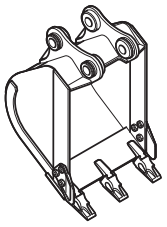
CX17B
Mini Excavator

SERVICE MANUAL

Print No. 84345206
From serial No. PU09-08001

CASE
CONSTRUCTION

2.7 TYPE OF BUCKET

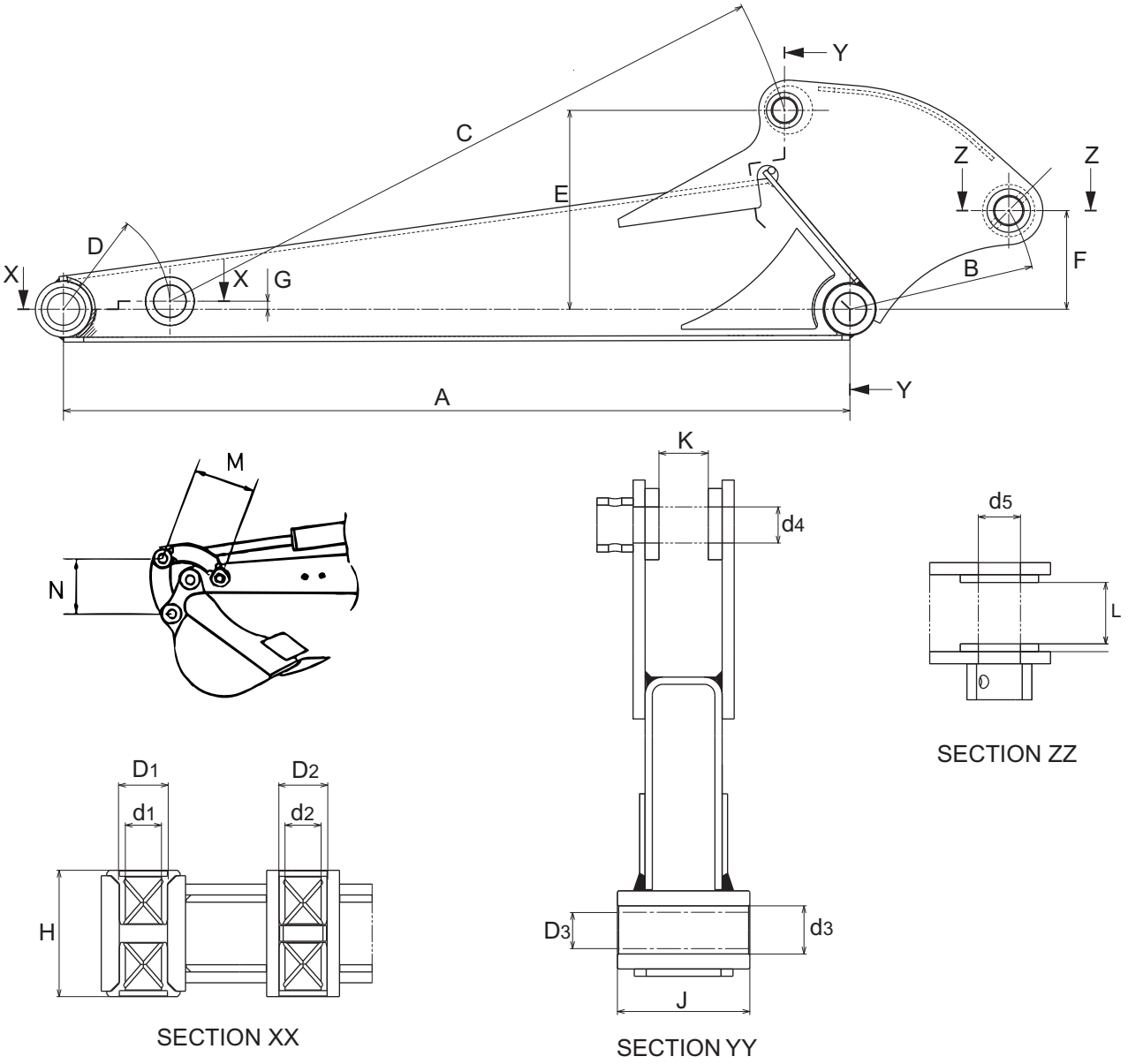
Type	Heaped Capacity m^3 (cu yd)	Outer width mm (in)		Number of tooth	Weight kg (lbs)
		with side cutter	without side cut		
Bucket 	0.044 (0.058)	450 (1'5.7")	420 (1'4.5")	3	35 (77)

Note

this table shows Japanese standard bucket.

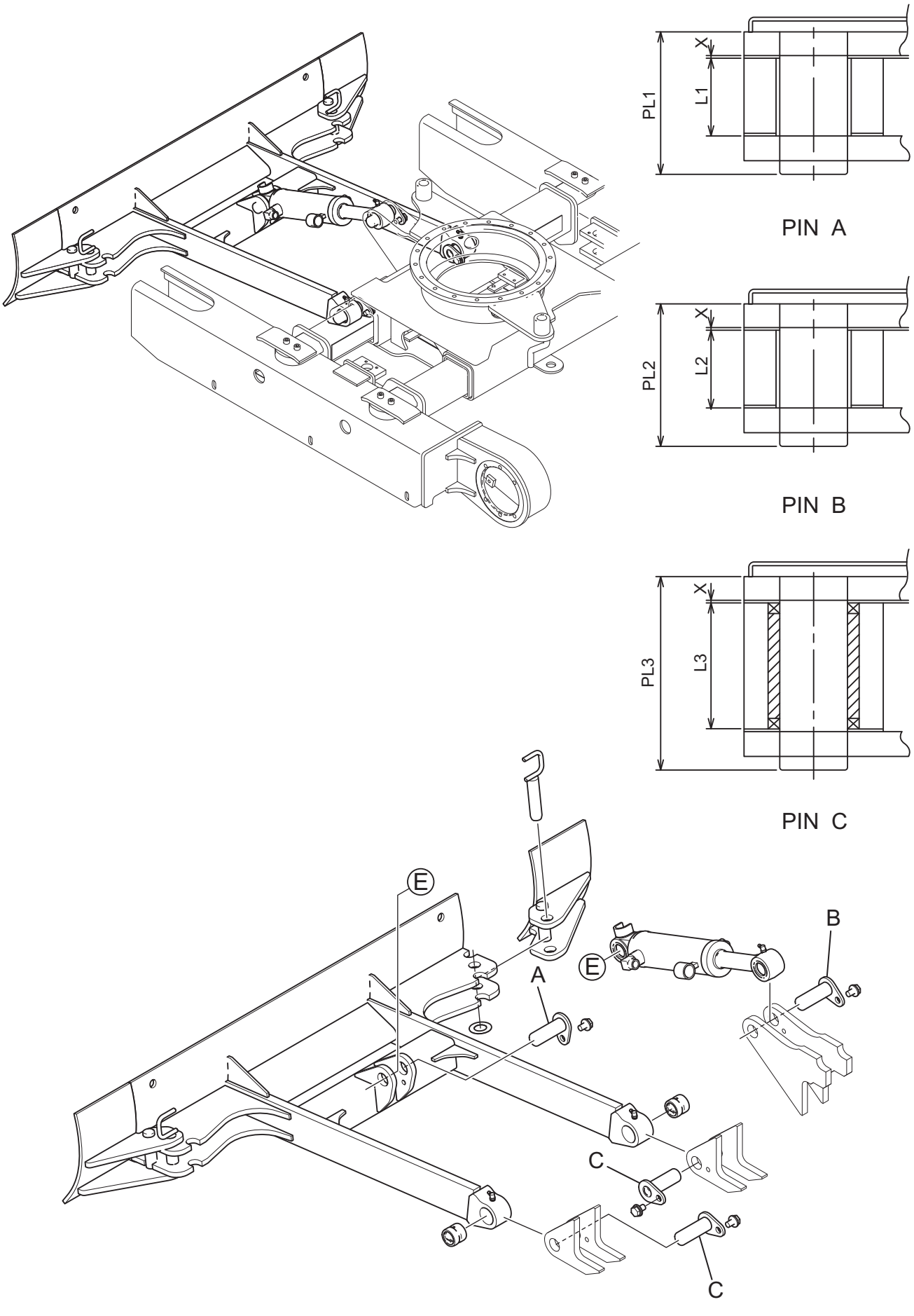
3.2 ARM

3.2.1 ARM DIMENSIONAL DRAWINGS



Arm dimensional drawings

3.4.2 DOZER MAINTENANCE STANDARDS



Dozer maintenance standards

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. Make certain to tighten all Capscrews & Nuts to proper 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)

