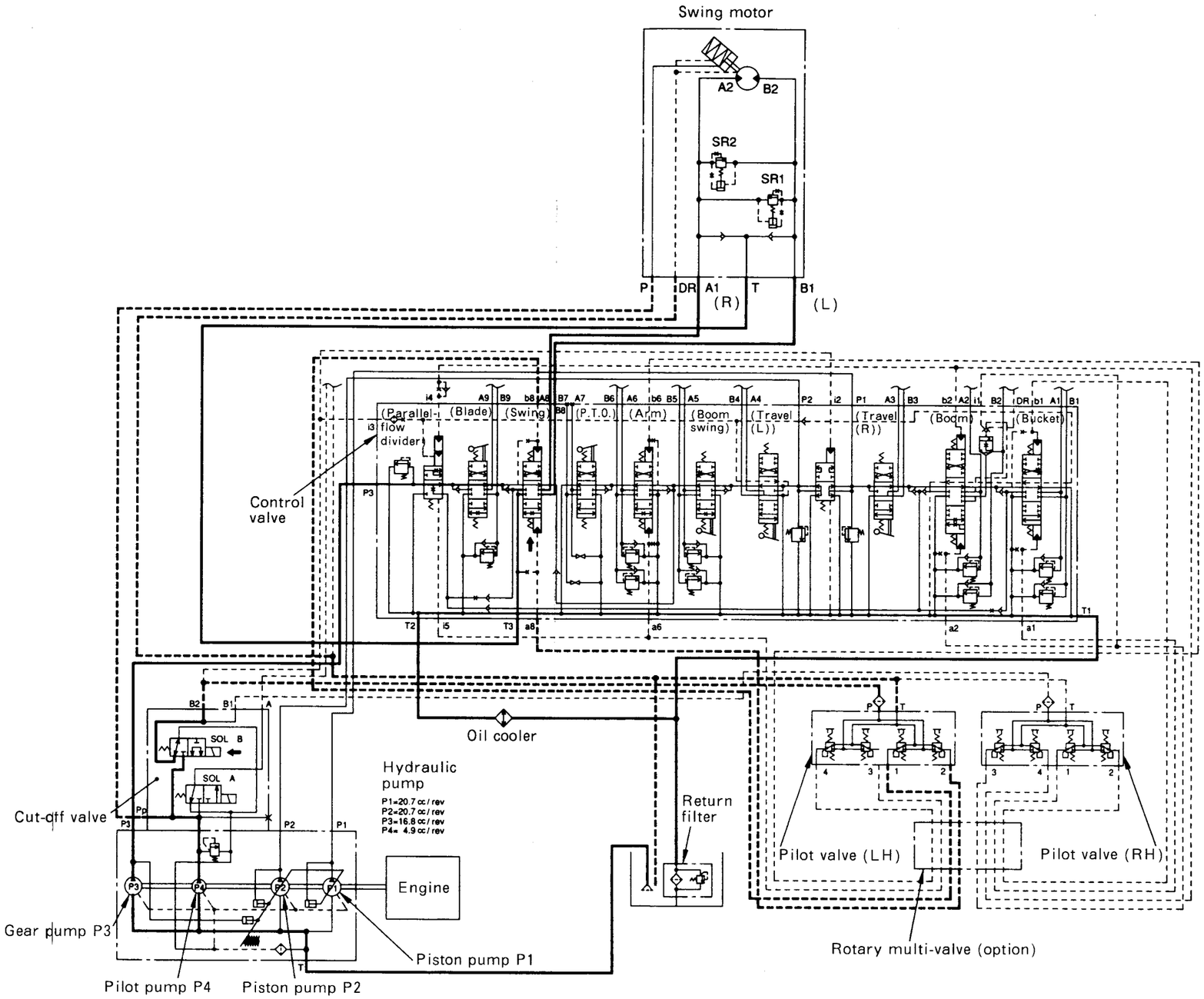
The oil from the gear pump P3 flows through the ports P3 and A8 of the control valve and the port A1 of the brake valve to the swing motor.

The return oil from the motor flows back to the hydraulic oil tank through the port B1 of the brake valve, the ports B8, T1 and T2 of the control valve and the return filter.

When the swing control lever is released (i.e., returned to the neutral position), the oil from the gear pump P3 is blocked and the pressures of the ports A1 and B1 of the brake valve become equal. However, the upperstructure continues to swing in a short time due to its inertia. This causes the motor to act like a pump and increase the pressure of the port B2. The increased pressure opens the relief valve SR1 to let the oil escape to the port A2, so that the shock due to the inertia is absorbed, and the brake valve is also installed in the motor to prevent cavitation of the port A2. The port T of the brake valve serves to suck up the oil from the port T3 of the control valve in order to provide the draining function and prevent the cavitation of the motor.

When the swing control lever is moved to the left, the oil from the pilot pump P4 flows through the cut-off valve and the port 1 of the pilot valve (LH) to the port b8 of the control valve to move the swing spool.

The oil from the gear pump P3 to the motor flows in the opposite direction to the oil flow in the right swing operation with the swing motor.



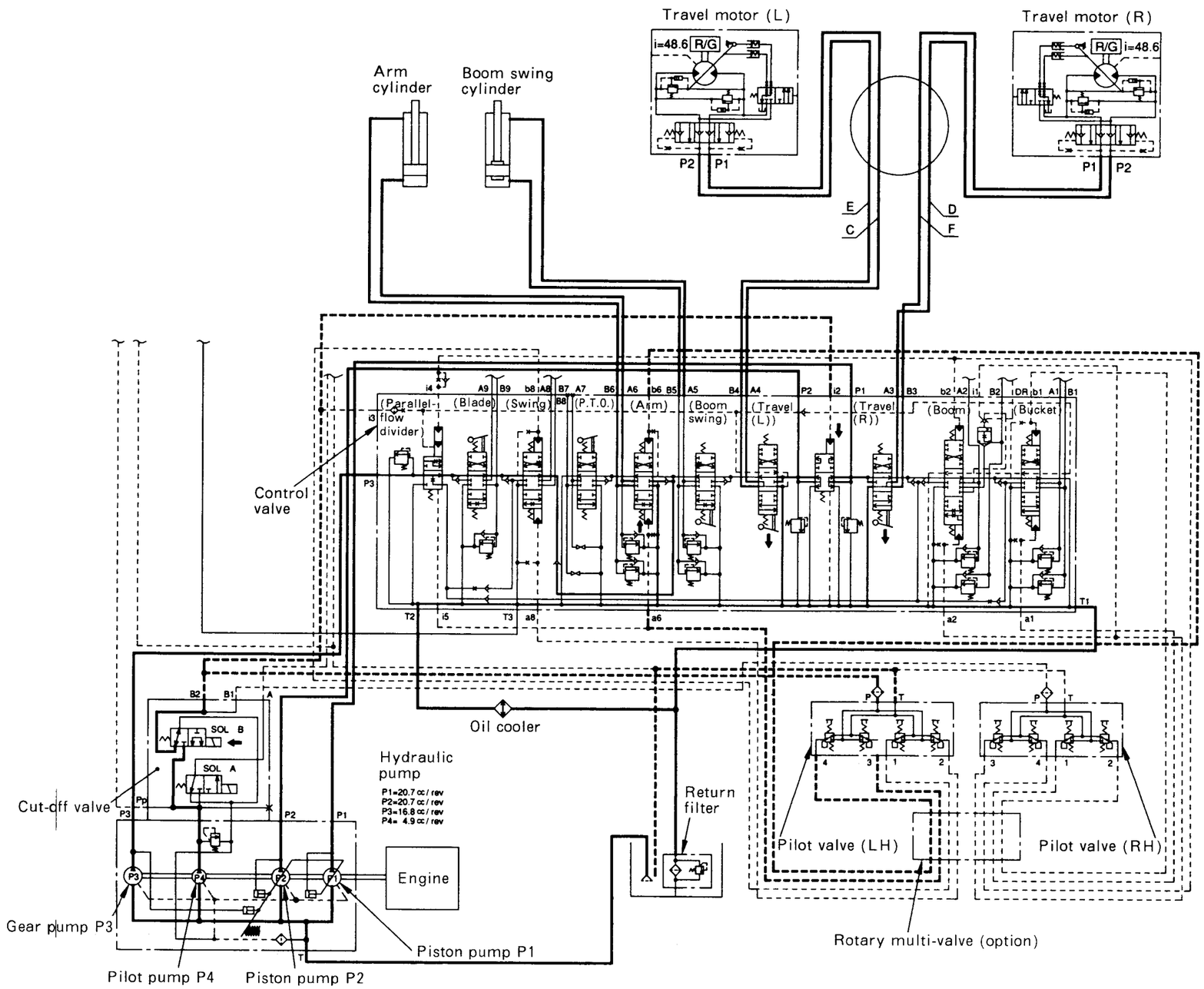
5-3-9 Simultaneous Operation of Travel and Arm/Boom Swing

The right and left travel valves are installed the most upstream and in series in the circuits of the piston pumps P1 and P2, respectively, so that the oil from each piston pump is supplied only to the travel motor when the travel lever is operated.

When the arm control lever is operated while the machine is traveling, the oil from the piston pump P2 flows only to the left travel section and the oil from the gear pump P3 is only led to the arm cylinder through the ports P3 and A6 (B6) of the control valve.

In that way, the right and left travel motors are supplied with oil from the piston pumps P1 and P2, respectively, and the arm cylinder is only supplied with oil from the gear pump P3. Therefore, the arm can be operated while the machine is traveling without any deviation.

Since the left travel section and the boom swing section are connected in series, the oil from the piston pump P2 is supplied only to the left travel motor and not supplied to the boom swing circuit even if the boom swing pedal is moved while the machine is traveling. Therefore, the boom swing cannot be operated when the machine is traveling.



5-3-14 Hydraulic P.T.O.

