SERVICE MANUAL

E50B

Hydraulic Excavator

PIN number PJ06 - and higher

Part number S5PJ0033E01
English
July 2010

NEW HOLLAND CONSTRUCTION

1.1.3 DISASSEMBLING AND ASSEMBLING HYDRAULIC EQUIPMENT

(1) Removing hydraulic equipment

1. Before disconnecting pipes, release the hydraulic pressure of the system, or open the return side cover and take out the filter.
2. Carefully drain oil from the removed pipes into a container without spilling on the floor.
3. Apply plugs or caps on the pipe ends to avoid oil spillage and dust intrusion.
4. Clean off the external surface of the equipment before disassembling, and drain hydraulic and gear oil before placing it on the workbench.

(2) Disassembling hydraulic equipment

1. Do not disassemble, reassemble or modify the hydraulic equipment without the permission of the manufacturer, who is not responsible for the performance and function of the product after modification.
2. When disassembling and reassembling for unavoidable reason, refer the work to qualified personnel who have the specific knowledge or completed the parts service training.
3. Provide matching marks to facilitate reassembling work.
4. Before starting the work, read the manual of disassembling procedure, if it is provided, and decide whether the work can be performed by yourself.
5. Use the special jig and tools without fail if they are specified.
6. If it is hard to remove a part according to the procedure, do not force it - investigate the cause.
7. Place the removed parts in order and attach tags to facilitate the reassembling.
8. Note the location and quantity of parts commonly applied to multiple locations.

(3) Inspecting parts

1. Ensure that the disassembled parts are free from seizure, interference and uneven contact.
2. Measure and record wear condition of parts and clearance.
3. If the problem is found in a part, repair or replace it with a new one.

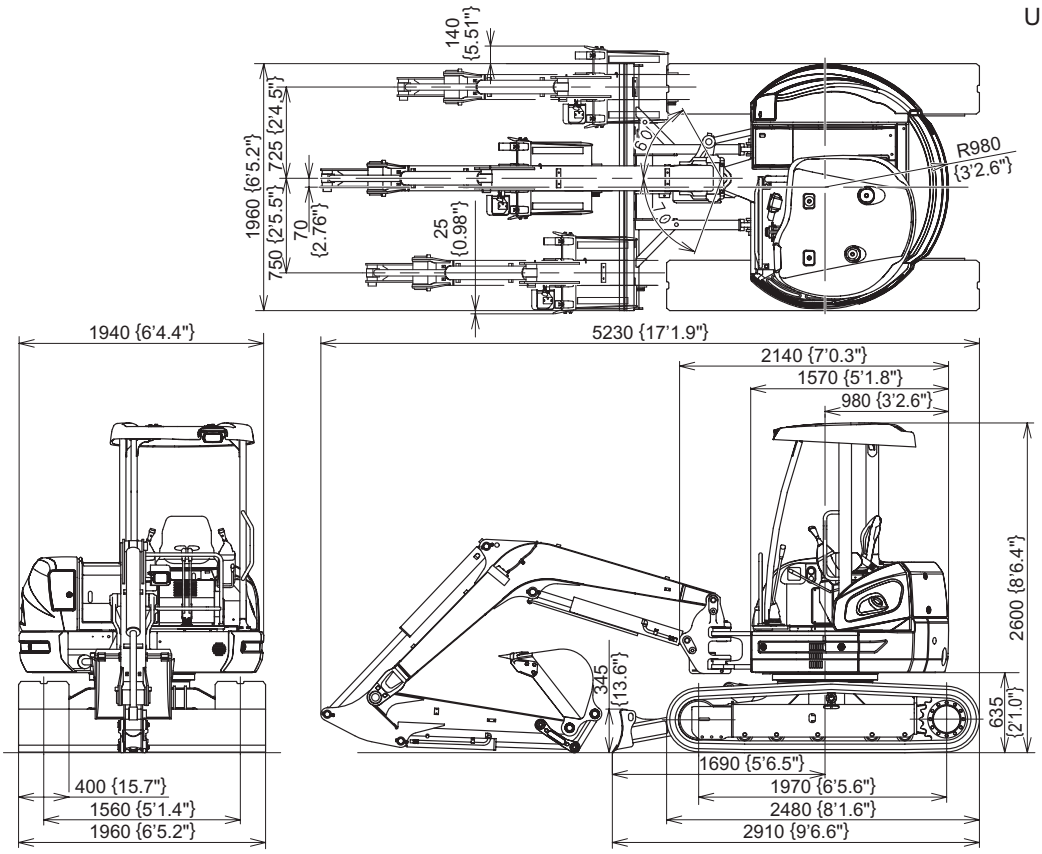
(4) Reassembling hydraulic equipment

1. Turn ON the ventilation fan or open windows to maintain good ventilation prior to starting the cleaning of parts.
2. Perform rough and finish cleaning before assembling.
3. Remove washing oil by air and apply clean hydraulic or gear oil for assembling.
4. Always replace the removed O-rings, backup rings and oil seals with new ones and apply grease in advance.
5. Remove dirt and moisture from and perform degreasing on the surface where liquid gasket to be applied.
6. Remove rust preventive agent from the new parts before use.
7. Fit bearings, bushings and oil seals using special jigs.
8. Assemble the parts utilizing matching marks.
9. Ensure all the parts are completely assembled after the work.

2.2 MACHINE DIMENSIONS

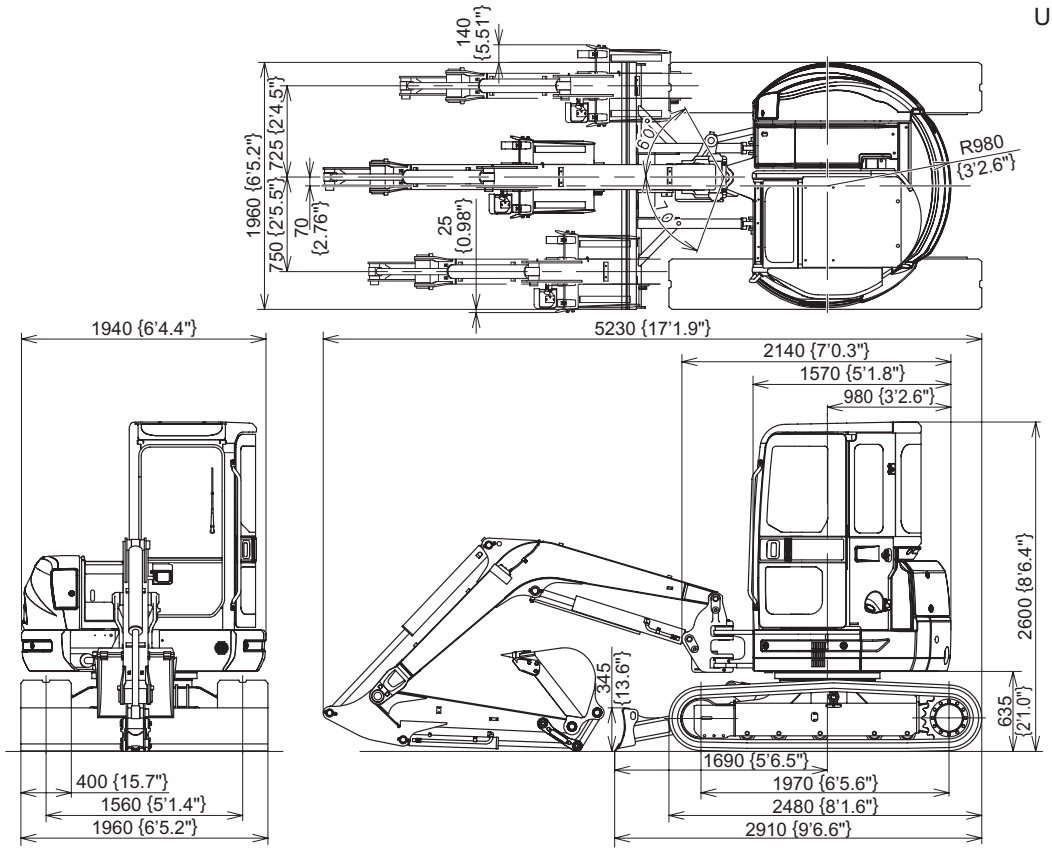
(1) E50B (CANOPY)

Unit: mm (ft-in)



(2) E50B (CAB)

Unit: mm (ft-in)



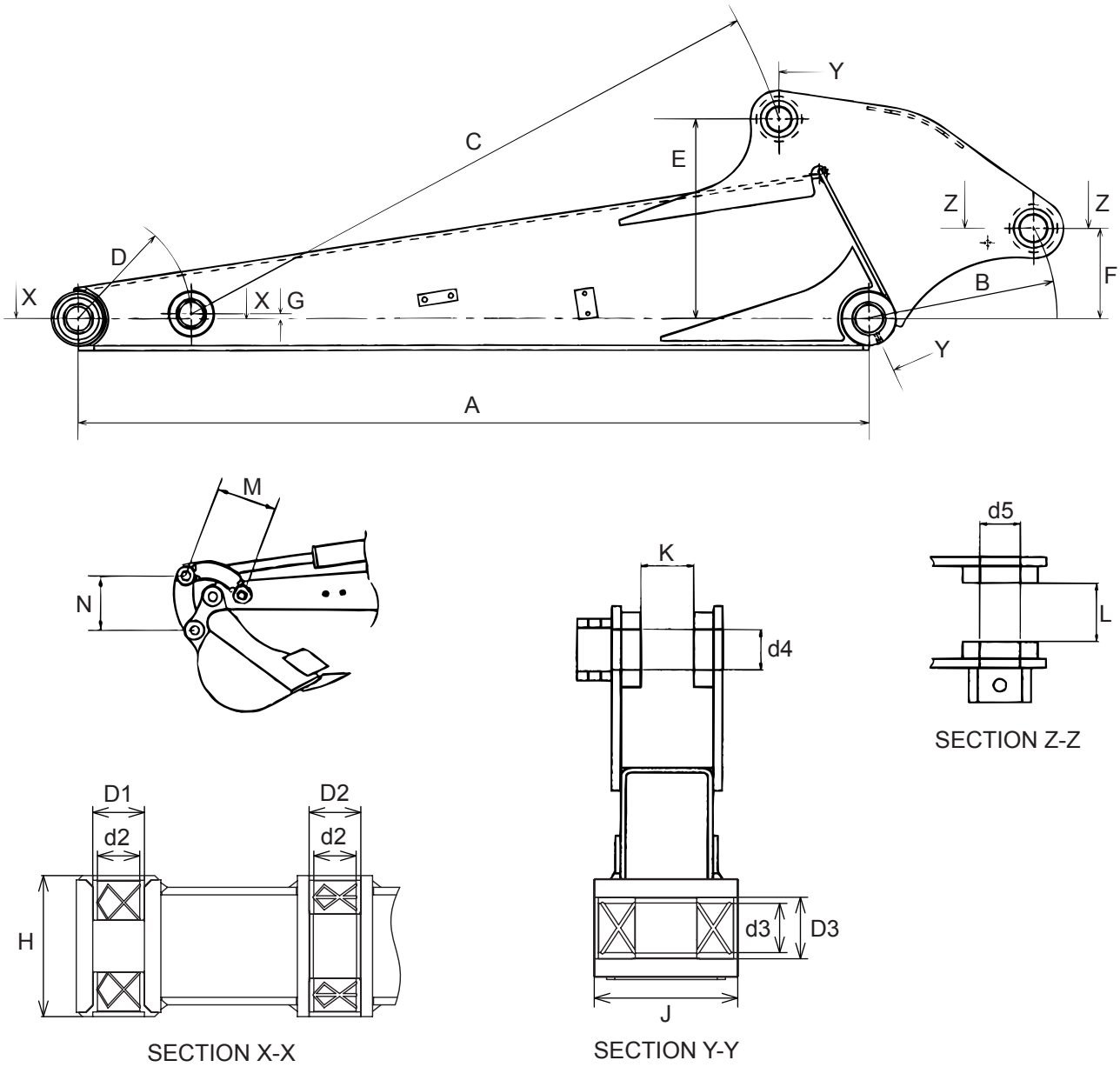
2.8 ENGINE SPECIFICATIONS

2.8.1 SPECIFICATIONS

Model		E50B	
Engine Model (YANMAR)		4TNV88-BXYB (EDM-4TNV88)	
Type		Vertical, 4-cycle water-cooled diesel engine	
No. of cylinders - Bore × Stroke		4 - 88 mm (3.46 in) × 90 mm (3.54 in)	
Total displacement		2.189 liter (134 cu•in)	
Compression ratio		19.1	
Rated output		29.3 kW (40 PS) at 2400 rpm	
Maximum torque		131 ~ 147.1 N•m (97 ~ 109lbf•ft) at 1440 rpm	
Low idling		1175±25 rpm	
High idling		2600±25 rpm	
Fuel consumption rate		Less than 242 g / kWh (178 g / PS•h)	
Allowable tilting angles		Continuous ; 30° for all direction	
Rotating direction		Counterclockwise as seen from flywheel side	
Firing order		1-3-4-2-1	
Fuel injection timing (b.T.D.C.)		15.5±1°	
Fuel injection pressure		19.6^{+1}_{0} MPa (2840^{+145}_{0} psi)	
Valve action		Open	Close
	Intake valve	b.T.D.C. 15±5°	a.B.D.C. 45±5°
	Exhaust valve	b.T.D.C. 56±5°	a.B.D.C. 18±5°
Valve clearance	Intake valve	0.2 mm (0.008 in) in cold condition	
	Exhaust valve	0.2 mm (0.008 in) in cold condition	
Thermostat action		Start 71 ± 1.5°C (160 ± 3°F) / Full open 85°C (185°F)	
Compression pressure		3.4 ± 0.1 MPa (500 ± 14 psi) at 250 rpm	
Lubrication oil pressure		0.44 MPa (64 psi) at 2300 rpm	
Dimensions L × W × H		659 × 523 × 617 mm (26.0 ×20.6 × 24.3 in)	
Dry weight		170 kg (375 lb)	
Governor		Mechanical centrifugal governor (All speed type)	
Fuel filtration		cartridge type paper filter	
Lubrication system		Forced lubrication with trochoid pump	
Cooling system		Liquid cooling / Radiator	
Starter capacity		12 V × 2.3kW	
Generator capacity		12 V × 55 A	
Starting aid		Glow plug	
Cooling water capacity : Max / Engine		6.0 / 2.7 liter (1.59 / 0.71 gal)	
Engine oil volume : Max / Effective		7.4 / 4.0 liter (1.96 / 1.06 gal)	

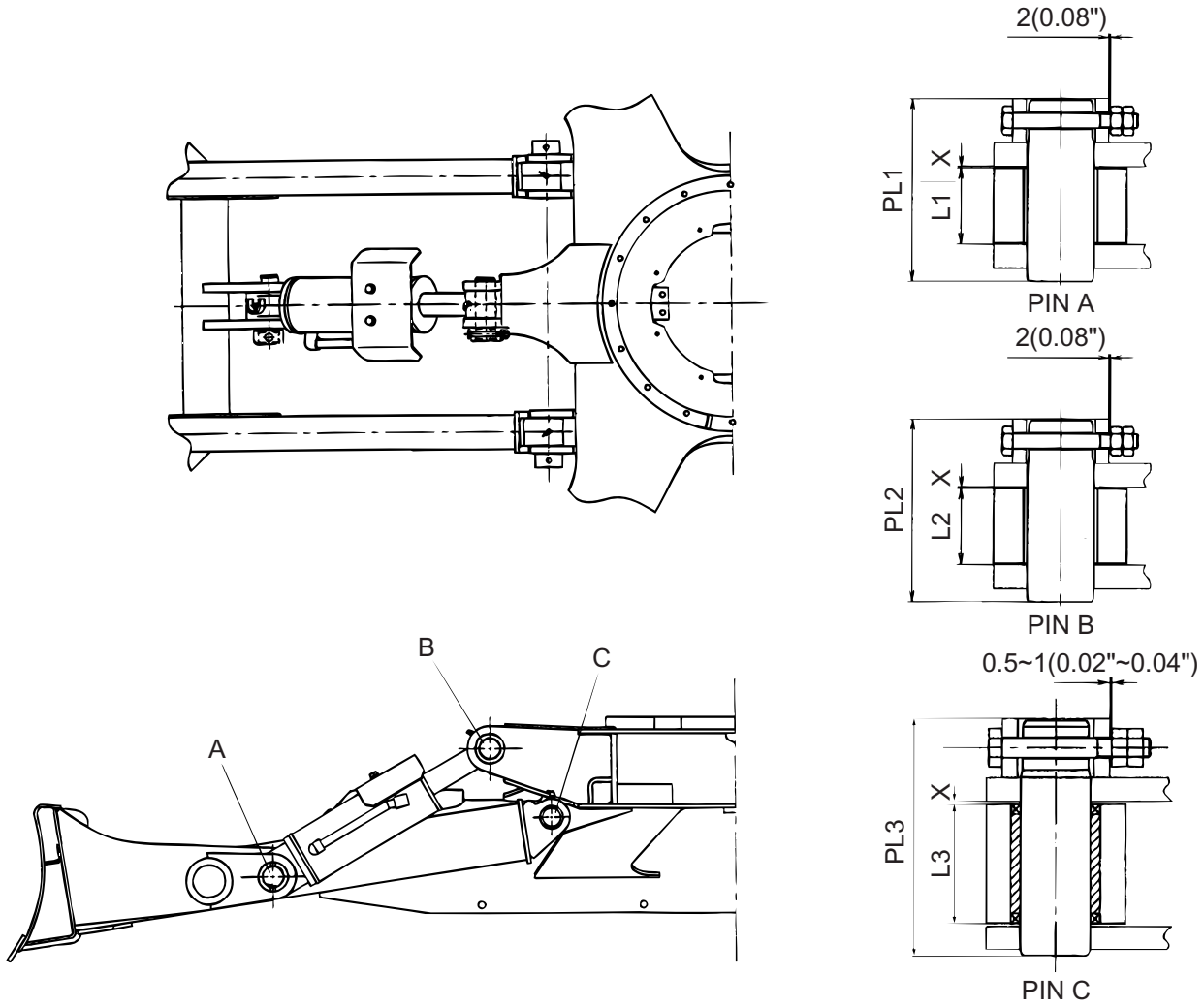
3.2 ARM

3.2.1 ARM DIMENSIONAL DRAWINGS



Arm dimensional drawings

3.4.2 DOZER MAINTENANCE STANDARDS



Dozer maintenance standards

(1) Clearance of pin and bushing

Unit : mm (in)

Pos.	Item	Pin part No.	Standard dimension			Clearance			Remedy
			Pin dia.	Tolerance on pin dia.	Tolerance on bushing bore dia.	Standard value	Standard value for repair	Serviceability limit	
A	Dozer blade cylinder (Head side)	PY51B01107P1	ø55 (2.17)	–0.15 –0.21 (-0.0059) (-0.0083)	+0.20 +0.05 (+0.0079) (+0.0020)	0.20~ 0.46 (0.0079~ 0.0181)	1.5 (0.059)	2.0 (0.079)	Replace bushing or pin
B	Dozer blade cylinder (Rod side)								
C	Dozer blade foot	PH51B01001P1	ø40 (1.57)	–0.06 –0.09 (-0.0024) (-0.0035)	+0.215 +0.115 (+0.0085) (+0.0045)	0.175~ 0.305 (0.0069~ 0.0120)			

Note

-The tolerance for bushing inside diameter means the dimension after fitting of it into place.
-The part number for pins may be changed owing to improvement, use them only for reference.

Torque value Unit : N•m (lbf•ft)

Classification		4.8T		7T		10.9T	
Nominal size		No lubrication	Oil lubrication	No lubrication	Oil lubrication	No lubrication	Oil lubrication
M22	P=2.5	226±20 (167±15)	192±20 (142±15)	500±49 (369±36)	422±39 (311±29)	902±88 (665±65)	755±78 (557±58)
M24	P=3	294±29 (217±21)	235±29 (173±21)	637±69 (470±51)	520±49 (383±36)	1160±118 (856±87)	941±98 (694±72)
M27	P=3	431±39 (318±29)	353±39 (260±29)	941±98 (694±72)	765±78 (564±58)	1700±167 (1250±123)	1370±137 (1010±101)
M30	P=3.5	588±59 (434±44)	490±49 (361±36)	1285±127 (948±94)	1079±108 (796±80)	2300±235 (1700±173)	1940±196 (1430±145)
M33	P=3.5	794±78 (586±58)	667±69 (492±51)	1726±177 (1270±131)	1451±147 (1070±108)	3110±314 (2290±232)	2610±265 (1930±195)
M36	P=4	1030±98 (760±72)	863±88 (637±65)	2226±226 (1640±167)	1863±186 (1370±137)	4010±402 (2960±297)	3360±333 (2480±246)

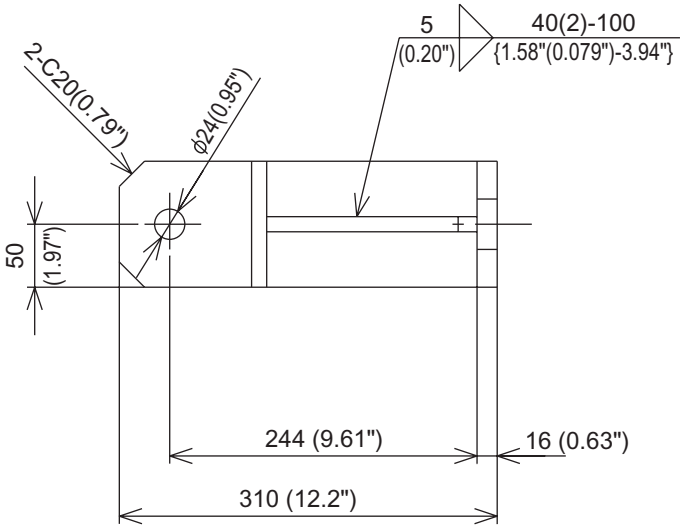
11.1.2 Metric Fine Thread Standard Tightening Torque values.

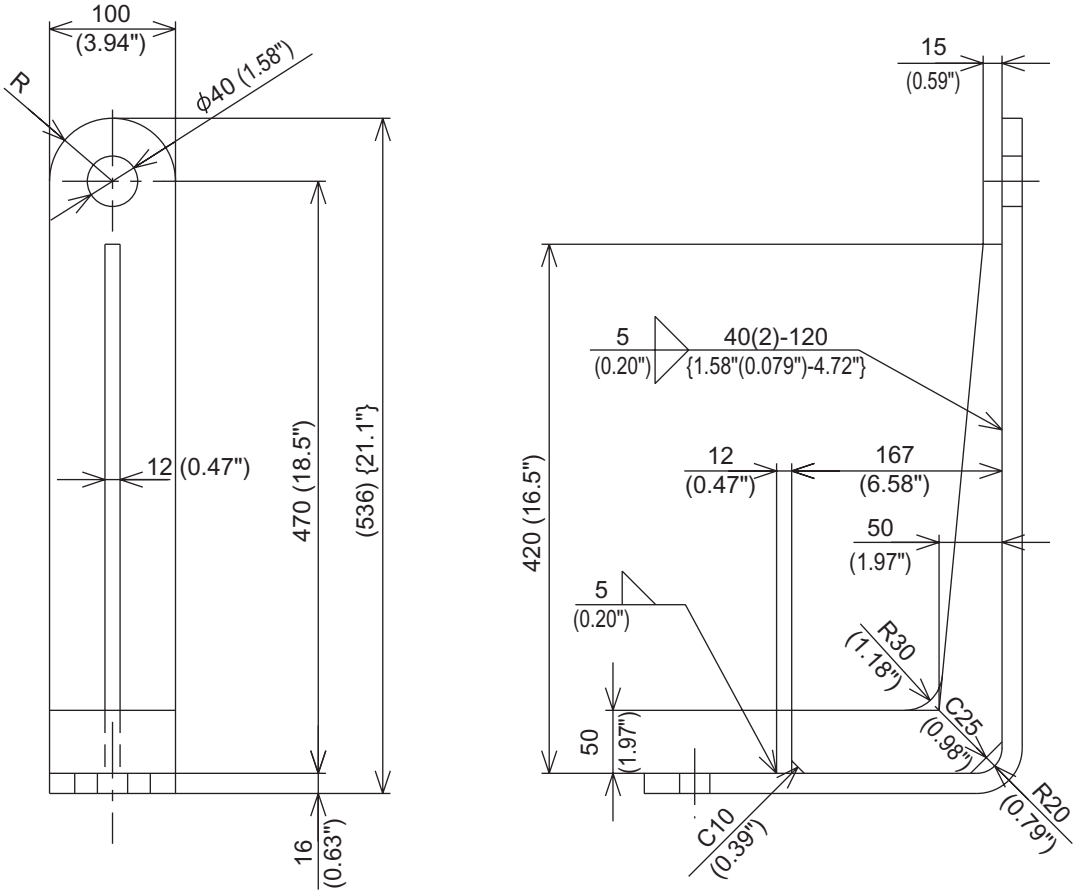
Torque value Unit : N•m (lbf•ft)

Classification		4.8T		7T		10.9T	
Nominal size		No lubrication	Oil lubrication	No lubrication	Oil lubrication	No lubrication	Oil lubrication
M8	P=1.0	11.3±1.1 (8.3±0.8)	9.5±1.0 (7.0±0.7)	24.5±2.0 (18.1±1.5)	20.6±2.0 (15.2±1.5)	44.1±3.9 (32.5±2.9)	37.3±3.9 (27.5±2.9)
M10	P=1.25	22.6±2.0 (16.7±1.5)	18.7±1.9 (13.8±1.4)	48.1±4.9 (35.5±3.6)	41.2±3.9 (30.3±2.9)	87.3±8.8 (64.4±6.5)	73.5±6.9 (54.2±5.1)
M12	P=1.25	39.2±3.9 (28.9±2.9)	33.3±2.9 (24.6±2.1)	85.3±8.8 (62.9±6.5)	71.6±6.9 (52.8±5.1)	154±16 (114±12)	129±13 (95.2±9.6)
M16	P=1.5	92.2±8.8 (68.0±6.5)	77.5±7.8 (57.2±5.8)	196±20 (145±15)	169±17 (125±13)	363±39 (268±29)	304±29 (224±21)
M20	P=1.5	186±19 (137±14)	155±16 (114±12)	402±39 (297±29)	333±29 (246±21)	726±69 (535±51)	608±59 (448±44)
M24	P=2	314±29 (232±21)	265±29 (195±21)	686±69 (506±51)	569±59 (420±44)	1240±118 (915±87)	1030±98 (760±72)
M30	P=2	637±59 (470±44)	530±49 (391±36)	1390±137 (1030±101)	1157±118 (853±87)	2500±255 (1840±188)	2080±206 (1530±152)
M33	P=2	853±88 (629±65)	706±70 (521±52)	1860±186 (1370±137)	1550±155 (1140±114)	3350±334 (2470±246)	2790±275 (2060±203)
M36	P=3	1070±108 (789±80)	892±88 (658±65)	2330±226 (1720±167)	1940±196 (1430±145)	4200±422 (3100±311)	3500±353 (2580±260)

11.10 UPPER FRAME LIFTING JIG

Q'ty : 2 sets
Material : Mild steel
Unit : mm (in)





Upper frame lifting jig

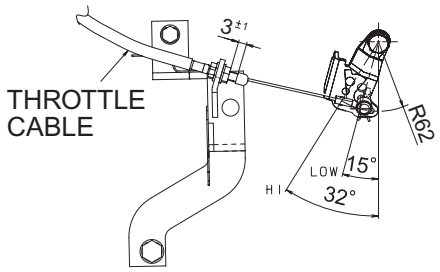
03 Upper structure(4/4)

No.	EQUIPMENT PORTION	WORK TO BE DONE	UNIT	REMARKS	UNIT: HOUR
130	Upper frame portion			Refer to 33.1.22	
131	Upper frame ASSY	Rem./Inst.	1 pc.		1.0
132	-Fixing bolt	Rem./Inst.	1 set	Apply sealant	0.3
133	-Upper frame slinging	Rem./Inst.	1 pc.		0.3
134	-Cleaning	Cleaning	1 pc.		0.2
	Other necessary works	Rem./Inst.	1 pc.	Canopy	0.2
		Rem./Inst.	1 pc.	Guard (Cover, support)	1.5
		Rem./Inst.	1 pc.	Counterweight	0.4
		Drain / Feed	1 pc.	Hydraulic oil	0.2
		Rem./Inst.	1 set	Swivel joint hose	0.5
		Rem./Inst.	1 set	Boom	1.0

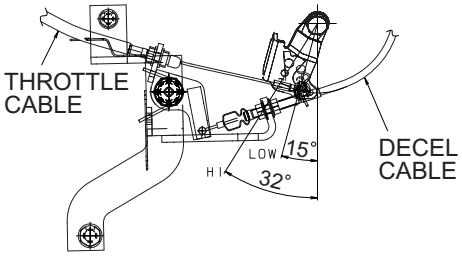
(4) Speed Adjustment

1. Low / High Idling Speed is low ;

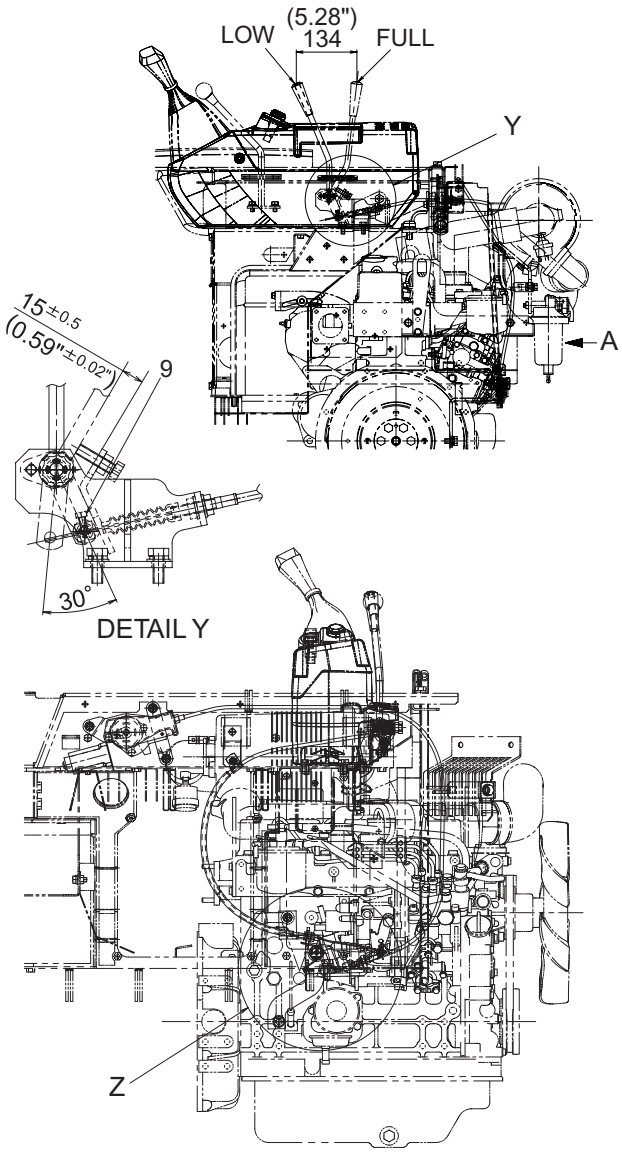
   The proper engine speed is obtained with the length of accelerator wire as shown in the sketch. When the engine speed is lower than the standard speed, adjust the length of wire with loosening the capscrew (9) of throttle lever side.



DETAIL Z (STD)



DETAIL Z [WITH DECEL (OPT)]



DETAIL Y

VIEW A

Accelerator wire adjustment

CAUTION

However, if the proper high idling speed is not obtainable, consult with the engine manufacturer.

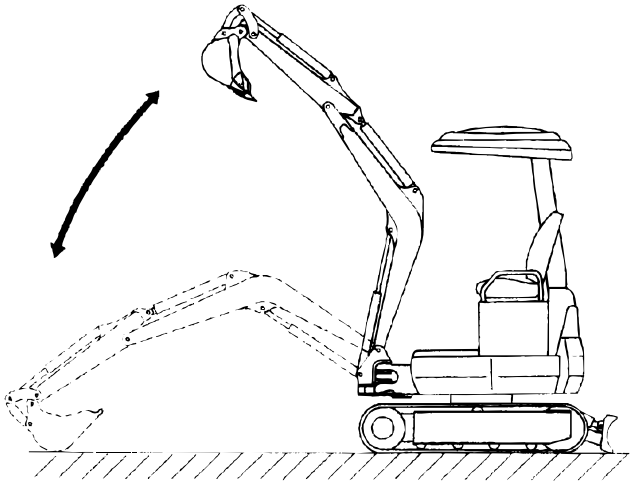
13.7 MEASURING ATTACHMENT OPERATING PERFORMANCES

TEST PROCEDURES
Measure 3-time each.
Apply average data of the above for judgment.