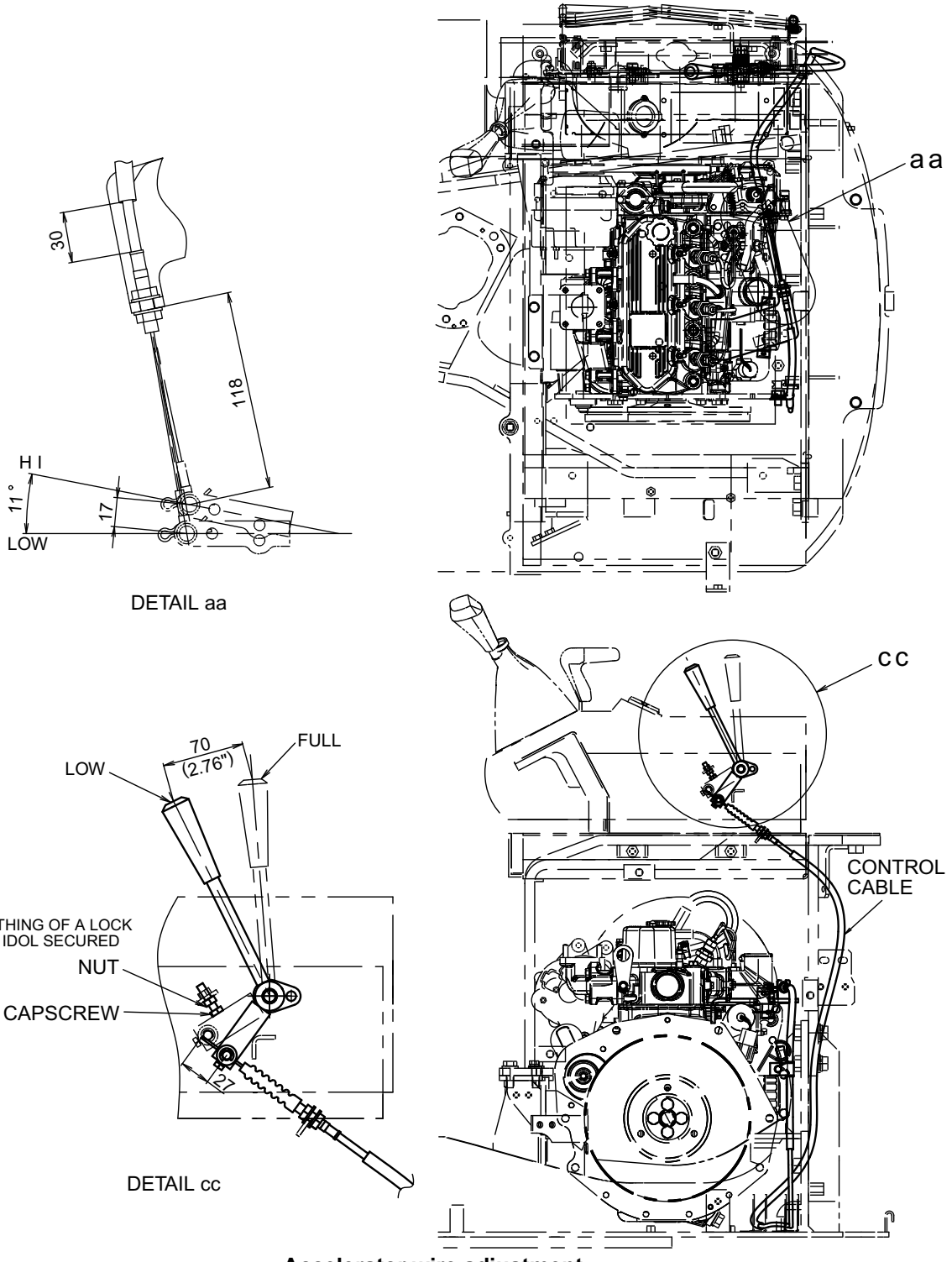
03 Upper structure (4/4)

No.	EQUIPMENT PORTION	WORK TO BE DONE	UNIT	REMARKS	UNIT : HOUR
130	Upper frame portion			Refer to 33.1.21	
131	Upper frame ASSY	Rem./Inst.	1 pc.		1.0
132	-Fixing bolt	- ditto -	1 set	Apply sealant	0.3
133	-Upper frame slinging	- ditto -	1 pc.		0.3
134	-Cleaning	Cleaning	1 pc.		0.2
	Other necessary works	Rem./Inst.	1 pc.	Canopy	0.2
		- ditto -	1 pc.	Guard (Cover, support)	1.5
		- ditto -	1 pc.	Counterweight	0.4
		Drain / Feed	1 pc.	Hydraulic oil	0.2
		Rem./Inst.	1 set	Swivel joint hose	0.5
		- ditto -	1 set	Boom	1.2

(4) Speed Adjustment

Low / High Idling Speed is low ;

The proper engine speed is obtained with the length of accelerator wire as shown in the right 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.



Accelerator wire adjustment

⚠CAUTION

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

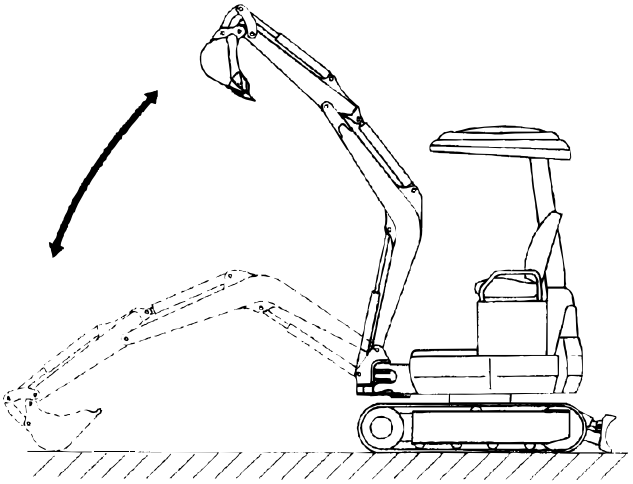
13.7 MEASURING ATTACHMENT OPERATING PERFORMANCES

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

13.7.1 CYLINDER SPEED

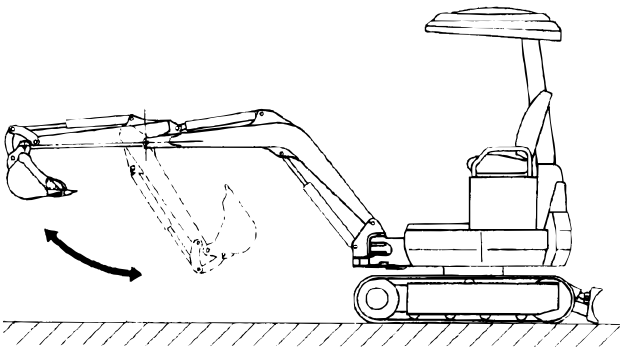
(1) Boom Cylinder Speed

- Engine : High Idle
- Hydraulic Oil Temp. : 50 to 60C degrees (122 to 140F degrees)
- 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.)



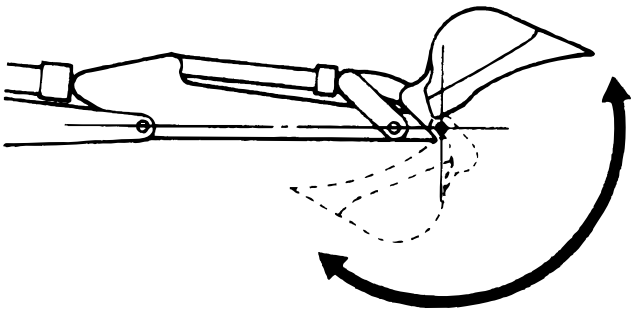
(2) Arm Cylinder Speed

- Engine : High Idle
- Hydraulic Oil Temp. : 50 to 60C degrees (122 to 140F degrees)
- 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 Temp. : 50 to 60C degrees (122 to 140F degrees)
- 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).



22.3 HYDRAULIC CIRCUIT OPERATION

22.3.1 COLOR CODING STANDARD FOR HYDRAULIC

Blue : Feed, drain circuit, less than 0.34 MPa (50 psi)
Green : Return, make-up circuit, 0.34~ 0.59 MPa (50~86 psi)
Purple : Secondary pilot pressure, 0.59~3.5 MPa(85~508 psi)
Red : Primary pilot pressure, 3.5~3.9 MPa (508~ 566 psi)
Orange : Main pump drive pressure, 4.9~23 MPa (711~3340 psi)
Blue tone : At valve selection
Red valve : When proportional valve (reducing) is operating
Red solenoid : In active and exciting
Displaying the flow circuit and standby circuit when operating.
Regarding the electrical symbols in this manual, refer to the electric circuit diagram.

22.3.2 NEUTRAL CIRCUIT

(1) Pilot Circuit

1. Pilot Primary Pressure Circuit
   The oil delivered from the P4 port on pump assy (1) enters into the solenoid valve (13) through the line filter (19).
   The pressurized oil from the port A1 of the solenoid valve (13) with the safety lock lever released (in the operating condition) is supplied to the P ports of the pilot valves for attachment (11) and, travel (12).
   Since the operating circuit is fully closed in the neutral position, the oil delivered by the pump other than the oil supplied to the Pp1 port of the control valve loses its flowing passage, and returns to the hydraulic tank (21) through the relief valve (set pressure : 3.5MPa [508 psi]) built in the solenoid valve (13).
   The oil supplied to the Pp1 port is led to the tank passage through the pilot passages provided to the right and left travel spools.
2. Pilot Secondary Pressure Circuit
   While the pilot valves (11) and (12) are being in neutral, the pilot secondary pressure is not generated.
   By means of operating the operating lever, the secondary pressure is generated in accordance with its motion and led to the control valve (2) from the pilot valve to shift each spool of shifting valve.

(2) Main Circuit

1. Variable Pump Circuit
   The delivered oil from P1 and P2 ports on variable pump enters into P1 and P2 ports on control valve (2) respectively.
   All the discharged oil from these two ports finally returns to the hydraulic oil tank (21), through each valve of travel left, boom and bucket for the P1 oil, and through each valve of travel right, swing, arm and service for the P2 oil.
2. Third Pump Circuit
   The oil delivered from P3 port on 3rd pump enters into P3 port on control valve (2).
   The whole amount of oil discharged through the port P3 flows through the selector valves for the slewingr and the dozer and through the independent travel and flow conflux valves into the P2 line and returns to the hydraulic oil tank (21).