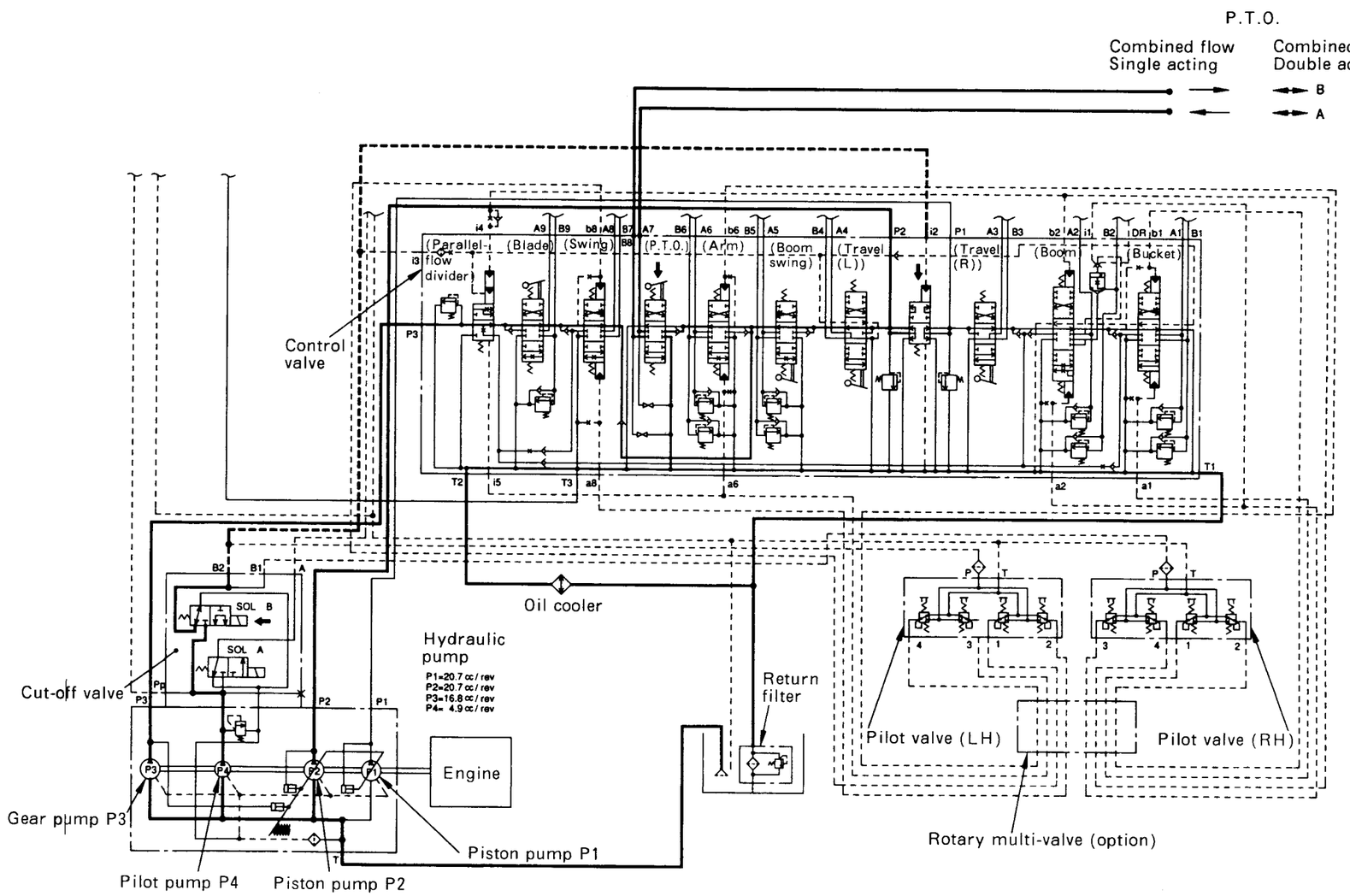
Combined oil/Double acting actuators

When the P.T.O. pedal is moved to the left, the oil from the piston pump P2 and that from the gear pump P3 flow through the ports P2 and P3 of the control valve, respectively, and are combined in the arm section, and the combined oil flows through the port B7 of the control valve to the port B of the P.T.O.. The return oil from the port A of the P.T.O. flows back to the hydraulic oil tank through the ports A7, T1 and T2 of the control valve and the return filter.

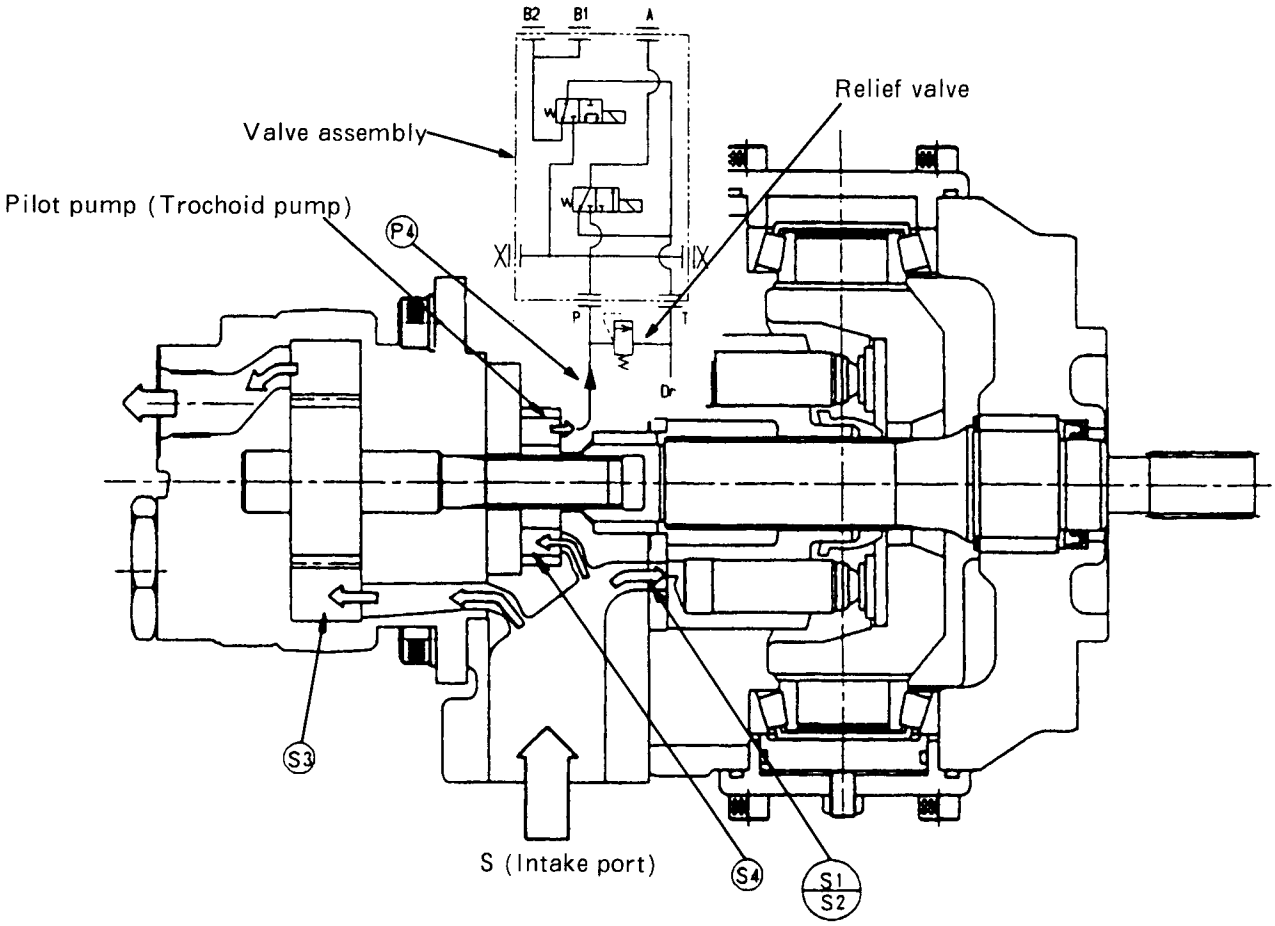
When the P.T.O. pedal is moved to the right, the oil flows in the opposite direction with regard to the P.T.O..

Note:

When the lock lever is in the "Lock" position, no oil from the piston pump P2 flows and only the oil from the gear pump P3 flows.



3) Oil flows from intake port and pilot pump discharge port



The oil flows from the intake port S of this pump and the discharge port P4 of the pilot pump are as follows:

- The oil sucked in from the intake port S flows into the intake ports S1, S2, S3, and S4 of the piston pumps, the gear pump and the pilot pump, as shown with arrows in the above figure, and the oil is discharged to their respective circuits.
- The oil discharged from the discharge port P4 of the pilot pump flows to the valve assembly through the relief valve installed in the oil port block, as shown with an arrow in the above figure.

5. Disassembly and reassembly .

1) Precautions for disassembly and reassembly

(1) Since the parts of this hydraulic system are precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean area that is free from dust.

(2) Prepare clean tools and cleaning oil and handle the parts carefully.

(3) First clean the external surface of the removed assemblies.

(4) Before beginning disassembly, review the drawings of the internal construction and prepare the required parts according to the purpose and extent of the disassembly.

(5) Never disassemble or readjust the adjust screws unless required. If they are disassembled or readjusted, it may cause the set horsepower to be changed and have a negative influence.

(6) In principle, the removed seals and rings must be replaced with new ones. As some replacement parts are available only in subassemblies, refer to the parts catalog to prepare the necessary subassemblies in advance.

(7) Handling of O-rings

[1] Lubricate the O-rings and the O-ring fitting seats with clean grease or hydraulic oil.

[2] The O-rings may not be damaged in handing or distorted by heat.

[3] Do not permanently deform the O-rings.

[4] Avoid rolling the O-rings when fitting them.

A distorted O-ring may not return to its original shape, and therefore may cause oil leak.

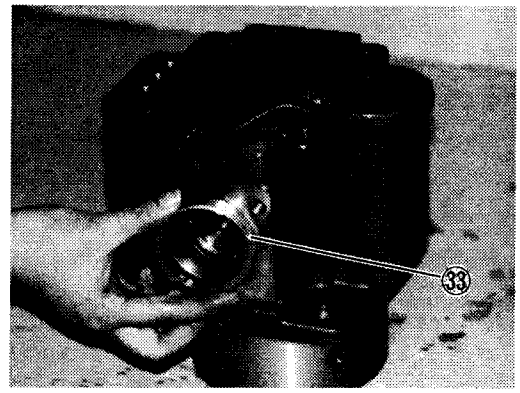
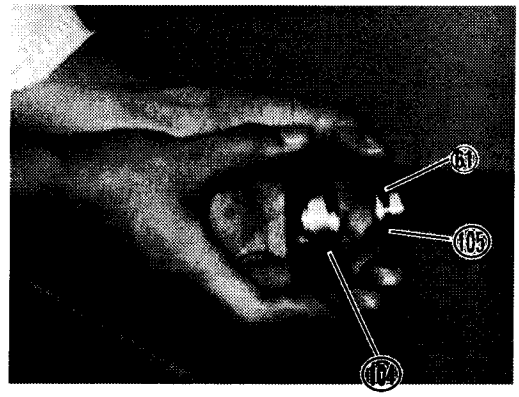
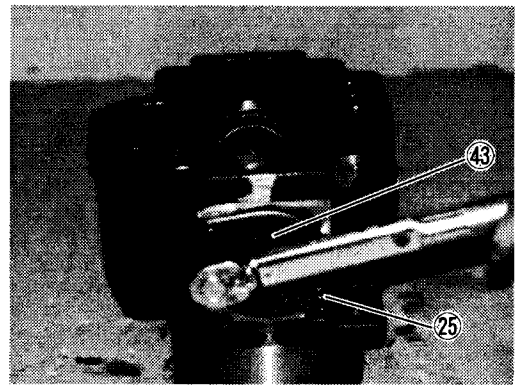
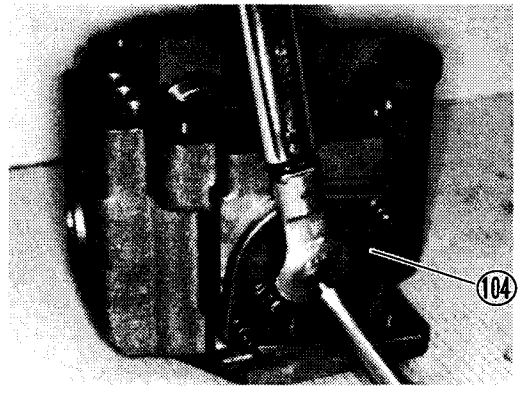
(8) Before beginning reassembly, check the mating surfaces of each section to be sure that there is no cleaning oil or hydraulic oil on the outer surface of the O-ring grooves. If reassembly is performed without cleaning such oil, it may be mistaken for oil leak.

(9) Use a torque wrench to tighten the bolts following the torque specification.

2) Tools for Disassembly and Reassembly

(Unit : mm)

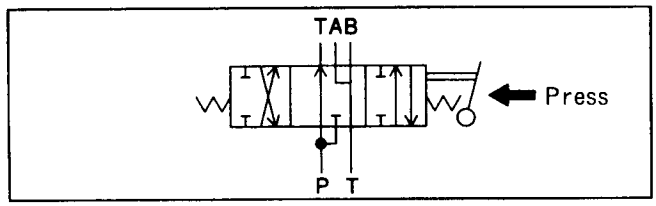
No.	Tools		No.	Tools	
1	Torque wrench (preset type)	450	13	Monkey wrench	Full length : 250
2	Torque wrench (preset type)	230	14	Screwdriver	Width across flats: 36
3	Hexagon bar bit for the above wrench	Width across flats : 3	15	Snapring pliers	ϕ30 for internal snap ring
4	Hexagon bar bit for the above wrench	Width across flats : 4	16	Snapring pliers	ϕ40 for internal snap ring
5	Hexagon bar bit for the above wrench	Width across flats : 6	17	Pliers	
6	Hexagon bar bit for the above wrench	Width across flats : 8	18	Hammer	
7	Hexagon bar bit for the above wrench	Width across flats : 10	19	Plastic hammer	
8	Hexagon bar wrench	Width across flats : 3	20	Others	Grease (lithium grease)
9	Hexagon bar wrench	Width across flats : 4			Oil (specified oil)
10	Hexagon bar wrench	Width across flats : 6			Jig for holding pump
11	Hexagon bar wrench	Width across flats : 8			
12	Hexagon bar wrench	Width across flats : 10			

Procedure	
(9) Install outer races of both sides bearings ㉝ in housing ①.	
(10) Install O-ring ⑩⑤ on bush ⑥① and install them onto trunnion cover ⑩④.	
(11) Install O-rings ④④ on trunnion covers ④③ and ⑩④. Put housing ① with the three-hole side upward and install trunnion cover ⑩④ on the left side of housing ① and trunnion cover ④③ on the right side, and then, fasten them with hexagon socket head bolts ②⑤. ***Note:*** *Check if swash plate swings smoothly after tightening hexagon socket head screws ②⑤.* Tightening torque : 3.0 kgf-m.	
(12) Screw set screw ③① into trunnion cover at a tightening torque of 0.2 kgf-m and tighten locknut ⑩④. Tightening torque for locknut : 1.4 kgf-m.	