13.7.1 CYLINDER SPEED

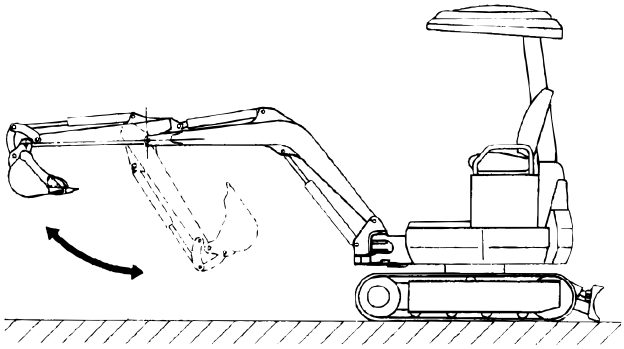
(1) Boom Cylinder Speed

- Engine : High Idle
- Hydraulic Oil Temperature :
  50° to 60°C (122° to 140°F)
- Measurement Posture : Completely retract the arm cylinder, fully extend the bucket cylinder and place the dozer blade on the ground.
- Then measure the time required for the bucket to reach its highest point (lowest point) from its lowest point (highest point) placing on the ground. (Do not include the cushioning time.)



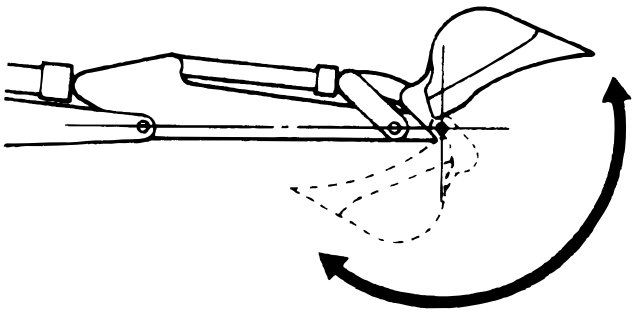
(2) Arm Cylinder Speed

- Engine : High Idle
- Hydraulic Oil Temperature :
  50° to 60°C (122° to 140°F)
- Measurement Posture : Completely retract the arm cylinder, fully extend the bucket cylinder, position the arm horizontally and place the dozer blade on the ground.
- Then measure the time required for the arm cylinder to completely retract (extend) from a fully extended state (retracted state).

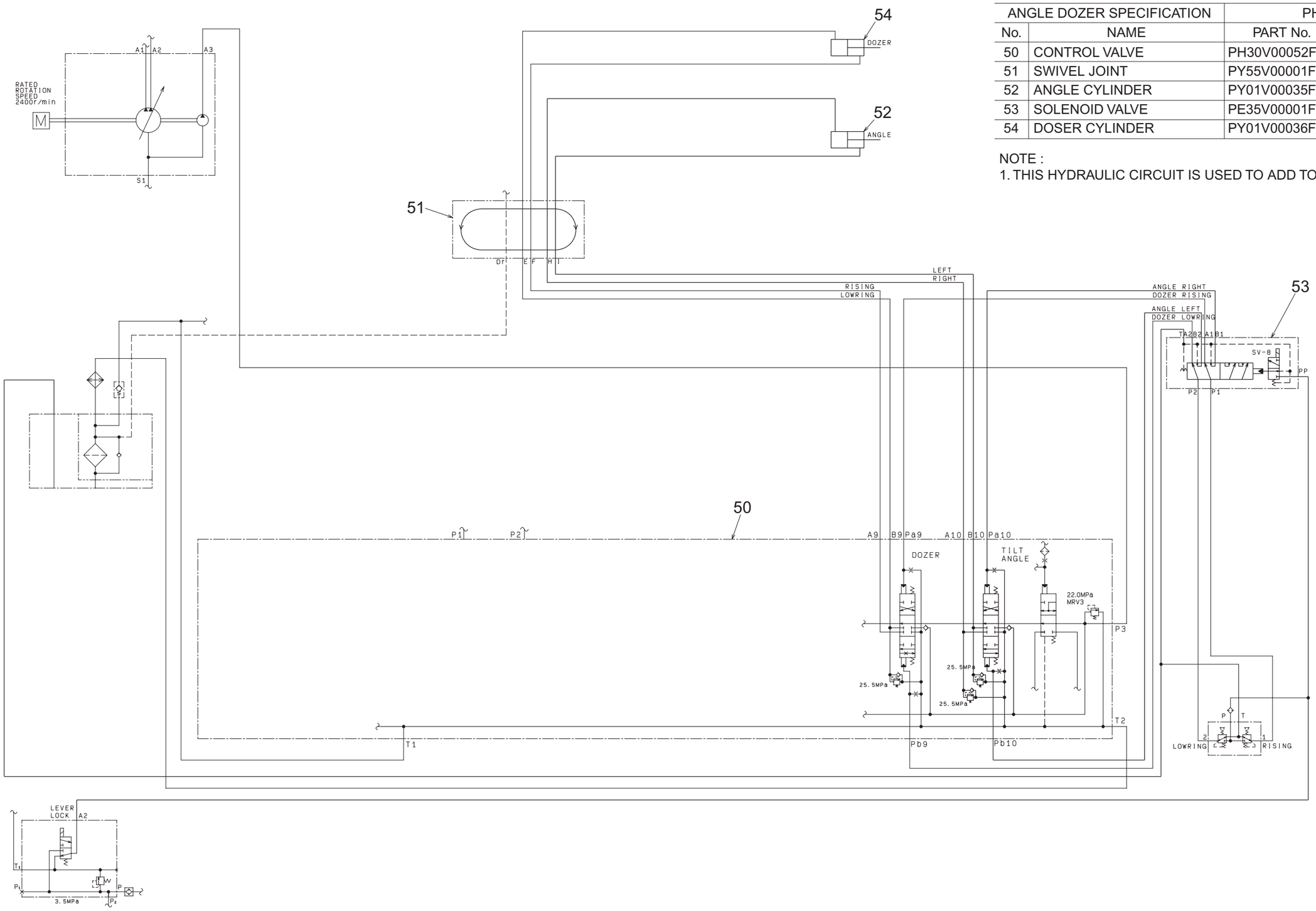


(3) Bucket Cylinder Speed

- Engine : High Idle
- Hydraulic Oil Temperature :
  50 to 60°C (122° to 140°F)
- Measurement Posture : Completely retract the arm cylinder, position the arm horizontally and place the dozer blade on the ground.
- Then measure the time required for the bucket cylinder to completely retract (extend) from a fully extended state (retracted state).



22.2.2 ANGLE DOZER SPECIFICATION



ANGLE DOZER SPECIFICATION		PH01Z00041P1	
No.	NAME	PART No.	MODEL No.
50	CONTROL VALVE	PH30V00052F3	KVSE-72-12
51	SWIVEL JOINT	PY55V00001F1	
52	ANGLE CYLINDER	PY01V00035F2	90-45-335
53	SOLENOID VALVE	PE35V00001F2	16351-00000
54	DOSER CYLINDER	PY01V00036F1	110-55-175

NOTE :
1. THIS HYDRAULIC CIRCUIT IS USED TO ADD TO STANDARD CIRCUIT.

22.3.6 BOOM OPERATING CIRCUIT

Pilot oil hydraulic system with operating lever

22.3.6.1 Boom UP Operating Circuit

(1) Pilot Circuit

1. Boom Spool Shifting
   When the operating lever is put at boom up position, the pilot secondary pressure oil is generated from pilot valve (11). The pressurized oil entered into Pb2 port on control valve (2) shifts the boom valve spool.

(2) Main Circuit

1. Supply Circuit for Cylinder (5)
   The oil delivered from A1 port on variable pump of pump assembly (1) enters into P1 port on control valve (2). The oil supplied from B2 port through boom valve and lock valve is entered into the head side of boom cylinder (5) to up the boom.

22.3.6.2 Boom Down Operating Circuit

(1) Pilot Circuit

1. Boom Spool Shifting
   When the operating lever is put at boom down position, the pilot secondary pressure oil is generated from pilot valve (11), and enters into Pa2 port on control valve (2) to shift the boom valve spool.
   At the same time, the pilot secondary pressure is led to the boom lock valve (206) to push up the check valve and open the oil path from closed condition.

(2) Main Circuit

1. Supply Circuit for Cylinder (5) and Return Oil Circuit
   The pressurized oil delivered from A1 port on variable pump is led to boom valve provided on control valve (2), and supplied to the rod side of boom cylinder (5) to down the boom.
   The oil returned from the head side of cylinder (5) enters into B2 port on control valve (2), and returns to the tank through the boom lock valve (206) and boom valve.
   Its flow rate is restricted by the throttle effect in boom valve, accordingly the boom is lowered at a stable speed.

a. Boom lock valve (206)
   This is of a check valve mechanism to prevent the boom from lowering due to its own weight while the boom valve is being at neutral position.

22.3.11 TRAVEL / DOZER COMBINED OPERATING CIRCUIT

At the combined operation of travel and dozer at the same time, the straight traveling is secured with this function.

22.3.11.1 Travel (1st Speed Forwarding) / Dozer Down Operating Circuit

(1) Pilot Circuit

Both the travel and dozer are operated by the lever using the pilot oil system.
The operation of each lever directly shifts the travel valve spool and dozer valve spool in the control valve (2) respectively.

(2) Main Circuit

The oil delivered from A1 and A2 ports on the variable pump (1) enters into P1 and P2 ports on control valve (2), and each flow of left and right is led to swivel joint (10) and travel motor (4) respectively through each travel valve of left and right.
The oil delivered from A3 port on the third pump enters into P3 port on control valve (2), then it is led to the dozer cylinder (9) through dozer valve and swivel joint (10).

1. The dozer is operated by the pressurized oil supplied by the third pump which has no relation with travel circuit. Then there is no variation on the supply volume of pressurized oil for both travel motors of left and right even though the dozer is operated during traveling.
   Thus the straight traveling is secured.
   (The slewing is operated in the same way as the dozer.)
2. As the above mentioned, the traveling speed is not changed from the single operation for traveling securing the straight traveling.

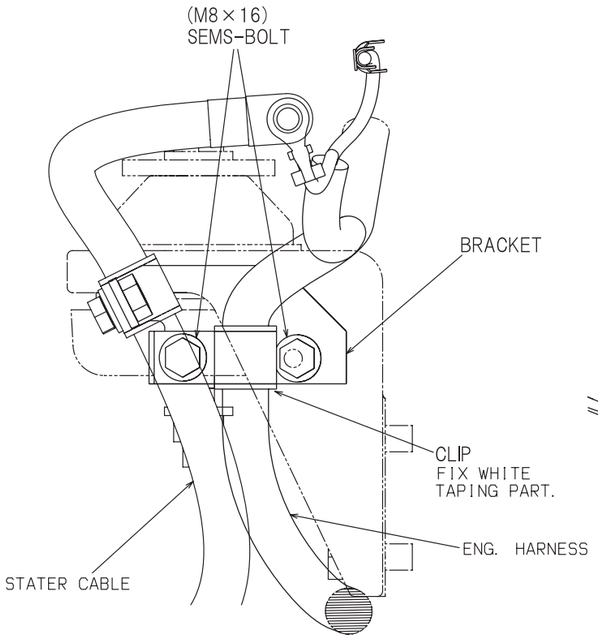
23.2.2 HARNESS & CABLE LIST

Code	Name	Part No.	Remarks
H-1	Inst · Main Harness	PH14E01042P1	
H-2	Proportional N&B Harness	PH14E01041P2	
H-3	Engine Harness	PH16E01011P3	
H-4	Starter Cable (+)	PH13E01087P1	
H-5	Battery Ground Cable (-)	PH13E01086P1	
H-6	Engine Ground Cable	PW13E01043D1	
H-7	Boom Harness	PH15E01018P1	
H-8	Key Switch Harness	PW50E01002P1	
H-9	Canopy Work Light Harness	PW11E01026D4	
H-10	Boom Work Light Extension Harness	PH14E01018D1	
H-11	Connection Harness with Cab	PW14E01041P1	(OPT.)
H-12	Air Filter Harness	PW11E01044D2	
H-13	Cab Work Light Harness	PW80E01003D1	(OPT.)

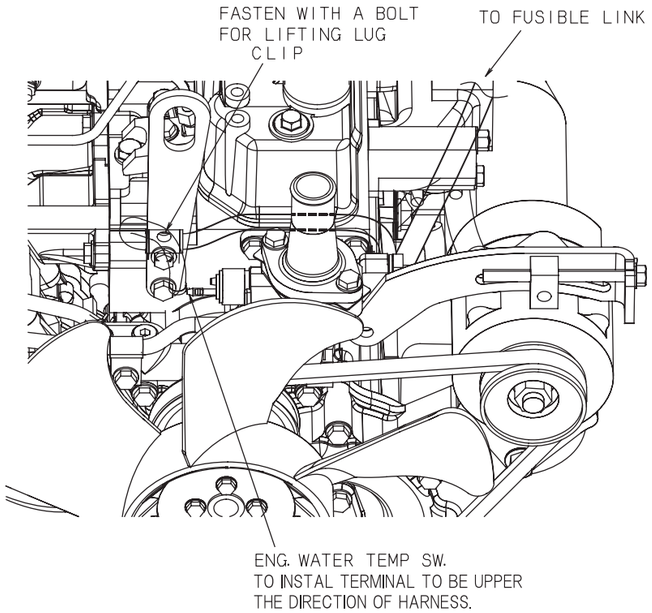
Note

The part number may be changed owing to modification, use them only for reference.

23.2.4.2 Engine Portion : PH16E00004F1

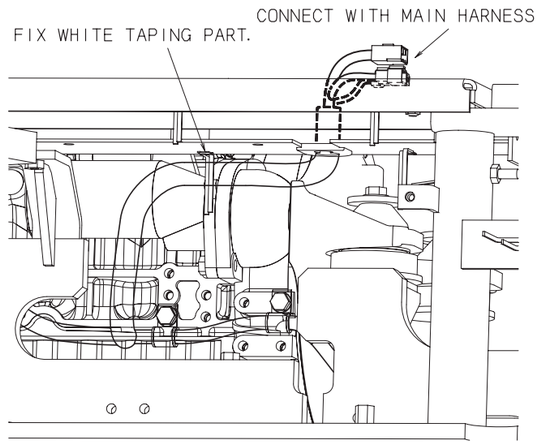


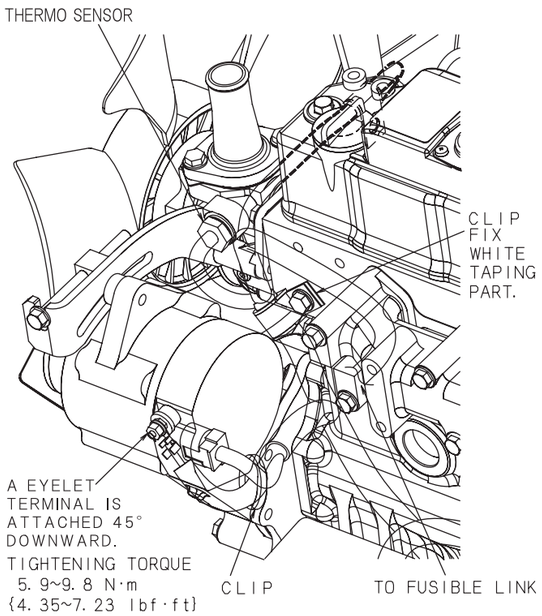
DETAIL OF A



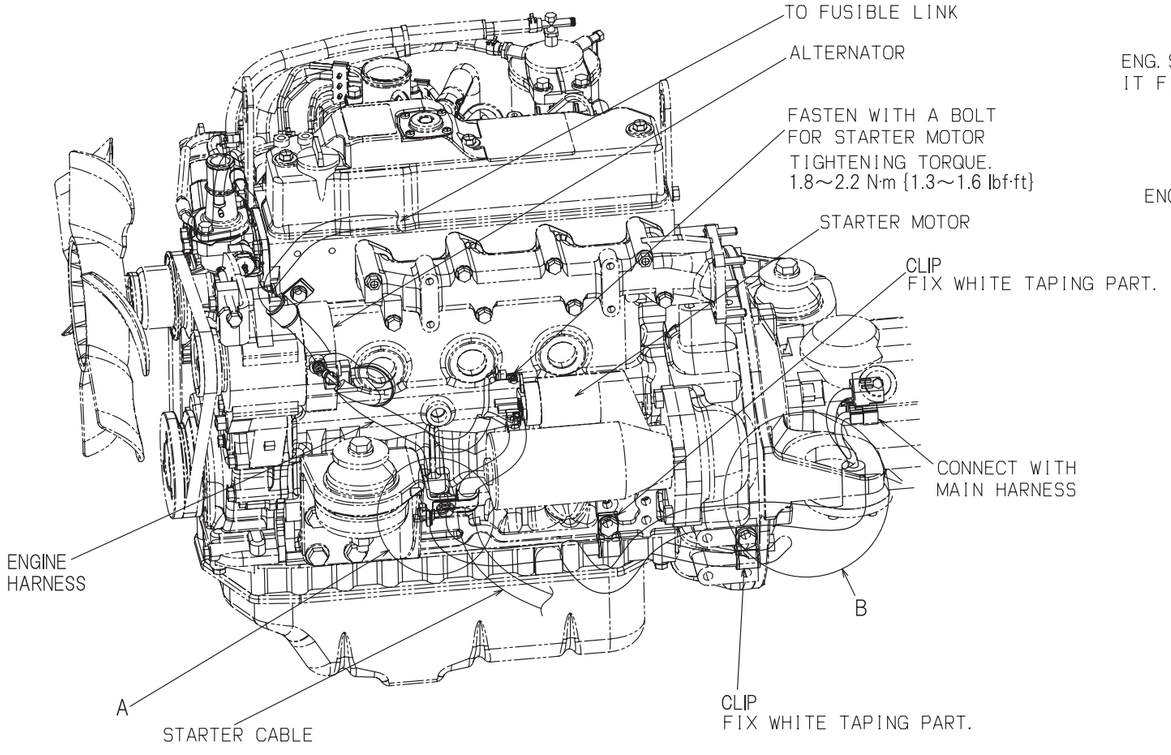
NOTES
1. TIGHTENING TORQUES TO BE

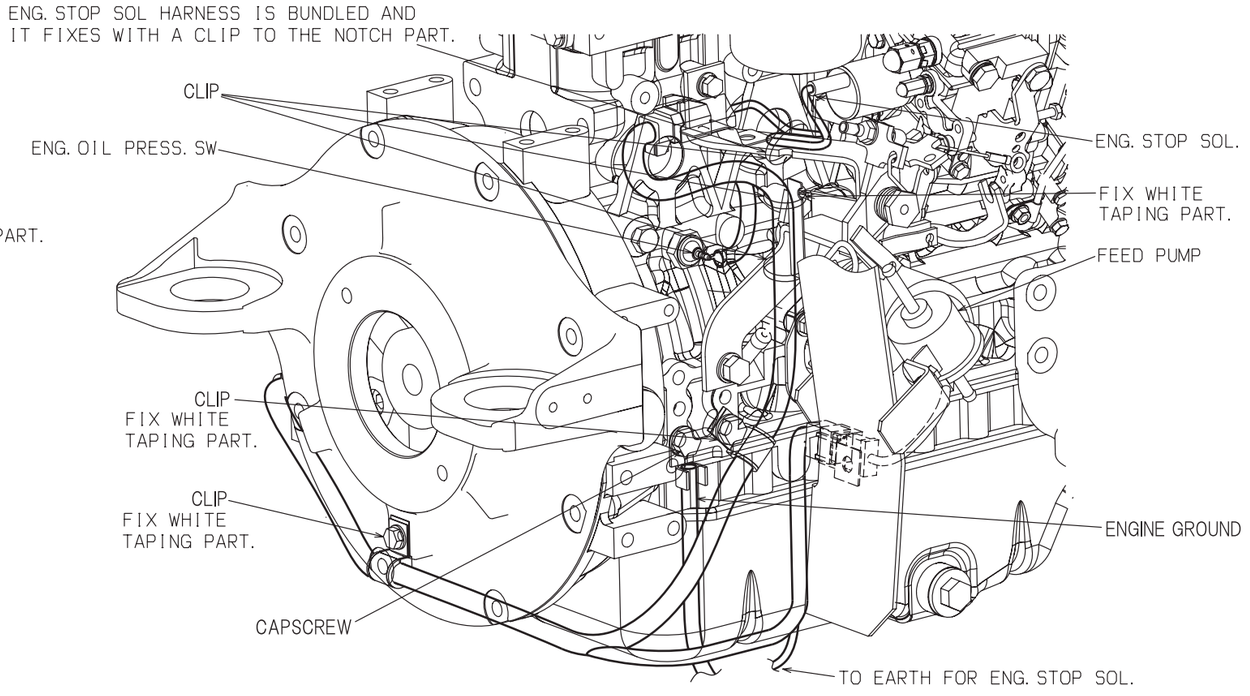
THREADS SIZE	TIGHTENING TORQUES
M8	23.5 N·m {17.3 lbf·ft}
M10	46.1 N·m {34.0 lbf·ft}
M12	79.4 N·m {58.6 lbf·ft}





DETAIL OF B



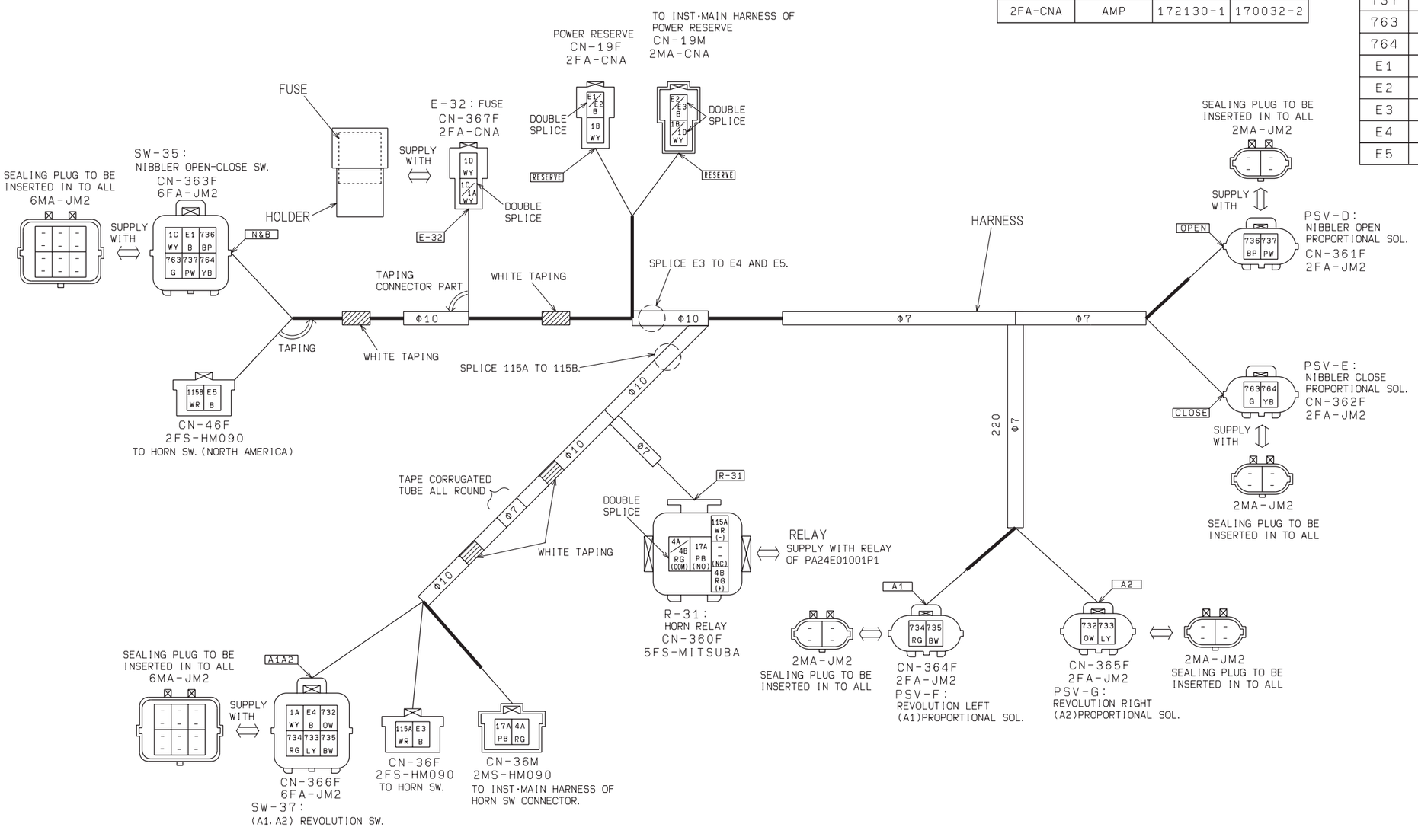


23.2.5.2 Proportional N&B Harness (No. H-2 : PH14E01041P2)

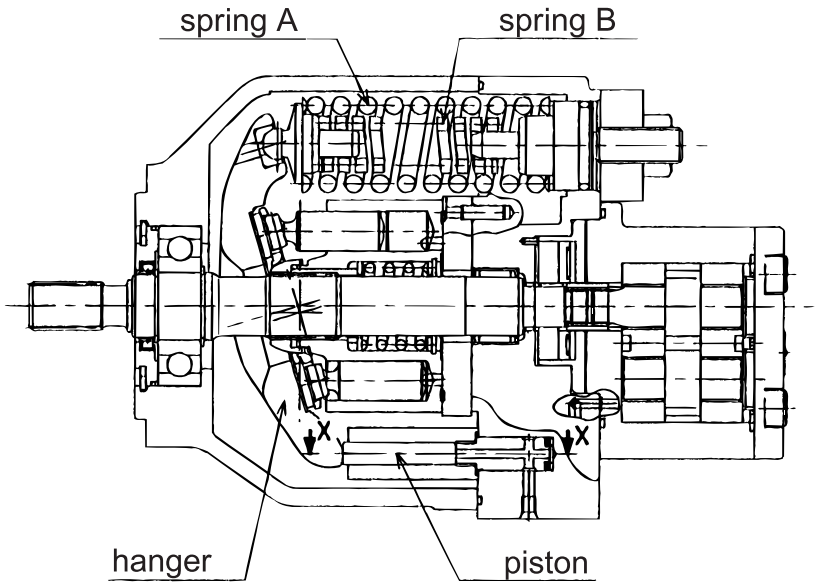
CONNECTORS SELECTION TABLE

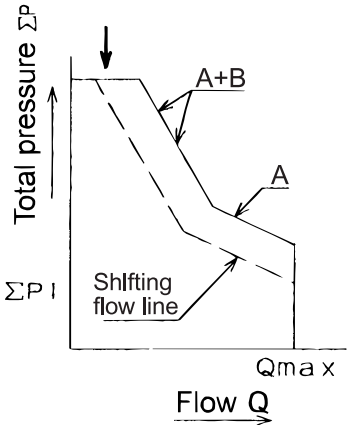
CONNECTOR NAME (PIN NUM.)	MANUFUC.	PART. NUMBER	
		TERMINAL	HOUSING
2FS-HM090	SUMITOMO	6090-1001	8240-4422
2MS-HM090	SUMITOMO	6090-1031	8230-4282
5FS-MITSUBA	SUMITOMO	6098-1493	1500-0207
			8240-4242
2FA-JM2	AMP	174352-2	171662-1
6FA-JM2	AMP	174262-2	171662-1
2MA-JM2	AMP	174354-2	
6MA-JM2	AMP	174264-2	
2MA-CNA	AMP	172129-1	170340-1
2FA-CNA	AMP	172130-1	170032-2

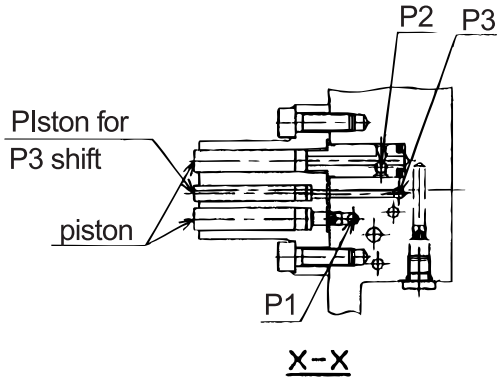
WIRE NO	WIRE COLOR	WIRE SIZE	FROM	CONNECTION	TO
1A	WY	AVSS0.75sq	CN-367F	DOUBLE SPLICE	CN-366F
1C	WY	AVSS0.75sq	CN-367F		CN-363F
1B	WY	AVSS0.75sq	CN-19M	DOUBLE SPLICE	CN-19F
1D	WY	AVSS0.75sq	CN-19M		CN-367F
4A	RG	AVSS0.75sq	CN-360F	DOUBLE SPLICE	CN-36M
4B	RG	AVSS0.75sq	CN-360F		CN-360F
17A	PB	AVSS0.75sq	CN-360F		CN-36M
115A	WR	AVSS0.75sq	CN-360F		CN-36F
115B	WR	AVSS0.75sq	CN-46F		
732	OW	AVSS0.75sq	CN-366F		CN-365F
733	LY	AVSS0.75sq	CN-366F		CN-365F
734	RG	AVSS0.75sq	CN-366F		CN-364F
735	BW	AVSS0.75sq	CN-366F		CN-364F
736	BP	AVSS0.75sq	CN-361F		CN-363F
737	PW	AVSS0.75sq	CN-361F		CN-363F
763	G	AVSS0.75sq	CN-362F		CN-363F
764	YB	AVSS0.75sq	CN-362F		CN-363F
E1	B	AVSS0.75sq	CN-363F	DOUBLE SPLICE	CN-19F
E2	B	AVSS0.75sq	CN-19M	DOUBLE SPLICE	CN-19F
E3	B	AVSS0.75sq	CN-19M		CN-36F
E4	B	AVSS0.75sq	CN-366F		
E5	B	AVSS0.75sq	CN-46F		



2. Control

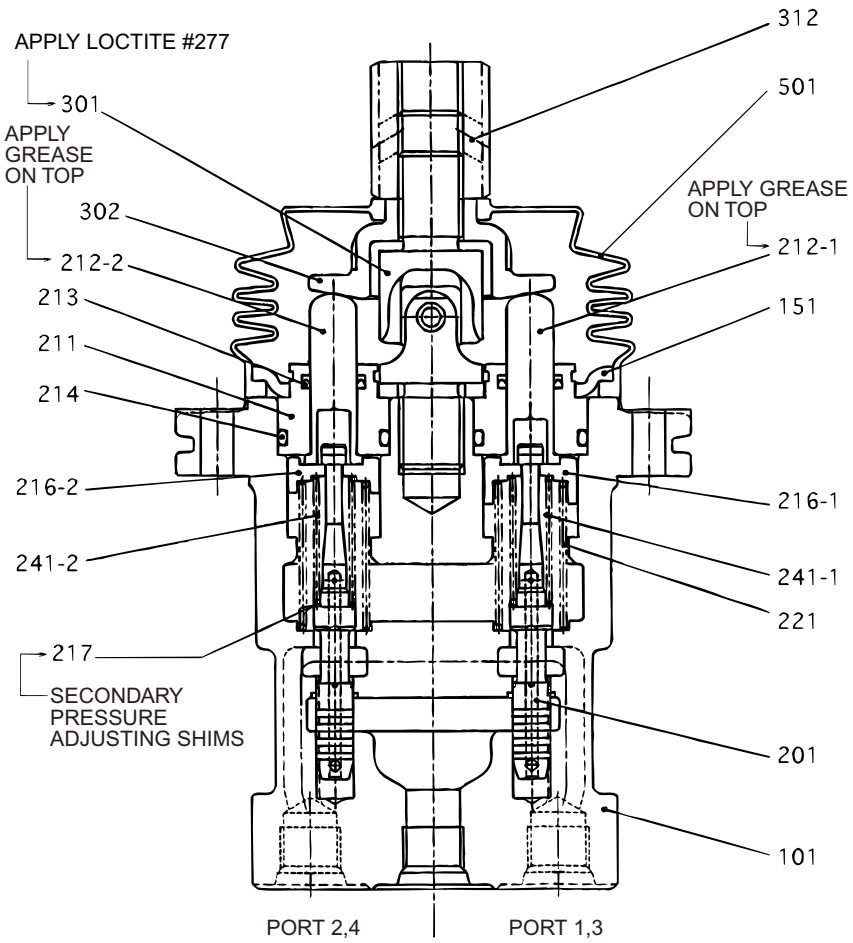


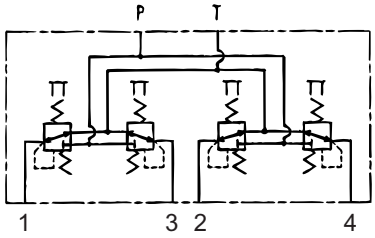




a. The delivery pressures P1 and P2 are directed to the piston which slides and acts on the hanger.
b. The spring is provided to act against the delivery pressure.
c. When the oil pressure via piston acting on the hanger is less than the installation load of the spring, the hanger is fixed to the maximum tilting position.
d. When the oil pressure via piston acting on the hanger exceeds the installation load of the spring, the hanger is tilted and kept tilted at a position where the oil pressure is balanced with the spring forces. (Region A in above figure)
e. When the oil pressure acting on the piston rises further to reduce the tilting angle, the spring B which has been inactive up to now becomes active.
f. To overcome the spring force of two springs, the oil pressure must be higher and the shifting line becomes more steep. (Regions A + B in the middle of the figure above)
g. When the P3 oil pressure acts on the shift piston, the control shifting line is shifted.