22.3.7 ARM OPERATING CIRCUIT

Pilot oil system with operating lever
With oil flow conflux function for the third pump.

22.3.7.1 Arm In Operating Circuit

(1) Pilot Circuit

1. Shift for Arm Spool
   At the arm in operation, the pilot secondary pressure generated from the pilot valve (11) is led to the Pa4 port on control valve (2) to shift the arm valve spool.
   Oil supplied to the Pp1 port is led to the tank passage through the pilot passages provided to the right and left travel spools.
   Therefore the independent travel and flow conflux valves are not actuated, that is to say, the flow conflux valve remains active.

(2) Main Circuit

1. Supply Circuit for Cylinder (6)
   The oil delivered from the P2 port on variable pump enters into P2 port on control valve (2).
   The pressurized oil from the P3 port joins with the oil from the P2 port through the independent travel and flow conflux valves. The joined oil flows out from the A4 port through the arm valve and is supplied to the head side of the arm cylinder (6) to perform arm in work.
2. Return Line from Cylinder (6)
   The return oil from the rod side of arm cylinder enters into the B4 port on control valve(2), and is led to the return line from the T3 port through arm valve, then return to the tank.

22.3.7.2 Operating Circuit for Arm Out

(1) Pilot Circuit

At the operation for arm out, the pilot secondary pressure is generated from the pilot valve (11), and led to the Pb4 port on control valve (2) to shift the arm valve spool.
The independent travel and flow conflux valves are not actuated, that is to say, the flow conflux valve remains active as in the excavating operation.

(2) Main Circuit

As in the case of excavating operation, the oil having flown into the control valve (2) joins with the pressurized oil from P2 and P3, flows out from the B4 port and is supplied to the rod side of the arm cylinder to perform arm out work.

22.3.12 NIBBLER & BREAKER OPERATING CIRCUIT

Link drive system with operating pedal, and with 3rd. pump conflux function

22.3.12.1 Nibbler Close Operating Circuit

(1) Nibbler operation

When depress the left side of control pedal, the service valve spool in control valve (2) is shifted by the link mechanism. Since the pilot oil pressure is not utilized for it is activated regardless to the safety lock lever.

(2) Main Circuit

1. Supply Circuit for Nibbler Cylinder
   Delivery oil from P2 port on the variable displacement pump enters into P2 port on control valve (2). And the pressurized oil from P3 port flows together the oil from P2 port thru travel independent/conflux valve.
   The confluent oil flows from B3 port thru service valve, enters into head side of Nibbler cylinder, and closes the Nibbler.
2. Return Line from Nibbler Cylinder
   The return oil from Nibbler cylinder enters into A3 port on control valve (2), and flows into return path thru the service valve, and then returns from T3 port to the hydraulic tank.

22.3.12.2 Nibbler Open Operating Circuit

(1) Nibbler Operation

When depress the right side of control pedal, the service valve spool in control valve (2) is shifted by the link mechanism.
By this shift of service spool, the independent and flow conflux valves are actuated like the Nibbler-close operation.

(2) Main Circuit

The pressurized oil is flowed in the control valve (2) together, and it is same operation as closing circuit.
The confluent oil flows from A3 port, enters into rod side of Nibbler cylinder, and opens the Nibbler.

22.3.12.3 Breaker Blow Operating Circuit

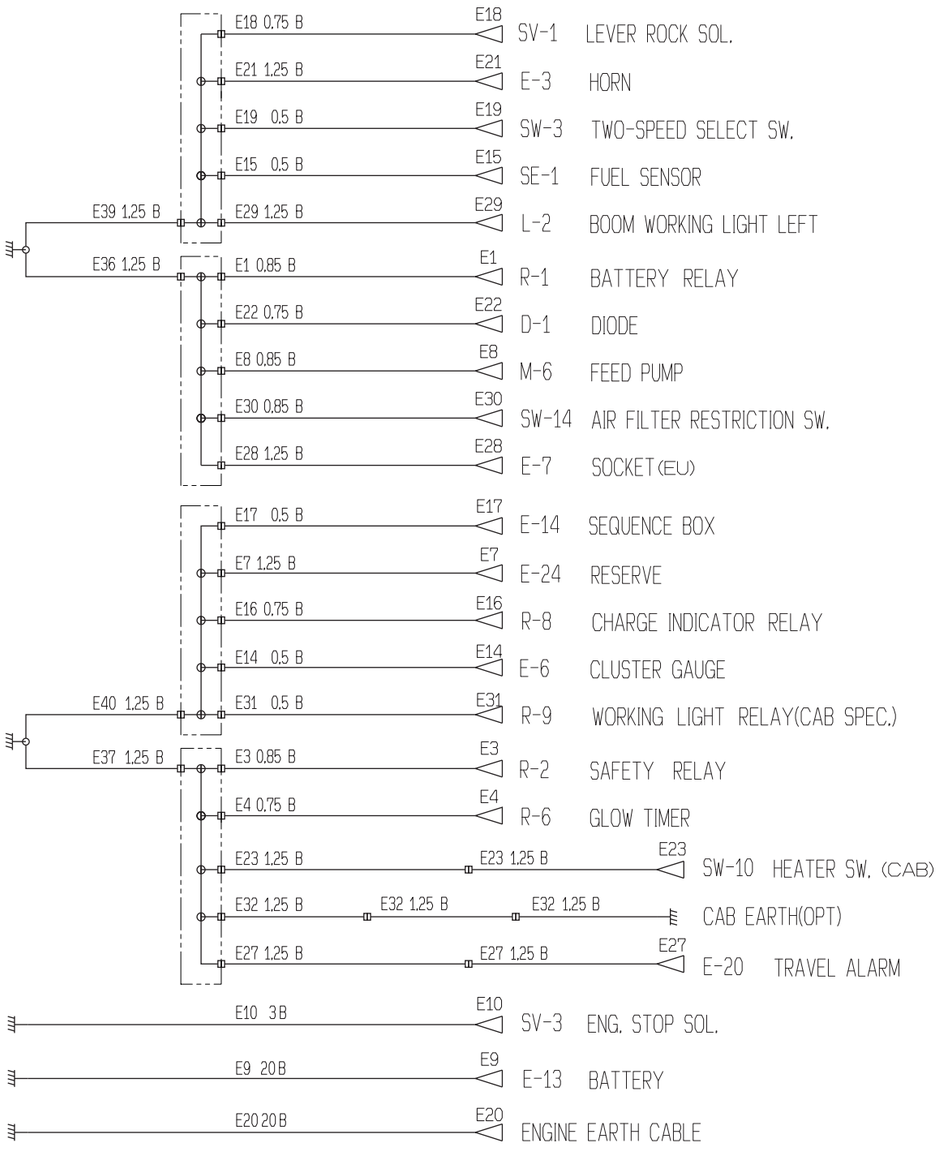
Change the valve position of stop valve (23) to the position for Breaker.

(1) Breaker Operation

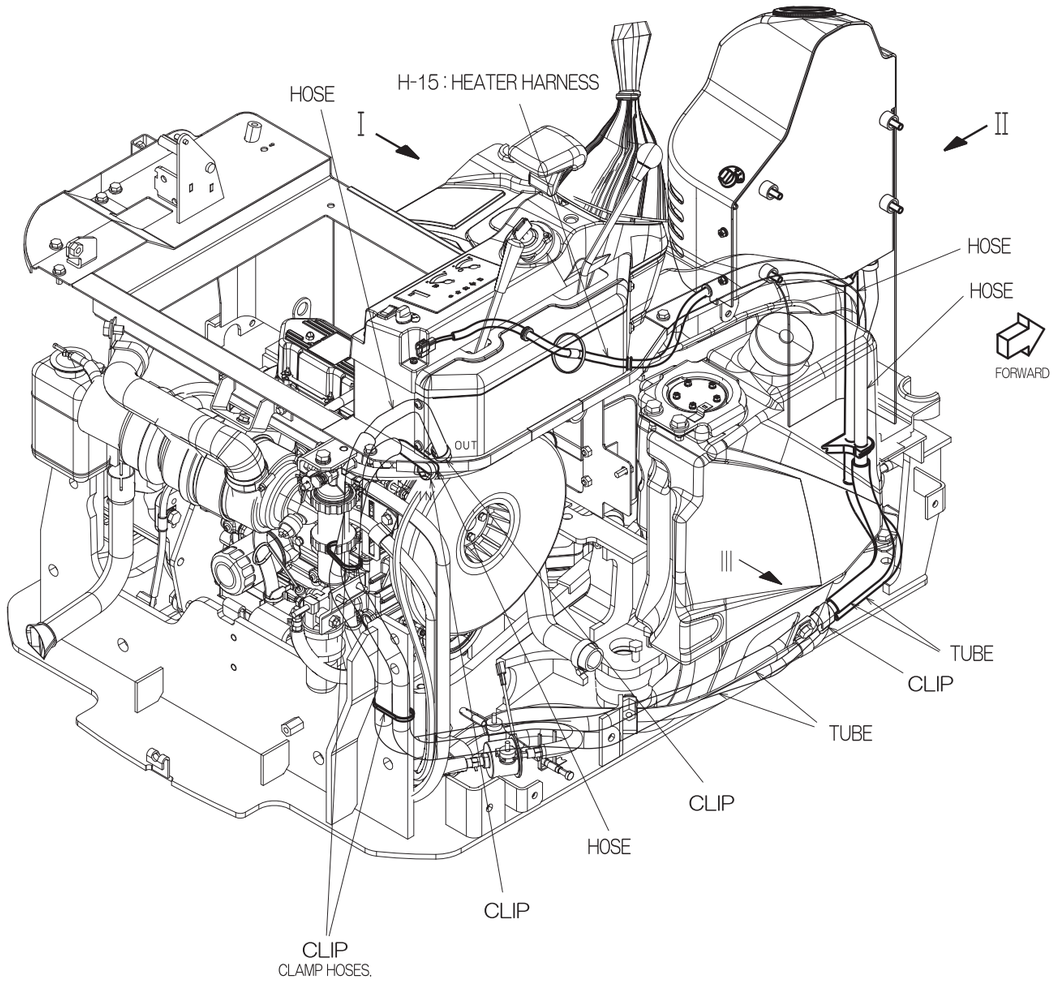
When depress the right side of control pedal, the service valve spool in control valve (2) is shifted by the link mechanism. Since the pilot oil pressure is not utilized for it is activated regardless to the safety lock lever.