2) Valve assembly and relief valve

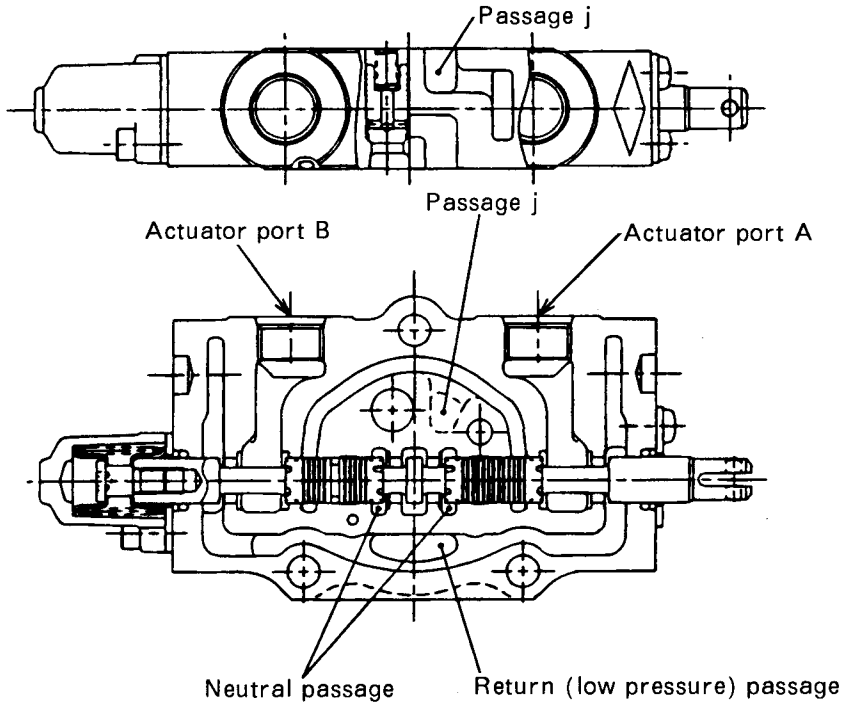
Trouble	Check	Result	Cause	Remedy
1. **Malfunction of valve** **(Oil does not flow properly.)** **(Pressure is not stable.)**	(1) Check the relief valve.	• Set pressure is low.	• Pressure is not set correctly.	• Set the pressure to the specified value.
		• Spool does not work properly.	• Clogged spool	• Remove and wash the spool, and replace hydraulic oil.
			• Damaged or worn spool	• Replace the valve.
	(2) Check the solenoid valves.	• Current does not flow through the solenoid.	• Damaged solenoid	• Replace the solenoid.
			• Disconnected connector	• Connect the connector.
		• Spool does not work properly.	• Clogged spool	• Remove and wash the spool, and replace hydraulic oil.
			• Damaged or worn spool	• Replace the valve.
2. **External leakage**	(1) Check the tightening torque of the bolt.	• Bolt is loosened.	• Improper installation	• Retighten the bolt at the specified torque.
	(2) Check the O-ring and packing.	• O-ring or packing is faulty.	• Damaged O-ring or packing	• Replace the O-ring or packing.
	(3) Check the fitting face of the O-ring and packing.	• Fitting face is faulty.	• Damaged fitting face	• Replace the valve.

3) Travel (R)



(1) Neutral

The oil discharged from the piston pump P1 returns to the hydraulic oil tank through the neutral passage. Both actuator ports A and B are connected to the return (lower pressure) passage.

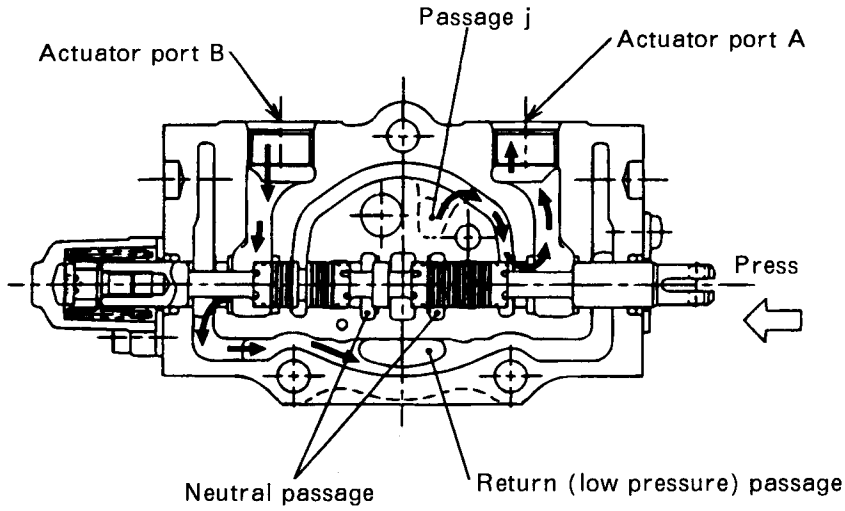


(2) Backward travel operation

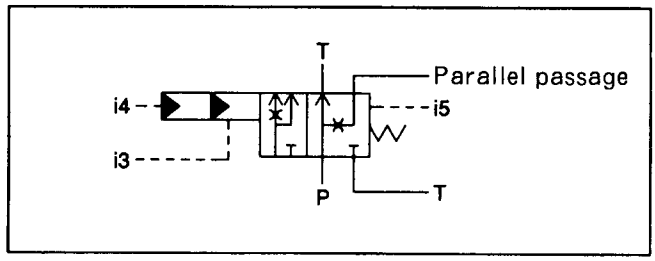
When the right travel control lever is pulled back, the spool is moved to the left and the neutral passage is closed. The oil from the piston pump P1 flows through the passage j to the actuator port A. The oil returned from the actuator port B flows back to the hydraulic oil tank through the return (lower pressure) passage.

The spool is returned to the neutral position by the return spring.

When the right travel control lever is pushed forward, the oil flows to the actuator port B and returns from the actuator port A to the hydraulic oil tank.



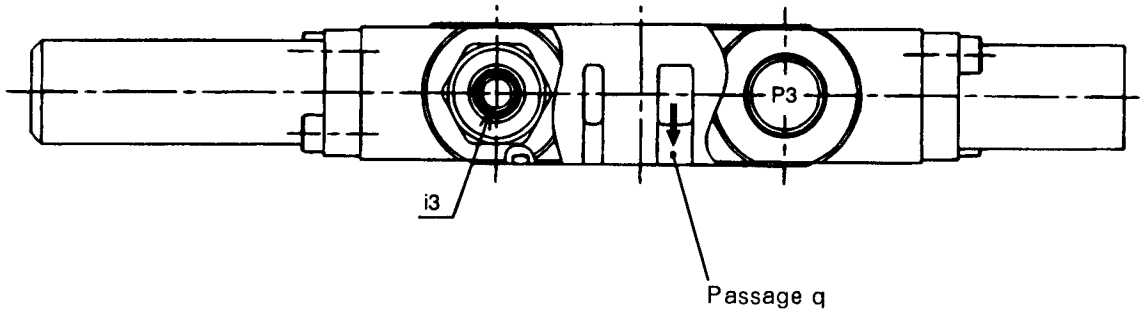
11) Parallel-flow divider

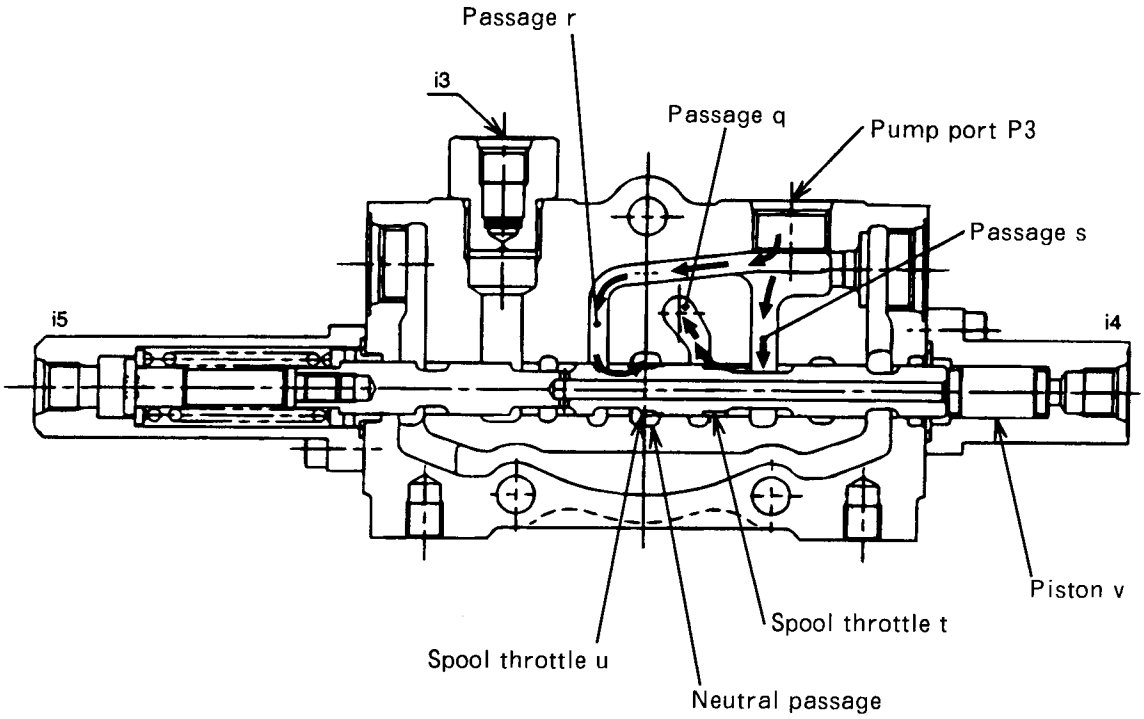


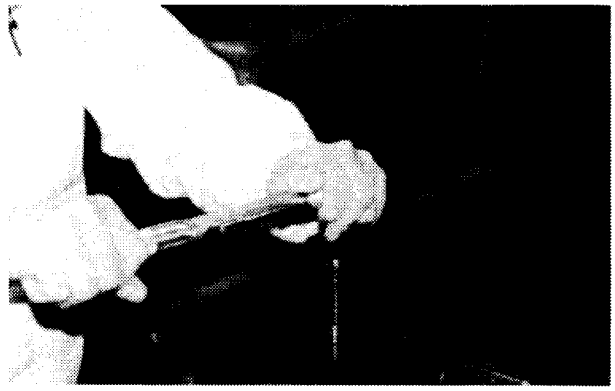
(1) Neutral

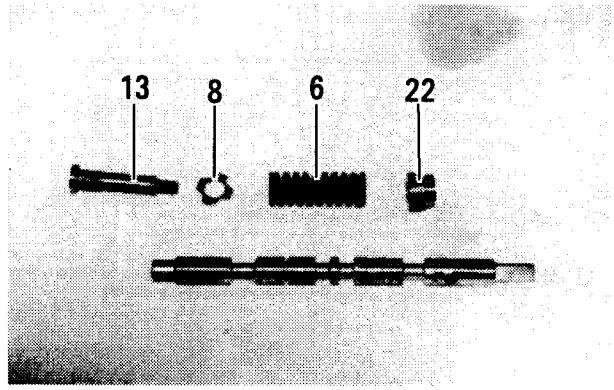
The oil from the gear pump P3 flows to the neutral passage through the passage r and also to the swing, bucket and boom sections through the passage s and the spool throttle t.