24.1.2.2 CONSTRUCTION





HYDRAULIC SYMBOLS

RIGHT PILOT VALVE	
PORT NO.	OPERATION
1	BUCKET DIGGING
2	BOOM DOWN
3	BUCKET DUMP
4	BOOM UP

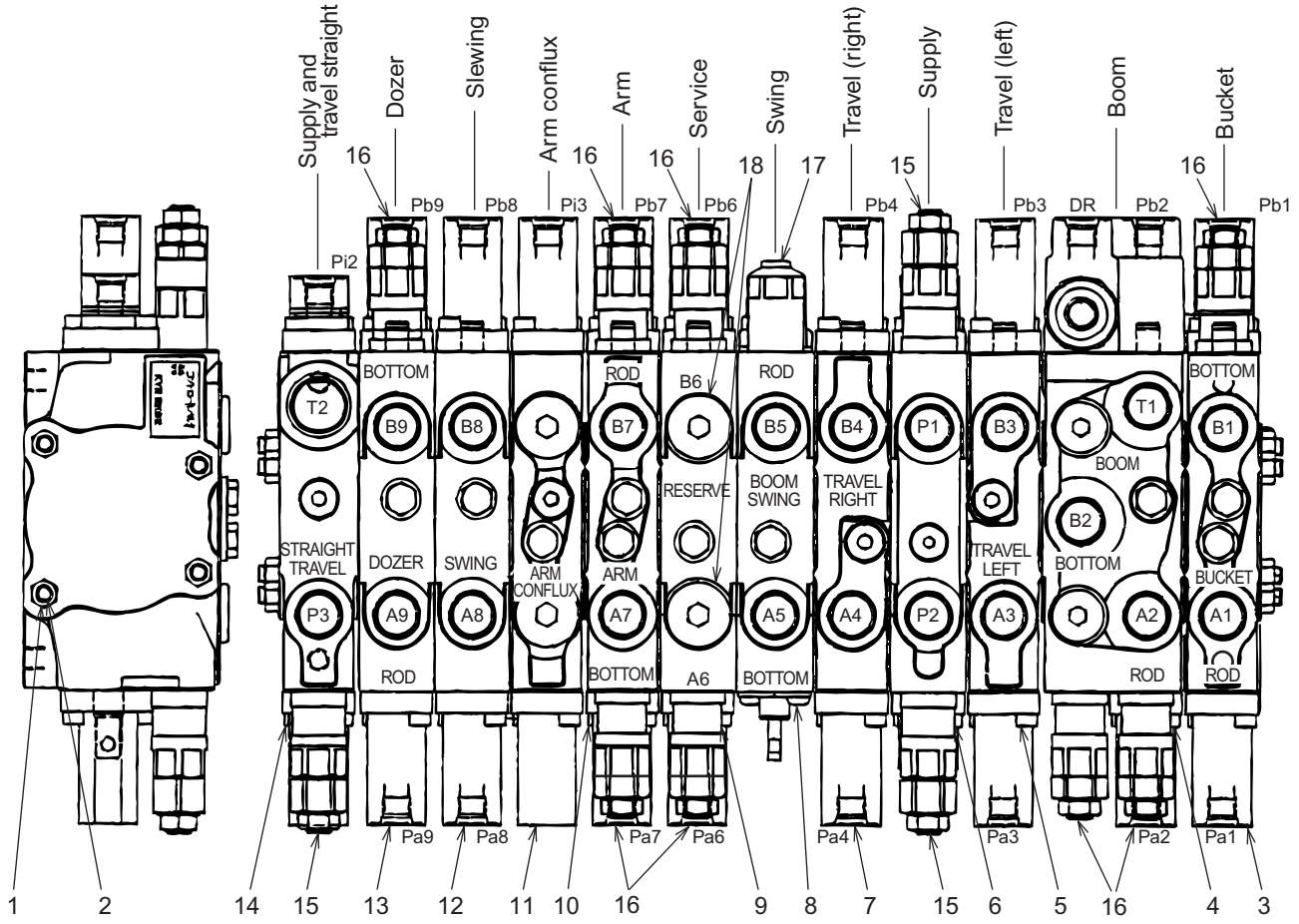
LEFT PILOT VALVE	
PORT NO.	OPERATION
1	SLEWING LEFT
2	ARM OUT
3	SLEWING RIGHT
4	ARM IN

Pilot valve-Sectional view

No.	NAME	Q'TY	No.	NAME	Q'TY	No.	NAME	Q'TY
101	Casing	1	213	Seal	4	241-1	Spring	2
151	Plate	1	214	O-ring; 1B P20	4	241-2	Spring	2
201	Spool	4	216-1	Spring seat	2	301	Joint; M14	1
211	Plug	4	216-2	Spring seat	2	302	Disk	1
212-1	Push rod	2	217	Washer 2	4	312	Adjusting nut; M14	1
212-2	Push rod	2	221	Spring	4	501	Bellows	1

24.1.4.3 CONSTRUCTION

(1) Control Valve: Overall composition



No.	NAME	Q'TY	No.	NAME	Q'TY
1	Nut	8	10	Arm section	1
2	Tie rod	4	11	Arm conflux section	1
3	Bucket section	1	12	Slewing section	1
4	Boom section	1	13	Dozer section	1
5	Travel (left) section	1	14	P3 inlet and travel straight conflux section	1
6	P1 and P2 inlet section	1	15	P1, P2, P3 Main relief valve	3
7	Travel (right) section	1	16	Over load relief valve (B1,A1,B2,A6,B6,A7,B7,B9)	8
8	Swing section	1	17	Anti-void valve (B5)	1
9	Service section	1	18	Plug assembly (PF1/2)	2

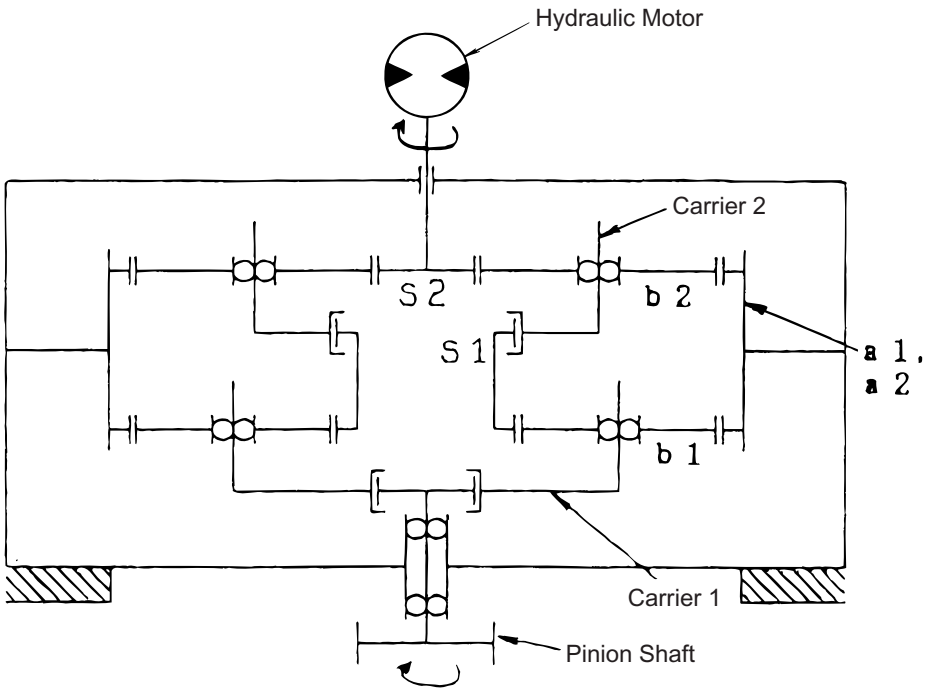
(4) Reduction Unit (Planetary 2 stage)

This slewing reduction unit for the slewing motor is made up of two stage planetary gear sets. It converts high-speed rotary motion from the slewing motor into low speed and high-torque motion to rotate the pinion shaft.
Refer to the Fig. "Operation of slewing reduction", sun gear 2 (S2) is splined on the output shaft of the slewing motor and the rotation of sun gear 2 (S2) performs primary reduction through gears (S2), (b2), and (a2).
After primary reduction, rotation performs secondary reduction through gears (S1) (splined to carrier 2), (b1), and (a1).
After secondary reduction, rotation is transmitted to the pinion shaft splined to carrier 1 creating slewing force.

The gear ratio of the two-stage planetary gear can generally expressed by :

$$R=\frac{Zs1}{Zs1+Za1}\times\frac{Zs2}{Zs2+Za2}$$

Where ;
Zs1, 2 : S1, 2 Number of teeth
Za1, 2 : a1, 2 Number of teeth

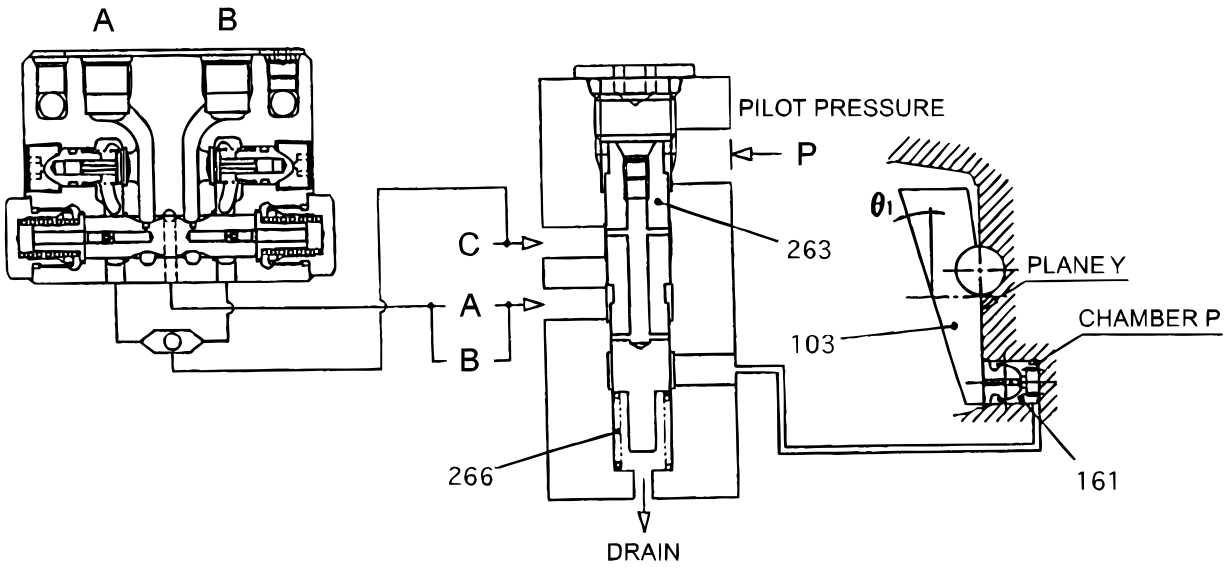


Operation of slewing reduction

4. High / Low 2-speed shifting mechanism

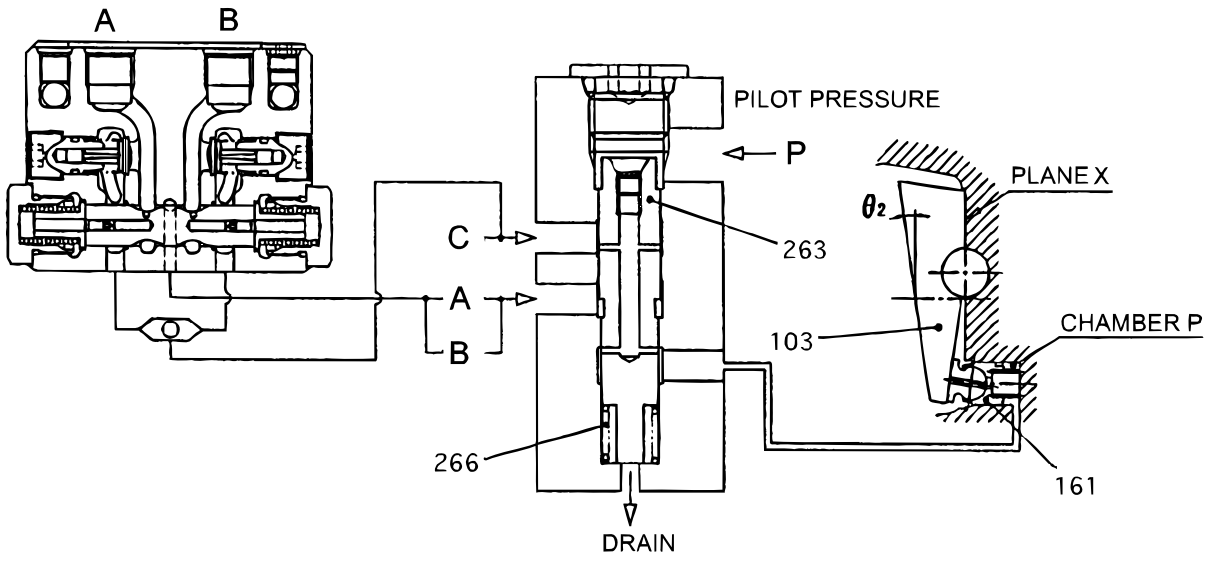
a. Low speed

When the pilot pressure is not supplied through the port (D), the valve (263) is pushed up to the upper position due to the spring (266) force and pressurized oil through the port (A) or (B), the pressurized oil is cut off at port (C), and oil in the chamber (P) is released into the drain (motor case) through the valve (263). Accordingly, the tilt angle of the swash plate (103) becomes the maximum θ 1 resulting the maximum stroke volume and low speed rotation of the hydraulic motor.



b. High speed

When 3.5MPa (507 psi) of the pilot pressure is supplied through the port (D), it defeats the spring (263) force and pressurized oil through the port (A) or (B) to push down the valve (263) to lower position, the pressurized oil at the port (C) is led to the chamber (P) through the valve (263), and the piston (161) pushes the swash plate (103) up to the plane X and maintain it at its position. At that time, the tilt angle of the swash plate becomes the minimum θ 2 resulting the minimum stroke volume and high speed rotation of the hydraulic motor.



24.1.8.2.2 Function (Example for boom cylinder)

(1) Fundamental Function

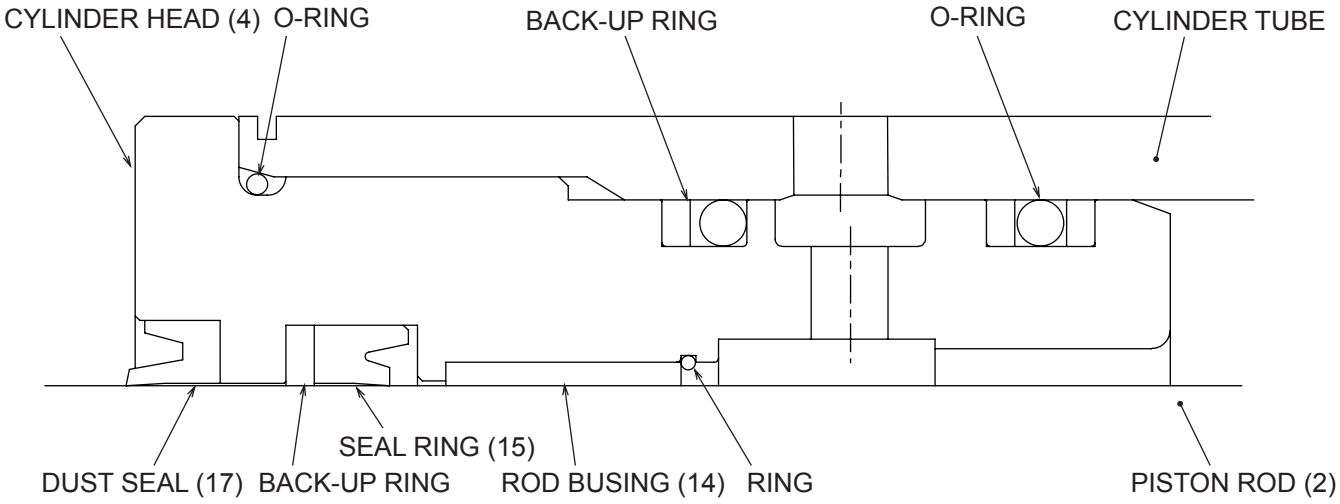
This hydraulic cylinder is a linear actuator that converts the energy in pressurized oil supplied by the hydraulic pump from rotary force to linear force conveyed by the piston. It also changes the operating direction for extension or retraction by actuating the valve lever to change the direction of pressurized oil flow.

(2) Function of each Part

The following description is based on a cylinder with a cushion bearing structure (Arm cylinder).

1. Cylinder Head Assembly

   The cylinder head assembly also works as a bearing by means of press fitting the rod bushing (14) into the cylinder head (4). The oil leakage is prevented by insersion of the seal ring (15) into the bore of cylinder head. The dust invasion is protected by pressing the dust seal (17) into the bore of cylinder head. By means of fitting with the cushion bearing (5) at adjacent to the fully extended position of the cylinder, a high oil pressure is generated to absorb the cylinder shock at the fully extended position. And the cylinder head has another function of charging and discharging highly pressurized oil from the inside of cylinder tube to the port.



Cylinder head assembly

a. Rod Bushing (14)

   The rod bushing (14) is pressed into the bore on cylinder head to support the piston rod. Along with the wear ring installed outer periphery of the piston, the bushing (14) bears radial load imposed on the cylinder, and performs linear movement against the piston rod at high facial pressure, and minimized the eccentricity of piston rod that badly affects to the sealing effect by supporting its one end.

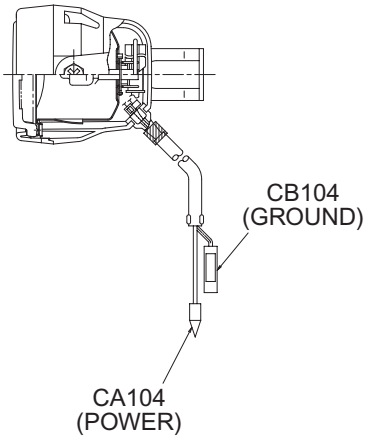
b. Dust Seal (17)

   The dust seal (17) is located at the entrance where the piston rod comes in and out. Its function is to protect invasion of dust and water into the cylinder to secure good sealing effect of the seal ring (15), as well as to remove dust and mud adhered on the piston rod.

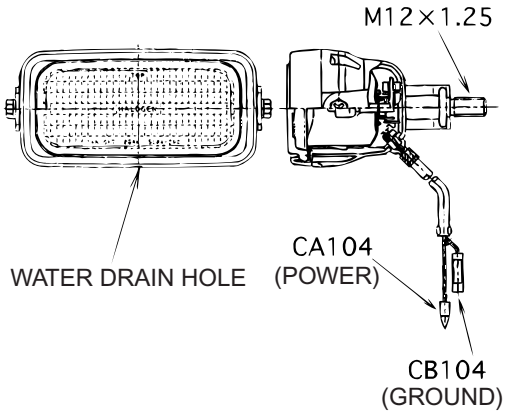
Code No. Parts Name Parts No. Use Applicable Machine	Specifications	Description

L-5 Light PW80S00003F1(Canopy) PW80S00004F1 (Cab) Canopy/Cab working light PJ06-08890~		

Maker's P/No.	BL84-290
Effective area of lens	54cm²
Bulb	Halogen12V-55W

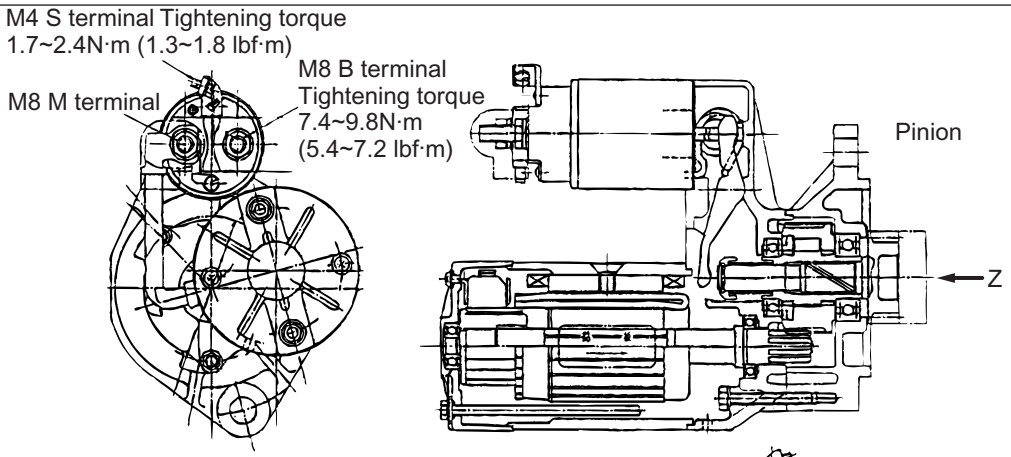


(FOR CAB)

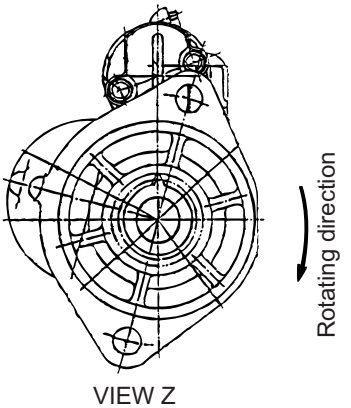


(FOR CANOPY)

M-1 Motor 129136-77011 E/G starter PH05-03501~ PJ04-03001~ PJ05-06001~ PJ06-08001~ PJ06-08890~	

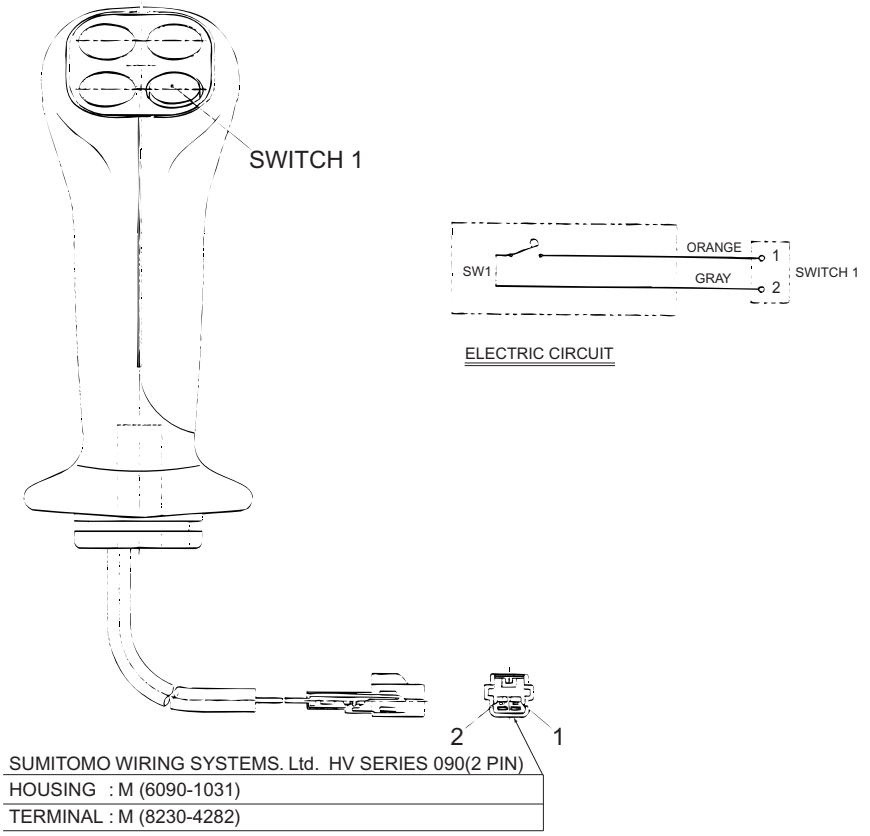


YANMAR Part No.	129136-77011
Rated voltage	DC12V
Output	2.3 kW
Rated time	30 Sec
Rotating direction	Clockwise as seen from pinion
Weight	5.3 kg (11.7 lb)

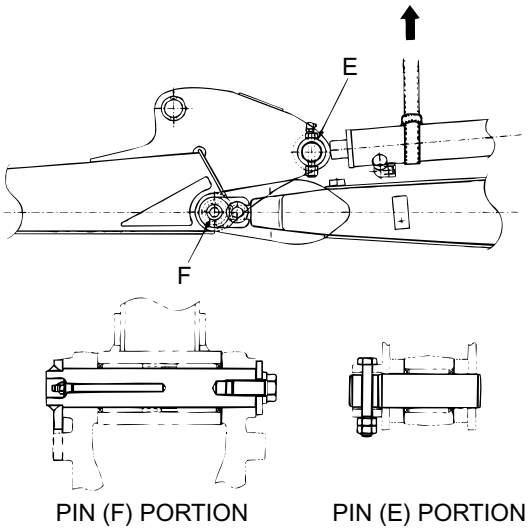


VIEW Z

Code No. Parts Name Parts No. Use Applicable Machine	Specifications	Description

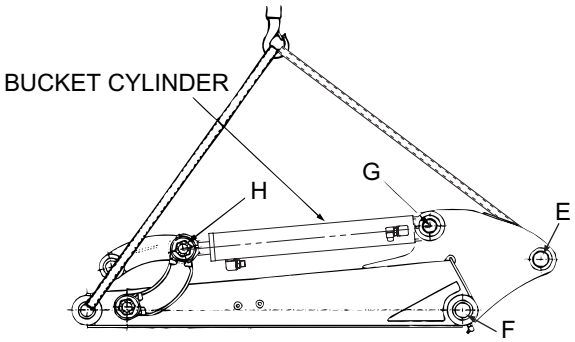
SW-37 Grip & Switch PW03M01960F1 (A1,A2) Revolution SW. (North America) PV13-33292~ PJ06-08890~	Left  SUMITOMO WIRING SYSTEMS. Ltd. HV SERIES 090(2 PIN) HOUSING : M (6090-1031) TERMINAL : M (8230-4282)

(4) Lift up the arm cylinder body with a nylon sling in order not to exert any load to the pin (E).
(5) Remove the capscrew and nuts that are preventing the pin (E) from coming off. Then remove the pin (E) and shims.
Tools : Spanner : 19mm
(6) Placing a wood block under the arm cylinder, get down the cylinder.
(7) Install the pin (E) to the original position, and install the capscrew and nuts that prevent the pin (E) from coming off. Applying a rope to the pin (E) and the arm tip, slightly lift it up in order not to exert any load to the pin (F).



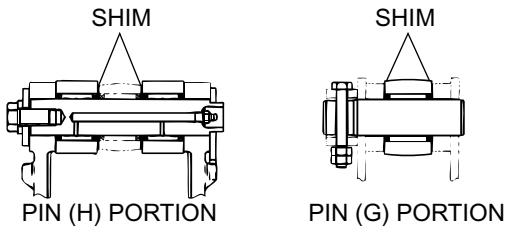
Sectional view of Installing Pin

(8) Remove the capscrew that is preventing the pin (F) connecting the arm and boom, from coming off. Then pull off the pin (F).
Tools : Spanner : 36mm
(9) Remove the arm assembly paying attention to the stability of arm.
Weight of arm assembly : approx.
180kg (397 lbs) - E50B



Removal of Arm assembly

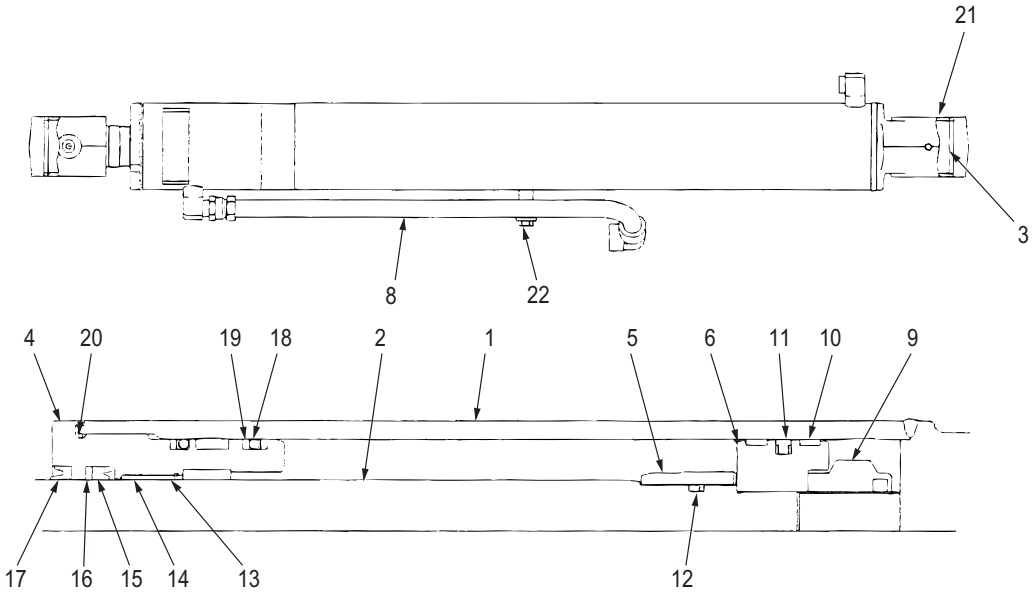
(10)Removal of Bucket Cylinder
1. Remove the capscrew that is preventing the rod pin (H) from coming off, then pull off the pin (H).
Tools : Spanner : 24mm
2. Remove the capscrew and nuts that are preventing the head pin (G) from coming off, then pull off the pin (G).
Tools : Spanner : 17mm
3. Apply a nylon sling to the tube of bucket cylinder, and remove the cylinder.
Weight ; approx. 27kg (60 lbs)



Sectional view of Installing Pin

32.2.1.3 CYLINDER CONSTRUCTION (EXAMPLE OF BOOM CYLINDER)

- See 24.1.8 CYLINDER for the others.



Construction of boom cylinder

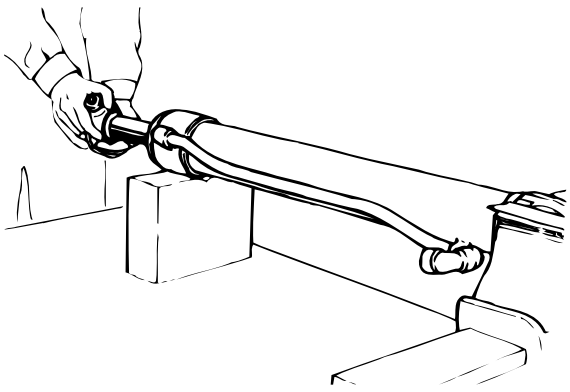
No.	NAME	Q'TY	No.	NAME	Q'TY	No.	NAME	Q'TY
1	Tube assembly	1	9	Lock nut	1	16	Back-up ring	1
2	Rod assembly	2	10	Wear ring	1	17	Dust seal	1
3	Bushing	1	11	Seal ring	1	18	O-ring	2
4	Cylinder Head	1	12	Seal ring	1	19	Back-up ring	3
5	Cushion bearing	1	13	Ring	1	20	O-ring	1
6	Piston	1	14	Rod bushing	1	21	Dust seal	4
8	Pipe	2	15	Seal ring	1	22	Bolt	2

32.2.1.4 DISASSEMBLY

- The numbers in ( ) following to each part name are the Items corresponding to those in Fig. "Construction of boom cylinder" unless otherwise noted.

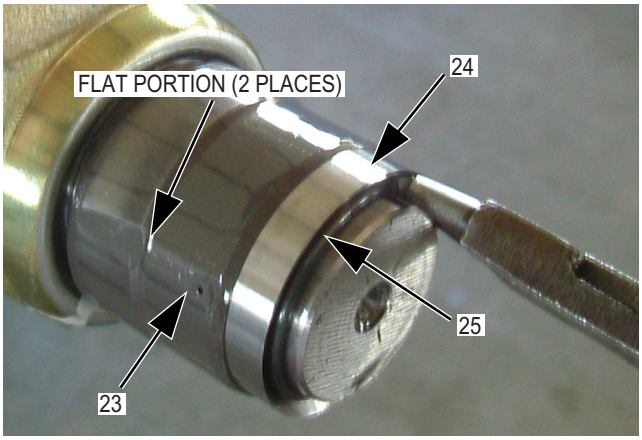
(1) Disassembly of cylinder assembly

1. Fix the clevis portion of tube with a vise, and hold the other end with a wooden stand to hold the cylinder in level.
2. Drain hydraulic oil remained in the cylinder.
   -Slowly move the piston rod so that the hydraulic oil does not spout out.



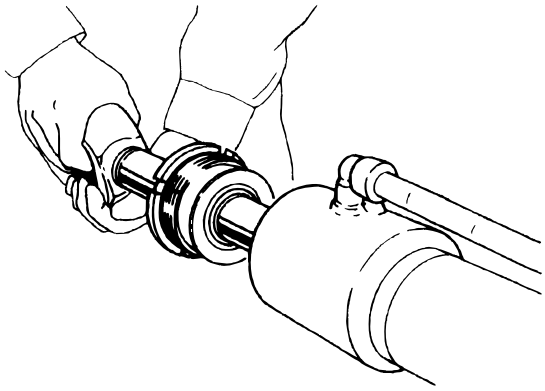
Disassembling cylinder assembly

5. Install the cushion bearing (23) of rod retracting side, plate ring (24) and ring (25).
   (Arm cylinder only)
   -Place the flat portion (2 places) of cushion bearing (23) toward the direction as shown in the right photo.
   -Confirm that the cushion bearing is movable after fixing the ring.