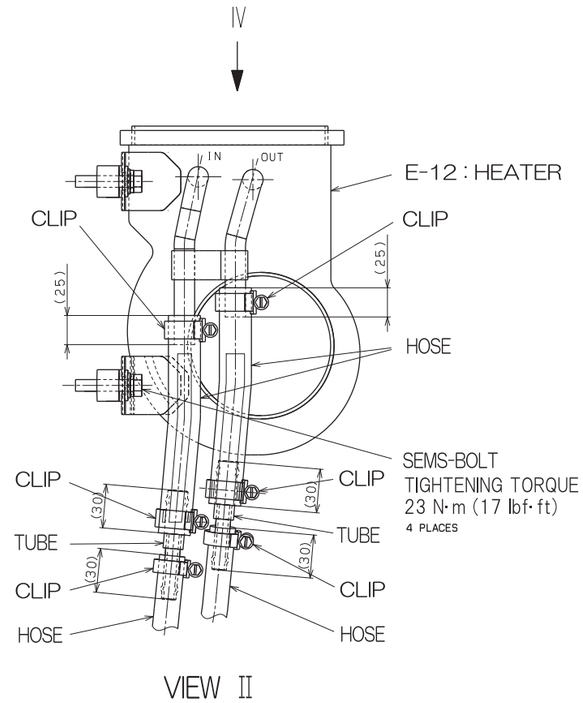
(2) Main Circuit

1. Supply Circuit for Breaker
   Both P2 and P3 pump oil flow together in the control valve, and this is same operation as closing Nibbler.
   The conflux oil is delivered from A3 port through the service valve, and is supplied into Breaker, and makes the blow work of Breaker.
2. Return Line from Breaker
   The return oil of Breaker flows through the stop valve (23), and the oil returns directly to hydraulic tank.

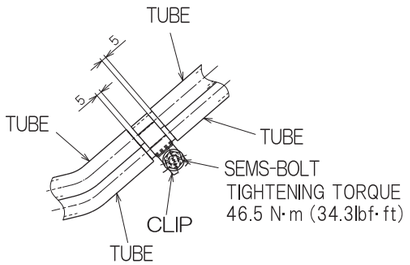

E18 0.75 B
E18
SV-1 LEVER ROCK SOL.
E21 1.25 B
E21
E-3 HORN
E19 0.5 B
E19
SW-3 TWO-SPEED SELECT SW.
E15 0.5 B
E15
SE-1 FUEL SENSOR
E39 1.25 B
E29 1.25 B
E29
L-2 BOOM WORKING LIGHT LEFT
E36 1.25 B
E1 0.85 B
E1
R-1 BATTERY RELAY
E22 0.75 B
E22
D-1 DIODE
E8 0.85 B
E8
M-6 FEED PUMP
E30 0.85 B
E30
SW-14 AIR FILTER RESTRICTION SW.
E28 1.25 B
E28
E-7 SOCKET(EU)
E17 0.5 B
E17
E-14 SEQUENCE BOX
E7 1.25 B
E7
E-24 RESERVE
E16 0.75 B
E16
R-8 CHARGE INDICATOR RELAY
E14 0.5 B
E14
E-6 CLUSTER GAUGE
E40 1.25 B
E31 0.5 B
E31
R-9 WORKING LIGHT RELAY(CAB SPEC.)
E37 1.25 B
E3 0.85 B
E3
R-2 SAFETY RELAY
E4 0.75 B
E4
R-6 GLOW TIMER
E23 1.25 B
E23 1.25 B
E23
SW-10 HEATER SW. (CAB)
E32 1.25 B
E32 1.25 B
E32 1.25 B
CAB EARTH(OPT)
E27 1.25 B
E27 1.25 B
E27
E-20 TRAVEL ALARM
E10 3B
E10
SV-3 ENG. STOP SOL.
E9 20B
E9
E-13 BATTERY
E20 20B
E20
ENGINE EARTH CABLE

23.2.4.7 Heater Portion (OPT) : PU21M00015F1

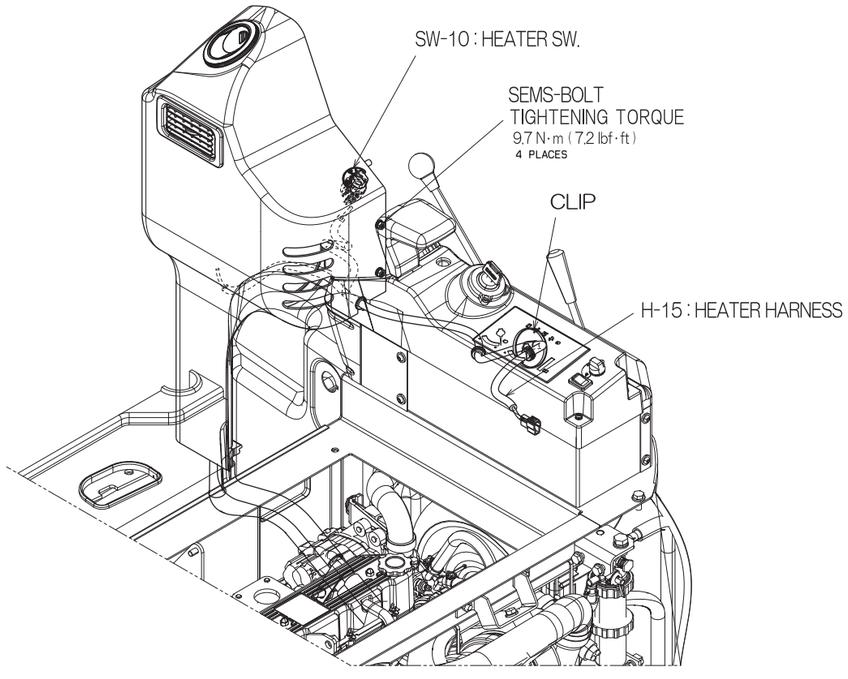




VIEW II



VIEW III



VIEW I

2. Dumping mechanism

(1) In case of neutral position,

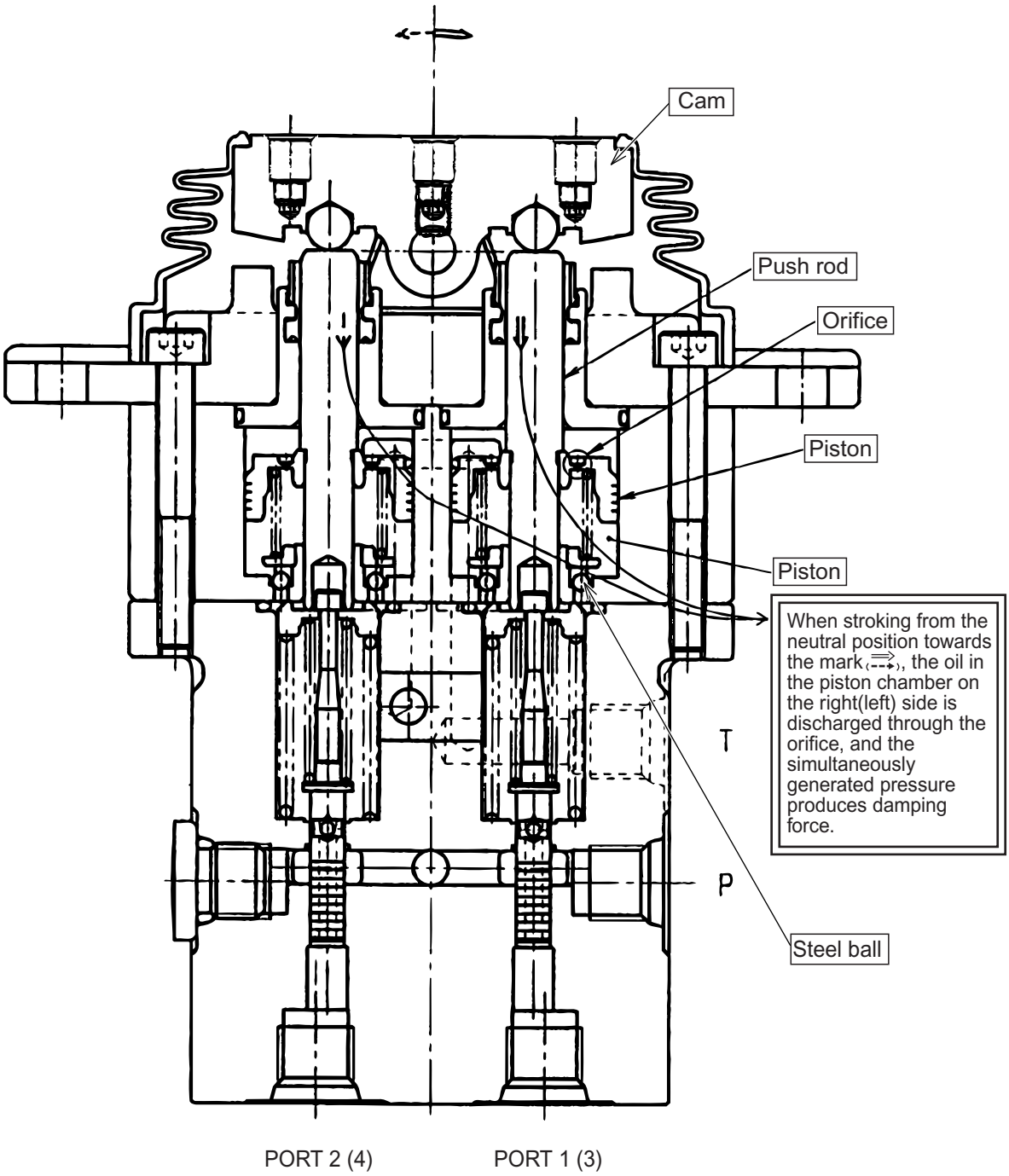
Push rod (214) is pushed up by dumping spring (336) through piston (224), and holds at the position shown in Fig. "Pilot valve-Sectional view".