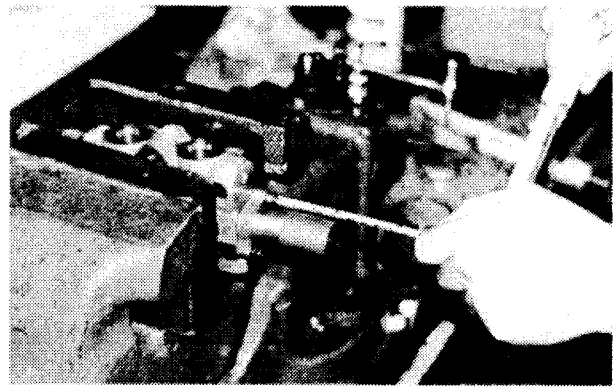
The pilot oil from the port i3 is led to the return (lower pressure) passage through the pilot line.

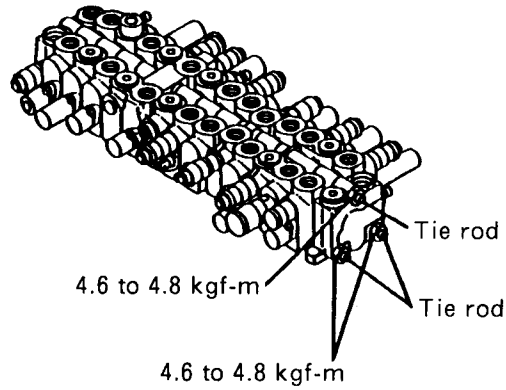


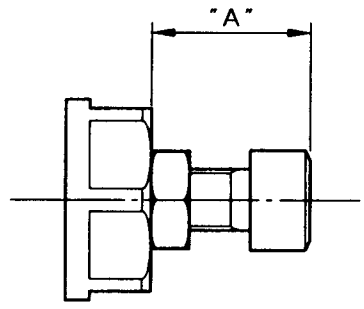


Procedure	
(12) Hold spool assembly with a bench vice. ***Note***: *Install wooden spool holder (refer to P. 6-2-27) or jaw covers on the bench vice.*	

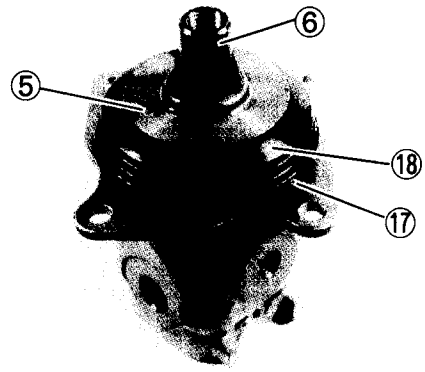
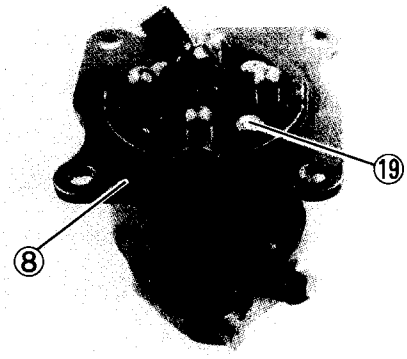
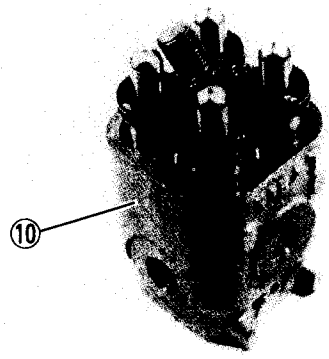
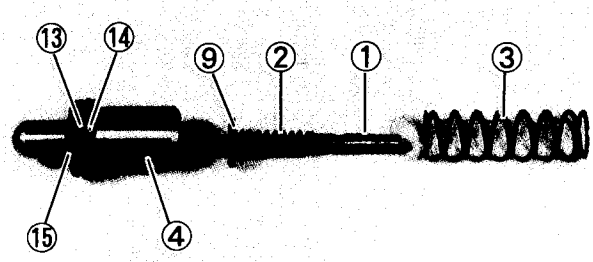
(13) Slowly loosen spool end **13** to remove spring seat **8**, spring **6** and spring seat **22** in order. ***Note***: *When loosening the spool end, take care not to get it to jump out.*	

Procedure	
(16) Install cap with O-ring onto the valve housing and fasten it with hexagon socket head bolts. Tightening torque : 0.9 to 1.1 kgf-m	

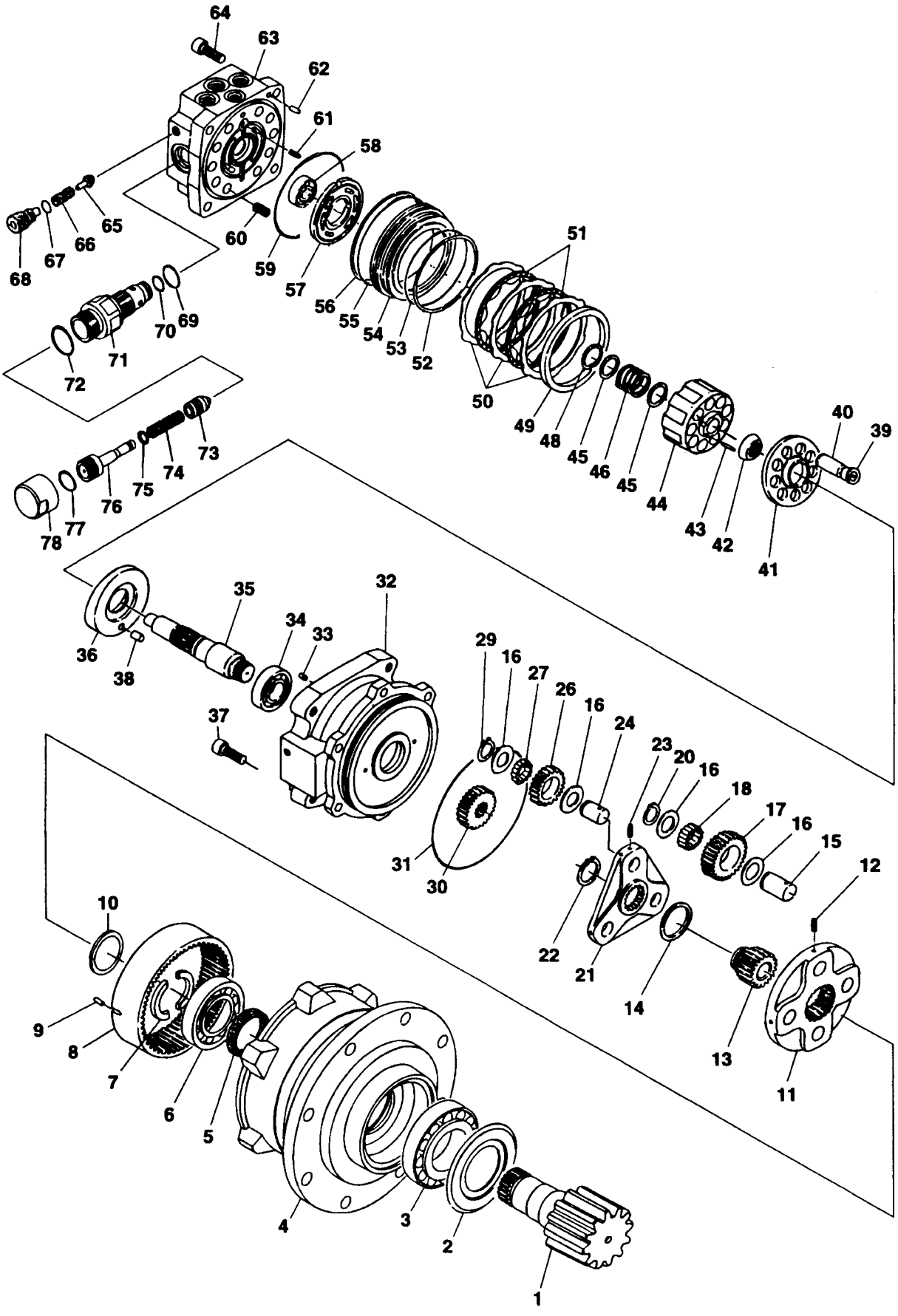
(17) Place all the valves in the correct order, and insert tie rods into them and tighten nuts (width across flats: 12) to fasten them. Tightening torque : 4.6 to 4.8 kgf-m ***Notes***: *a) Take care not to install the springs for load check valves in bent condition.* *b) Apply grease to O-ring to hold it in place during assembly.*	

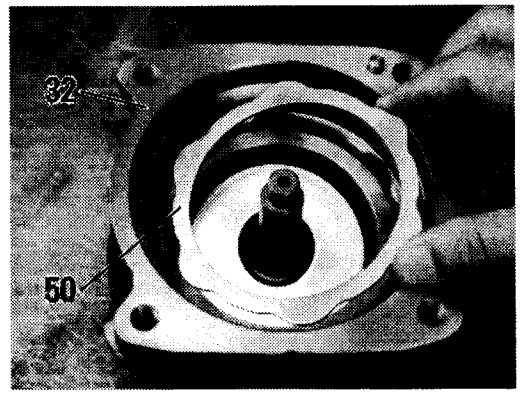
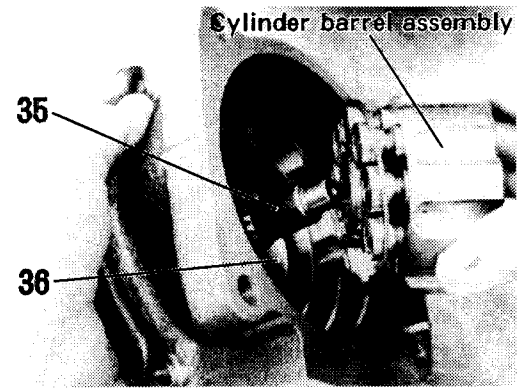
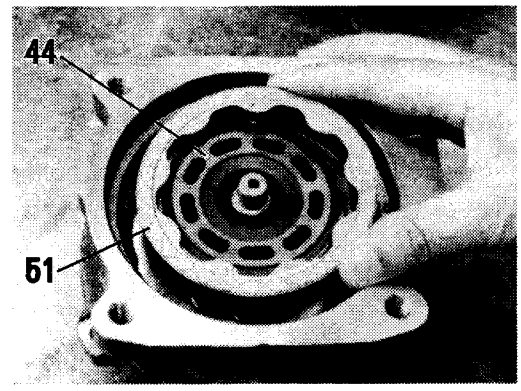
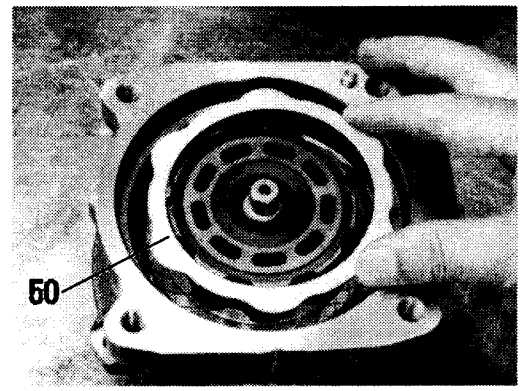
(18) Adjust the height A of hexagon socket head bolts for shut-off valves as follows: A: • Standard : 23.5 to 25.5 mm • For hydraulic P.T.O. : 20.6 mm	

2) Disassembly

Procedure	
(1) Clean and dry the valve. (2) Remove boot ⑱ and O-ring ⑰. (3) Remove nut ⑥ and disc ⑤. ***Note:*** *Loosen nut ⑥ while holding disc ⑤ with a wrench (width across flats : 27 mm).*	
(4) Remove hexagon head bolts ⑲. (5) Remove plate ⑧.	
(6) Remove piston assembly, spool assembly and spring ③ from body ⑩. (7) Remove retainer ⑨ to remove spool ①, spring ② and shim ⑫. (8) Remove oil seal ⑮, collar ⑭ and O-ring ⑬ from piston④.	 