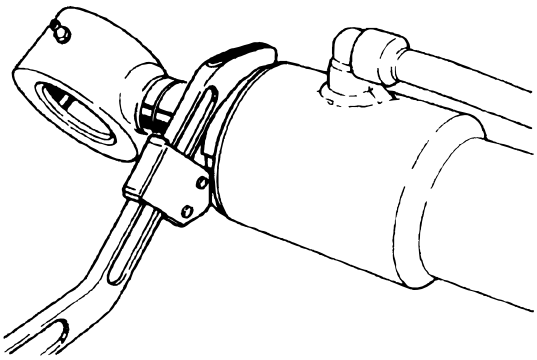
(5) Assembly of cylinder :

1. Level the tube and install the piston rod assembly into it.
   -At the installation, align the center of piston rod to the center of tube and install the piston rod in straight, paying attention not to damage seals.



Inserting piston rod assembly

2. Install the cylinder head (4).
   -Apply hydraulic oil on the packings (seals) prior to install.
   -Tightening torque for cylinder head :
   See 32.2.1.6 (4) in MAINTENANCE STANDARDS .



Installing cylinder head

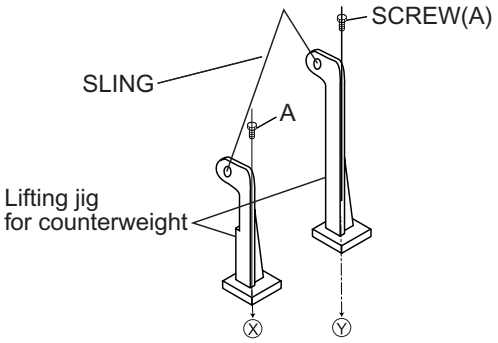
33. UPPER SLEWING STRUCTURE

Issue	Date of Issue	Applicable Machines	Remarks
First Edition	April, 2010	E50B : PJ06-	S5PJ3333E01 (NH-NA)

33.1.5 COUNTERWEIGHT

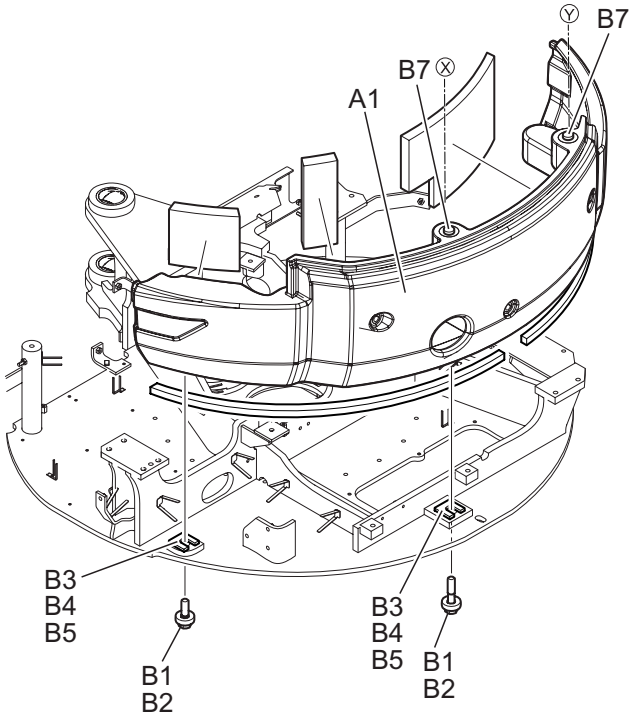
33.1.5.1 REMOVAL PREPARATION

(1) Remove the cover assemblies (1), (2), (4), (5), (9) and guard assembly (6) as well as the hood assembly (3)
(See Section 33.1.2).
(2) Lifting tools preparation
- Lifting jigs for counterweight (see Tool list)
- Two M20X35 screws (A)
- Wire rope (Nylon sling)



33.1.5.2 REMOVAL

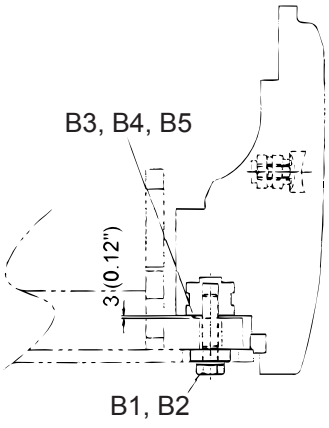
(1) Remove the plate (B7) and attach the lifting jigs for counterweight.
(2) Put a rope through the lifting lugs and temporarily lift up the counterweight so that the rope is not slack.
Counterweight weight :
580 kg (1,285 lbs)
(3) Loosen three M20X70 capscrews (B1).
Tools: Socket: 30 mm
(4) Remove the shims (B3), (B4) and (B5).
(5) Remove counterweight (A1).



Counterweight removal

33.1.5.3 INSTALLATION

(1) Install the counterweight in reverse order of the removal.
(2) Reinstall the shims (B3), (B4), and (B5).
(3) Lifting counterweight
Make sure that all the three fixing bolts can be manually screwed.
(4) Apply Loctite #262 on the capscrews (B1) and tighten them together with the washer (B2).
Tools: Socket: 30 mm
Tightening torque : 373 N-m (275 lbf-ft)
(5) Remove lifting jigs.

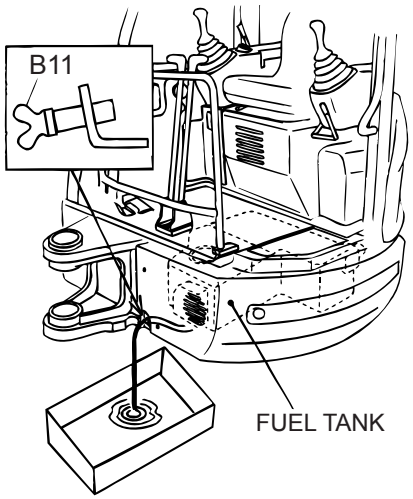


Counterweight installation

33.1.10 FUEL TANK

33.1.10.1 DISASSEMBLY PREPARATION

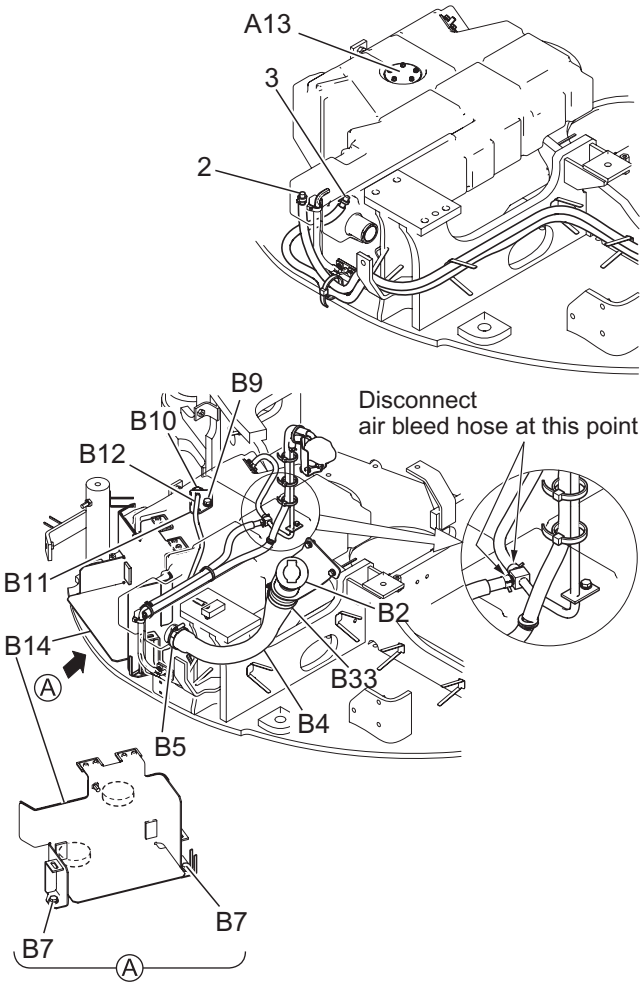
(1) Remove the floor mats (5) and (8), the floor covers (2) and (4), and the floor plate (1) (See Section 33.1.3.1).
(2) Remove the cover assembly (4) on the left lower side (See Section 33.1.2.1-(4)).
(3) Remove the battery (See Section 33.1.4.2).



Fuel drain

33.1.10.2 DISASSEMBLY

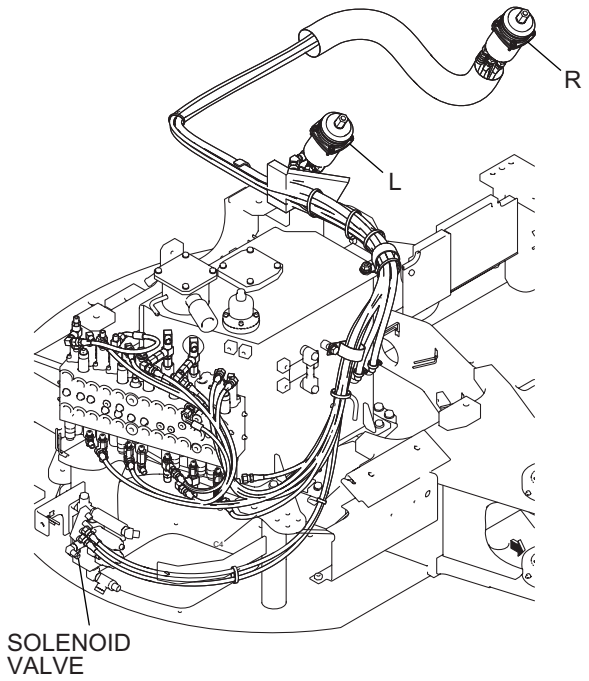
(1) Open the fuel filler cap (B2) and loosen the drain cock (B10) to drain fuel.
Tank capacity : 52 liters (14 gal)
(2) Disconnect the hoses (2) and (3) for the fuel inlet and outlet, the hose (B4) for the fuel supply port, and the air bleed hose.
(3) Loosen the M10X20 sems-bolt (B9) to remove the boss (B11) together with the drain hose (B12).
Tools: Socket: 17 mm
(4) Disconnect connector (A13) for the level sensor.
(5) Remove two M10X20 capscrews (B7).
Tools: Spanner: 17 mm
(6) Remove the fuel tank (A1) together with the bracket assembly (B14).



Fuel tank removal

(9) Disconnecting pilot hose

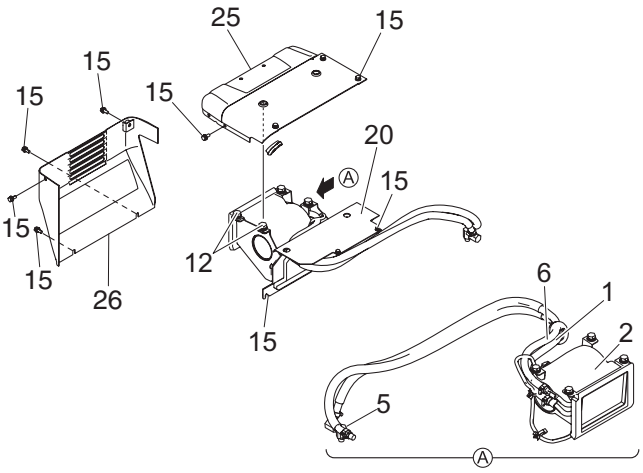
1. Disconnect the hose of the right pilot valve (R) under the pilot valve
(See Section 33.1.19.2).
2. Disconnect the hose of the left pilot valve (L) from the control valve and solenoid valve sections (See Sections 33.1.7.2 and 33.1.8.2).
-When a multi-control valve is equipped, disconnect hose at the multi-control valve section.



Pilot hose disconnection

(10) Removing heater hose (option)

1. Loosen five sems-bolts (15) M8X20 to remove the cover (25) and (26).
Tools: Socket: 13mm
2. Loosen five sems-bolts (15) M8X20 to remove the cover (20).
Tools: Socket: 13mm
3. Remove the engine side clips (5), and disconnect the hose (1) and (6).
4. Loosen four sems-bolts (12) M8X16 to remove the heater (2).
Tools: Socket: 13mm



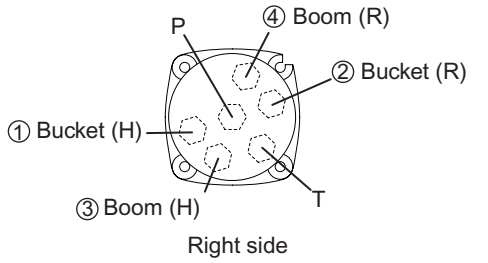
Heater hose disconnection

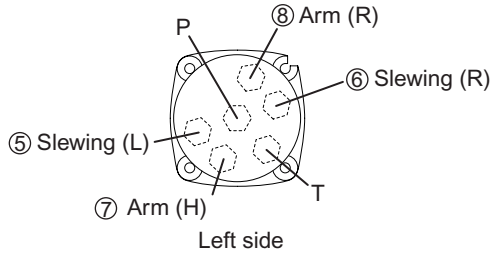
33.1.19.3 INSTALLATION

(1) Install the pilot valve in reverse order of the removal according to the following tightening torque :

1. 1. Attaching sems-bolts (20).
   Tools: Torx driver (T25)
   T=0.27 N-m (0.2 lbf-ft)
2. Installing hoses, etc.

		Tightening torque N•m (lbf•ft)	
Thread size (PF)	Spanner used (mm)	O-ring type fitting	30° flare type fitting
1/4	19	36.3 (27)	29.4 (22)
3/8	22	—	49 (36)





Pilot valve port location

Note

Take care of the tightening torque as the pilot valve is made of aluminum. Tightening torque of pilot valve ports. 29.4 N-m {22 lbf-ft}

(3) Pressurize the hydraulic tank (See Section 33.1.11.3).

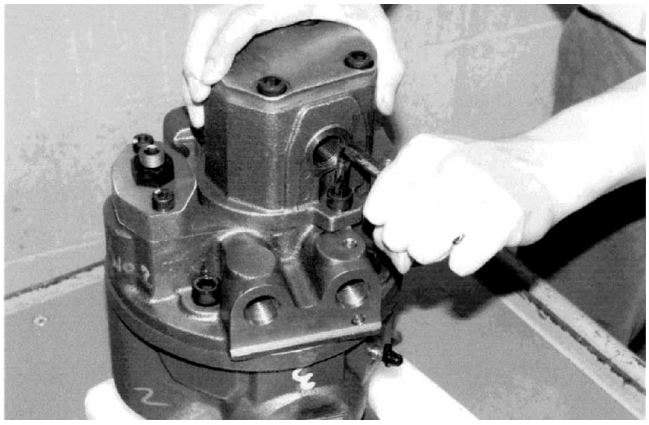
(4) Operate the attachment to check the performance.

(5) Check the tank and piping for oil leakage and oil level.

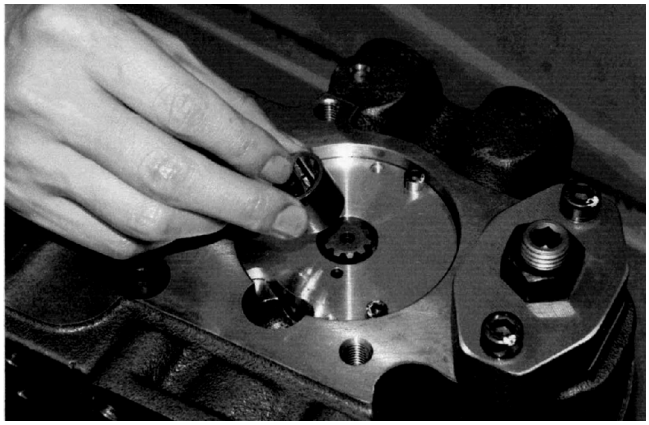
33.2.1.2.3 Disassembly

(1) Removing gear pump

1. Remove two capscrews (M10X25).
   Tools: Allen wrench: 8mm

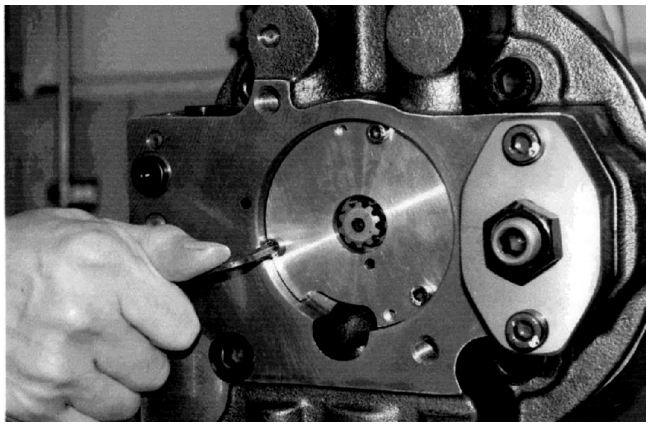


2. Remove the coupling.

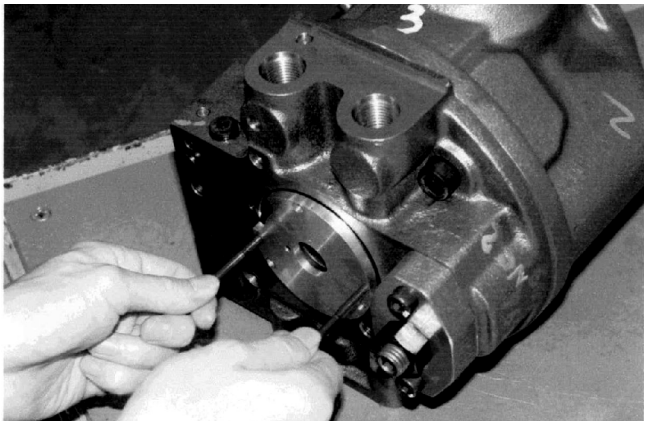


(2) Removing trochoid pump

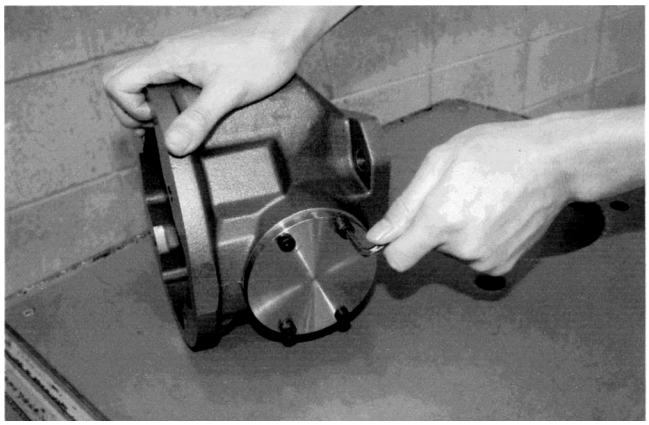
1. Remove three M5X12 capscrews.
   Tools: Allen wrench: 4mm



2. Remove the case.
   -Use two M5X50 screws.

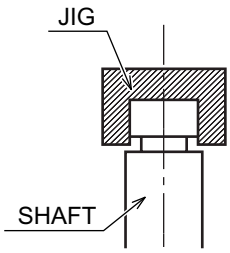


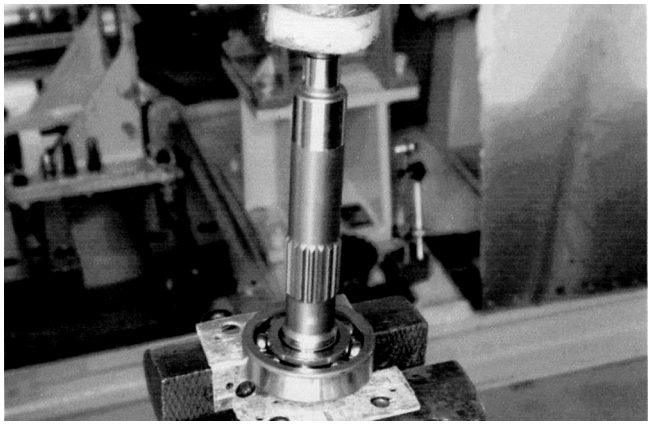
4. Install the plate with four socket bolts (M6X16).
   Tools: Allen wrench: 5mm
   Torque : 1.35 N-m (9.8 lbf-ft)



5. Assembling shaft assembly.

a. Place bearing on the pedestal, and press-fit shaft with jig. When there is no press, drive the shaft with jig and plastic hammer in the same manner as the above.

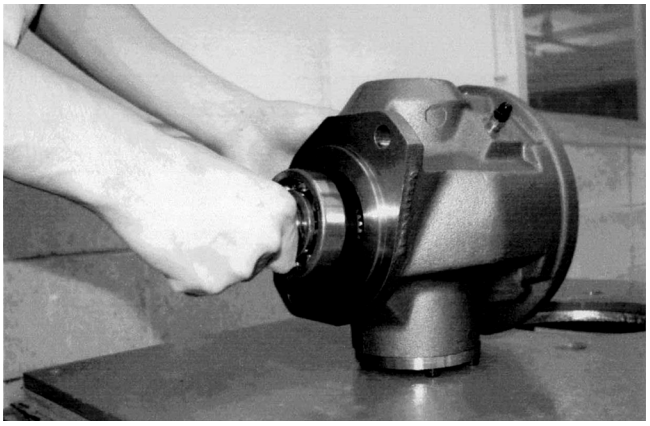




b. Fix snap rings and bearing.

   Snap ring plier
   (for shaft : 28 dia., 30 dia.)

c. Install shaft in housing and tap the spline end with a plastic hammer lightly to fit outer race of bearing into the hole of housing completely.

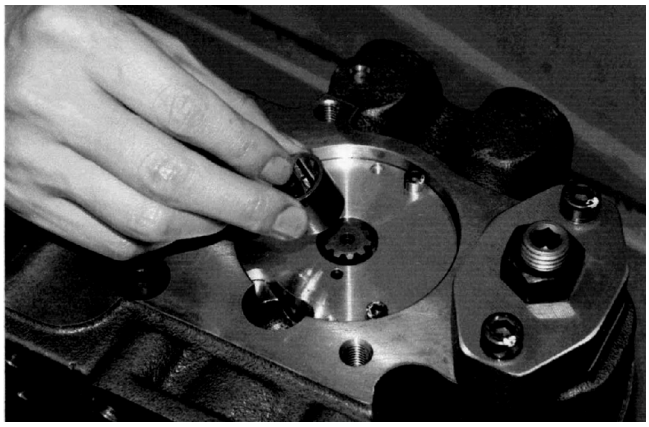


8. Fix the housing and the cover with four M10X20 capscrews.
   Tools: Allen wrench: 8mm
   Tightening torque : 55 to 69 N-m (41 to 51 lbf-ft)

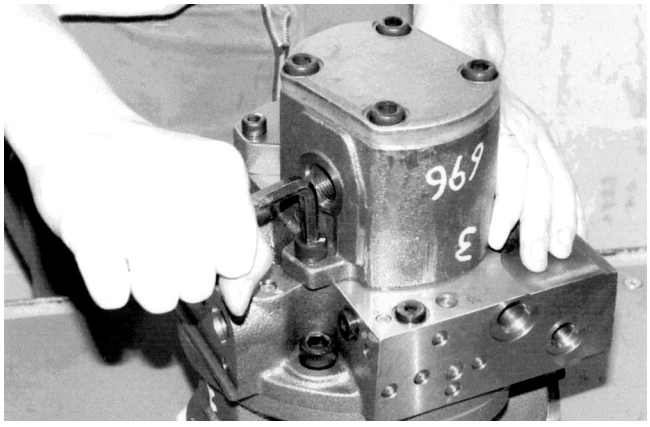
9. Install O-ring on attaching surface of gear pump.

(4) Installing gear pump

1. Fit the coupling to the shaft end on the main pump side.

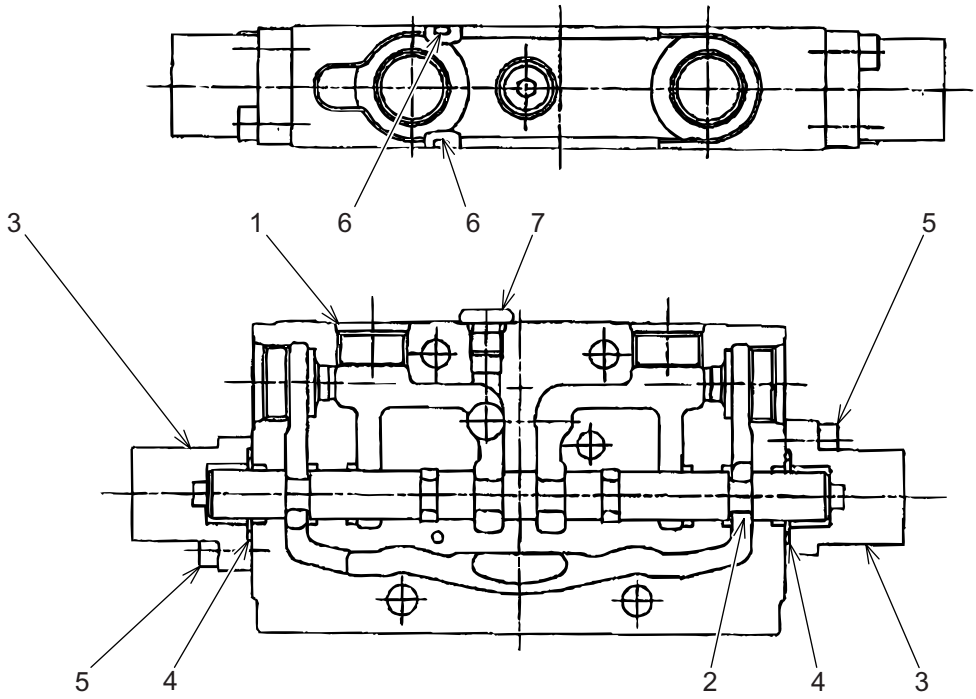


2. Connect the gear pump to the main pump.
   Fix the gear pump with 2 socket bolts (M10X25).
   Tools: Allen wrench: 8mm
   Tightening torque : 62 N-m (46 lbf-ft)



(4) Disassembling inlet section

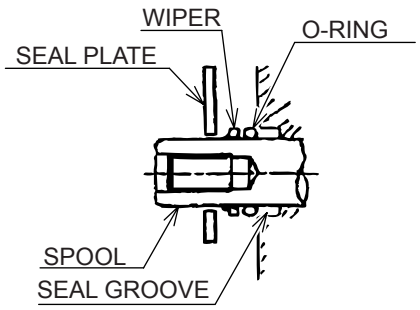
1. Loosen socket bolt (5) (Opposing flats 5mm) and remove cap (3). And remove O-ring (4). Then remove spool (2) from valve housing (1).
2. Remove cap (3) on other side by the same procedure.



Inlet section

(5) Assembling swing section / Manual operation

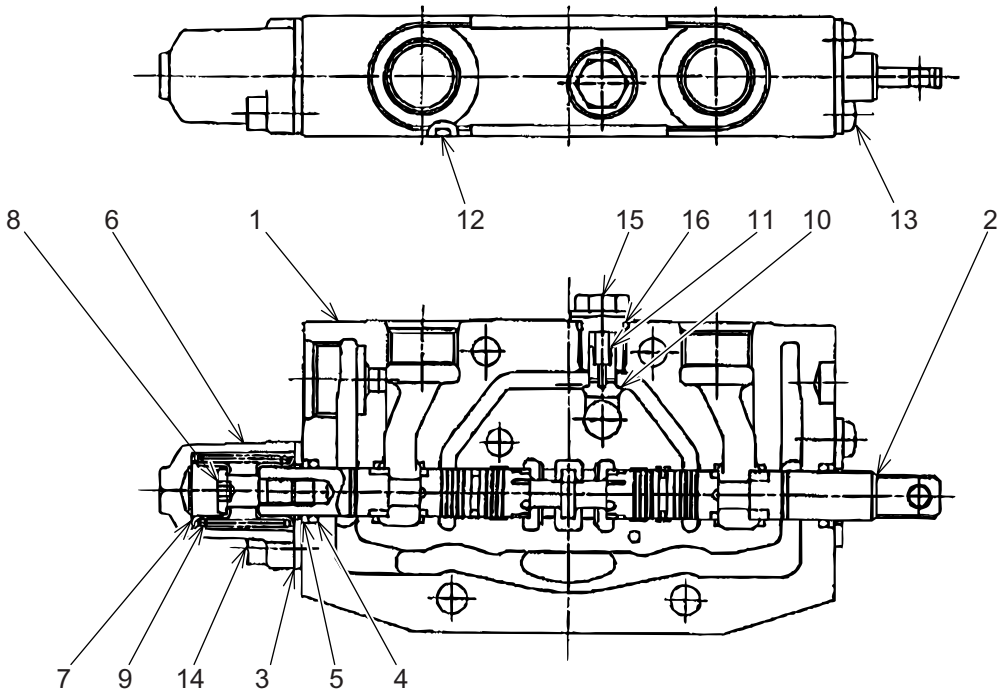
1. Install O-ring (4), wiper (5), and seal plate (3) in spool (2) in order. Put spring (9) between spring seats (7), and attach it to spool with cap screw (8) (Opposing flats 5mm). Then be sure to assemble the spool sandwiching it between wood blocks and fixing it to vise to protect the outside surface from damage (see 33.2.2.4(5) Fig. "Connecting port relation").
   Tightening torque: 19 to 22N-m 14.0 - 16.2 lb ft)
2. Place previously sub-assembled spool in valve housing (1) and attach O-ring (4), wiper (5) and seal plate (3) on other side with machine screw (13).
   Tightening torque: 2.5 to 2.9N-m (1.8 - 2.13 lb ft)



Wiper (5) installing direction

CAUTION

Pay attention to the wiper (5) direction.



Swing section

(6) Remove the plate (151).

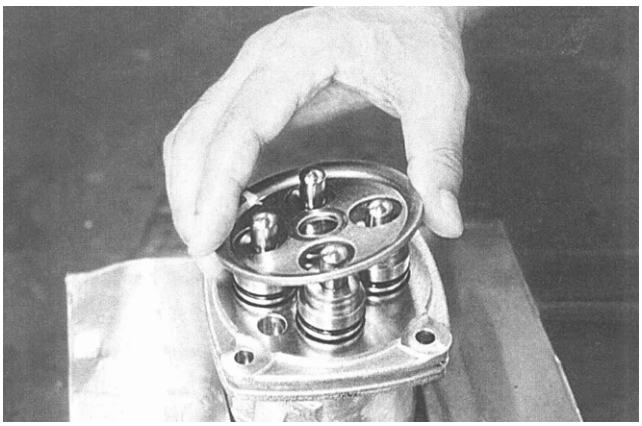
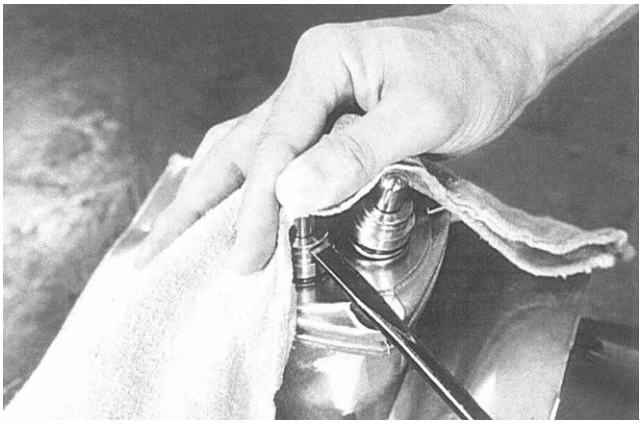


Plate (151) removal

(7) If the return spring (221) is not strong, use a flat screwdriver to pull out the plug (221) which remains inside the casing (101) due to sliding resistance of the O-ring.
-Apply the tip of the flat screwdriver to the external groove of the plug (211) while preventing damage to the plug due to eccentric load.

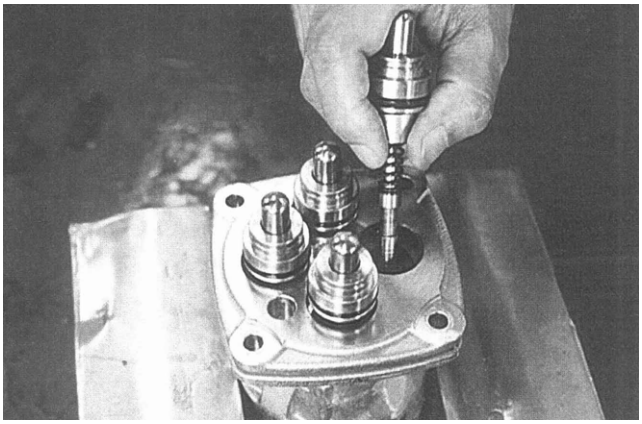


Spring (221) removal

CAUTION

Be careful that the plug (211) may pop up due to the return spring (221) force when removing the plug.

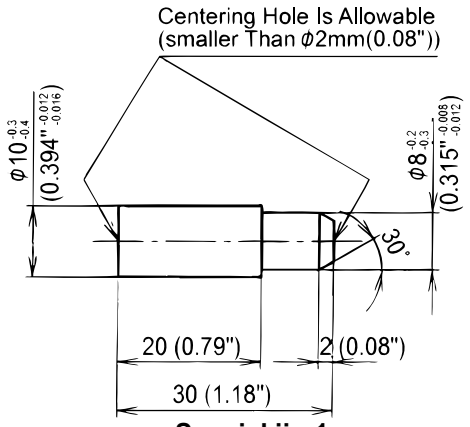
(8) Remove the push rod (212), plug (211), pressure reducing valve section assembly, and return spring (221) from the casing (101).
-Record the relation between the casing hole positions and these parts.