(2) Where the control section is inclined from the neutral position,

By rotating the cam clockwise, the push rod on the port 1 side is pushed down, and the piston also moves down. Then, the oil in the dumping piston chamber is discharged through the orifice, and the simultaneously generated pressure produces dumping force.

On the other hand, the push rod on the port 2 side moves up by the dumping spring through the piston.

Then, oil is sucked from the tank into the dumping piston chamber through three ball check valves. The oil outside of the piston chamber flows out through the passage leading to port T on the casing top end.



Operation when the lever is stroked from the neutral position

(2) Pilot operating section

1. Forward travel operation

As for the principle of travel operations, the following paragraphs explain only Pa pressurization operation, the principle of which (for forward travel) is identical with that of Pb pressurization (for reverse travel).

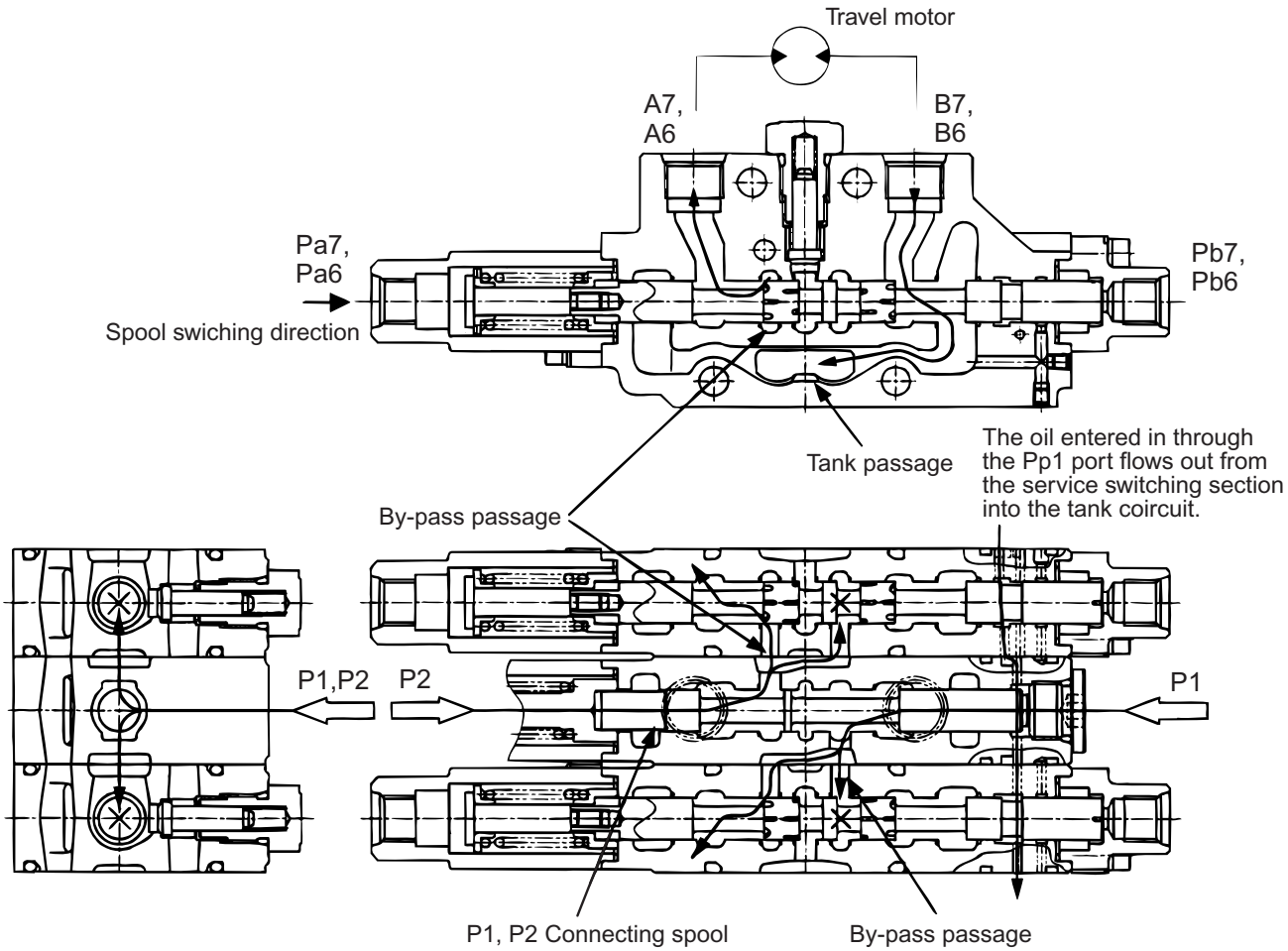
When the left and right forward travels are operated, the pilot secondary pressure is supplied to Pa 7 and Pa 6 ports to move the travel spools.

The oil having flowed in from the P1 and P2 ports passes through the supply section and flows out into the P1 and P2 side by-pass passages. The oil having entered the P1 and P2 side by-pass passages flows out into the A7 and A6 ports opened by the movement of the travel spool, and then out into the travel motor.

On the other hand, the return oil from the travel motor flows from the B7 and B6 ports into the control valve, and then out into the tank passage opened by the movement of the spool.

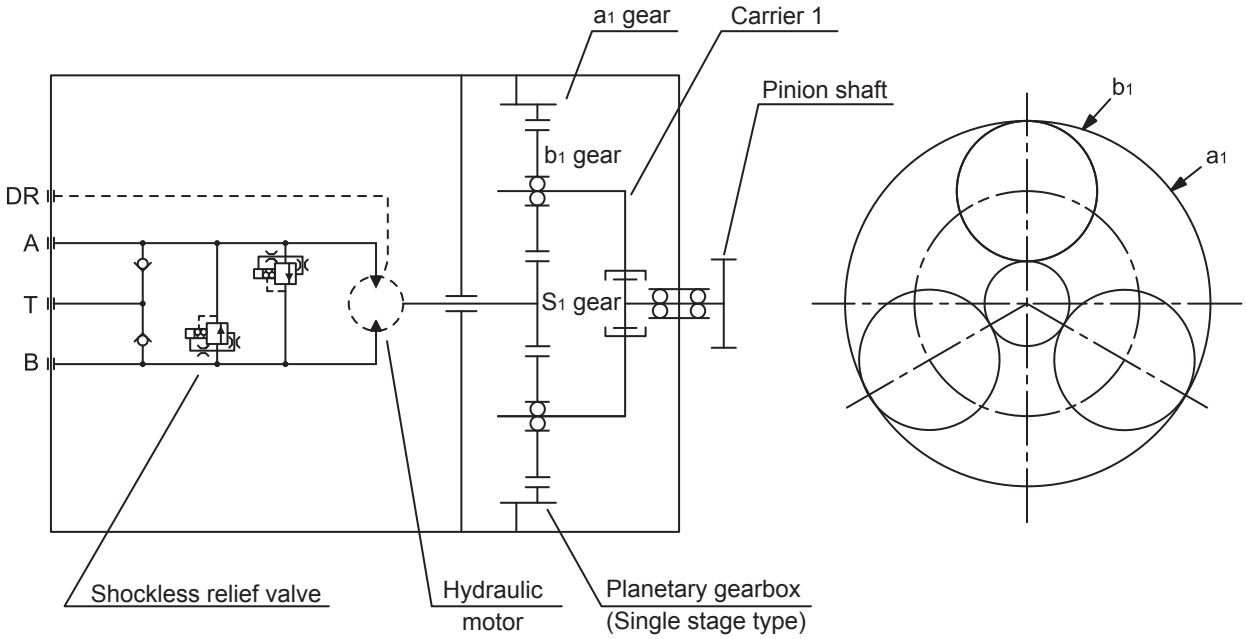
The oil having flowed in from the Pp1 port passes through the orifice passage provided on the P3 supply section and then flows out into the independent travel signal passage.