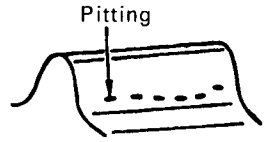
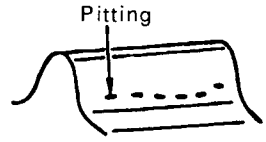
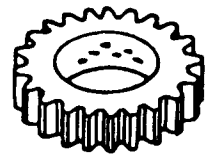
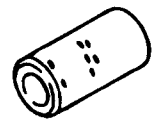
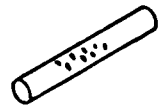
3) Exploded view and component parts



Procedure	
(9) Install one of steel plates **50** in groove of body S **32**.	
(10) Install cylinder barrel assembly into body S **32** with shaft **35** put through cylinder barrel assembly until shoes **39** reach swash plate **36**.	
(11) Install one of disc plates **51** in groove of cylinder barrel **44**.	
(12) Install another steel plate **50** in groove of body S **32**.	

6) Service standards

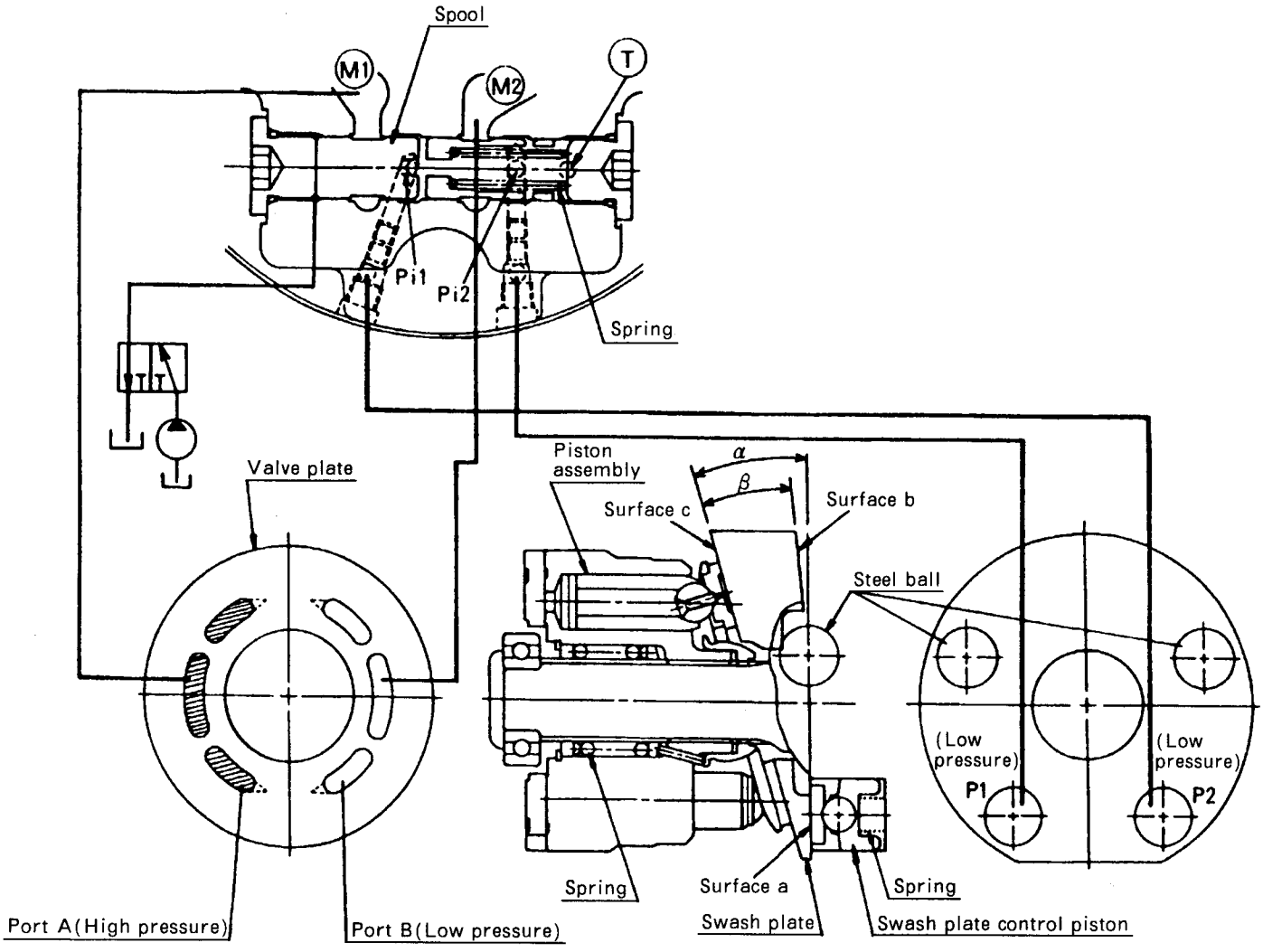
(1) Reduction gear

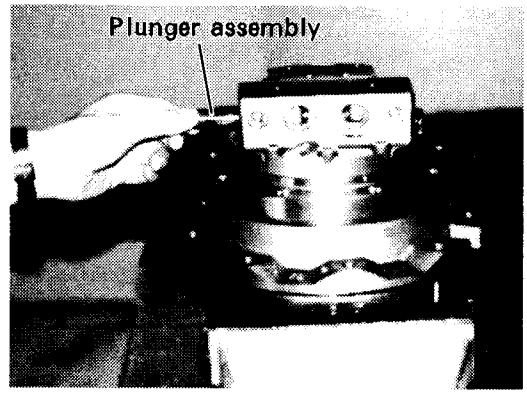
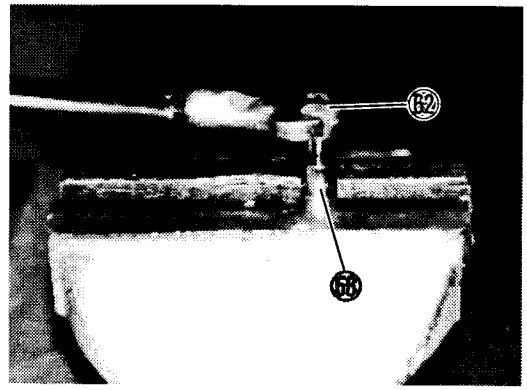
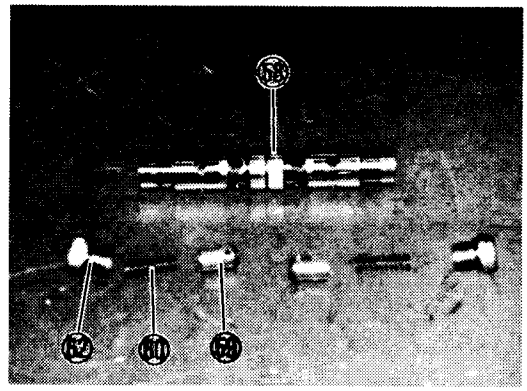
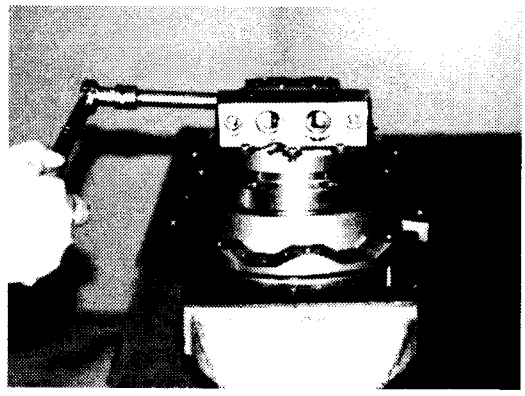
No.	Parts	Inspection item	Inspection standard		Remedy
1	Internal gear a	Wear of tooth surfaces	Pitting area rate: 5% or more of the engaged area	Rate of pitting area to tooth surface 	Replace pinion kit.
2	Carriers 1 and 2	Shear droop and damage in splined area	Check for any damage with eyes		Replace carrier kit.
		Looseness of pins b1 (Carrier 1)	Wear of holes	Looseness by manual check: 0.005 mm or more	
		Looseness of pins b2 (Carrier 2)	Wear of holes		
3	Gears S1, S2, b1 and b2	Wear of tooth surfaces and damage of teeth	Pitting area rate: 5% or more of the engaged area	Rate of pitting area to tooth surface 	Replace carrier kit and/or S2 gear.
		Wear of surface contacted with roller bearing (Gears b1 and b2)	Flaking or pitting seen by eyes		
4	Pins b1 and b2	Wear of surface contacted with roller bearing	Flaking or pitting seen by eyes		Replace carrier kit.
5	Bearings	Wear of rollers and contacted surfaces of inner and outer races	Flaking or pitting seen by eyes		Replace carrier kit.
6	Others (Screws, bolts, O-rings, etc.)	Damage and excessive rust			Replace part.

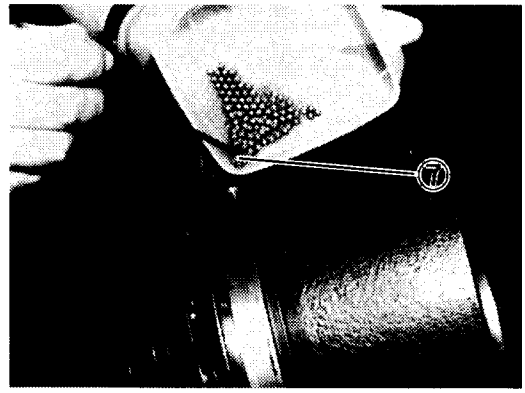
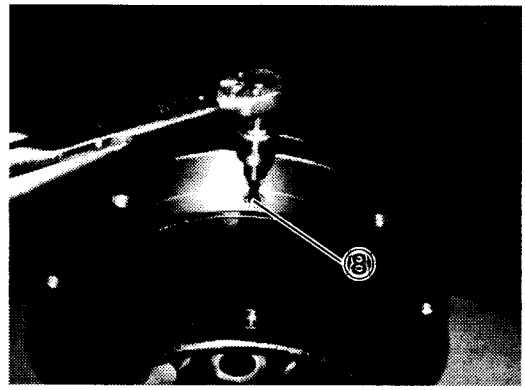
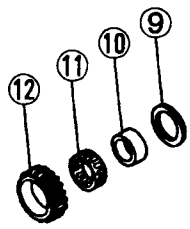
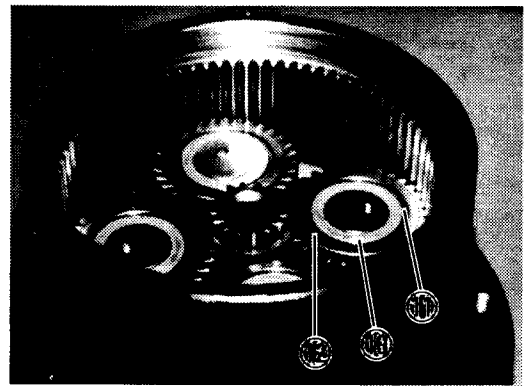
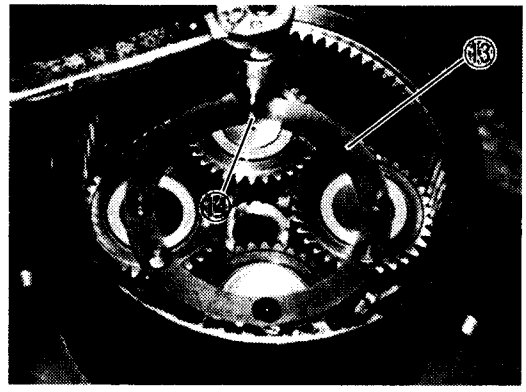
4) 2-speed switching mechanism

1) 1st speed (Slow speed)

The swash plate has three surfaces a, b and c, as shown in the figure below, and is installed on the flange holder with two steel balls so that it can move. When the control valve is in the 1st speed position, since the spool is located in the position as shown in the figure below by the force of the spring and oil passage is connected to the port T via Pi 1 and Pi 2, the low pressure of the return passage only works on the swash plate control piston. In this condition, the swash plate control piston does not push up the swash plate. Accordingly, the surface a at the rear of the swash plate is pressed against the vertical surface by the thrust force of the motor and the force of the spring with the steel balls as the inclination axis. The inclination angle of the swash plate is " α " as shown in the figure.