Push rod (212) removal

33.2.4.2 DISASSEMBLY AND ASSEMBLY

(1) Special jig for disassembly and assembly
Special jig 1 (for removal of bushing)



Special jig 1

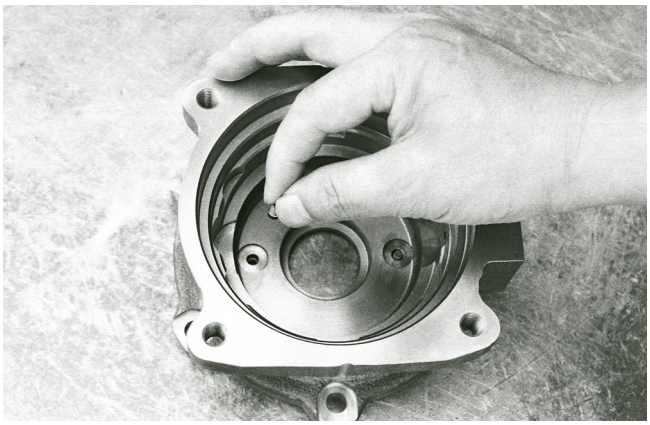
(2) Precautions for disassembly and assembly

1. Disassemble and assemble the pilot valve paying attention not to let dust, dirt, etc. enter in.
2. Handle parts carefully not to damage.
3. Write down the installing positions of respective parts during disassembly, and assemble respective parts to the position as they were before.

(3) Disassembly

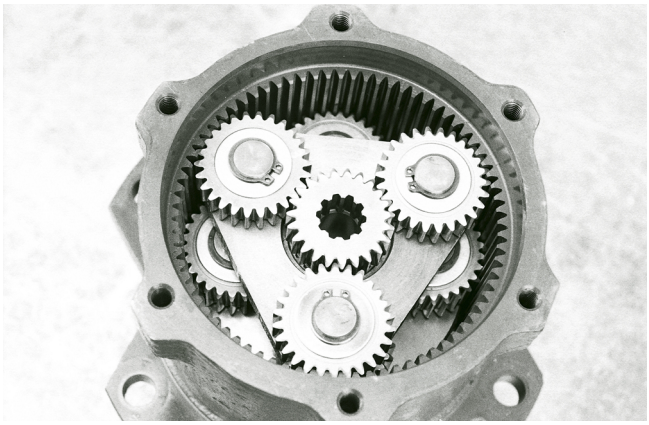
1. Stop respective port (P, T, 1, 2, 3, and 4) of the valve with plugs and clean the outer surface.
2. Fix the cleaned valve with vise.
3. Remove bellows (501) from cover (201).
4. Remove set screw (472).
   Tools: Allen wrench: 6 mm
5. Contact pry bar (7 dia. or less) to one end of cam shaft (413), and strike it lightly with a hammer.
6. Remove cam (420).
7. Remove socket bolt (271).
   Tools: Allen wrench: 6 mm
8. Remove cover (201).
9. Remove the casing upper assembly and fix the assembly with vise, again.
10. Draw push rod (214) out of plug (202).
11. Remove plug (202) with grease cup (203), packing (210) and O-ring (212).
12. Remove piston (224).
13. Remove damping spring (336) from the casing.
14. Take out spring seat (218) from casing (102) with tweezers.
15. Take out steel ball (225) using magnet.
16. Fix the lower casing assembly with vise, and take out O-rings (211 and 213) from casing (101).
17. Remove reduction unit valve assembly and return spring (335) from casing (101).
18. Place cover (201) on the flat bench transverse, apply bushing (414) to special jig 1, strike it lightly with hammer, and pull the bushing out.
19. For disassembly of the reduction unit valve assembly first push spring seat (311) in and shift the spring seat crosswise making secondary pressure spring (324), remove it from spool (301) passing through the large hole.

13.Remove two filters (214) and parallel pin (225).

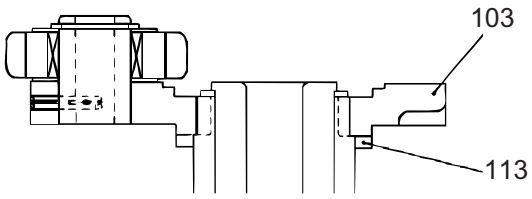


(4) Disassembling of Reduction Unit

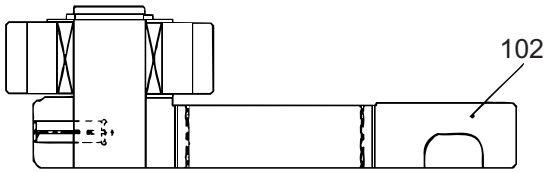
1. Remove sun gear 2 (109).



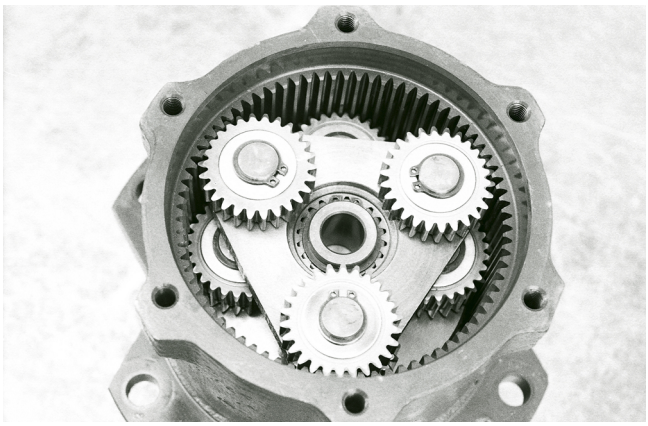
2. Remove carrier 2 assembly (103) and carrier 1 assembly (102).



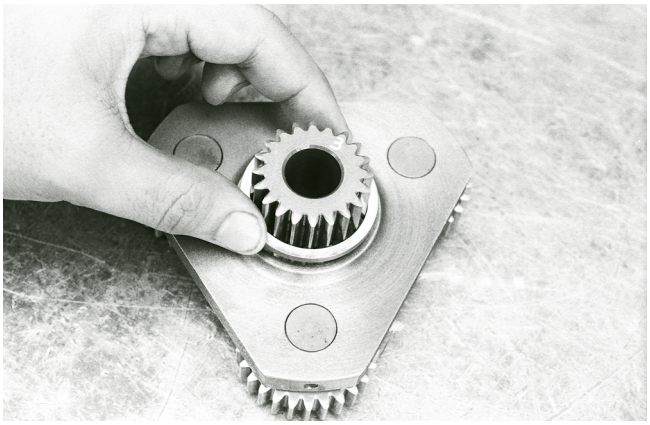
CARRIER 2 ASSY



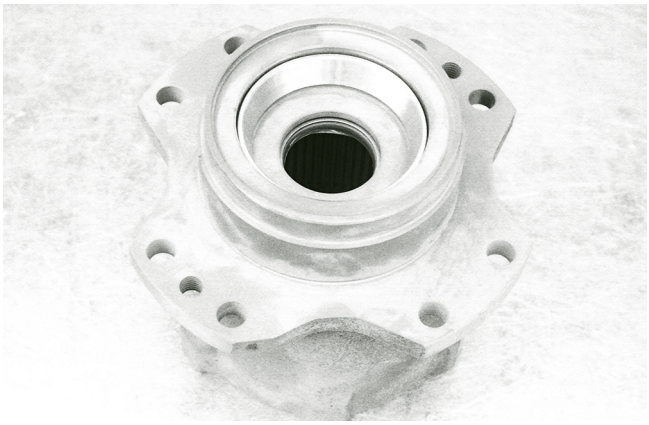
CARRIER 1 ASSY



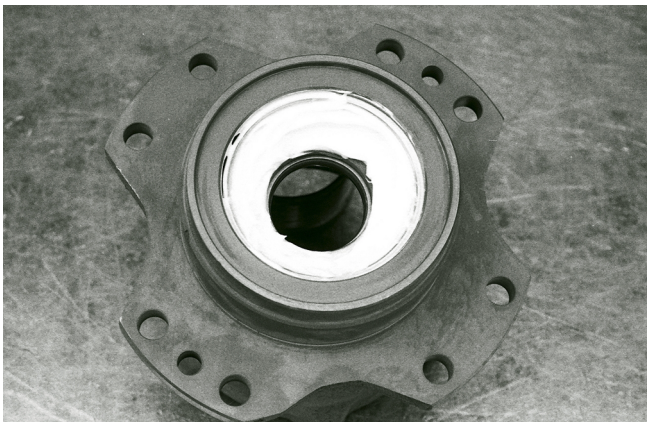
3. Remove the thrust collar (113) installed back side of the carrier 2 assembly (103).



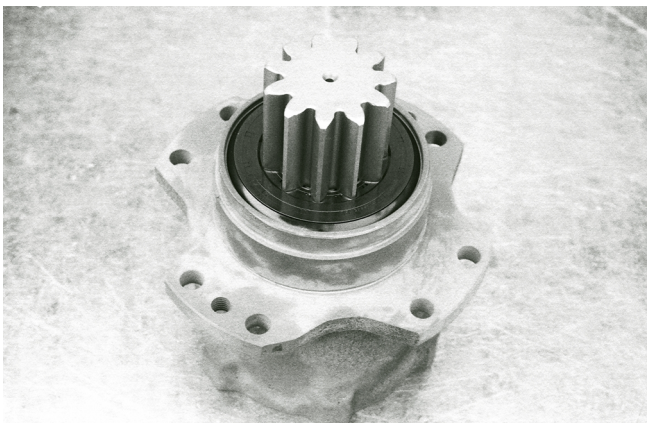
5. Press-fit the outer race of the taper roller bearing (115) into the casing (101).



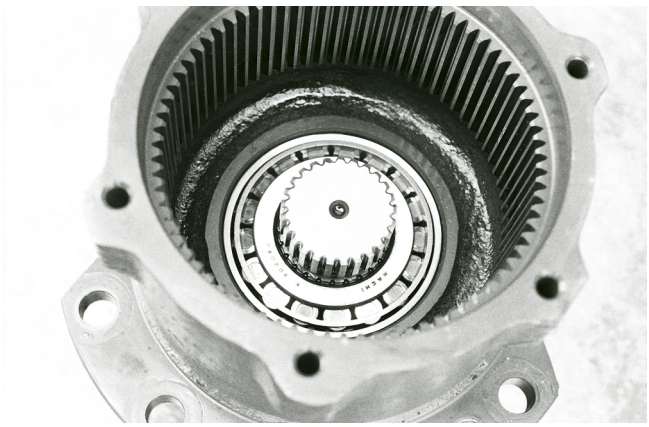
6. Apply grease in the space in the casing (101) where the taper roller bearing (115) is to be installed.
   -Grease amount :Approximately 80% of the empty capacity



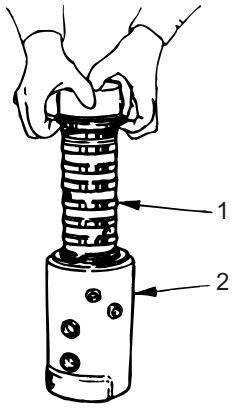
7. Install the shaft (104) into the casing (101).
   -Take care that the oil seal lip is not damaged by the shaft.



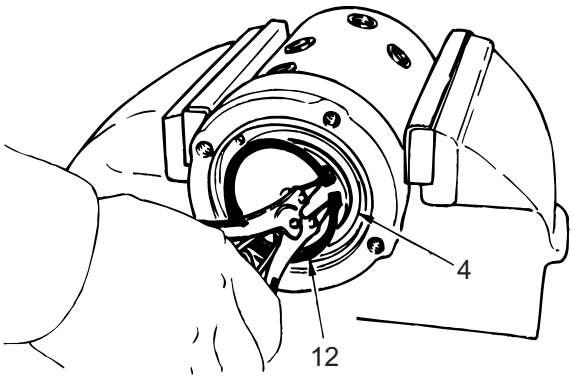
8. Turn over the casing (101) and press-fit the inner race of the taper roller bearing (116).



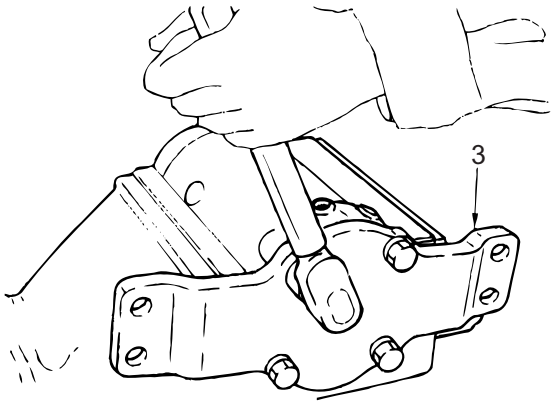
(3) Install stem (1) to body (2).
-Apply hydraulic oil or grease around the stem lightly.
-Strike the stem with a plastic hammer carefully not to damage seal.



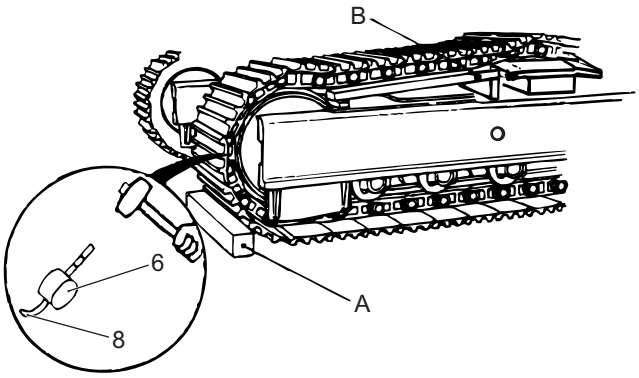
(4) Fit spacer (4) and snap ring (12).
-Fit the snap ring in the groove correctly.



(5) Fit O-ring (9) and install flange (3).
(6) Install spring washer (15) and bolt (13).
Tools: Socket: 17mm
or
Tools: Spanner: 17mm
-Tightening torque : 46.5 N-m (34 lbf-ft)
-Put pipe through the locking pin of the stem, and check that the shaft rotates smoothly at a torque of approximately 78 to 108 N-m (58 to 80 lbf-ft)

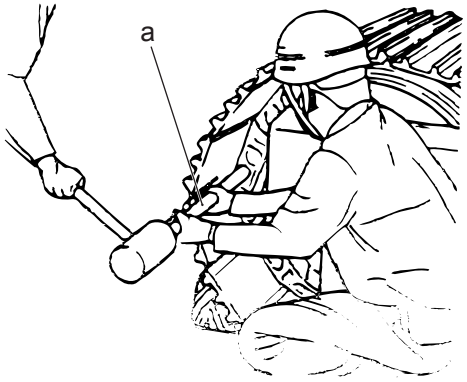


4. Straighten the curve of lock pin, and draw it out striking by hammer.
   -Remove lock pin (8) with shoe plate.



Removing lock pin

5. Apply master pin drawing out jig (a) to the small diameter section of master pin (6), and draw it out striking by hammer.



Removing master pin

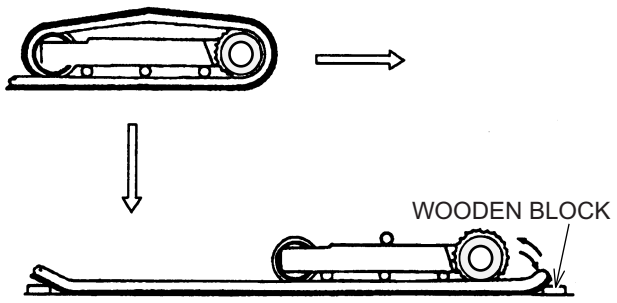
WARNING

-Especially pay attention to the front idler which may spring out due to the force of spring when drawing out master pin (6) to repair broken parts relating to the front idler.
-Be careful not to be injured by flying debris, when large hammer is used.

WARNING

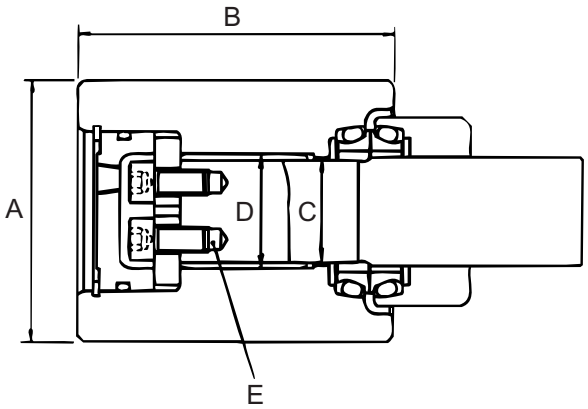
Do not approach the machine because the end of the crawler may drop just before extending the track link assembly to the ground while rotating the sprocket. Put wood block just in case.

6. Move the machine back slowly, and remove the crawler extending it to the ground.
   Weight of steel crawler (One side) :
   E50B : 275kg (610 lb)



Removing crawler

34.1.4 MAINTENANCE STANDARDS



Sectional view of upper roller

Unit : mm (in)

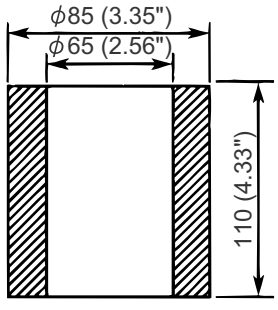
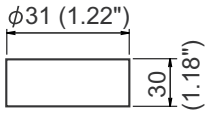
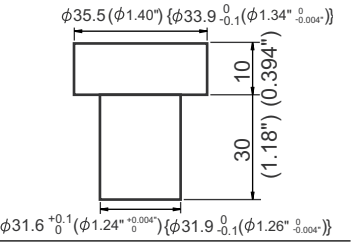
CODE	ITEM	STANDARD VALUE			REPAIRABLE LEVEL	SERVICE LIMIT	REMEDY
A	Tread dia.	ø82 (3.23)			ø73 (2.87)	ø70 (2.76)	Replace
B	Tread width	102 (4.01)			95 (3.74)	92 (3.62)	
C	Clearance between shaft and bushing	Basic dimension	Tolerance		Fit	Fit	Replace bushing
		ø32 (1.26)	Shaft	-0.025 (-0.001) -0.050 (-0.002)	Clearance 0.7 (0.03)	Clearance 1.0 (0.04)	
D	Interference between roller and bushing	ø36 (1.42)	Hole	+0.03 (+0.0012) 0	Interference 0 (0)	Clearance 0.01 (0.0004)	
E	Tightening torque of socket bolt	3.33 N•m (24.5 lbf•ft)					Apply Loctite #262
	Oil	Engine oil API CD class #30, 20cc (1.2 cu•in)					Replenish
	Roller rotation	Roller rotates smoothly by hand					Reassembly

34.1.5 TOOLS AND JIGS

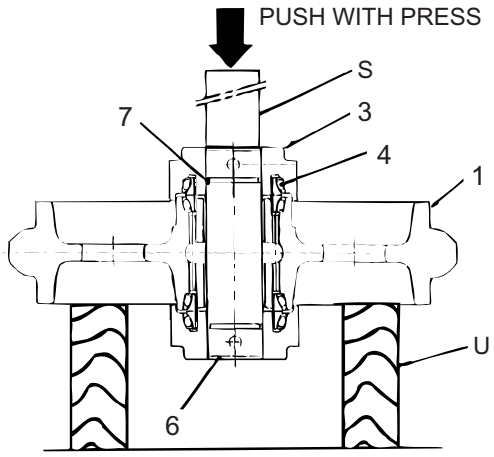
34.1.5.1 Tightening tools

Tools	Opposing flats
Socket	17mm
Allen wrench	5mm, 6mm

34.1.5.2 Jig

Symbol	Jig	Sketch	Symbol	Jig	Sketch
f	Stand jig		g	Fixing jig	
			h {j}	Fixing jig {Extruding jig}	

(3) Put idler (1) on repair stand (U), apply pushout jig (S) on shaft (6), push out shaft (6) with collar (3), then remove collar (3).

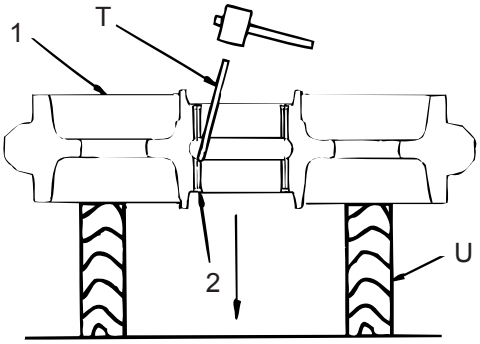


Extruding shaft

(4) With idler (1) placed on the stand (U), tap bushing (2) lightly by hammer, while placing the bushing extruding rod (T) against the end face of bushing (2) evenly all round, till it comes out.

(5) Take out floating seals (4) from idler (1), collar (3). If you intend to reuse floating seals (4), confirm that there is no scoring and rusting on the contact surface and store the floating seals in pairs by placing thick paper between the sealing faces.

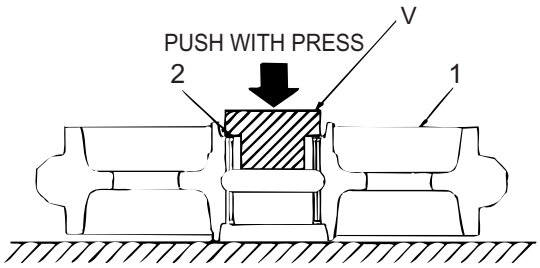
(6) Remove O-ring (7) from shaft (6).



Removing bushing (2)

34.1.7.3.2 Assembly

(1) Align inner hole of idler (1) and bushing (2) and press fit it vertically with press.

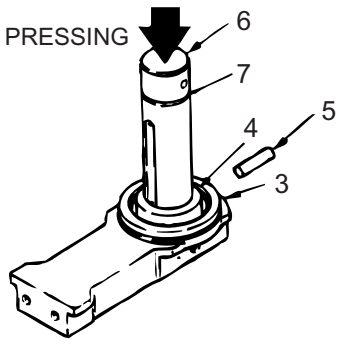


Pressing in bushing (2)

(2) Fit O-ring (7) to O-ring groove on shaft (2).
-Apply grease to O-ring

(3) Installing collar (3) (See 32.2.1.3)
Press fit the O-ring installed side of shaft into collar (3), and drive pin (5).

(4) Fit one piece of two (2) pieces type floating seal (4) on each side of collar (3) and idler (1).

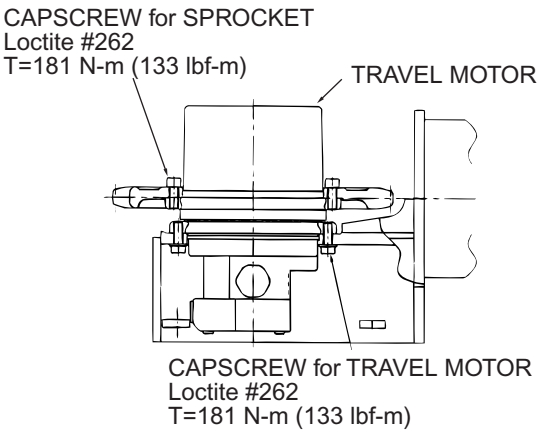


Pressing in shaft (6)

34.1.10.1.2 Installing

(1) If there are burrs and dirt on fitting part with which the travel motor are fastened, eliminate it beforehand. Place a wire sling in the travel unit with the same way as in the removing, and install it to the lower frame.

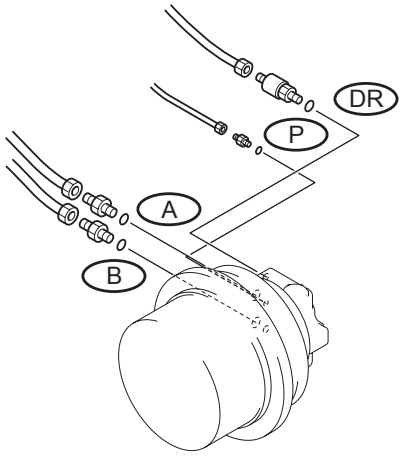
(2) Coat the threaded part of the mounting capscrew (B2) with Loctite #262 and tighten them.
Tools: Socket: 22 mm,
T=181 N-m (133 lbf-ft)



Installing travel motor

(3) Reconnect the hydraulic pipings as before, and tighten the joints to the specified torque.
-Fill the casing with hydraulic oil prior to perform drain piping.

			Tightening torque N•m (lbf•ft)	
Port	Thread size (PF)	Spanner used (mm)	O-ring type fitting	30° flare type fitting
A,B	1/2	27	108 (80)	78.5 (58)
P	1/4	17	36.3 (27)	29.4 (22)
DR	3/8	22	73.5 (54)	49.0 (36)

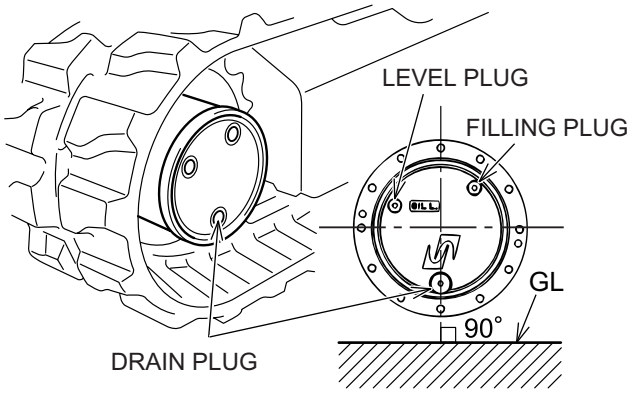


Installing hydraulic pipings (LH-travel motor)

(4) Install the covers (A1) located inside the lower frame, and tighten capscrews (A4).
(See Fig. Removing cover and travel motor)
Tools : Spanner : 17 mm
T : 65.7 N-m (48.7 lbf-ft)

(5) Remove the wooden block supporting the lower frame and install the crawler.

(6) Check the oil level in the reduction unit of travel motor [See Item (7) below] and replace or replenish oil as required.
Oil : GEAR OIL SAE #90 GL4
Volume of oil : 900 cc (55cu-in)
Tools : Allen wrench : 8 mm



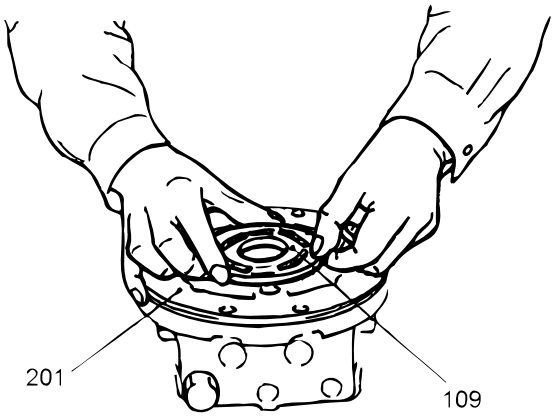
Checking oil level

(3) Tools

APPLICATION ITEM (Item in cross-sectional or exploded view)	NAME	SIZE	REMARKS	Q'TY
Disassembly and assembly	General workbench			1 set
Parts cleaning	Cleaning bath	For rough and finish cleaning		1 set
104 and 149	Workbench for press	Pressing capacity : 1.96 kN [440 lbs] or over		1 set
149	Heating bath	Heating capacity : 100C degrees or over (212F degrees) Volume 500 X 500 X 500 mm (20" X 20" X 20")		1 set
Drying after cleaning	Compressed air	Pressure (294~490 kPa) (43~71 psi)		

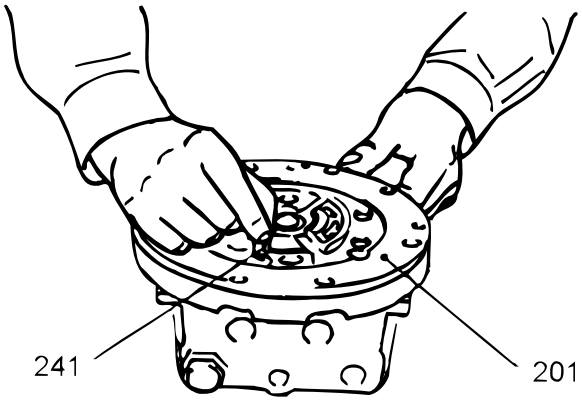
(9) Removing rear flange fittings

1. Place the rear flange (201) on the workbench, with the mating surface for the spindle (2) facing up.
2. Remove the timing plate (109) from the rear flange (201).
   -It may be hard to remove the rear flange as the mating surface of it is stuck with oil.
   Insert a spatula into the draft groove of the mating surface on the rear flange side and hold the timing plate up. Then the rear flange comes off.
   If a sharp tool like a screwdriver is put into the mating surface, the mating surface may be damaged to cause an oil leakage. Do not use sharp tools.



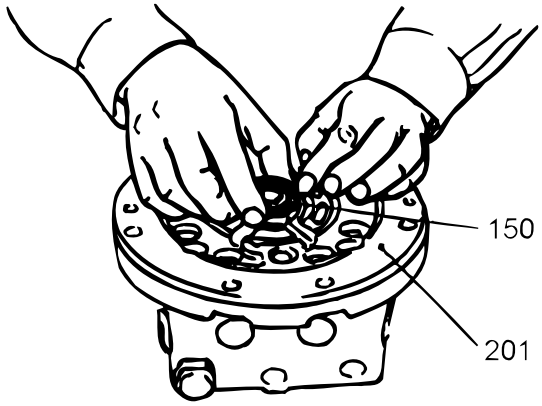
Removing timing plate (109)

3. Remove the parallel pins (241) from the rear flange (201).



Removing parallel pin (241)

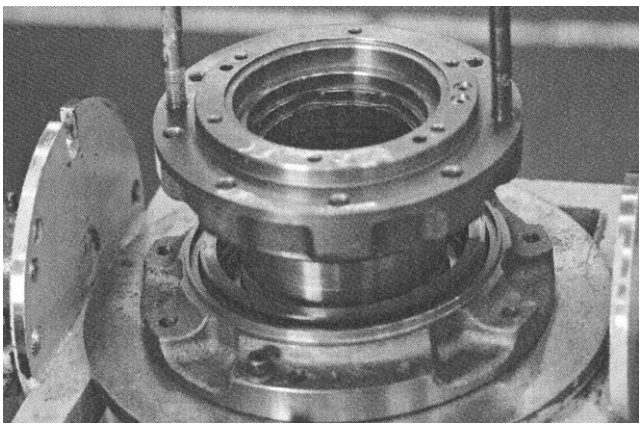
4. Remove bearing (150) from the rear flange (201).



Removing bearing (150)

(18)Removal of spindle

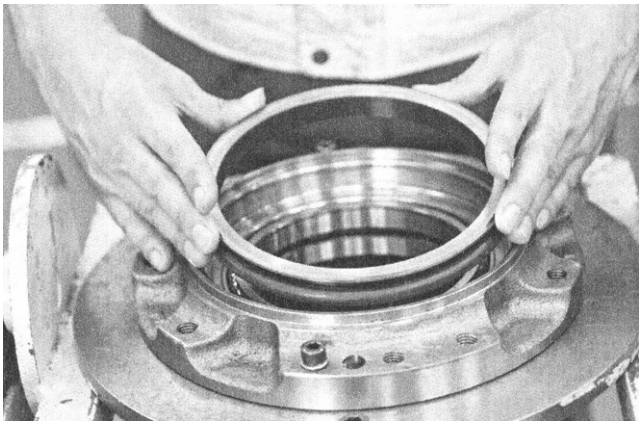
1. Turn over the travel motor. (Direct the motor side upward.)
2. Remove the clamp plates from the workbench.
3. Tighten two M12 eyebolts in the mounting thread holes of the spindle (2) in the diagonal position.
4. Hook a wire rope with hook to M12 eyebolts, and lift by a crane to remove the spindle (2) from the hub (1). At this time, the floating seal (31) and oil seal (132) will be removed together with the spindle (2).



Removing spindle (2)

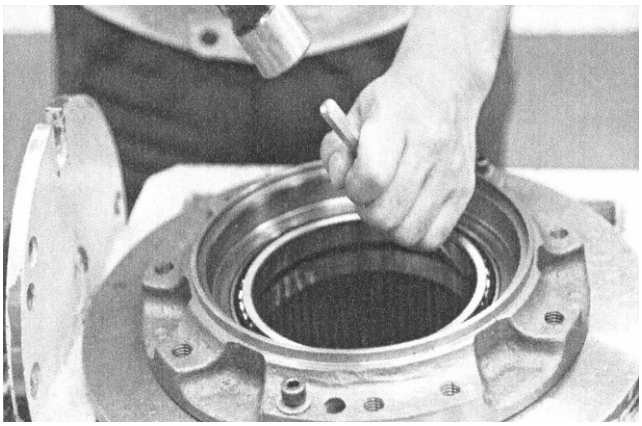
(19)Removing main bearing

1. Remove the floating seal (31) from the hub (1).
   -Do not reuse the removed floating seal (31).
2. Apply a punch between the inside periphery of the hub (1) and the main bearing (24) to remove the main bearing using a hammer.
   -When the fit section of the outer race of ball bearing (24) comes out of hub (1), the ball bearing drop from the hub.
   Therefore place a tray under the workbench and spread a rubber mat on the tray so as not to damage the parts.