The movement of the travel spools blocks the travel signal passage (See the belew figure) in the travel switching section, which is open with the travel spools in the neutral positions. If the other switching sections in the P1 and P2 lines are not switched, since the oil passes through the pilot passages of the boom, bucket, swing and arm, and then flows out from the service switching section into the tank passage to allow the pilot passage pressure to be equal to the tank pressure, the independent travel spool on the P3 supply section and the communication valve spool between the P1 and P2 supply sections keep their positions.



Operation at travel foward

24.1.5.5 OPERATION PRINCIPLE



24.1.5.6 FUNCTION AND OPERATION

Slewing motors consist of a planetary gear speed reducer, a hydraulic motor and the hydraulic valves.

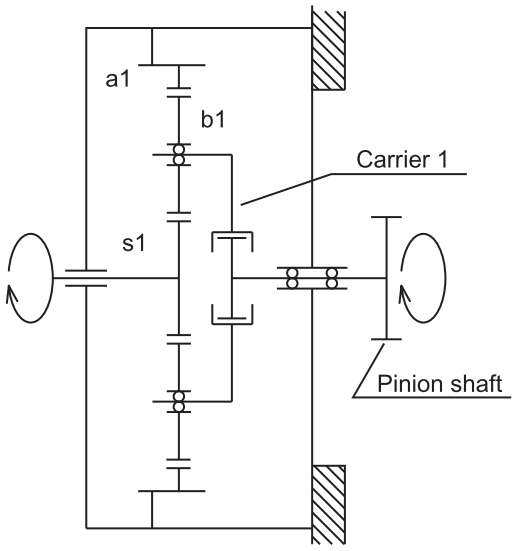
24.1.5.6.1 REDUCTION UNIT

(1) Function

The speed reducer of slewing motor is a simple planetary gear type with a single stage. The high output speed of the hydraulic motor is reduced to low speed with high torque and obtaining the pinion shaft rotation.

(2) OPERATION

The S1 gear is attached to the hydraulic motor shaft, and the S1 output speed is reduced between the gears (S1, b1, a1), This reduced output speed is transmitted to the pinion shaft, and drives the machine.



The gear ratio of single stage simple planetary speed reducer is calculated using the following formula.

$$R = \frac{ZS1}{ZS1+Za1}$$

NOTE. Z ** : Number of gear teeth

24.1.6.3.2 HYDRAULIC MOTOR

(1) Function of Motor

This hydraulic motor of an axial piston (swash plate) type converts the hydraulic energy furnished by the pump into rotary motion.

(2) Construction and Operation Principle of Motor

The pressurized oil supplied through the counterbalance valve is supplied to the valve plate (5). When pressurized oil is supplied to port A, it flows into the cylinder port on the cylinder barrel (4) of aligning with port A, and pushes the piston (6). The force on the piston is converted through the swash plate (7) into rotary motion, which is transmitted to the shaft (3) through the spline provided on the cylinder barrel (4).

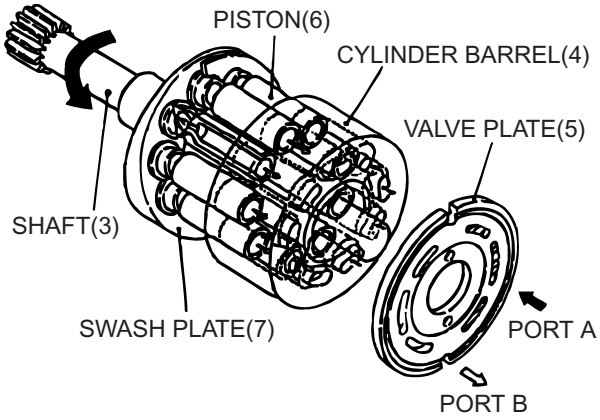
The return oil from the cylinder port flows out through port B on the valve plate (5).

In case of the reverse rotation, the oil flows into port B, and the return oil flows out port A.

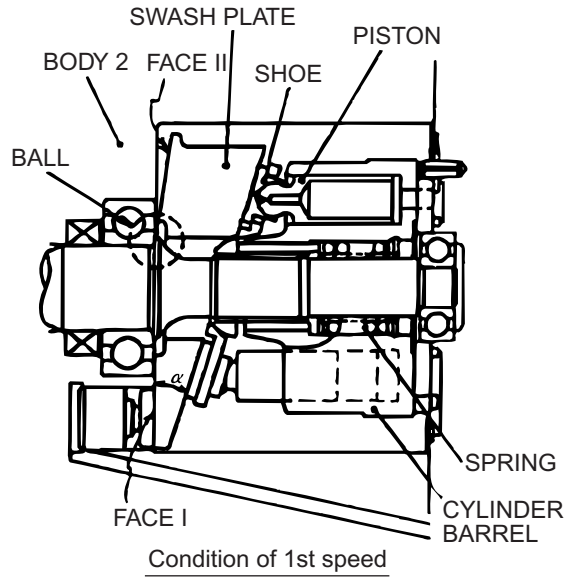
(3) Operation Principle of two-Speed Motor

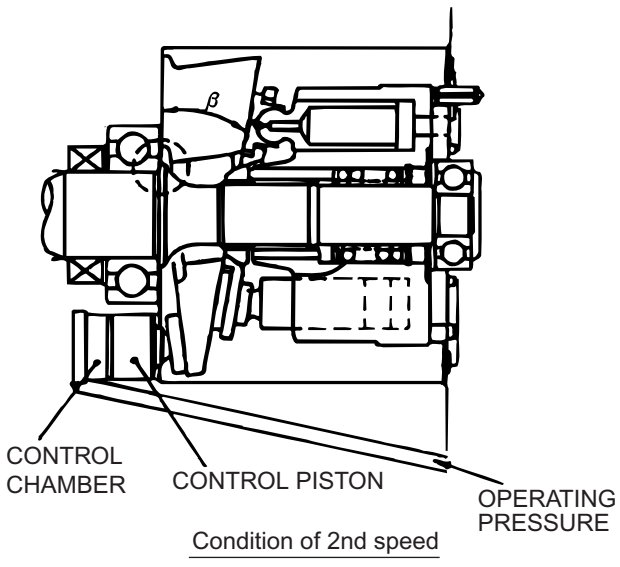
The swash plate has two faces, I and II, on the opposite face on which the piston shoes are sliding, and is supported by two balls which are fixed to the body.

Since the balls are eccentrically provided above the center line of the shaft, at the case of 1st speed, the combined force of the pressure oil exerted to the piston and the spring in the cylinder barrel pushes "I" face to the body, making the slant angle of the swash plate to Éø causing a large displacement. When the switch for 2nd speed is set on, the pressurized oil is led into the control room through the solenoid valve and the 2nd speed spool. Then the control piston pushes the swash plate to move it up to getting contact of "II" face with the body, and fix the swash plate with the slant angle of É¿ causing a small displacement. While the engine is at a standstill, the control room is connected to the drain port through the 2nd speed spool. Then the swash plate is returned the 1st speed position by the spring force. Therefore, the travel motor is always set at 1st speed at every start-up of the engine.



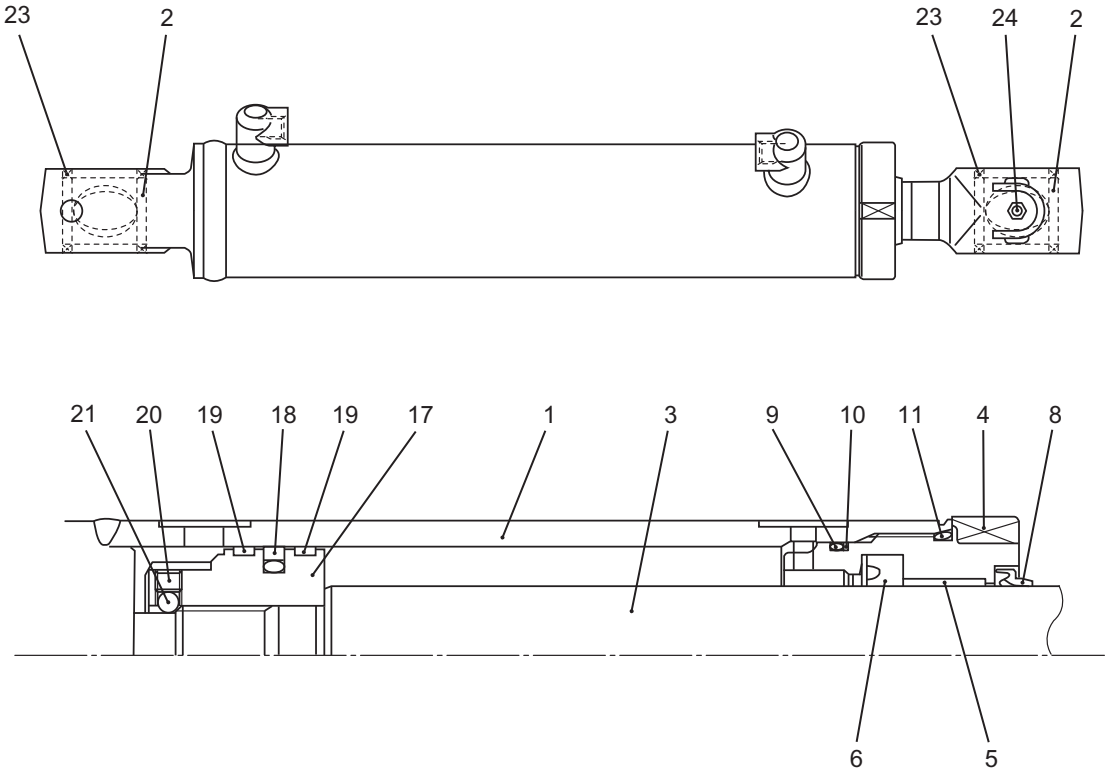
Structure of Hydraulic Motor





Hydraulic motor operation

(4) Swing cylinder



Construction of swing cylinder

No.	NAME	Q'TY	No.	NAME	Q'TY	No.	NAME	Q'TY
1	CYLINDER TUBE ASSY	1	8	WIPER RING	1	19	SLIDE RING	2
2	PIN BUSHING	2	9	O-RING	1	20	SETSCREW	1
3	PISTON ROD ASSY	1	10	BACK-UP RING	1	21	STEEL BALL	1
4	CYLINDER HEAD	1	11	O-RING	1	23	DUST SEAL	4
5	BUSHING	1	17	PISTON	1	24	GREASE NIPPLE	1
6	U-RING	1	18	SEAL RING ASSY	1			