Procedure	Photo
(5) Turn plunger assembly slowly to remove it. ***Note:*** *Take care not to damage or dent the outside of plunger ⑱.*	
(6) Insert a pin (ϕ5×30 mm) into the through hole (ϕ6 mm) in the plunger assembly. Hold it with a vice to remove plug ⑫. ***Note:*** *Disassemble the plunger assembly only when required.* **Tools:** • Torque wrench (5) • Wrench (15) • Pin ϕ5×30 mm (S-13)	
(7) Remove spring ⑩ and check valve ⑨. ***Note:*** *Keep the right check valve and the left one separately to identify them with regard to the plunger for correct reassembly.*	
(8) Remove plugs ⑳ and ⑰. **Tools:** • Torque wrench (3) • Hexagon bit (9) • Socket (12)	

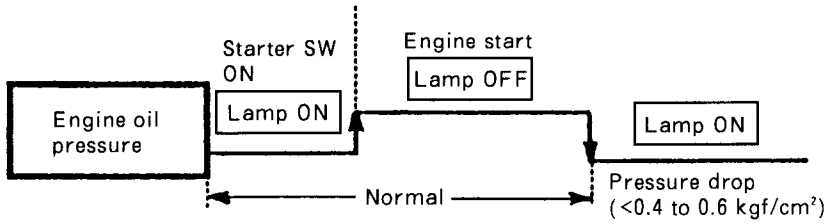
Procedure	Photo
(8) Insert steel balls ⑦ (99 pcs.).	
(9) Wind a seal tape around plug ⑧ and tighten it. Tightening torque : 0.7 to 0.9 kgf-m **Tools:** • Torque wrench (1) • Hexagon bit (7)	
(10) Install thrust washers ⑨, inner races ⑩, needle bearings ⑪ and planetary gears B ⑫. 	
(11) Fit thrust plate ⑬ on the trunnion of the flange holder, apply adhesive (Loctite #262 or its equivalent) to four screws ⑭ and tighten them. Tightening torque : 0.35 to 0.40 kgf-m ***Note:*** *Before applying adhesive, remove oil and grease completely from the screws, and use hardening accelerator.* **Tools:** • Torque wrench (1) • Hexagon bit (6)	

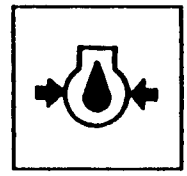
No.	Parts	Inspection item	Standard value (recommended value for replacement)	Measure
16	Cylinder barrel ㊵	Clearance between it and piston assembly. Sliding surface against valve plate. Surface roughness	0.02 mm (0.04 mm) No excessive flaws (over 0.02 mm), wear or seizure. 0.4 Ra (0.8 Ra)	Replace cylinder barrel and piston assembly together. When sliding surface has roughened, repair it by lapping (#1000). If the damage is beyond repair, replace the cylinder barrel and piston assembly together.
17	Springs ㉞, ㊸, ㊿, ㊹, ㊽ and ㊷	Breakage or distortion		Replace.
18	Piston assembly ㊲	Clearance between it and cylinder barrel. Sliding surface against swash plate and surface roughness. Play between pistons and shoes	Same as No.16 Same as No.15 0.15 mm (0. 4 mm)	Same as No.16 Same as No.15 Replace.
19	Piston assembly ㉟	Clearance between it and flange holder. Sliding surface against swash plate and surface roughness.	Same as No.16 Same as No.15	Same as No.16 Same as No.15
20	Valve plate ㊻	Sliding surface against cylinder barrel and surface roughness. Thickness: 5 mm	Same as No.16 4.8 mm	Same as No.16 Replace.
21	Base plate ㊸	Sliding surface against plunger. Sliding surface against spool.	No excessive flaws, wear or seizure. No excessive flaws, wear or seizure.	Replace base plate and plunger together. Replace base plate and spool together.
22	Plunger ㊽	Sliding surface against base plate. Sliding surface against check valve.	No excessive flaws, wear or seizure. No excessive flaws, wear or seizure.	Replace base plate and plunger together. Replace plunger and check valve together.
23	Check valve ㊾	Sliding surface against plunger. Seat surface against plunger.	No excessive flaws, wear or seizure. The plunger is seated completely.	Replace plunger and check valve together. Replace plunger and check valve together.
24	Spool ㊼	Sliding surface against base plate.	No excessive flaws, wear or seizure.	Replace base plate and spool together.
25	Free piston ㊹	Sliding surface against valve body.	No excessive flaws, wear or seizure.	Replace valve body and free piston together.

1. Meters and gauges

1) Engine oil

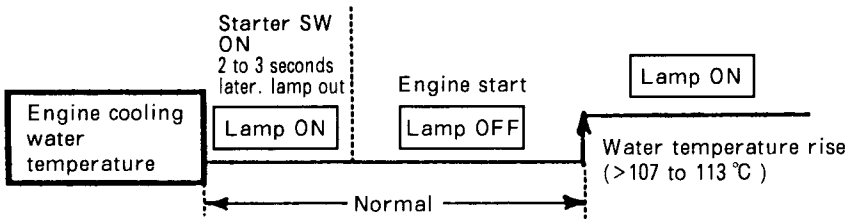
When the engine oil pressure falls, the lamp goes on and the buzzer sounds.

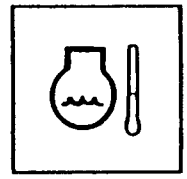




2) Water temperature

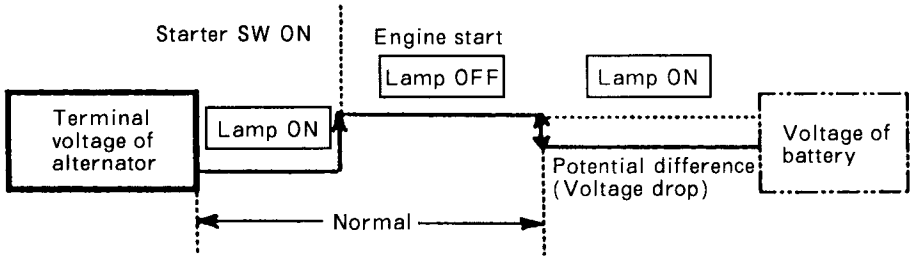
When the temperature of the engine cooling water rises excessively, the lamp goes on and the buzzer sounds.

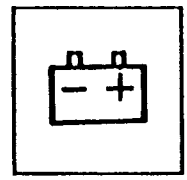




3) Battery charge

When there is caused a potential difference between the output voltage of the alternator and the voltage of the battery, the lamp goes on and the buzzer sounds.

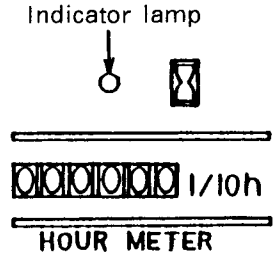




4) Hour meter

When the engine is started, the hour meter starts to work.

While the hour meter is working, the green indicator lamp is kept on.



c) Set the seal surface of the floating seal to a level.

d) There should no distortion on the O-ring.

(4) Put the drain plug of the idler ③ upward to install the other half of the floating seal ⑦ into the idler ③ using the jigs A-015 and A-017, and then, install the idler seal cover A ⑥ (with the idler shaft ④) to the idler ③.

Notes:

a) Apply oil thinly to the seat surface of the floating seal ⑦.

b) Handle the floating seal carefully to prevent the breakage of the seat surface of it due to rough handling.

(5) Put the drain plug of the idler ③ downward to install the O-ring ⑨ (using the jig A-012), the floating seal ⑦ (using the jig A-015 and A-017) and the idler seal cover B ⑤ in order.

Note:

Refer to the above steps (3) and (4) for the installation of the floating seal and the idler seal cover B.

(6) Install the external snap ring ② using the jig A-014.

(7) Put oil into the idler ③ from the drain plug.

- Type of oil : Engine oil SAE 30
- Quantity of oil : 0.1 L

Note:

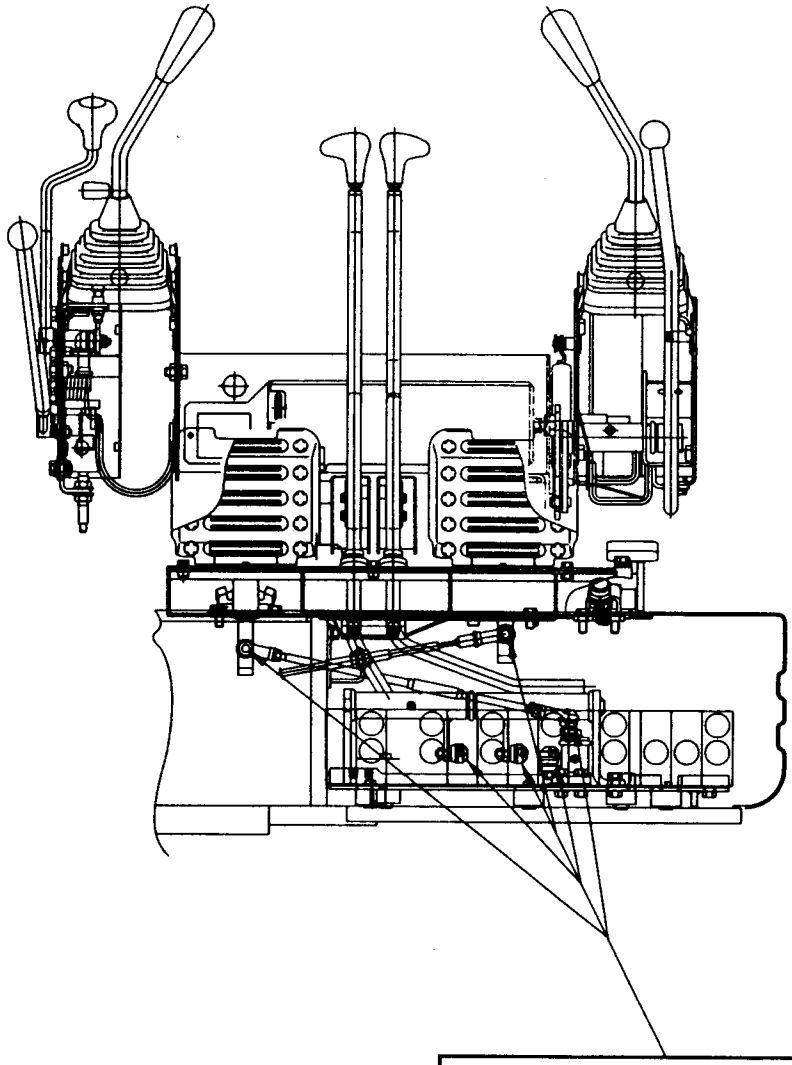
Use a jig to put oil into the idler.

(8) Install the plug ① on the idler ③ and tighten it at a specified tightening torque.

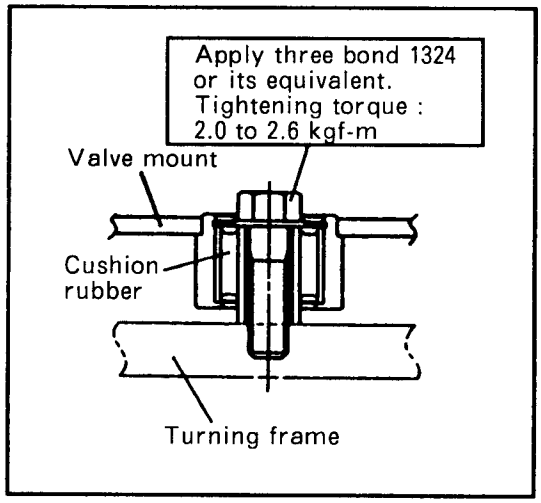
Adhesive : Loctite 572 or its equivalent
Tightening torque : 0.9 to 1.0 kgf-m

(9) After completing the reassembly, make sure that the idler rotates smoothly.