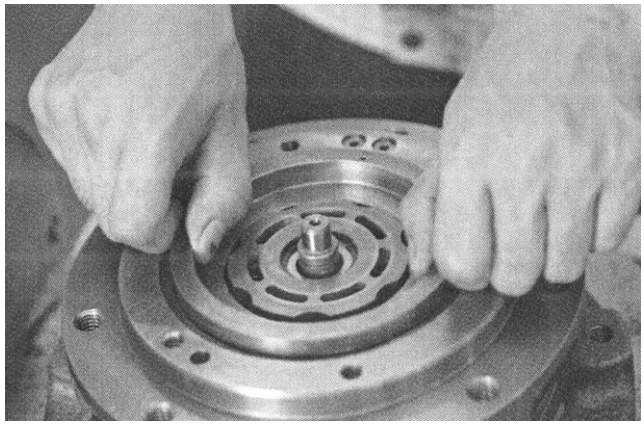
Removing floating seal (31)

3. Turn over the travel motor.
4. Tapping the end face of outer race of ball bearing (24) with aluminum rod (pin punch) and hammer, remove the ball bearing from hub (1)
   -To avoid misalignment of the ball bearing, tap the bearing race end evenly at 3 or 4 points of the hub. And remove the ball bearing little by little.



Removing ball bearing (24)

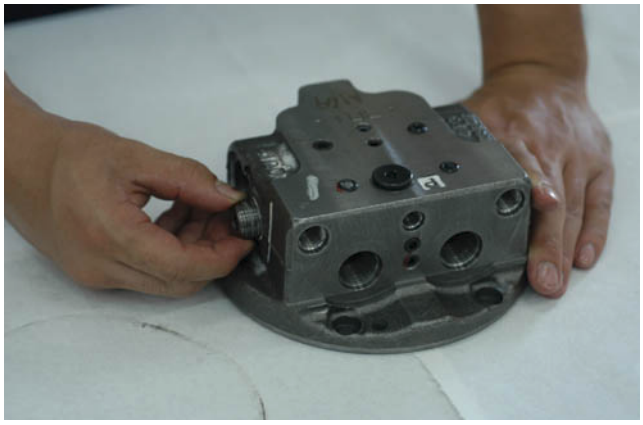
4. Install the piston (112) into the spindle (2).
   -If it is hard to fit the piston (112) into the spindle (2) due to the resistance of the O-rings (135) and (139), lightly tap the end face of the piston (112) with a plastic hammer.
   -Take care not to damage the O-rings when installing the piston (112).



Installing piston (112)

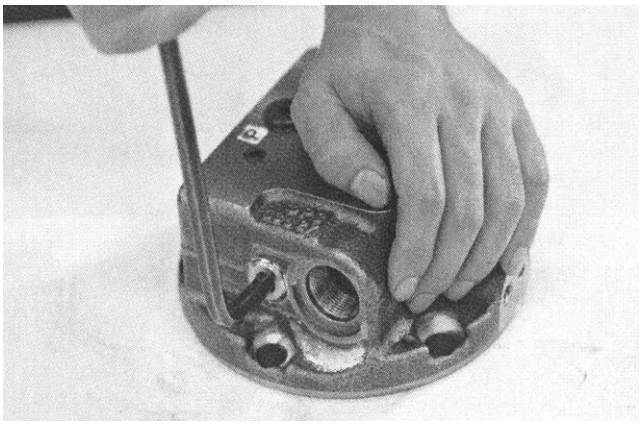
(8) Assembling brake valve parts inside rear flange

1. Fit two O-rings (237) to two plugs (226).
   -Coat the O-rings (237) with grease.
2. Install the valve (227) and spring (230) onto the plug (226), applying grease to them so as to connect all of them by adhesion of grease.
3. Insert the plug (226) with the valve (227) and spring (230) assembled in one piece, into the rear flange (201).



Inserting plug (226)

- For insertion of the plug (226), place the rear flange (201) on the workbench, facing the tapped hole for plug mounting of the rear flange (201) upward and align the center of tapped hole with the plug center. This is intended to prevent the O-ring from being damaged and spring (230) from coming out of valve (227) due to contact between the bore of the rear flange and the valve.



Temporarily tightening plug (226)

34.2.1.6 Performance verification test

- After finishing maintenance of the GM motor, carry out performance verification tests according to the procedures below :

(1) Measuring instruments to be used

1	Pressure gauge for 35 kgf/cm2 (500 psi)	2
2	Measuring cylinder (for 5 liters) (1.32 gal)	1
3	Stop watch	1

(2) Test procedure

1 Mounting and piping of GM motor

Mount the GM motor on the body (frame section) and connect piping. However, do not install the crawlers.
(Because the performance test (no-load run) of the GM motor is carried out.)

Note) 1. Connect piping so that a pressure gauge can be installed (in the main circuit) and an amount of drain of the hydraulic motor can be measured.
2. Mount the GM motor carefully using bolt holes without hammering.

2 Running-in of GM motor

	GM motor speed	Pressure	Rotating direction	Operating time
1	10 rpm	No load	Right and left	One minute or more each
2	20 rpm			

3 Performance verification test of GM motor

1 Preparation operation before testing ··· Run the machine for preparation until the following temperatures are approximately achieved:
- Hydraulic oil temperature 45-55ºC (113-131ºF)
- External temperature of reduction unit hub 40-80ºC (104-176ºF)

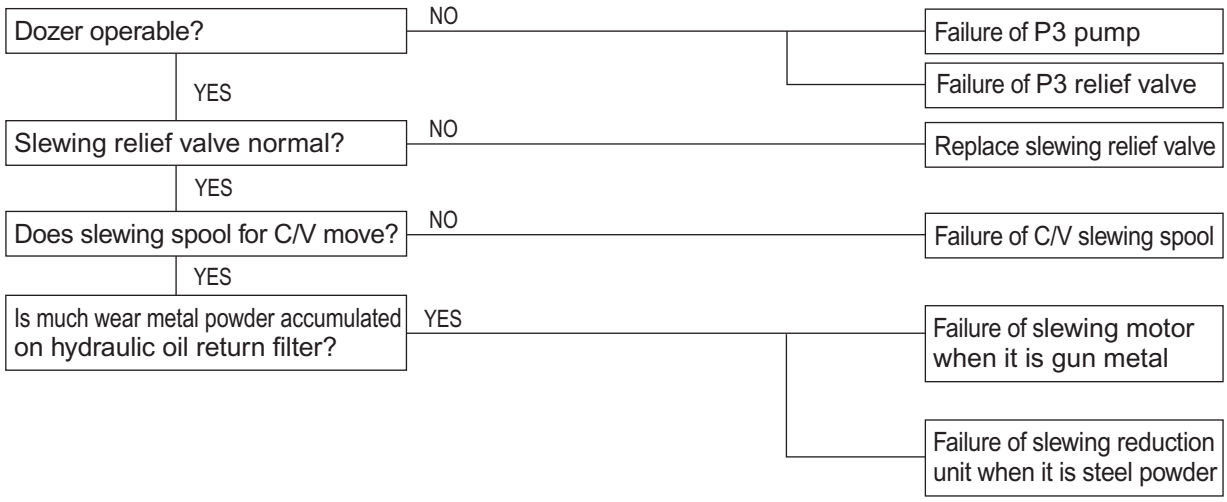
2 Verification test ··· Measure the following values to decide acceptance or rejection.
Acceptance criteria - GM motor drive pressure 1.57 MPa (228 psi) or lower at 10 rpm
Drain amount of hydraulic motor 0.5 L/min (0.13 gal) or less at 10 rpm

Accept → Install crawlers

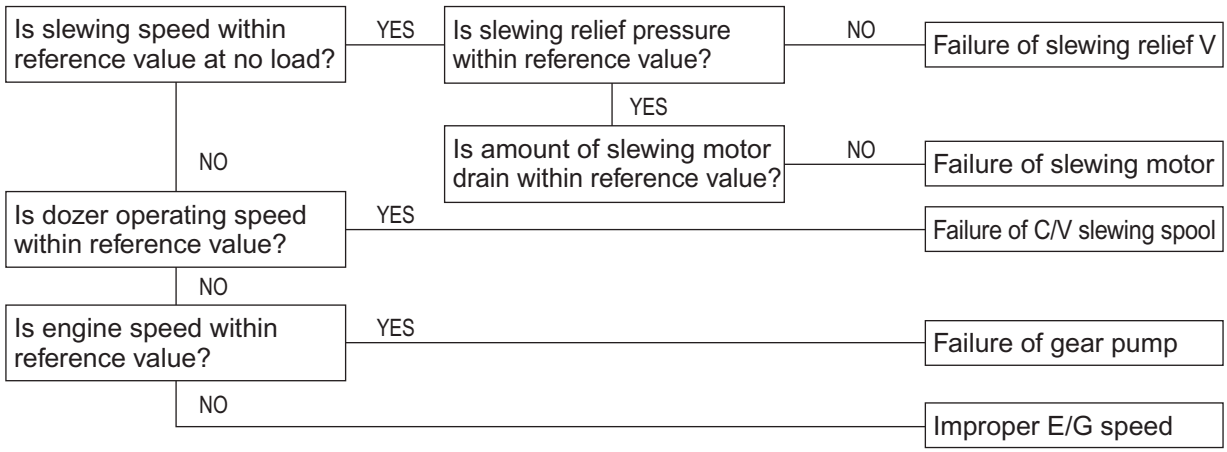
Reject → Disassemble and adjust again

42.3.3 SLEWING OPERATION

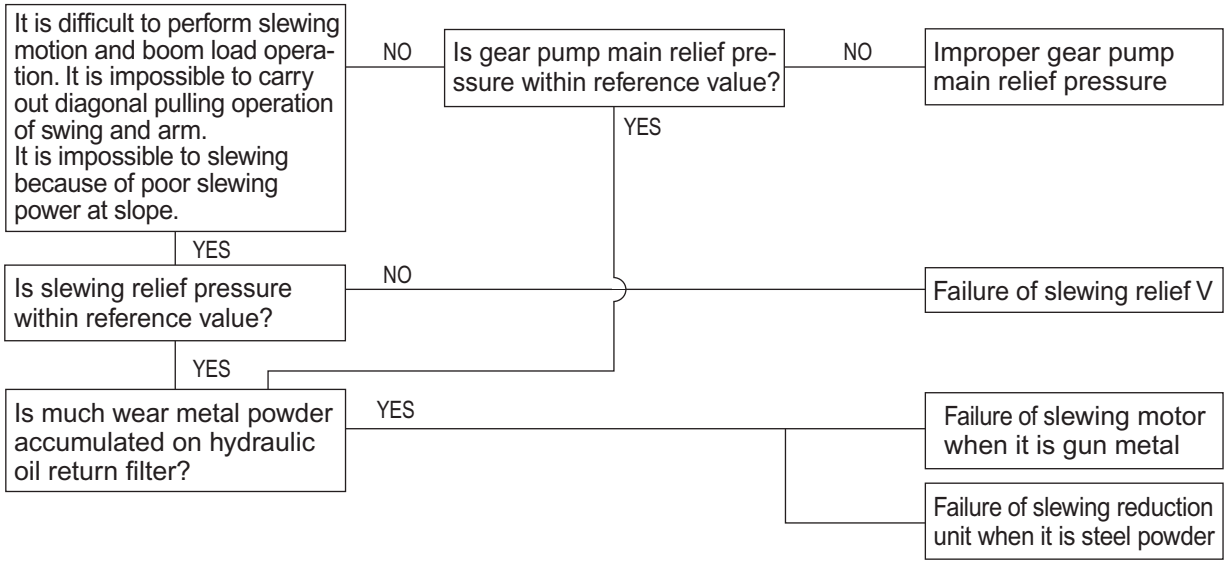
42.3.3.1 SLEWING OPERATIONAL FAILURE



42.3.3.2 SLEWING SPEED IS SLOW

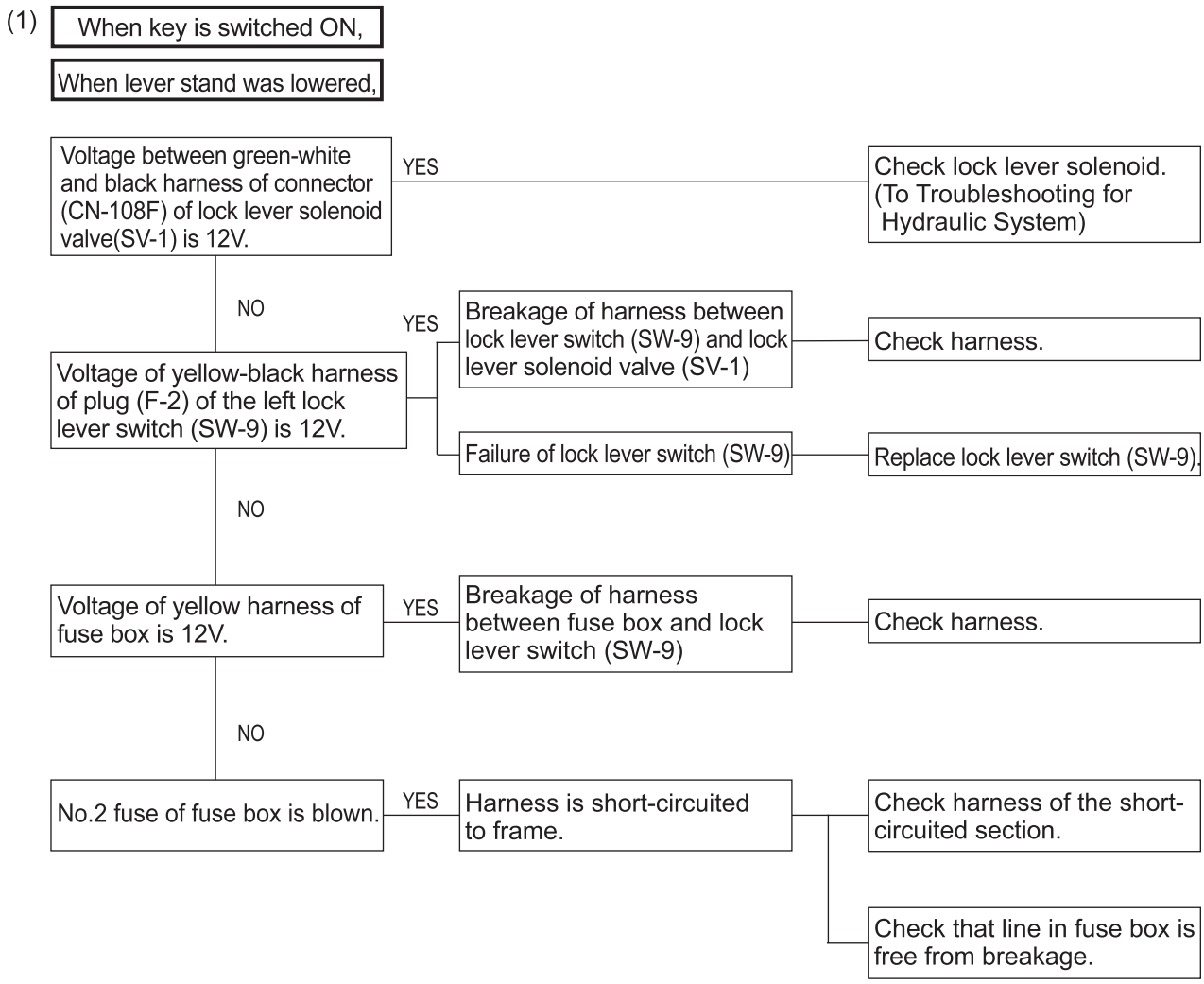


42.3.3.3 SLEWING POWER IS LOW



43.2.2 ATTACHMENT OPERATION

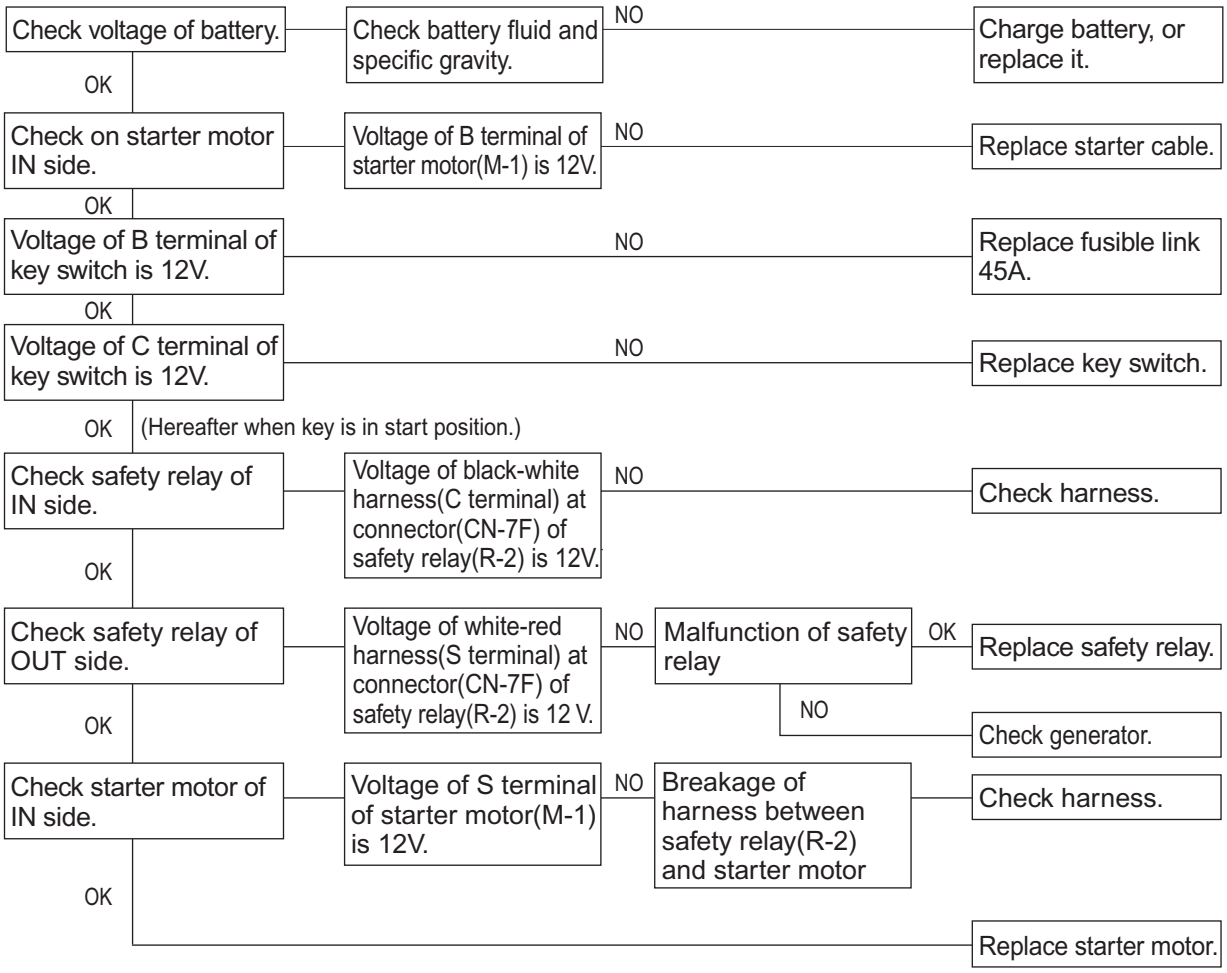
43.2.2.1 ALL CONTROLS DO NOT FUNCTION



44.2 TROUBLESHOOTING

44.2.1 STARTING TROUBLE

44.2.1.1 STARTER DOES NOT ROTATE



California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm.

Wash hands after handling.

Yanmar Limited Warranty - Continued

To Locate an Authorized Yanmar Industrial Engine Dealer or Distributor:

You can locate your nearest authorized Yanmar industrial engine dealer or distributor by visiting the Yanmar Corp., LTD. website at:

http://www.yanmar.co.jp (The Japanese language page will be displayed.) For English language “click” on “English Page.”)

- “Click” on “Network” in the website heading to view the “Yanmar Worldwide Network.”
- Choose and “Click” on the desired product group.
- “Click” on the Icon closest to your region.
- “Click” on the desired country or Associate company to locate your nearest authorized Yanmar industrial engine dealer or distributor.
- You may also contact Yanmar by clicking on “Inquiry” in the website heading and typing in your question or comment.

What Yanmar Will Do:

Yanmar warrants to the original retail purchaser of a new Yanmar engine that Yanmar will make such repairs and / or replacements at Yanmar’s option, of any part(s) of the Yanmar product covered by this Warranty found to be defective in material and / or workmanship. Such repairs and / or replacements will be made at a location designated by Yanmar at no cost to the purchaser for parts or labor.

What is Not Covered by this Warranty?

This Warranty does not cover parts affected by or damaged by any reason other than defective materials or workmanship including, but not limited to, accident, misuse, abuse, “Acts of God,” neglect, improper installation, improper maintenance, improper storage, the use of unsuitable attachments or parts, the use of contaminated fuels, the use of fuels, oils, lubricants, or fluids other than those recommended in your Yanmar Operation Manual, unauthorized alterations or modifications, ordinary wear and tear, and rust or corrosion. This Warranty does not cover the cost of parts and / or labor required to perform normal / scheduled maintenance on your Yanmar engine. This Warranty does not cover consumable parts such as, but not limited to, filters, belts, hoses, fuel injector nozzles, lubricants and cleaning fluids. This Warranty does not cover the cost of shipping the product to or from the Warranty repair facility.

DANGER

FIRE AND EXPLOSION HAZARD!

- Diesel fuel is flammable and explosive under certain conditions.
- Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.
- NEVER place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.
- Failure to comply will result in death or serious injury.

0000014en

DANGER

CRUSH HAZARD!

- When you need to transport an engine for repair, have a helper assist you to attach it to a hoist and load it on a truck.
- NEVER stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you, causing death or serious injury.
- Failure to comply will result in death or serious injury.

0000008en

DANGER

FIRE AND EXPLOSION HAZARD!

- Diesel fuel is flammable and explosive under certain conditions.
- Before you operate the engine, check for fuel leaks. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of engine operation, whichever comes first.
- Failure to comply will result in death or serious injury.

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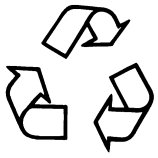
CAUTION



- ALWAYS be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- NEVER dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

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CAUTION

NEVER engage the starter motor while the engine is running. This may damage the starter motor pinion and / or ring gear.

0000012en

CAUTION

New Engine Break-in:

- On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper engine oil pressure, diesel fuel leaks, engine oil leaks, coolant leaks, and for proper operation of the indicators and / or gauges.
- During the first hour of operation, vary the engine speed and the load on the engine. Short periods of maximum engine speed and load are desirable. Avoid prolonged operation at minimum or maximum engine speeds and loads for the next four to five hours.
- During the break-in period, carefully observe the engine oil pressure and engine temperature.
- During the break-in period, check the engine oil and coolant levels frequently.

0000011en

CAUTION

- NEVER attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the fuel injection quantity control.
- Failure to comply may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may affect the warranty coverage of your engine. *See Yanmar Limited Warranty in Warranty Section.*

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Description of Model Number 4-21
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3TNV88-U (complies with EPA Interim Tier4) 4-37
3TNV88-B (complies with EPA Interim Tier4) 4-38
4TNV84T-Z (complies with EPA Interim Tier4) 4-39
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DIESEL FUEL

Diesel Fuel Specifications

Diesel fuel should comply with the following specifications. The table lists several worldwide specifications for diesel fuels.

Diesel Fuel Specification	Location
No. 2-D, No. 1-D, ASTM D975-94	USA
EN590:96	European Union
ISO 8217 DMX	International
BS 2869-A1 or A2	United Kingdom
JIS K2204 Grade No. 2	Japan
KSM-2610	Korea
GB252	China

Additional Technical Fuel Requirements

- The fuel cetane number should be equal to 45 or higher.
- The sulfur content must not exceed 0.5% by volume. Less than 0.05% is preferred.
  For electronically controlled engines 4TNV84T-Z, 4TNV98-Z, 4TNV98-E, and 4TNV98T-Z, it is mandatory to use fuel that does not contain 0.05% or more sulfur content.
  In general, using a high sulfur fuel may possible result in corrosion inside the cylinder.
- Bio-Diesel fuels. *See Bio-Diesel Fuels on page 4-12*.
- NEVER mix kerosene, used engine oil, or residual fuels with the diesel fuel.
- The water and sediment in the fuel should not exceed 0.05% by volume.
- Keep the fuel tank and fuel-handling equipment clean at all times.
- Poor quality fuel can reduce engine performance and / or cause engine damage.
- Fuel additives are not recommended. Some fuel additives may cause poor engine performance. Consult your Yanmar representative for more information.
- The ash content must not exceed 0.01% by volume.
- The carbon residue content must not exceed 0.35% by volume. Less than 0.1% is preferred.
- The total aromatics content should not exceed 35% by volume. Less than 30% is preferred.
- The PAH (polycyclic aromatic hydrocarbons) content should be below 10% by volume.
- The metal content of Na, Mg, Si, and Al should be equal to or lower than 1 mass ppm. (Test analysis method JPI-5S-44-95)
- Lubricity: The wear mark of WS1.4 should be Max. 0.018 in (460 µm) at HFRR test.

Bio-Diesel Fuels

In Europe and in the United States, as well as some other countries, non-mineral oil based fuel resources such as RME (Rapeseed Methyl Ester) and SOME (Soybean Methyl Ester), collectively known as FAME (Fatty Acid Methyl Esters), are being used as extenders for mineral oil derived diesel fuels.

Yanmar approves the use of bio-diesel fuels that do not exceed a blend of 5% (by volume) of FAME with 95% (by volume) of approved mineral oil derived diesel fuel. Such bio-diesel fuels are known in the marketplace as B5 diesel fuels.

These B5 diesel fuels must meet certain requirements.

1. The bio-fuels must meet the minimum specifications for the country in which they are used.
   - In Europe, bio-diesel fuels must comply with the European Standard EN14214.
   - In the United States, bio-diesel fuels must comply with the American Standard ASTM D-6751.
2. Bio-fuels should be purchased only from recognized and authorized diesel fuel suppliers.

Engine General Specifications

Type	Vertical In-line, Water Cooled, 4-Cycle Diesel Engine	
Combustion System	Direct Injection Models	Direct Injection
	Indirect Injection Models	Swirl Chamber (Ball-Type)
Starting System	Electric Starting	
Cooling System	Radiator	
Lubricating System	Forced Lubrication with Trochoid Pump	
PTO Position	Flywheel End	
Direction of Rotation	Counterclockwise Viewed from Flywheel End	

Notes:

1. The information described in *Principal Engine Specifications* is for a “standard” engine. To obtain the information for the engine installed in your driven machine, please refer to the manual provided by the driven machine manufacturer.
2. Engine rating conditions are as follows (SAE J1349, ISO 3046/1):

   - Atmospheric Condition: Room temperature 77°F (25°C), Atmospheric pressure 29.53 in. Hg (100 kPa, 750 mm Hg), Relative humidity 30%
   - Fuel Temperature at Fuel Injector Pump Inlet: 104°F (40°C)
   - Fuel Feeding Pressure: 20 ± 10 kPa (net) after engine break-in has been performed with the cooling fan, air cleaner and muffler installed to the engine.
   - With Cooling Fan, Air Cleaner, Muffler: Yanmar Standard
   - After the Engine Break-In Period. Output Allowable Deviation: ± 3%
   - 1 PS = 0.7355 kW
   - 1 hp SAE (Society of Automotive Engineers) = 0.7457 kW

4TNV98T (~ EPA Tier2)

Engine Model	4TNV98T						
Version	CL			VM			
Type	Vertical In-line Diesel Engine						
Combustion System	Direct Injection						
Aspiration	Turbocharged						
No. of Cylinders	4						
Bore × Stroke	98 × 110mm						
Displacement	3.319L						
Continuous Rated Output	min^{-1}	1500	1800				
	kW	37.9	45.6				
	PS	51.5	62.0				
Max. Rated Output (Net)	min^{-1}	1500	1800	2000	2200	2400	2500
	kW	41.9	50.4	50.7	55.5	60.3	62.5
	PS	57.0	68.5	69.0	75.5	82.0	85.0
High Idling	min^{-1}	1600 ± 25	1895 ± 25	2180 ± 25	2400 ± 25	2590 ± 25	2700 ± 25
Engine Weight (Dry) *with Flywheel Housing	258 kg			245 kg			
PTO Position	Flywheel End						
Direction of Rotation	Counterclockwise Viewed From Flywheel End						
Cooling System	Liquid-Cooled with Radiator						
Lubricating System	Forced Lubrication with Trochoid Pump						
Normal Oil Pressure at Rated Engine Speed	0.29 - 0.39 MPa						
Normal Oil Pressure at Low Idle Speed	0.06 MPa						
Starting System	Electric Starting (Starter Motor: DC12V (2.3 kW)) ***						
	Alternator: DC12V, 40A***						
	Recommended Battery Capacity: 12V, 64Ah ***						
Dimensions (L × W × H)*	719 × 575 × 804mm						
Engine Oil Pan Capacity**	10.5/6.0L (Dipstick Upper Limit / Lower Limit)						
Engine Coolant Capacity	4.2L Engine Only						
Standard Cooling Fan	430mm O.D., 8 Blade Suction-Type ***						
Crank V-pulley dia./ Fan V-pulley dia.	ϕ130/ ϕ130mm ***						

* *Engine specifications without radiator.*

** *Engine oil capacity for a "Deep Standard" oil pan. Refer to the operation manual provided by the driven machine manufacturer for the actual engine oil capacity of your machine.*

*** *May vary depending on application.*

4TNV98-E (complies with EPA Interim Tier4)

Engine Model		4TNV98-E							
Version		CL		VM					
Type		Vertical, 4-cycle water-cooled diesel engine							
Combustion System		Direct Injection							
Aspiration		Natural aspiration							
No. of Cylinders		4							
Bore × Stroke		98 × 110mm							
Displacement		3.319L							
Continuous Rated Output	min^{-1}								
	kW								
	PS								
Max. Rated Output (Net)	min^{-1}				2100	2200	2300	2400	2500
	kW				36.8	38.2	39.7	41.6	43.0
	PS				50.0	52.0	54.0	56.5	58.5
High Idling	min^{-1}				2250 ± 25	2350 ± 25	2450 ± 25	2550 ± 25	2650 ± 25
Engine Weight (dry) *with Flywheel Housing				240kg					
PTO Position		Flywheel End							
Direction of Rotation		Counterclockwise Viewed From Flywheel End							
Governor		Electronic governor (All-speed governor)							
Cooling System		Liquid-Cooled with Radiator							
Lubricating System		Forced Lubrication with Trochoid Pump							
Normal Oil Pressure	Rated Engine Speed	0.29-0.39 (3.0-4.0) MPa							
	Low Idle Speed	0.06 (0.6) MPa							
Starting System		Electric Starting (Starter Motor: DC12V (2.3kW)) ***							
Charging system		Alternator (DC12V/40A) ***							
Recommended Battery Capacity		12V-64Ah*** (5h rating)							
Starting aid device		Air heater (12VDC/500W)							
Dimensions (L × W × H)*		719 × 540 × 721mm							
Engine Oil Pan Capacity**		10.2L/5.7L (Dipstick Upper Limit / Lower Limit)							
Engine Coolant Capacity		4.2L Engine Only							
Standard Cooling Fan		Resin F type pusher fan - ϕ410(Al) x 6							
Crank V-pulley dia./ Fan V-pulley dia.		ϕ130/ ϕ130mm							

* *Engine specifications without radiator.*

** *Engine oil capacity for a "Deep Standard" oil pan. Refer to the operation manual provided by the driven machine manufacturer for the actual engine oil capacity of your machine.*

*** *May vary depending on application.*

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CAUTION

- Only use the engine coolant specified. Other engine coolants may affect warranty coverage, cause an internal buildup of rust and scale and / or shorten engine life.
- Prevent dirt and debris from contaminating the engine coolant. Carefully clean the radiator cap and the surrounding area before you remove the cap.
- NEVER mix different types of engine coolants. This may adversely affect the properties of the engine coolant.

0000006en

CAUTION

- NEVER attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.
- Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use Yanmar genuine replacement parts.

0000079en

CAUTION

Observe the following environmental operating conditions to maintain engine performance and avoid premature engine wear:

- Avoid operating in extremely dusty conditions.
- Avoid operating in the presence of chemical gases or fumes.
- Avoid operating in a corrosive atmosphere such as salt water spray.
- NEVER install the engine in a floodplain unless proper precautions are taken to avoid being subject to a flood.
- NEVER expose the engine to the rain.

0000003en

CAUTION

Observe the following environmental operating conditions to maintain engine performance and avoid premature engine wear:

- The standard range of ambient temperatures for the normal operation of Yanmar engines is from +5°F (-15°C) to +113°F (+45°C).
- If the ambient temperature exceeds +113°F (+45°C) the engine may overheat and cause the engine oil to break down.
- If the ambient temperature is below +5°F (-15°C) the engine will be hard to start and the engine oil may not flow easily.
- Contact your authorized Yanmar industrial engine dealer or distributor if the engine will be operated outside of this standard temperature range.

0000065en

Engine Oil Filter Part No.		
	Standard	Dust proof *
3TNV82A 3TNV84 - 4TNV98 3TNV82A-B 3TNV88-B - 4TNV98-Z 4TNV98-E	129150-35153	119005-35151
4TNV98T 4TNV98T-Z 4TNV106, 4TNV106T	119005-35151	

* Consult the operation manual for the driven machine for applicability of the dust proof filter.