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

E-8

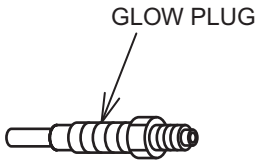
GLOW PLUG

VA30L66-00302

E/G stsrter

PU08-05001~
PU09-08001~

MITSUBISHI Part No.	VA30L66-00302
Rated voltage	DC11V
Rated current	9.5A



E-12

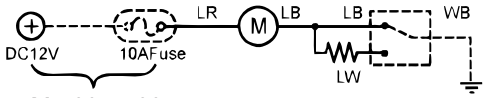
Heater

PM21M00005F1

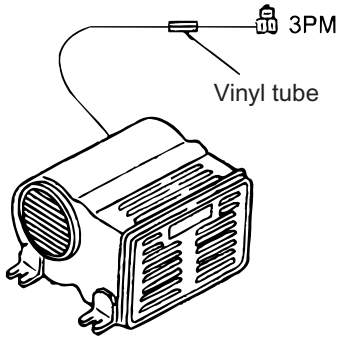
Heating (OPT)

PW12-40001~
PX13-15001~
PM09-09001~
PV12-31001~
PU08-05001~
PU09-08001~

ELECTRIC CIRCUIT



Machine side



E-13

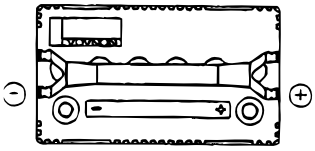
Battery

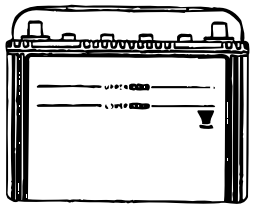
PU72S00014P1

Power source

PU08-05001~
PU09-08001~

Type	60B24L
Rated voltage	DC12V
Capacity	38Ah/5HR
Weight	12.7kg (28lbs)





E-14

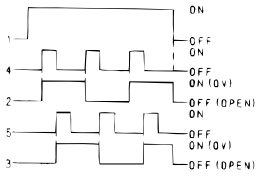
Relay

PA24S00002P3

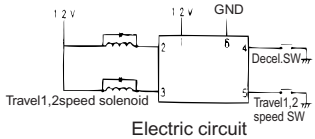
Sequence
(Holding circuit)

PW12-40001~
PX13-15001~
PM08-08501~
PV11-30001~
PU08-05001~
PU09-08001~

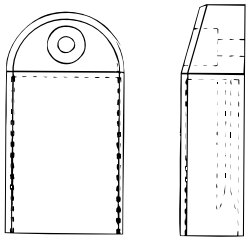
Rated voltage	DC12V

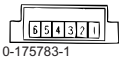


Input/output operation



Electric circuit



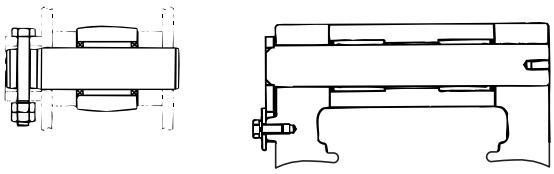


AMP : 0-175783-1
Mating connector : 0-174923-1
Terminal : 175027-1

Pin arrangement

(6) Removal of Arm Cylinder

1. Removing the capscrew and nuts that are preventing the head pin (D) from coming out, remove the pin (D).
   Tools: Spanner: 17mm
2. Applying a nylon sling to the tube of arm cylinder, remove the arm cylinder.
   Weight :18kg (40 lbs)



PIN (D) PORTION PIN (A) PORTION

Sectional view of Installing Pin

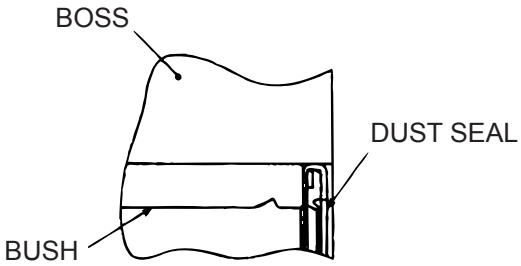
32.1.4.2 INSTALLATION OF BOOM

Installation is performed in the reverse order of removal, including the following.

CAUTION

- At the alignment of pin positions, never insert your finger into the bores.
- Make sure to align them with visual confirmation.

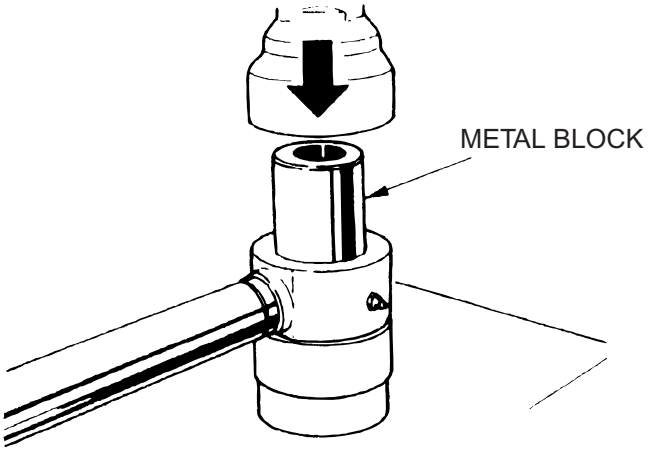
(1) Make clean the welded area on each of structure to inspect any cracks there.
(2) Check the dust seal for damages, and replace the faulty dust seal to new one (See Fig. "Dust seal installation").
(3) Referring to the Section "ATTACHMENT DIMENSIONS" of Specifications, replace the worn-out pin and bush to new ones.



Dust seal installation

(4) Before inserting the pin, apply grease to the shaft area.
(5) Referring to right Fig., install the capscrew and nuts to prevent the pin from coming out.
   Tools: Spanner: 17mm
(6) Make sure to provide an appropriate clearance for thrust direction at the installation of pin referring to (See Fig. "Sectional view of Installing Pin").
(7) For the adjustment for clearance, insert resin (plastic) shim first, then adjust the clearance with steel shims.

2. Remove the pin bushing (2).
   - Using a metal block, push it out with a press machine.

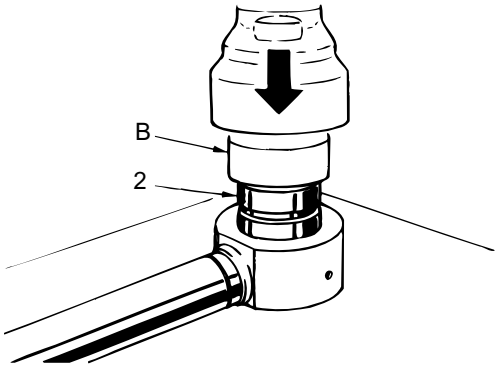


Removing pin bushing

32.2.1.5 ASSEMBLY

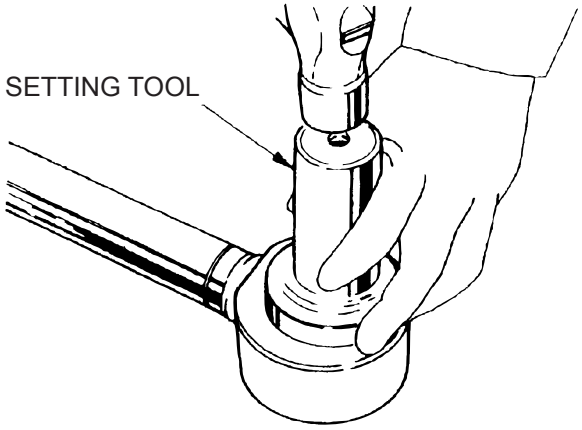
(1) Assembling Clevis Portion

1. With the installing jig (B) shown Item 32.2.1.7, press the bushings (2) into the piston rod assy (3) and tube assy (1).
   - Prior to the work, apply hydraulic oil on the surface of parts.