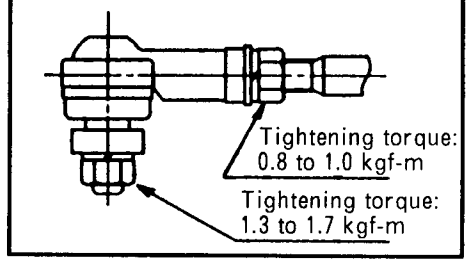
2) Tightening torque for rod joints and control valve mount



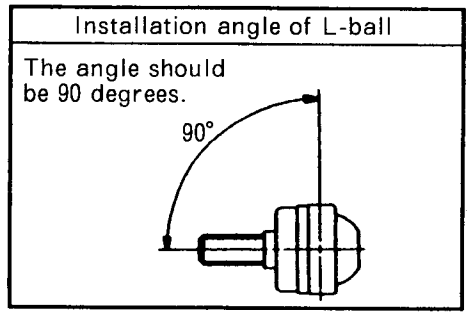
Control valve mount



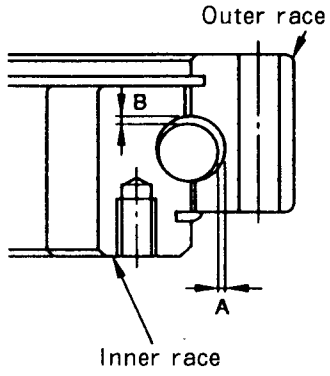
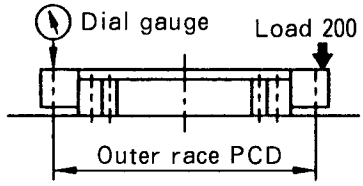
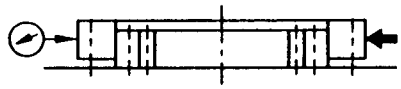
L-ball 8



Installation angle of L-ball



5. Service standards

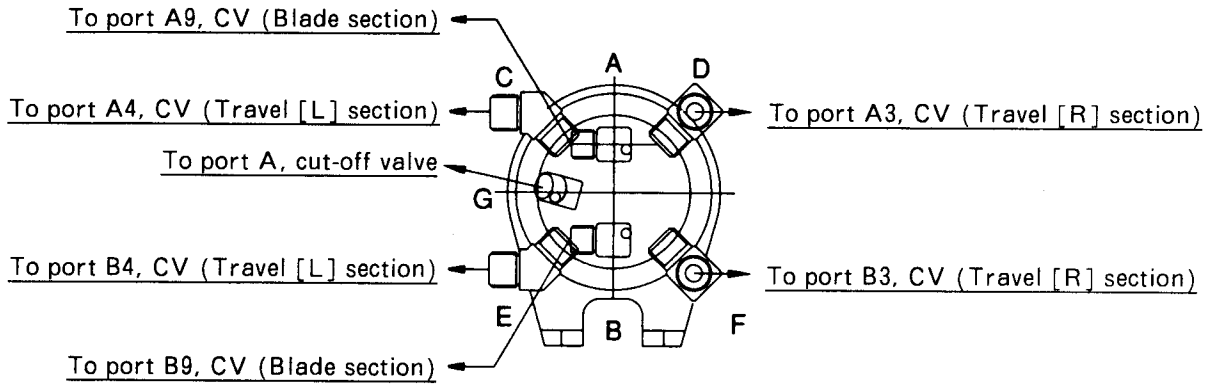
			Standard	Wear limit
	Axial clearance B 		0.05 to 0.25mm	0.55 mm
	Radial clearance, A Load 200 kgf 		0.05 to 0.30mm	0.6 mm
Steel ball dia.			ϕ25.4 mm	–
Tightening torque	Upperstructure × Outer race	M16×80	27 to 31 kgf-m	Apply LOCTITE 262 or its equivalent.
	Undercarriage × Inner race	M16×90		

Note:

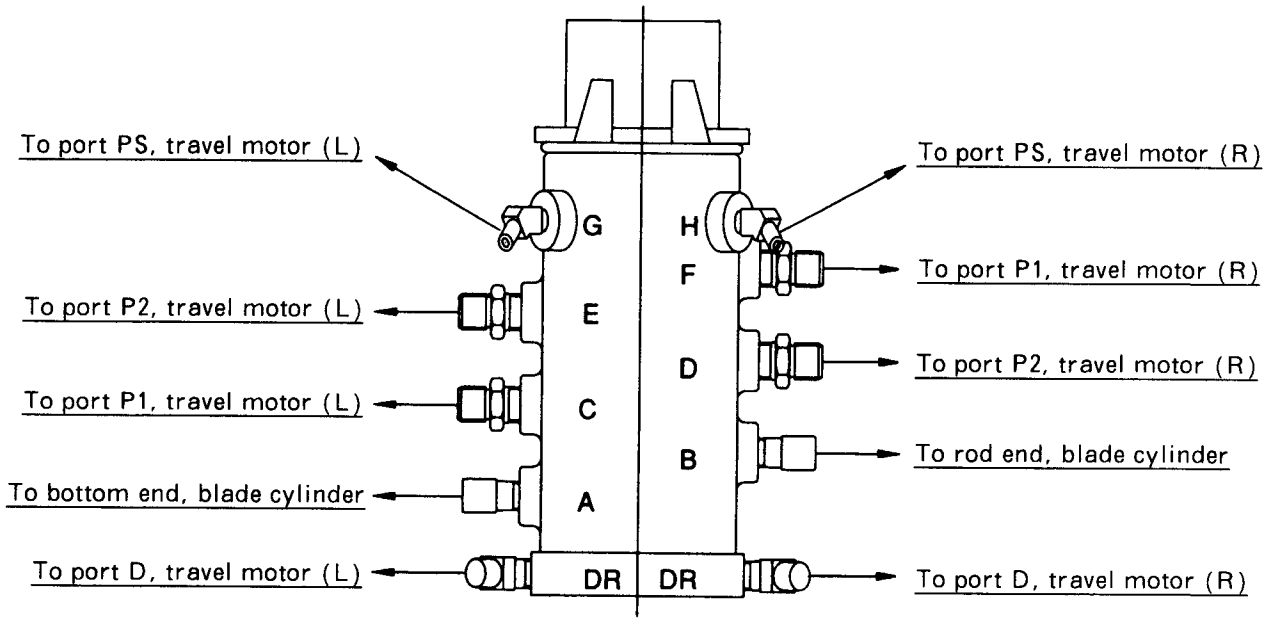
Supply multi-purpose grease to the swing bearing.

5) Piping for swivel joint

• Upperstructure piping



• Undercarriage piping



7-6 Engine Hood and Cabin

7-6-1 Engine Hood

⚠ When there are two people for the work, be sure to decide signs for communication between them before the work.

1. Adjustment of height

(1) Loosen the four bolts (with spring washers) 10×30.

(2) Turn the two bolts 10×50 to adjust the height of the brackets F and R.

Note:

The difference in height between the engine hood and the engine hood cover should be within 2 mm.

(3) Tighten the lock nuts 10 for the bolts 10×50.

2. Adjustment of position

(1) Install the engine hood onto the brackets B temporarily and tighten three bolts 10×20 for each bracket B lightly.

(2) After closing the engine hood, check the clearance A, which is shown in the right figure, and the position of the engine hood.

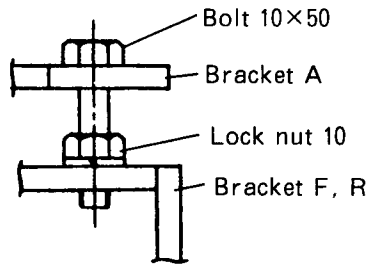
(3) Open the engine hood carefully and put a round rod into the remaining bolt hole in the bracket B to adjust the position of the engine hood by moving the round rod.

(4) Close the engine hood carefully to check the clearance A and the position of the engine hood again.

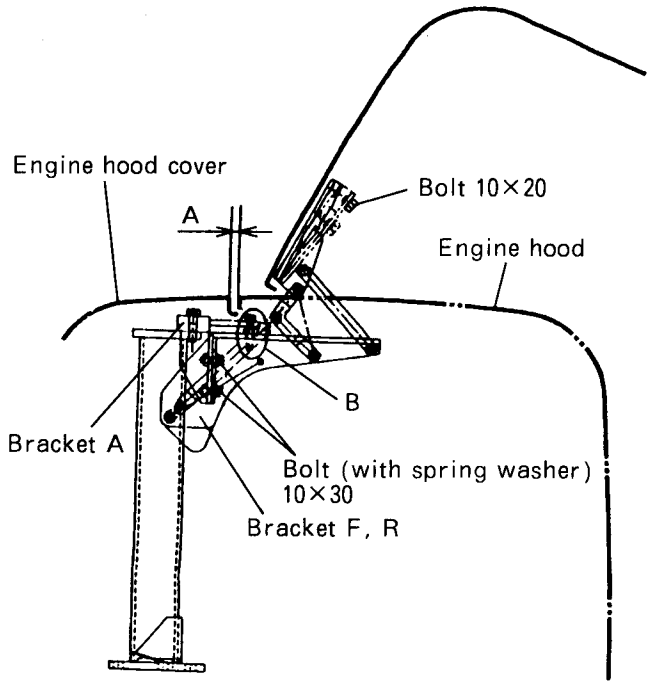
(5) If the clearance A is within the specified range and the difference in height between the engine hood and the engine hood cover is within the specified value, open the engine hood carefully and tighten all eight bolts for the brackets B.

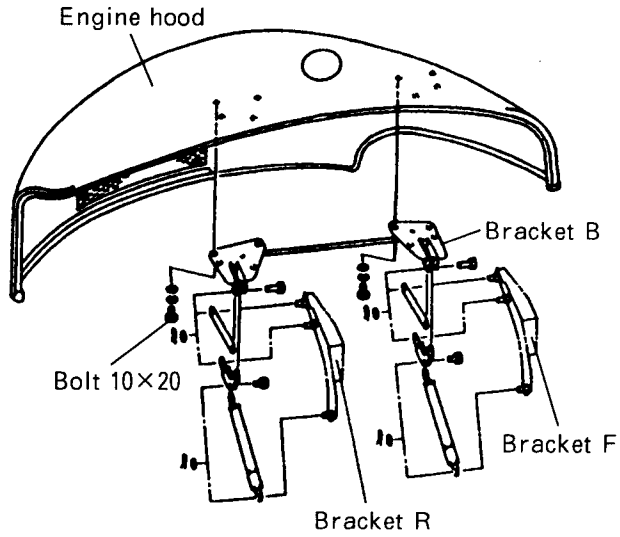
Clearance A : 13 to 15 mm
Difference in height : Within 2 mm

(6) If the values are not within the above ones, repeat the steps (2) to (5).



Enlarged view of B





7. Replacement of glass and acrylic glass

• Door glass, rear glass and glass L

(1) Remove broken glass and adhesive using metal scraper or cutter knife.

Notes:

a) For replacement of broken door glass, remove the door first.

b) There can be a little adhesive left.

(2) Clean and remove oil from areas of cabin and glass where adhesive is applied.

(3) Install dam seal on glass.

Notes:

a) Install dam seals on rear glass and glass L only.

b) Install dam seal around glass approx. 2 mm from glass end.

(4) Coat with primer areas of cabin and glasses where adhesive is applied.

Types of Primer

Glass: Sunstar #436-40 or its equivalent

Cabin: Sunstar #436-98 or its equivalent

• Points of primer coating

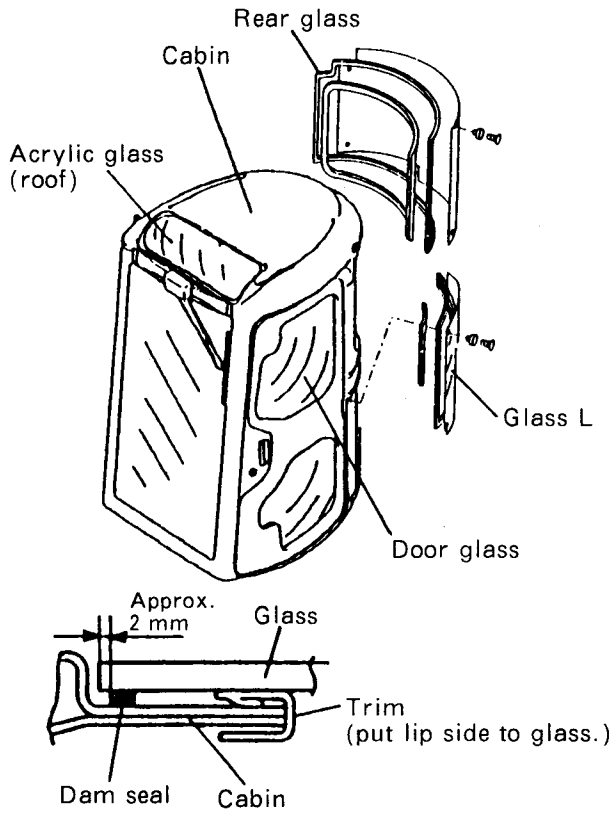
[1] Shake primer bottle for 3 to 5 minutes before opening it to stir carbon in it sufficiently.