4. Add new engine oil to the engine as specified in *Adding Engine Oil on page 4-17*.

CAUTION

- **NEVER overfill the engine with engine oil.**
- **ALWAYS keep the oil level between the upper and lower lines on the oil cap / dipstick.**

0000015en

5. Warm up the engine by running it for five minutes and check for any engine oil leaks.
6. After engine is warm, shut it off and let it sit for 10 minutes.
7. Recheck the engine oil level.
8. Add engine oil **(Figure 5-3, (5))** as needed until the level is between the upper **(Figure 5-3, (2))** and lower lines **(Figure 5-3, (3))** shown on the dipstick **(Figure 5-3, (1))**.

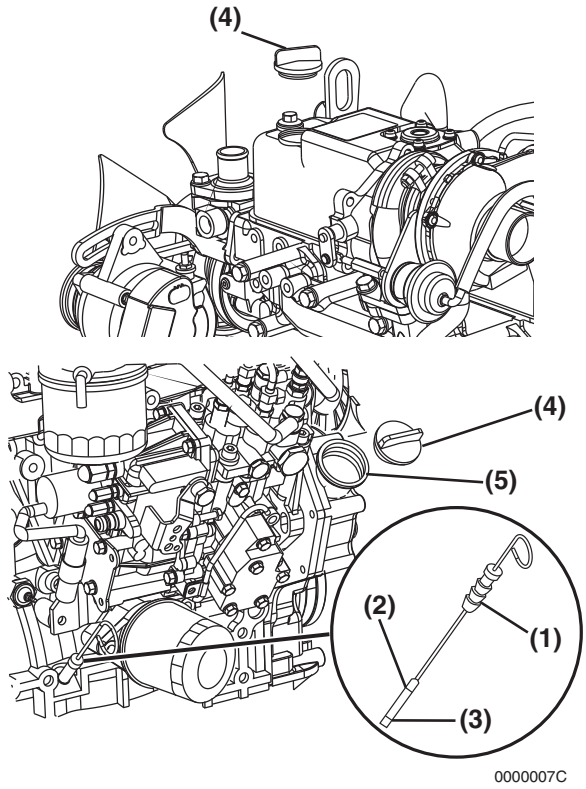


Figure 5-3

9. Reinstall the oil filler cap **(Figure 5-3, (4))**. If any engine oil is spilled, wipe it away with a clean cloth.

Check and Adjust Cooling Fan V-Belt

The V-belt will slip if it does not have the proper tension. This will prevent the alternator from generating sufficient power. Also, the engine will overheat due to the engine coolant pump pulley slipping.

Check and adjust the V-belt tension (deflection) as follows:

1. Press the V-belt down with your thumb with a force of approximately 22 ft·lb (98 N·m; 10 kgf) to check the deflection.

   There are three positions to check for V-belt tension **(Figure 5-4, (A)**, **(B)** and **(C))**. You can check the tension at whichever position is the most accessible. The proper deflection of a used V-belt at each position is:

6. Replace the element with a new one if the element is damaged, excessively dirty or oily.
7. Clean inside of the air cleaner cover.
8. Install the element into the air cleaner case **(Figure 5-12, (4))**.
9. Reinstall the air cleaner cover making sure you match the arrow **(Figure 5-12, (5))** on the cover with the arrow on the case **(Figure 5-12, (6))**.
10. Latch the air cleaner cover to the case.

CAUTION

- **When the engine is operated in dusty conditions, clean the air cleaner element more frequently.**
- **NEVER operate the engine with the air cleaner element(s) removed. This may allow foreign material to enter the engine and damage it.**

0000026en

Every 500 Hours of Operation

Perform the following maintenance every 500 hours of operation.

- **Replace Air Cleaner Element**
- **Replace Fuel Filter**
- **Clean Fuel Filter / Water Separator**

Replace Air Cleaner Element

CAUTION

The maximum air intake restriction, in terms of differential pressure measurement, must not exceed 0.90 psi (6.23 kPa; 635 mmAq). Clean or replace the air cleaner element if the air intake restriction exceeds the above mentioned value.

0000046en

Replace the air cleaner element **(Figure 5-12, (2))** every 500 hours even if it is not damaged or dirty.

When replacing the element, clean the inside of the air cleaner case **(Figure 5-12, (4))**.

If the air cleaner is equipped with a double element, *only remove and replace the inner element* **(Figure 5-13, (1))** *if the engine lacks power or the dust indicator actuates (if equipped).* This is in addition to replacing the outer element.

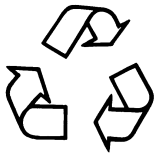
Every 2000 Hours of Operation

Perform the following maintenance every 2000 hours of operation.

- **Check and Replace Fuel Hoses and Engine Coolant Hoses**
- **Lap the Intake and Exhaust Valves. If necessary**

Check and Replace Fuel Hoses and Engine Coolant Hoses

CAUTION



- **ALWAYS be environmentally responsible.**
- **Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.**
- **NEVER dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.**
- **Failure to follow these procedures may seriously harm the environment.**

0000013en

Regularly check the fuel system and engine coolant system hoses. If they are cracked or degraded, replace them. Replace the hoses at least every two years.

Lap the Intake and Exhaust Valves

Adjustment is necessary to maintain proper contact of the valves and seats. *See Inspection of Intake and Exhaust Valves on page 6-42*.

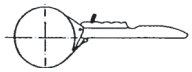
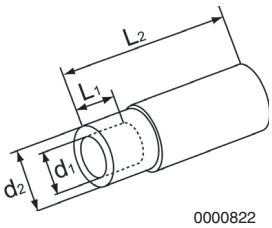
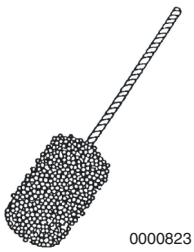
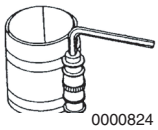
Valve Spring

Inspection Item	Model	Standard	Limit	Reference Page
Free Length	3TNV82A (2-Valve Head)	1.7480 in. (44.4 mm)	1.7283 in. (43.9 mm)	*See Inspection of Valve Springs on page 6-44 and 6-60.*
	4TNV84, 3TNV84, 3TNV84T, 4TNV88 (2-Valve Head)	1.6535 in. (42.0 mm)	1.6339 in. (41.5 mm)	
	4TNV84T (4-Valve Head)	1.4724 in. (37.4 mm)	1.4528 in. (36.9 mm)	
	4TNV94L, 4TNV98, 4TNV98T (4-Valve Head)	1.5630 in. (39.7 mm)	1.5433 in. (39.2 mm)	
	4TNV106, 4TNV106T (4-Valve Head)	1.9921 in. (50.6 mm)	1.9724 in. (50.1 mm)	
Squareness	3TNV82A (2-Valve Head)	-	0.0551 in. (1.4 mm)	
	4TNV84, 3TNV84, 3TNV84T, 4TNV88 (2-Valve Head)	-	0.0551 in. (1.4 mm)	
	4TNV84T (4-Valve Head)	-	0.0551 in. (1.3 mm)	
	4TNV94L, 4TNV98, 4TNV98T (4-Valve Head)	-	0.0551 in. (1.4 mm)	
	4TNV106, 4TNV106T (4-Valve Head)	-	0.0551 in. (1.5 mm)	

(Piston Ring Cont.)

Model	Inspection Item		Standard	Limit	Reference Page
4TNV94L, 4TNV98, 4TNV98T	Top Ring	Ring Groove Width	0.0803 - 0.0811 in. (2.040 - 2.060 mm)	-	*See Inspection of Pistons, Piston Rings and Wrist Pin on page 6-83.*
		Ring Width	0.0764 - 0.0772 in. (1.940 - 1.960 mm)	0.0756 in. (1.920 mm)	
		Side Clearance	0.0031 - 0.0047 in. (0.080 - 0.120 mm)	-	
		End Gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0213 in. (0.540 mm)	
	Second Ring	Ring Groove Width	0.0819 - 0.0825 in. (2.080 - 2.095 mm)	0.0864 in. (2.195 mm)	
		Ring Width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
		Side Clearance	0.0035 - 0.0049 in. (0.090 - 0.125 mm)	0.0096 in. (0.245 mm)	
		End Gap	0.0177 - 0.0256 in. (0.450 - 0.650 mm)	0.0287 in. (0.730 mm)	
	Oil Ring	Ring Groove Width	0.1187 - 0.1193 in. (3.015 - 3.030 mm)	0.1232 in. (3.130 mm)	
		Ring Width	0.1169 - 0.1177 in. (2.970 - 2.990 mm)	0.1161 in. (2.950 mm)	
		Side Clearance	0.0010 - 0.0024 in. (0.025 - 0.060 mm)	0.0071 in. (0.180 mm)	
		End Gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0217 in. (0.550 mm)	

(Special Service Tools Cont.)

<table>
<tr><th>No.</th><th>Tool Name</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>7</td><td>Filter Wrench (For Removal / Installation of Engine Oil Filter)</td><td>Available Locally</td><td> 
0000821</td></tr>
<tr><td>8</td><td>Camshaft Bushing Tool (For Extracting Camshaft Bushing)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr>
<tr><td>3TNV82A, 3TNV84, 3TNV84T, 3TNV88, 4TNV84, 4TNV84T, 4TNV88</td><td>0.709 in. (18 mm)</td><td>2.756 in. (70 mm)</td><td>1.772 in. (45 mm)</td><td>1.890 in. (48 mm)</td></tr>
<tr><td>4TNV94L, 4TNV98, 4TNV98T</td><td>0.709 in. (18 mm)</td><td>2.756 in. (70 mm)</td><td>1.968 in. (50 mm)</td><td>2.087 in. (553 mm)</td></tr>
<tr><td>4TNV106, 4TNV106T</td><td>0.709 in. (18 mm)</td><td>2.756 in. (70 mm)</td><td>2.283 in. (58 mm)</td><td>2.402 in. (61 mm)</td></tr>
<tr><td colspan="5">Allowance: d1 d2</td></tr>
<tr><td colspan="5">Locally Manufactured</td></tr>
</table>
</td><td> 
0000822</td></tr>
<tr><td>9</td><td>Flex-Hone (For Preparation of Cylinder Walls)</td><td>
<table>
<tr><th>Model</th><th>Yanmar Part No.</th><th>Cylinder Bore</th></tr>
<tr><td>3TNV82A</td><td>129400-92420</td><td>3.071 - 3.307 in. (78 - 84 mm)</td></tr>
<tr><td>3TNV88, 4TNV88, 4TNV94L</td><td>129400-92430</td><td>3.268 - 3.740 in. (83 - 95 mm)</td></tr>
<tr><td>4TNV98</td><td>129400-92440</td><td>3.504 - 3.976 in. (89 - 101 mm)</td></tr>
<tr><td>4TNV106, 4TNV106T</td><td>129400-92450</td><td>3.740 - 4.252 in. (95 - 108 mm)</td></tr>
</table>
</td><td> 
0000823</td></tr>
<tr><td>10</td><td>Piston Ring Compressor (For Installing Piston)</td><td>Yanmar Part No. 95550-002476
The Piston Insertion Tool is Applicable for
2.362 - 4.921 in. (60 - 125 mm) Diameter Pistons</td><td> 
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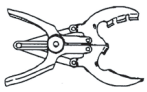
<tr><td>11</td><td>Piston Ring Expander (For Removal / Installation of Piston Ring)</td><td>Available Locally</td><td> 
0000825</td></tr>
</table>

Note: If the valves are to be reused, identify them so they can be installed in their original location.

8. Turn the cylinder head so the exhaust port side faces down. Remove the intake and exhaust valves **(Figure 6-13, (6))** from the cylinder head.
9. Remove the valve stem seals **(Figure 6-13, (5))**.

Removal of Valve Guides

Note: Removal of the valve guides should be postponed until inspection and measurement procedures have been performed. *See Inspection of Valve Guides on page 6-41*.

1. If the valve guides were not within specifications, use a drift pin and hammer to drive the valve guides **(Figure 6-14, (1))** out of the cylinder head.

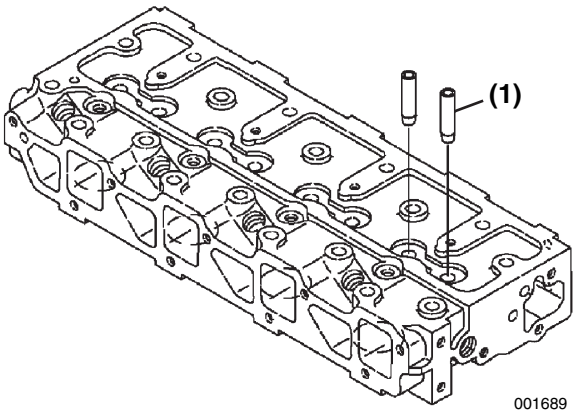


Figure 6-14

Cleaning of Cylinder Head Components

⚠ WARNING

FUME / BURN HAZARD!

- **Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.**
- **Failure to comply could result in death or serious injury.**

0000014en

Thoroughly clean all components using a non-metallic brush and an appropriate solvent. Each part must be free of carbon, metal filings and other debris.

Inspection of Cylinder Head Components

Visually inspect the parts. Replace any parts that are obviously discolored, heavily pitted or otherwise damaged. Discard any parts that do not meet its specified limit.

CAUTION

Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.

0000119en

1 – Crankcase Breather Cover
2 – Diaphragm Spring
3 – Diaphragm Cup
4 – Crankcase Breather Diaphragm
5 – Oil Fill Cap
6 – Valve Cover Nut
7 – Valve Cover Nut O-Ring
8 – Valve Cover Gasket
9 – Support Bolt
10 – Rocker Arm Shaft Support
11 – Wave Washer
12 – Fuel Injector Retainer Bolt
13 – Valve Adjusting Screw (Primary)
14 – Valve Adjusting Screw Lock Nut (Primary)
15 – Rocker Arm Shaft Aligning Stud
16 – Fuel Injector Retainer
17 – Valve Stem Seal
18 – Valve Guide
19 – Cylinder Head
20 – Intake Valve
21 – Exhaust Valve
22 – Cylinder Head Gasket
23 – Fuel Injector Nozzle Protector
24 – Fuel Injector Nozzle Seat
25 – Valve Spring
26 – Valve Bridge Guide
27 – Spring Retainer
28 – Valve Keepers
29 – Valve Bridge
30 – Valve Bridge Seat
31 – Valve Adjusting Screw Lock Nut (Secondary)
32 – Valve Adjusting Screw (Secondary)
33 – Push Rod
34 – Rocker Arm Shaft
35 – Crankcase Breather Components
36 – Valve Cover

Disassembly of 4-Valve Cylinder Head

Prepare a clean, flat working surface on a workbench large enough to accommodate the cylinder head assembly. Discard all gaskets, O-rings and seals. Use new gaskets, O-rings and seals on reassembly of the cylinder head.

1. Drain the coolant from the engine into a suitable container. *See Drain, Flush and Refill Cooling System With New Coolant on page 5-36.*

CAUTION

Identify all parts and their location using an appropriate method. It is important that all parts are returned to the same position during the reassembly process.

0000080en

2. Remove the high pressure fuel injection lines **(Figure 6-40, (1))**. *See Removal of Fuel Injectors on page 7-35.*

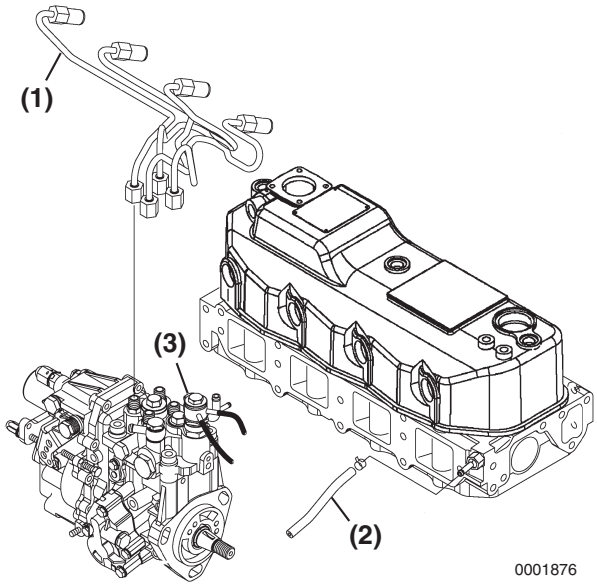


Figure 6-40

Grind the valve face and/or valve seat as necessary to return them to serviceable condition. Grinding is needed if the valve and valve seat do not contact correctly. Check the valve margin and valve recession after grinding.

If the valve or seat require grinding, lap the valve after grinding. Lap the valve face to the valve seat using a mixture of valve lapping compound and engine oil.

Be sure to thoroughly wash all parts to remove all grinding powder or compound.

Inspection of Valve Springs

Inspect the valve springs. If damage or corrosion is seen, or if measurements exceed the specified limits, replace the springs.

Fractures

Check for fractures on the inside and outside portions of the springs. If the valve spring is fractured, replace the valve spring.

Corrosion

Check for corrosion of spring material caused by oxidation.

Squareness

Use a flat surface and a square to check each spring for squareness **(Figure 6-62)**. *See Valve Spring on page 6-10 for the service limit.*

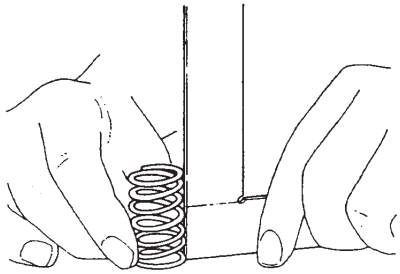


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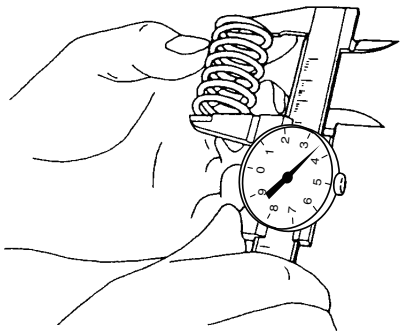
Figure 6-62

Free Length

Use a caliper to measure the length of the spring **(Figure 6-63)**. *See Valve Spring on page 6-10 for the service limit.*



0000200

Figure 6-63

Inspection of Valve Bridges

Visually inspect the contact surface at both ends of the valve bridge **(Figure 6-64, (2))** for excessive wear or mushrooming.

Remove and inspect the seat **(Figure 6-64, (1))**.

Measure the diameter of the valve bridge guide pin bore in the valve bridge and guide pin **(Figure 6-64, (3))**. *See Rocker Arm and Shaft on page 6-9 for the service limit.*

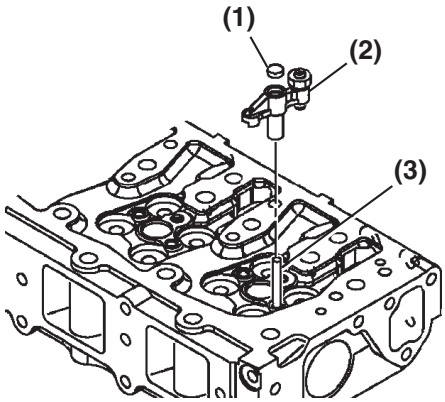


Figure 6-64

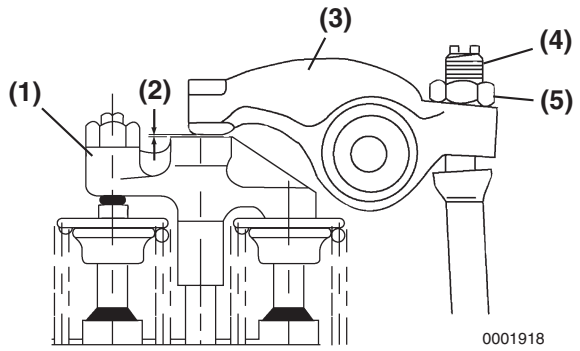


Figure 6-86

12. Hold the adjusting screw **(Figure 6-86, (4))** while tightening the valve adjusting screw lock nut **(Figure 6-86, (5))**. Recheck the clearance.
13. Apply oil to the contact surface between the adjusting screw and push rod.
14. Rotate the crankshaft to measure and adjust the set of valves. Continue until all valves are measured and adjusted.

Removal of Crankshaft

1. Remove the flywheel **(Figure 6-104, (1))** from the crankshaft.
2. Remove the bolts from the rear oil seal assembly **(Figure 6-104, (2-3))**. Remove the assembly from the engine.

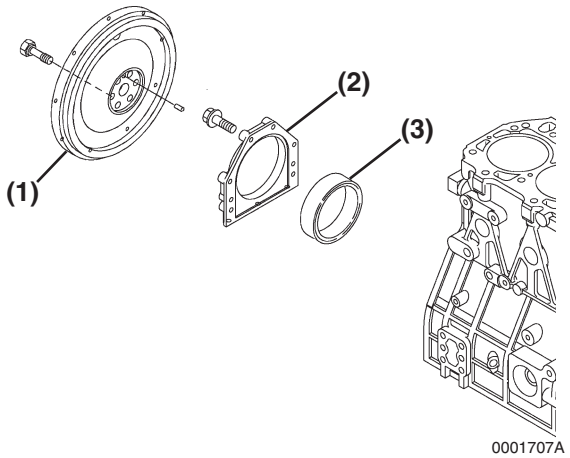


Figure 6-104

3. Before removing the main bearing caps, measure the crankshaft end play. Use either of the following two methods.
   - **Method A:** Install a dial gauge **(Figure 6-105, (1))** on the cylinder block. Move the crankshaft **(Figure 6-105, (2))** in and out to measure the end play. Record the measurement.

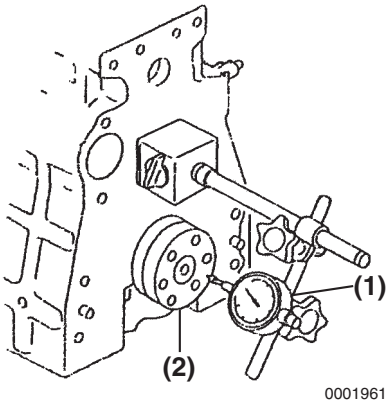


Figure 6-105

   - **Method B:** Use a feeler gauge to measure the clearance **(Figure 6-106, (3))** between the thrust bearing **(Figure 6-106, (1))** and crankshaft **(Figure 6-106, (2))**. Record the measurement. *See Thrust Bearing on page 6-15 for the service limit.*

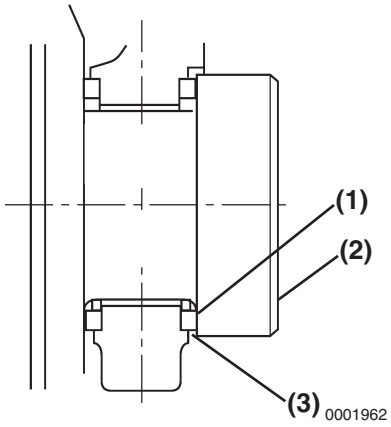
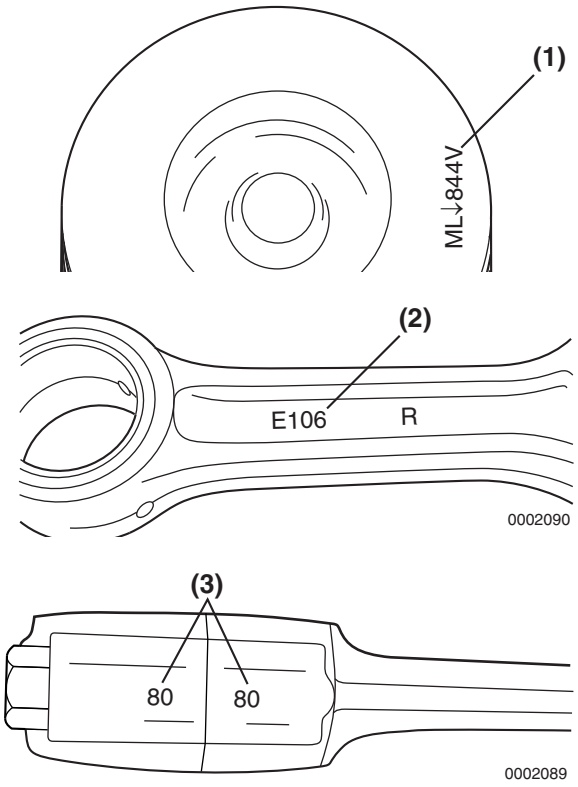


Figure 6-106

Note: The actual appearance of the match marks on the piston and connecting rod may vary, but they will always be in the same locations.



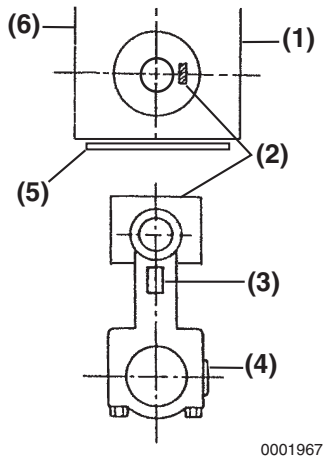
1 – Piston Identification Mark
2 – Embossed Mark on Connecting Rod
3 – Rod and Cap Match Marks

Figure 6-131

Piston Assembly - All TNV models - 82, 84(T), 88, 94, and 98(T)

When correctly assembled, the piston identification mark **(Figure 6-132, (2))** stamped into the top of the piston will be on the same side of the connecting rod as the match marks **(Figure 6-132, (4))** stamped into the connecting rod and connecting rod cap.

When installed in the cylinder, the piston identification mark **(Figure 6-132, (2))** stamped on the top of the piston must face the fuel injection pump side **(Figure 6-132, (1))** of the engine and the embossed mark on the connecting rod **(Figure 6-132, (3))** must face the flywheel end **(Figure 6-132, (5))** of the engine.



1 – Fuel Injection Pump Side of Engine
2 – Piston Identification Mark
3 – Embossed Mark on Connecting Rod
4 – Rod and Cap Match Marks
5 – Flywheel End of Engine
6 – Camshaft Side of Engine

Figure 6-132

EGR SYSTEM

EGR system

Applicable engines : 4TNV98-E, 4TNV98-Z

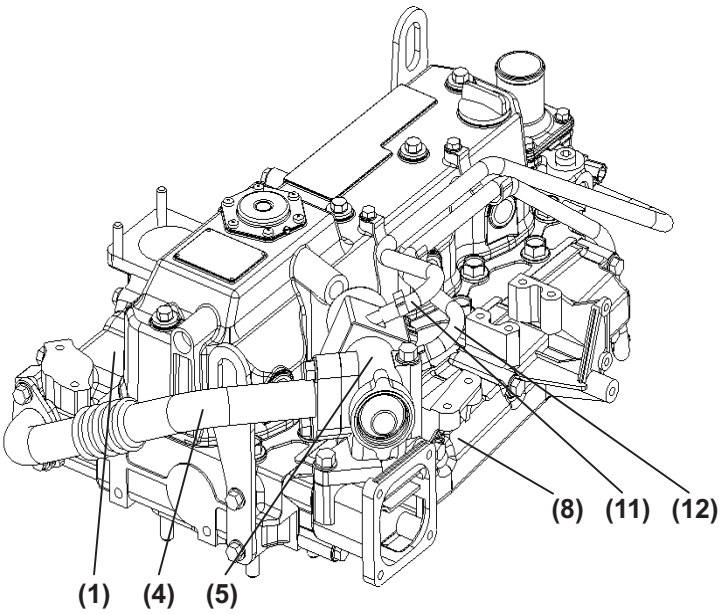


Figure 6-153

Fuel Injectors 7-35
Removal of Fuel Injectors 7-35
Testing of Fuel Injectors 7-38
Disassembly and Inspection of Fuel Injectors 7-39
Adjusting Fuel Injector Pressure 7-41
Reassembly of Fuel Injectors 7-41
Installation of the Fuel Injectors 7-42

Test and Adjustment Specifications

Model	Engine Class	Injector ID mark*	Fuel Injector Pressure	Fuel Injection Timing
3TNV82A - 4TNV88	CL	W	2843 - 2988 psi (19.6 - 20.6 MPa; 200 - 210 kgf/cm^2)	*See Checking and Adjusting Fuel Injection Timing on page 7-30*
3TNV82A - 4TNV88 3TNV84T - 4TNV84T	VM	W**	2843 - 2988 psi (19.6 - 20.6 MPa; 200 - 210 kgf/cm^2)	
		or	or	
		V**	3133 - 3278 psi (21.6 - 22.6 MPa; 220 - 230 kgf/cm^2)	
4TNV94L - 4TNV106 4TNV98T - 4TNV106T	CL VM	V	3133 - 3278 psi (21.6 - 22.6 MPa; 220 - 230 kgf/cm^2)	

Note: Fuel injection pressure of a new fuel injector is reduced approximately 72.5 psi (0.5 MPa; 5.0 kgf/cm^2) after about 5 hours of operation due to the initial break in of the engine. When adjusting a new fuel injector or after it has been disassembled for service, adjust the fuel injector 72.5 psi (0.5 MPa; 5.0 kgf/cm^2) higher than the above standard.

Note: All fuel injectors have a three character identification mark **(Figure 7-3, (1))**. The first character starts with “V” or “W”.

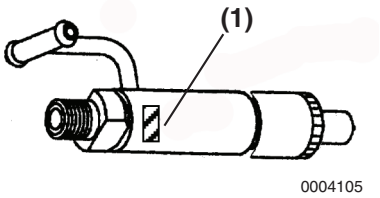


Figure 7-3

** Fuel injector identification is critical as each engine has a unique fuel injection pressure. The fuel nozzle is specifically matched to the fuel injector by engine model and / or engine speed.

- On TNV94 - 106 model engines, the idler gear is visible. Make a reference mark **(Figure 7-15, (1))** across both the fuel injection pump drive gear and the idler gear.

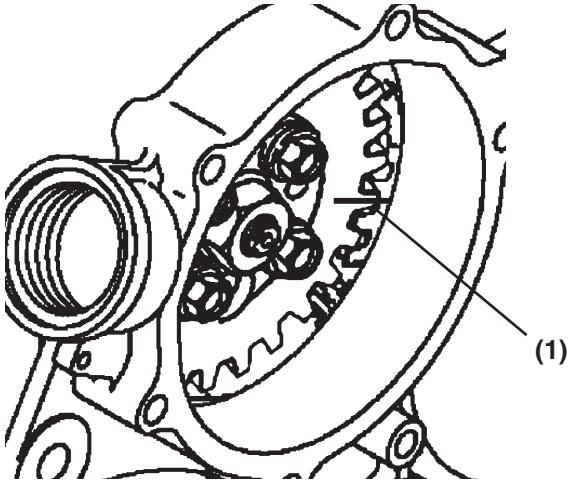


Figure 7-15

CAUTION

Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.

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18. Do not loosen or remove the four bolts **(Figure 7-16, (3))** retaining the pump drive gear to the hub. Only remove the single drive gear nut **(Figure 7-16, (1))** and washer **(Figure 7-16, (2))**, leaving the hub attached to the gear.

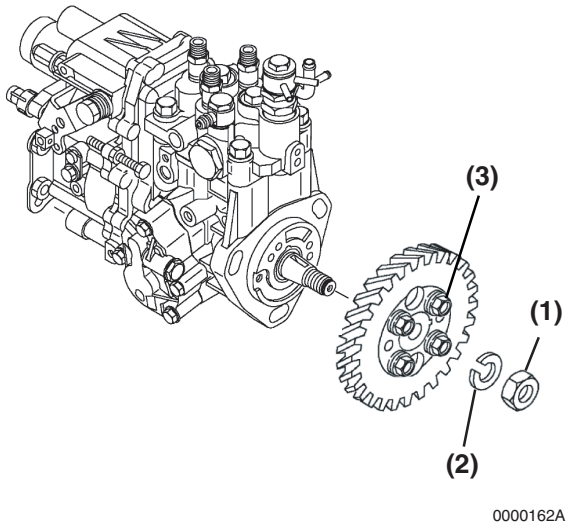


Figure 7-16

19. Hold the gear train using a large socket wrench on the crankshaft pulley nut. Loosen the fuel injection pump drive gear retaining nut **(Figure 7-16, (1))** and turn it out to the end of the fuel injection pump shaft.
20. Remove the pump drive gear and hub as an assembly using an appropriate two-bolt gear puller **(Figure 7-17).**

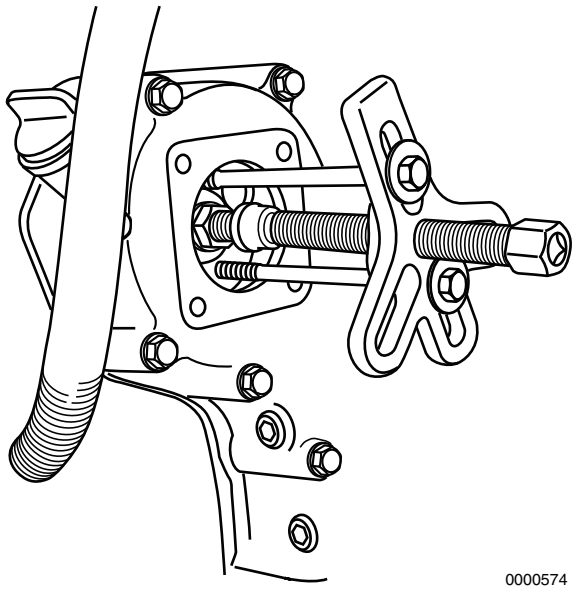


Figure 7-17

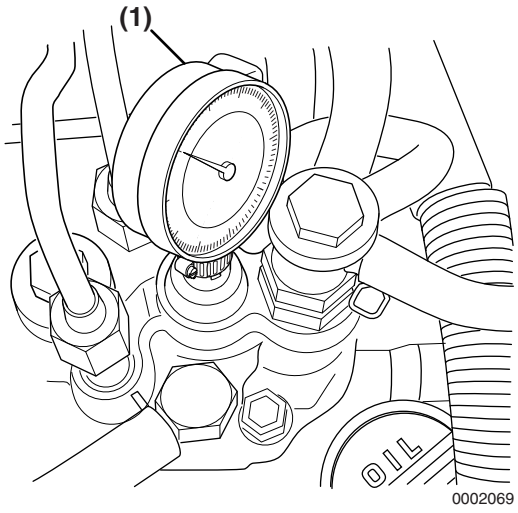


Figure 7-41

Note: The following references to the direction-of-rotation are facing the coolant pump end of the engine and are adjusted by turning the crankshaft pulley.