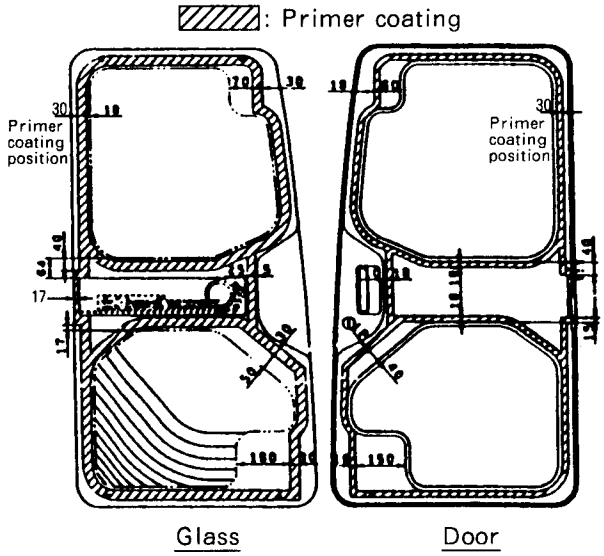
[2] Coat the areas with primer evenly, with no uncoated or thinner-coated area.

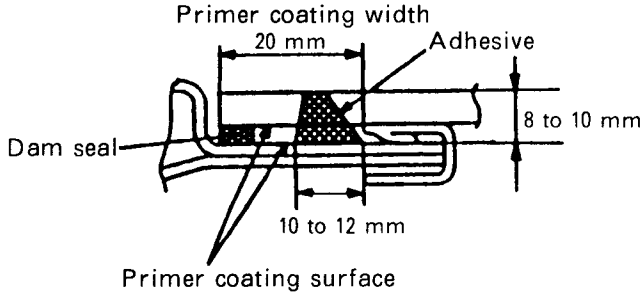
[3] Dry primer-coated area naturally for more than 3 minutes after coating. Then, check that the area has been dried and apply adhesive.

(If 24 hours or more have been passed after coating, coat the area with primer again.)

[4] Remove any contamination due to extra primer with white gasoline.



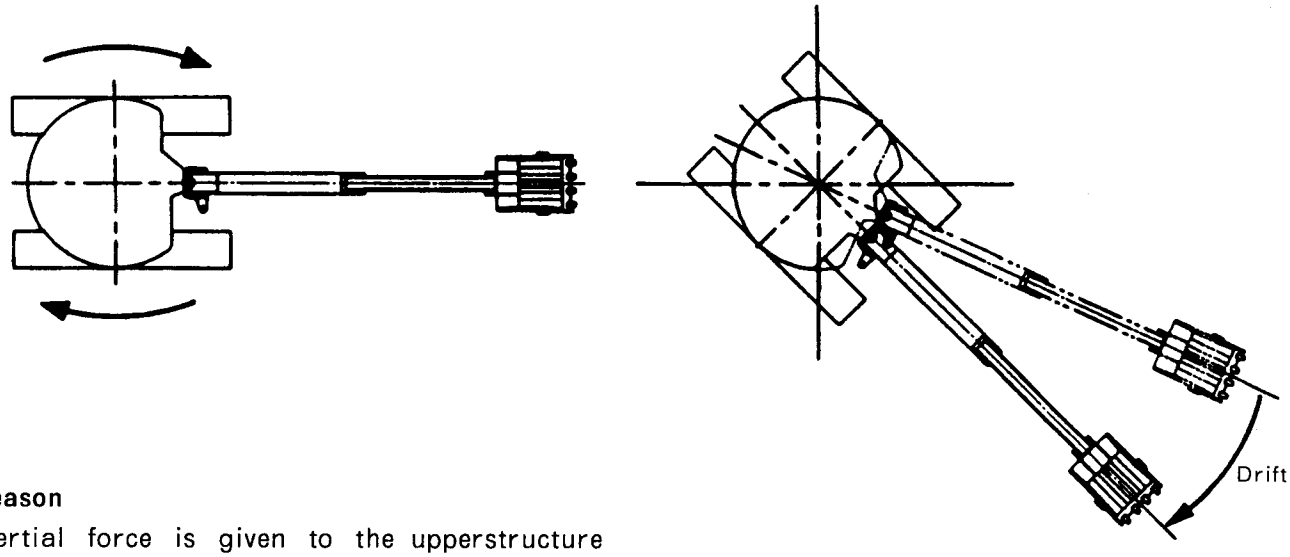




10-1-3 Drifting of Upperstructure on Quick Travel Operation

Phenomenon

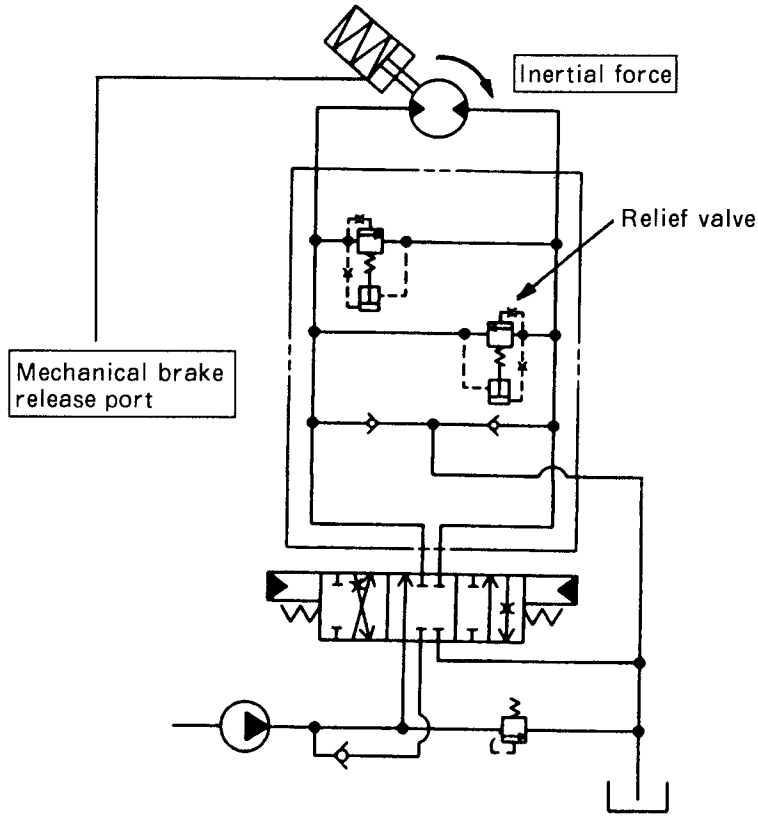
The upperstructure drifts on quick travel operation (especially, on spin-or pivot-turning).



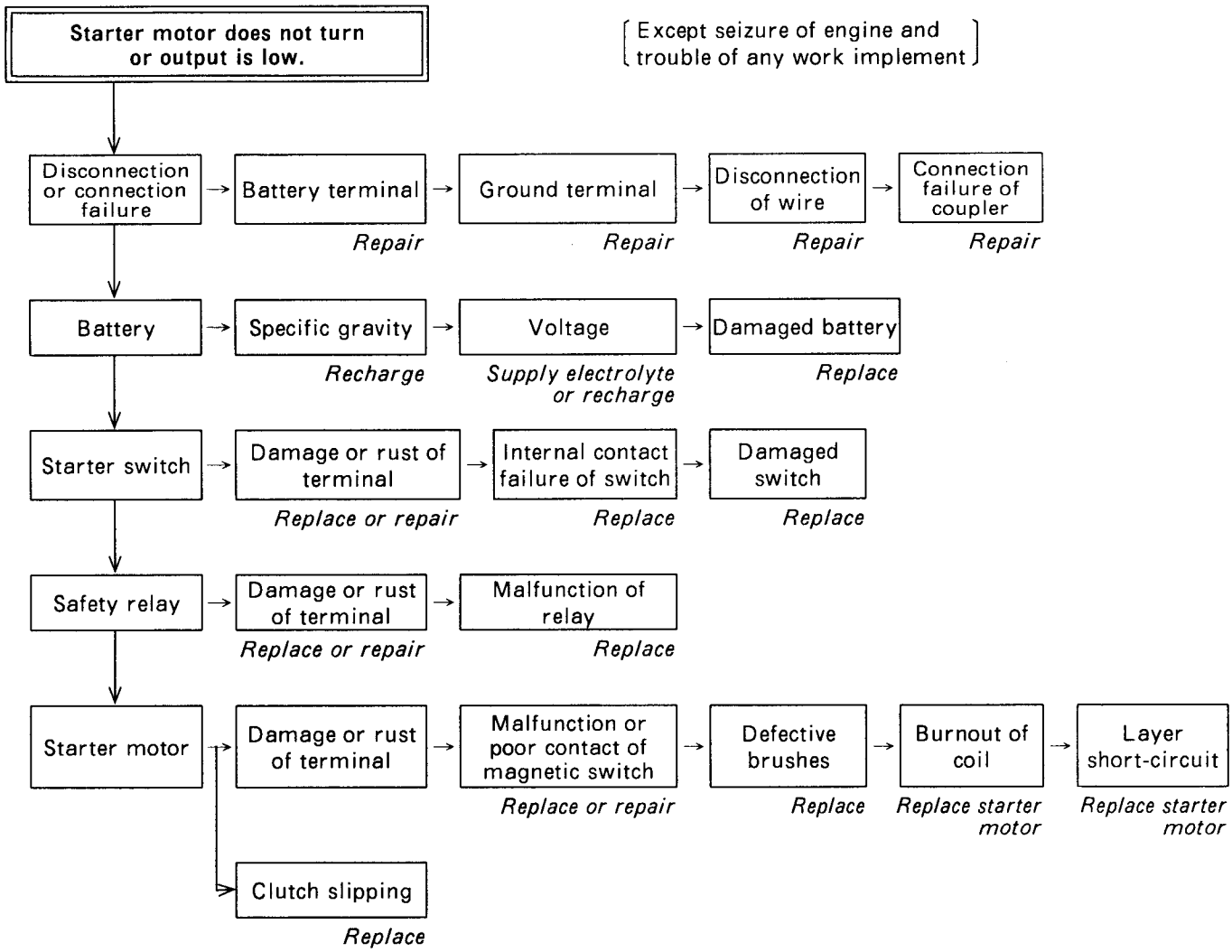
Reason

Inertial force is given to the upperstructure through the quick operation of the undercarriage, and high pressure is applied to the swing motor. The relief valve is activated to turn the swing motor.

(The mechanical brake is released when the engine is running.)



10. TROUBLESHOOTING



Inspection procedures

When the starter motor cannot be started by turning the starter switch on, check it as follows.
(Battery, starter switch and wiring assumed to be normal.)

(1) Safety relay & starter motor magnetic switch

Connect the S-and B-terminals of the starter motor directly.

a) When the starter motor turns .....The safety relay is faulty.

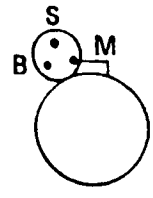
b) When the starter motor does not turn .....Either the starter motor magnetic switch or the starter motor is faulty.

(2) Starter motor

Connect the B-and M-terminals of the starter motor directly.

a) When the starter motor turns .....Magnetic switch is faulty.

b) When the starter motor does not turn .....Starter motor is faulty.



10. TROUBLESHOOTING

Travel Equipment