6. Using a wrench on the crankshaft pulley bolt, rotate the crankshaft in a clockwise direction while looking through the flywheel inspection port **(Figure 7-42, (1))**. Rotate the crankshaft until the injection timing marks on the flywheel are visible.

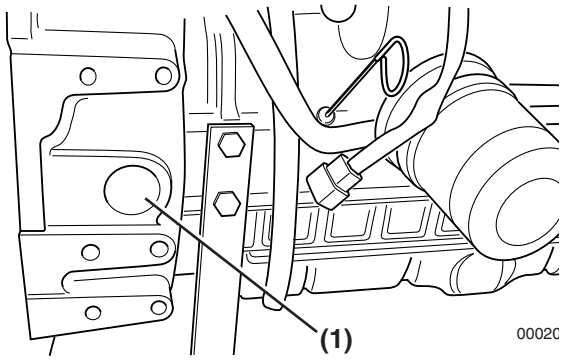
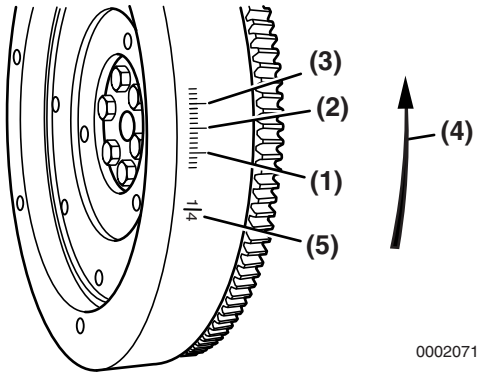


Figure 7-42

7. Typical flywheel markings are as shown in **(Figure 7-43, (1))**.

Note: A typical flywheel will have multiple timing grids depending on the number of cylinders. Any grid can be used to check the fuel injection timing.

The flywheel shown in **Figure 7-43** is for a Yanmar "Standard Specification" DI engine. Flywheels used on some "OEM Specific" DI engines may be marked differently. You should contact that specific OEM for information on the identification of the timing marks.



1 – 10° BTDC (Before Top Dead Center)
2 – 15° BTDC
3 – 20° BTDC
4 – Direction of Rotation
5 – TDC (Top Dead Center)

Figure 7-43

Note: The TDC (Top Dead Center) mark can be identified by the cylinder numbers stamped near the TDC mark on the flywheel.

If you are uncertain as to the timing degree designation of the timing marks on the flywheel timing grid, you can determine the timing degree designation by measuring the timing grid.

- First measure the distance between two of the "longer" marks on the timing grid. (They are 5° apart.) Then measure the distance from the TDC mark to the first "longer" mark on the timing grid. Divide that measurement by the distance between the two "longer" marks. The resulting answer will tell you how many degrees there are between the TDC mark and the first "longer" mark.

Installation of the Fuel Injectors

2-Valve Cylinder Head

1. Reinsert a new nozzle seat **(Figure 7-59,** (4)) and nozzle protector **(Figure 7-59,** (3)) in the cylinder head for each injector.
2. Reinstall a O-ring on to each injector body.
3. Reinsert each fuel injector into the cylinder head.
4. Reinstall the fuel injector retainers **(Figure 7-59,** (2)) and torque the retaining bolts to specification.
5. Reinstall the fuel return hoses **(Figure 7-59,** (1)), one on each side of each injector.
6. Reinstall the fuel high-pressure fuel line assembly and tighten the nuts using a “line” or “flare nut” wrench.

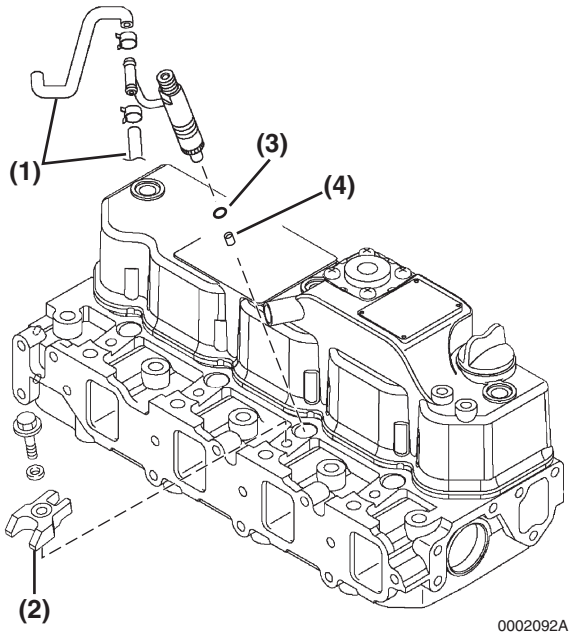


Figure 7-59

7. Prime the fuel system. *See Priming the Fuel System on page 4-15*.
8. Operate the engine and check for fuel and coolant leaks.

4-Valve Cylinder Head

1. Reinsert a new nozzle seat **(Figure 7-60,** (6)) and nozzle protector **(Figure 7-60,** (5)) in the cylinder head for each injector.
2. Reinstall a O-ring on to each injector body.
3. Reinsert each fuel injector **(Figure 7-60,** (4)) into the cylinder head.
4. Reinstall the fuel injector retainers **(Figure 7-60,** (3)) and torque the retaining bolts **(Figure 7-60,** (2)) to specification.
5. Reinstall the fuel injector return line assembly using new gaskets on each side of the injector line screws.
6. Reinstall the fuel high-pressure fuel lines to each injector and tighten the nuts using a “line” or “flare nut” wrench.

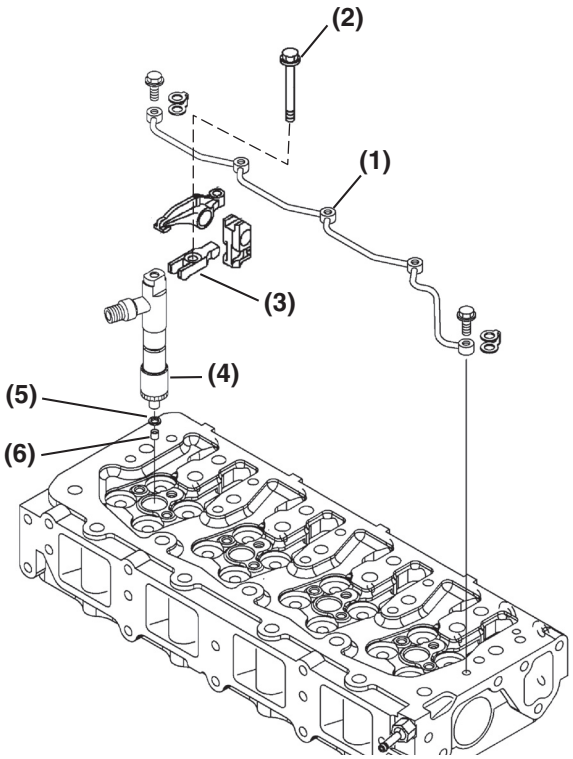


Figure 7-60

7. Prime the fuel system. *See Priming the Fuel System on page 4-15*.
8. Operate the engine and check for fuel and coolant leaks.

ENGINE COOLANT SYSTEM CHECK

Check the engine coolant system for leakage.

1. With the radiator properly filled, install a cooling system tester **(Figure 8-3, (1))**.

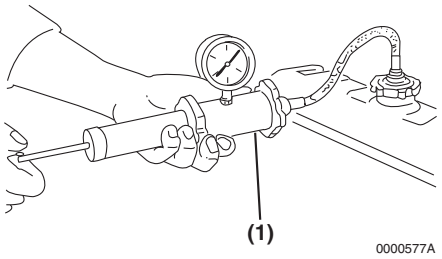


Figure 8-3

2. Apply 10.8 - 14.8 psi (75 - 105 kPa; 0.75 - 1.05 kgf/cm²) to the cooling system. If the pressure reading drops, the engine coolant system is leaking. Identify the source of the leak and repair it.

ENGINE COOLANT PUMP

Removal of Engine Coolant Pump

Verify the condition of the engine coolant pump before disassembling it from the engine. Check the engine coolant pump shaft bearing for abnormal noise, sticking, excessive play and water leakage. Replace the coolant pump if any of these conditions are present.

CAUTION

If the engine coolant pump must be replaced, replace the engine coolant pump as an assembly only. Do not attempt to repair the engine coolant pump or replace individual components.

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IMPORTANT

Make sure the engine and engine coolant are not hot.

1. Before removing the engine coolant pump or thermostat, it will be necessary to drain the engine coolant. Drain the coolant into a clean container if the coolant is to be reused. Otherwise, properly dispose of the coolant.
2. Remove the radiator cap **(Figure 8-4, (1))**.
3. Remove the drain plug or open the drain cock **(Figure 8-4, (1))** at the lower portion of the radiator and drain the coolant.

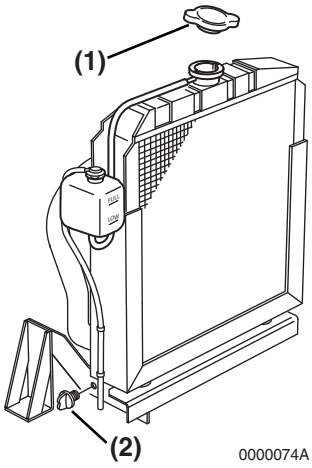

Figure 8-4

4. Drain the coolant from the engine block.
   - On models equipped with an oil cooler, remove the coolant hose **(Figure 8-5, (1))** at the oil cooler.

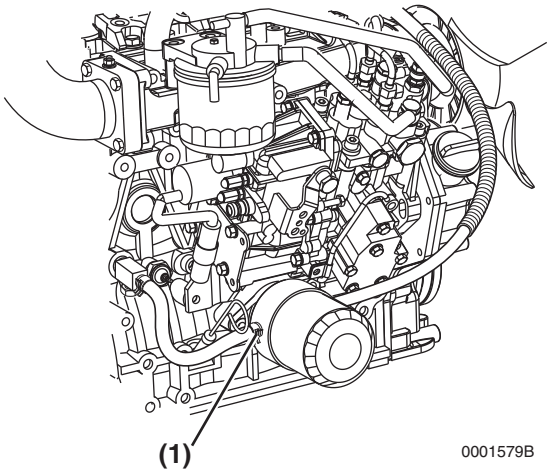

Figure 8-5

⚠ CAUTION

FLYING OBJECT HAZARD!

- **ALWAYS wear eye protection when servicing the engine and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.**
- **Failure to comply may result in minor or moderate injury.**

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⚠ CAUTION

If any oil pump component clearance exceeds its limit, the oil pump must be replaced as an assembly.

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CAUTION

- **Only use the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and / or shorten engine life.**
- **Prevent dirt and debris from contaminating the engine oil. Carefully clean the oil cap / dipstick and the surrounding area before you remove the cap.**
- **NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.**
- **NEVER overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.**

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CAUTION

If the oil pump must be replaced, replace it as an assembly only. Do not replace individual components.

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Disassembly of Oil Pump

CAUTION

If the oil pump must be replaced, replace it as an assembly only. Do not replace individual components.

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Remove the cooling water fan guard (if equipped), cooling fan **(Figure 9-15, (3))**, spacer **(Figure 9-15, (2))**, cooling water pump V-pulley **(Figure 9-15, (1))**, and V-belt.

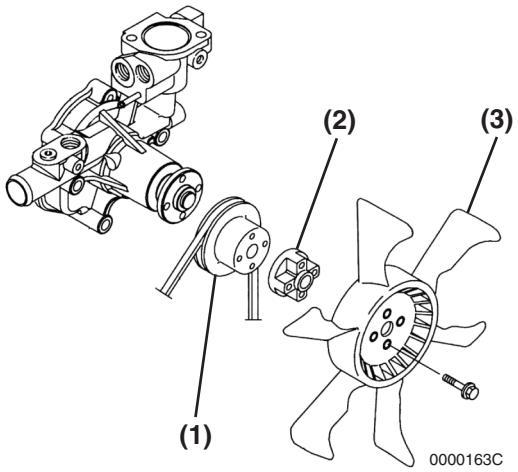

Figure 9-15

1. Remove the crank shaft pulley and gear case cover. See *Removal of Timing Gear Case Cover on page 6-73*.
2. Remove the lubricating oil pump assembly mounting bolts. Remove the lubricating oil pump assembly **(Figure 9-16, (1))** from the gear case flange **(Figure 9-16, (2))**.
3. You can remove by hand the lubricating oil pump cover **(Figure 9-14, (5))** and outer rotor **(Figure 9-14, (4))**.

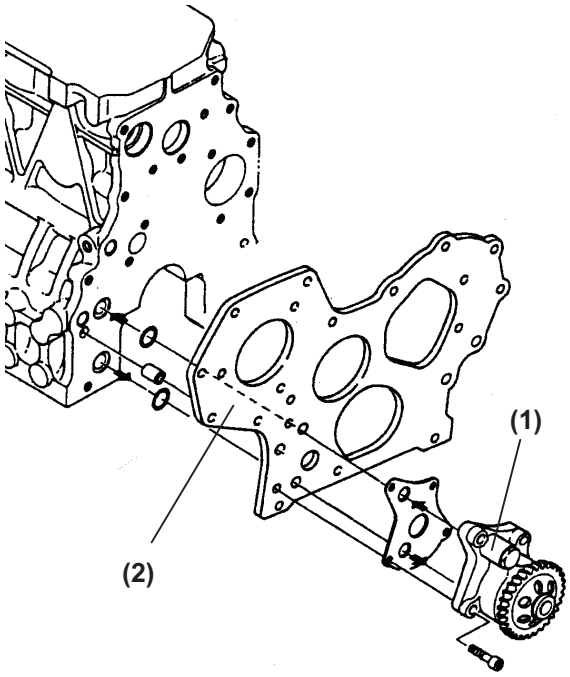

Figure 9-16

Cleaning and inspection

Clean the lubricating oil pump, pressure regulator valve **(Figure 9-14, (7))**, and rotor inserting portion. Check the parts for wear or flaw. Replace the parts with new ones as needed.

CAUTION

- **NEVER overfill the engine with engine oil.**
- **ALWAYS keep the oil level between the upper and lower lines on the oil cap / dipstick.**

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Check Outer Rotor Outside Clearance

Inspect the outside diameter clearance of the outer rotor. To inspect this, insert a feeler gauge between the outer rotor **(Figure 9-17, (1))** and the lubricating oil pump body **(Figure 9-17, (2))**.

CAUTION

Avoid damage to the turbocharger or the engine. Do not spray blower wash fluid or water too quickly.

Use short strokes from a spray bottle to inject blower wash fluid or water into the turbocharger.

Spraying too much wash fluid or water, or spraying too quickly will damage the turbocharger.

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CAUTION

Do not allow any material to fall into the oil lines or the oil inlet and outlet ports of the turbocharger.

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CAUTION

If the waste valve does not meet specifications, replace the turbocharger or have it repaired by a qualified repair facility.

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Checking Rotor Play

Note: If rotor play measurements are not within specification, replace the turbocharger assembly or have it repaired by a qualified facility.

Rotor Play	Standard Dimension			Wear Limit		
	RHF5	RHB31	RHB51	RHF5	RHB31	RHB51
End Play	0.0011 - 0.0024 in. (0.03 - 0.06 mm)	0.0009 - 0.0021 in. (0.022 - 0.053 mm)	0.0012 - 0.0024 in. (0.03 - 0.06 mm)	0.0044 in. (0.09 mm)	0.0028 in. (0.07 mm)	0.0035 in. (0.09 mm)
Run-out	0.0031 - 0.0051 in. (0.08 - 0.13 mm)	0.0024 - 0.0037 in. (0.061 - 0.093 mm)	0.0031 - 0.0051 in. (0.08 - 0.13 mm)	0.007 in. (0.17 mm)	0.0047 in. (0.12 mm)	0.0067 in. (0.17 mm)

To Check Rotor End Play:

1. Set up a dial indicator as shown **(Figure 10-4)**.
2. Manually move the rotor end-to-end while observing indicated readings. Replace the turbocharger if end play measurements are outside specified limits. *See table above.*

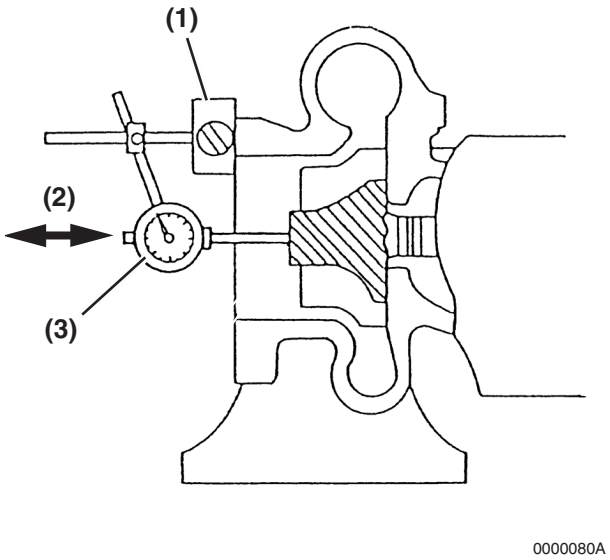

Figure 10-4

To Check Rotor Run-out:

1. Set up a dial indicator as shown **(Figure 10-5)**.
2. Manually rotate the rotor while observing indicated limits. Replace the turbocharger if run-out measurements are outside specified limits. *See table above.*

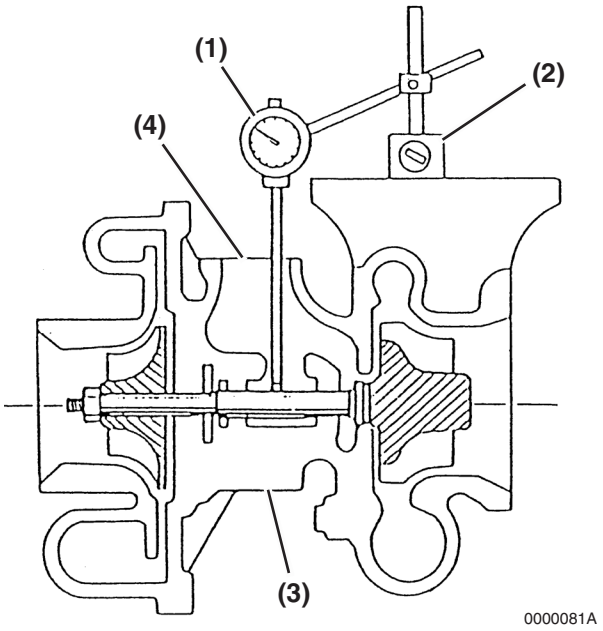

Figure 10-5

Waste Gate Valve Test

Before reinstalling the turbocharger, verify the operation of the waste gate valve. Poor waste gate operation will adversely affect the engine performance.

CAUTION

If the waste valve does not meet specifications, replace the turbocharger or have it repaired by a qualified repair facility.

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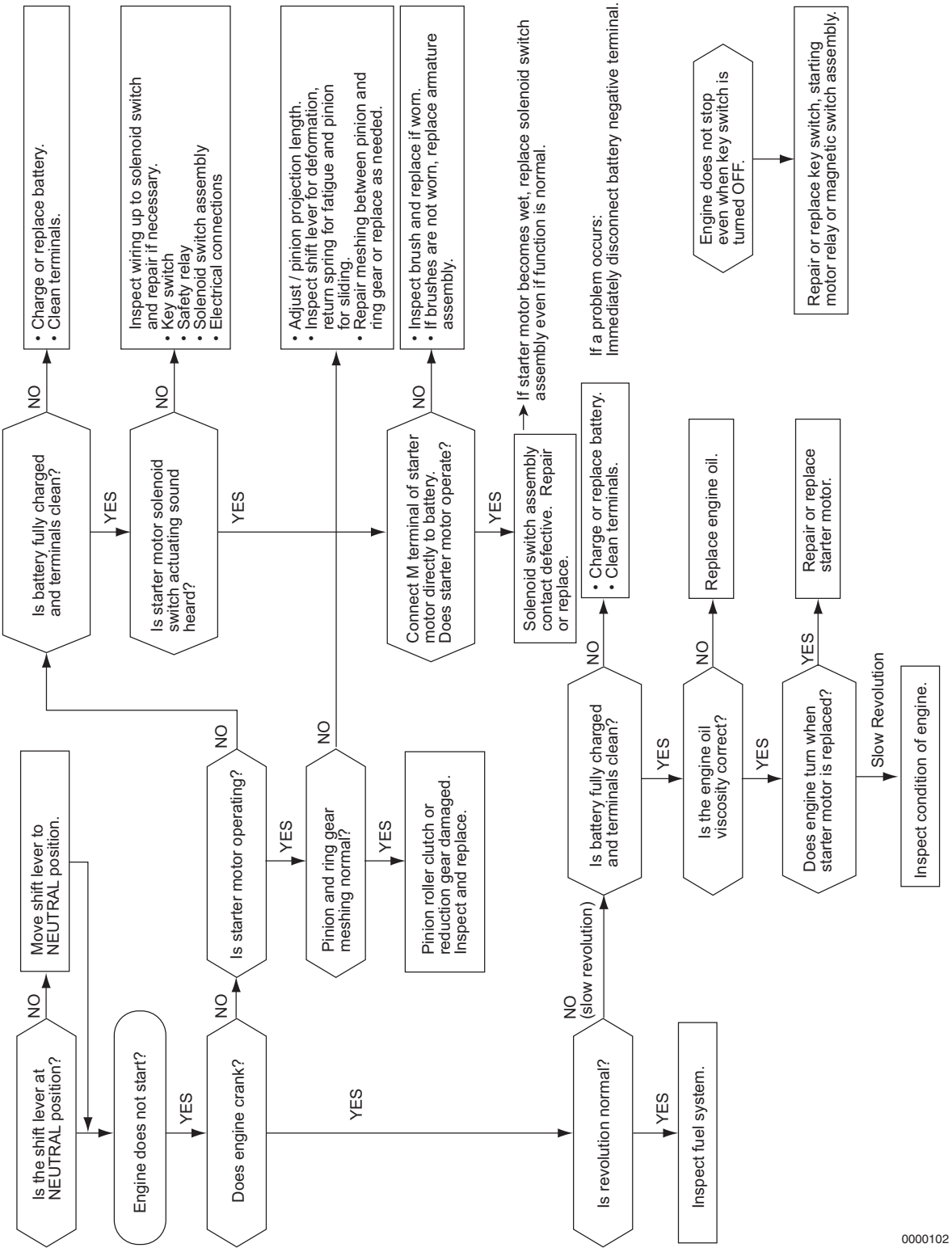
STARTER MOTOR TROUBLESHOOTING



7. Carefully install the armature assembly **(Figure 11-30, (1))** into the field coil assembly **(Figure 11-30, (2))**.

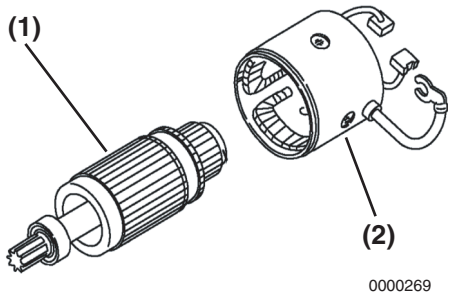


Figure 11-30

8. Position the brush springs in brush holders **(Figure 11-31)**. Reinstall the brushes in the brush holders. Reversing the brushes will cause the starter motor to turn backwards.

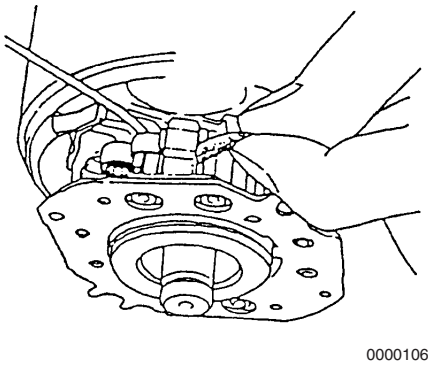


Figure 11-31

9. Carefully install the brush holder assembly to the armature assembly.
10. Reinstall the field coil assembly with the armature assembly to the gear housing.
11. Reinstall the rear cover to the brush holder assembly. Securely tighten the two bolts.
12. Reinstall the two M4 through bolts **(Figure 11-32)**. Securely tighten the through bolts. Reconnect the wire to the magnetic switch assembly. Tighten the M8 nut. Reinstall the cover over the connection.

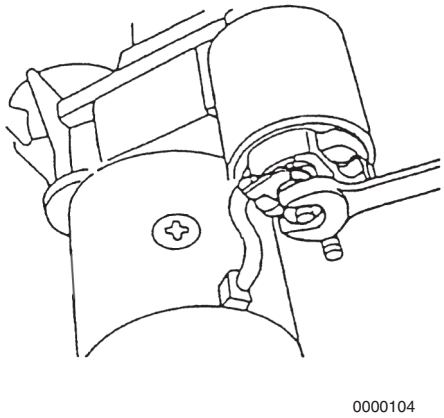


Figure 11-32

Check Pinion Projection Length

1. Connect the positive (+) lead from a battery to the “S” terminal.
2. Connect the negative (-) lead to the “M” terminal.
3. Lightly pull the pinion away from the gear housing.
4. Turn the switch ON and measure the pinion moving distance L in the thrust direction **(Figure 11-33)**. Perform this test within 10 seconds. *See Starter Motor Specifications on page 11-7 for the service limit.*

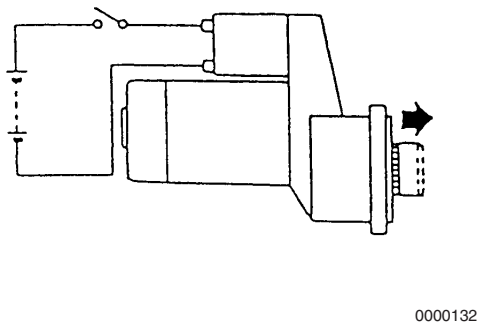
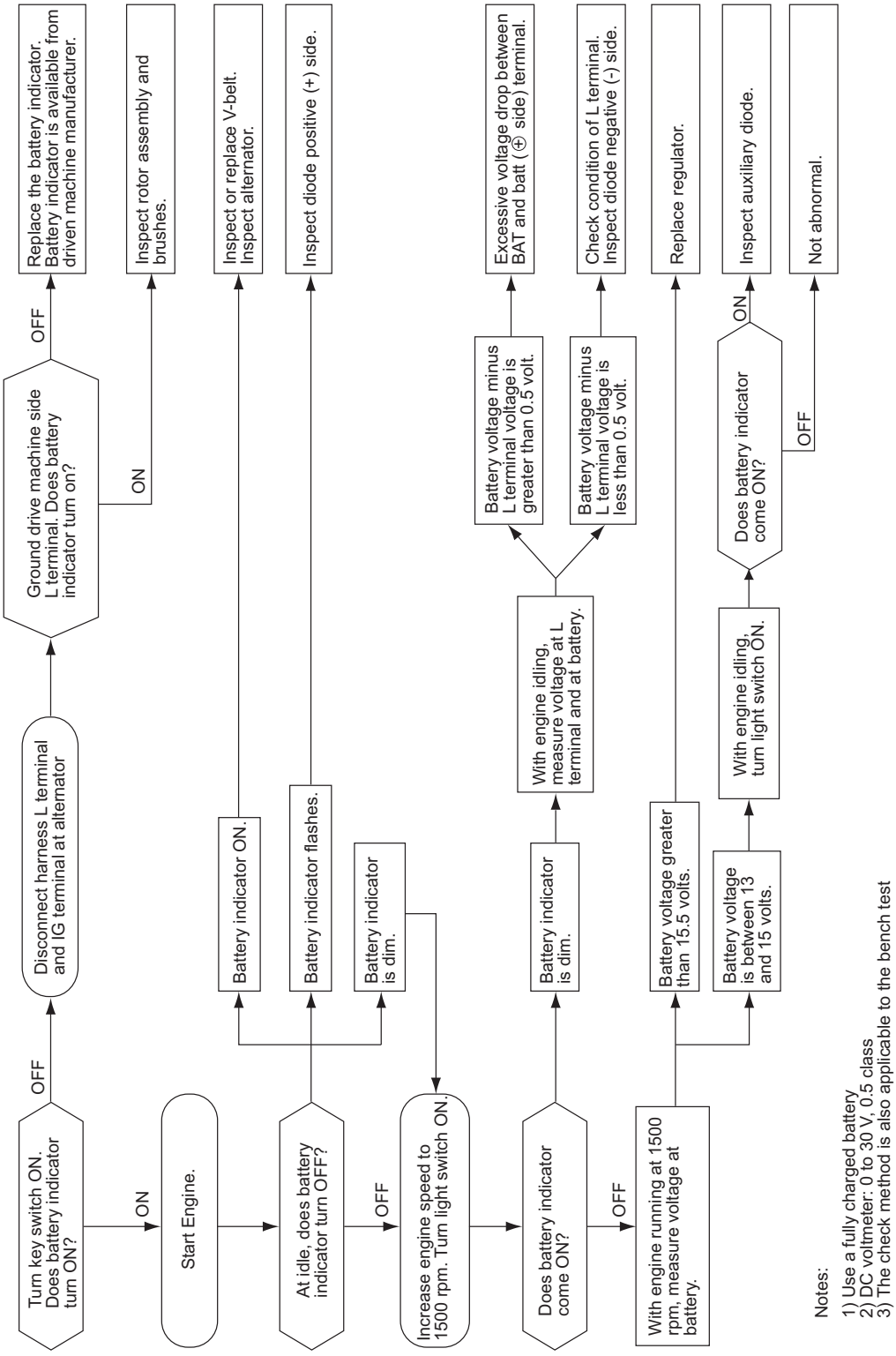


Figure 11-33

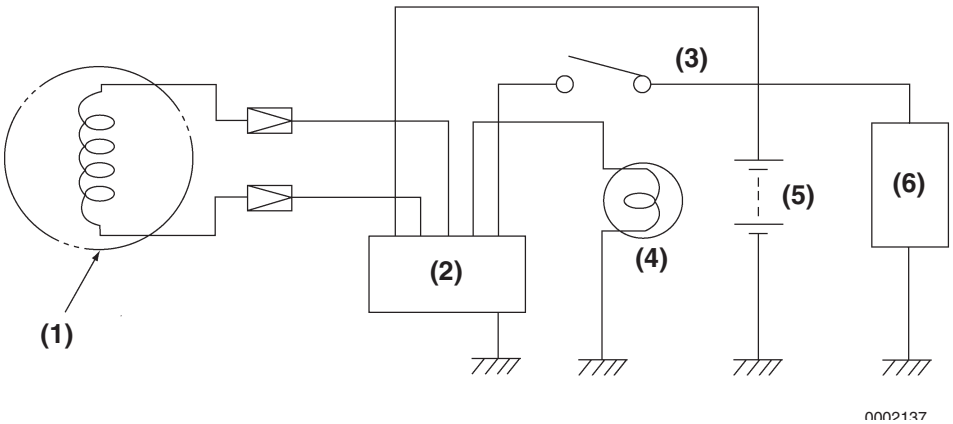
ALTERNATOR TROUBLESHOOTING



Notes:

1) Use a fully charged battery
2) DC voltmeter: 0 to 30 V, 0.5 class
3) The check method is also applicable to the bench test

DYNAMO WIRING DIAGRAM



1 – Dynamo
2 – Current Limiter
3 – Key Switch
4 – Charge Lamp (3.4 Watts Max.)
5 – Battery
6 – Load

Figure 12-21

OPERATION OF DYNAMO

The dynamo consists of a series of permanent magnets that rotate around a stationary stator coil. The magnets are attached to the flywheel which is rotated via the engine cooling fan drive belt. The resultant output is an AC (alternating current) signal. The AC is converted to DC (direct current) by the current limiter. The current limiter outputs charging DC current to the battery.

Measured Value and Troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective Action
1	Air Cleaner Element	Clogged element	Clean the element.
		Broken element	Replace the element.
		Defect at element seal portion	
2	Valve Clearance	Excessive or no clearance	Adjust the valve clearance.
3	Valve Timing	Incorrect valve clearance	Adjust the valve clearance.
4	Cylinder Head Gasket	Gas leak from gasket	Replace the gasket.
			Retighten the cylinder head bolts to the specified torque.
5	Intake / Exhaust Valve	Sticking valve	Replace the intake / exhaust valve.
	Valve Seat	Gas leak due to worn valve seat or foreign matter trapped in valve	Lap the valve seat.
6	Piston	Gas leak due to scratching or wear	Perform honing and use an oversized part.
	Piston Ring		
	Cylinder		

QUICK REFERENCE TABLE FOR TROUBLESHOOTING

The following table summarizes the general trouble symptoms and their causes. If any trouble symptom occurs, take corrective action before it becomes a serious problem so as not to shorten the engine service life.