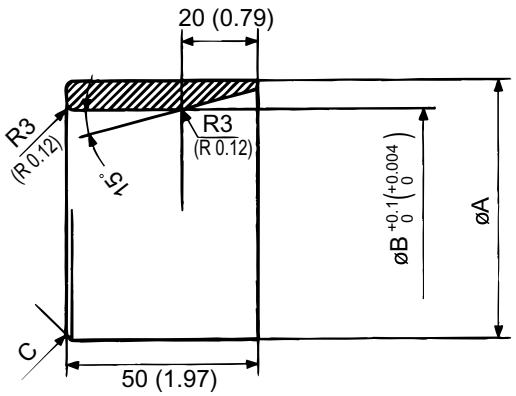
Installing Pin Bushing

2. With the setting tool, install the dust seal (23).



Installing Dust Seal

(5) Reforming Jig (E) for Seal Ring (18)



Material : STKM13C or carbon steel tube

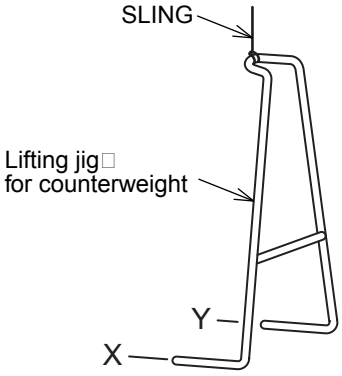
Unit : mm (in)

Applicable Cylinder	Dimension	
(Tube dia ; ø50 (1.97)) Bucket	A	65.0 (2.32)
	B	50.0 (1.79)
(Tube dia ; ø55 (2.17)) Crawler width	A	70.0 (2.50)
	B	55.0 (2.17)
(Tube dia ; ø60 (2.36)) Boom Arm Dozer	A	75.0 (2.68)
	B	60.0 (2.36)
(Tube dia ; ø65 (2.56)) Swing	A	80.0 (2.86)
	B	65.0 (2.56)

33.1.3 COUNTERWEIGHT

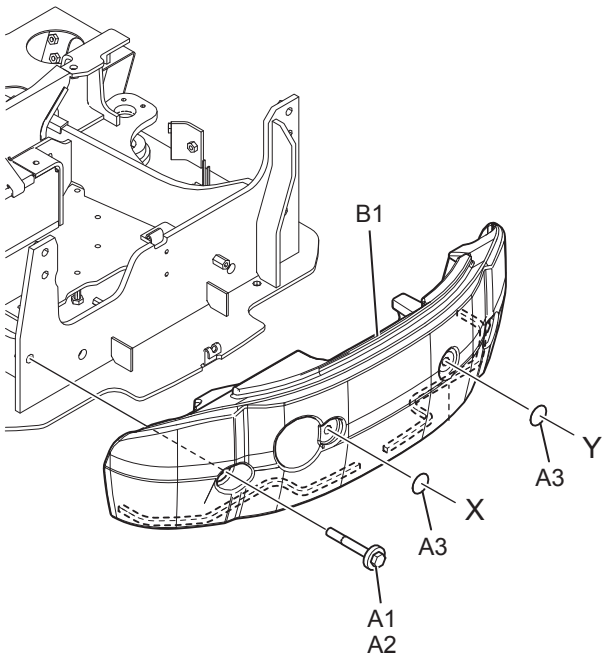
33.1.3.1 REMOVAL PREPARATION

(1) Remove the bonnet assembly (2) (See Section 33.1.2.1-(1)).
(2) (2) Lifting tools preparation
- Lifting jigs for counterweight (see Tool list)
- Wire rope (Nylon sling)



33.1.3.2 REMOVAL

(1) Remove the plate (A3) 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 : 120 kg (265 lbs)
(3) Loosen two M16X120 capscrews (A1).
Tools: Socket: 24 mm
(4) Remove counterweight (B1).



Counterweight removal

WARNING

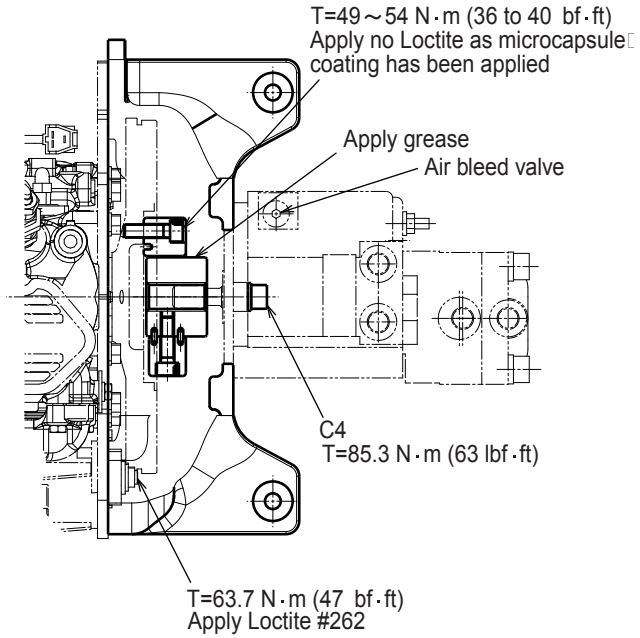
Exercise extra care to prevent the counterweight from falling off from the lifting jig.

33.1.9.3 INSTALLATION

Install the pump in reverse order of the removal according to the tightening torque and sealant instructions.

(1) Apply grease to the spline part of the pump input shaft.
Grease : Shell Retinax AM Grease or equivalent (Molybdenum disulfide extreme pressure multipurpose grease)
(2) Insert the pump spline part to the coupling.
(3) (3) Fix the pump by the capscrew (A3).
Tools: Allen wrench: Ball joint type 10 mm
(4) Install the main pump delivery hoses (2), (3), and (4), and the pilot delivery hose (C2) (See Fig. "Pump removal").

		Tightening torque N•m (lbf•ft)	
Thread size (PF)	Spanner used (mm)	O-ring type fitting	30º flare type fitting
3/8	22	73.5 (54)	49.0 (36)
1/2	27	108 (80)	78.5 (58)



Pump installation

(5) Tighten the capscrew (18) to install the suction tube (9).
Tools: Allen wrench: 8mm
(6) When the suction hose (9) is removed, apply sealant on the inserted portion of the hose and fix the tube with the clip (11). (See Fig. "Pump removal")
Tools: Minus screwdriver
T=5.5 N-m (4.1 lbf-ft)
(7) Supply the tank with hydraulic oil (approx. 9 liters (2.4 gal)).
(8) Loosen the air bleed valve of the pump to release air from the casing, and fill it with hydraulic oil (See Fig. "Pump installation").
(9) Reinstall each component removed in the above removal preparation.
(10)After starting the engine, release air (See Section 33.1.7.3).

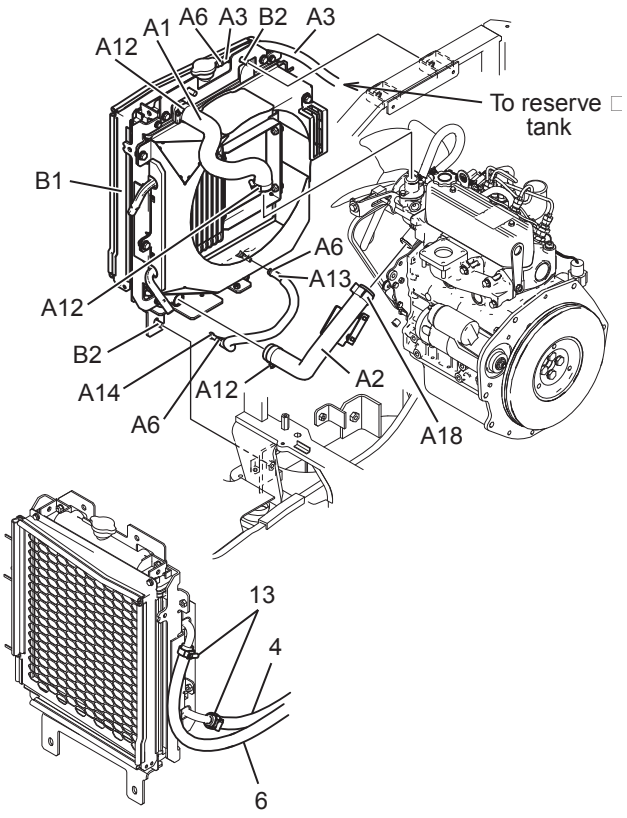
33.1.15 RADIATOR

33.1.15.1 DISASSEMBLY PREPARATION

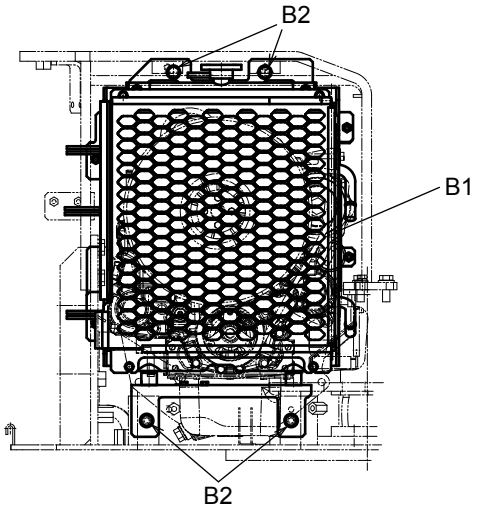
(1) Remove the right side cover assemblies (3) and the bonnet assembly (2) (See Section 33.1.2).
(2) Remove the counterweight (See Section 33.1.3).
- In order to facilitate the work, remove the related covers and components if necessary.

33.1.15.2 DISASSEMBLY

(1) Draining water form radiator
1.
Remove the radiator cap.
2.
Loosen the clip (A6), then remove the plug (A14) to drain water.
Volume : Approx. 1.9 litters (0.50 gal)
(2) Draining hydraulic oil in oil cooler
1.
Release the pressure in the hydraulic circuit.
2.
Remove the oil cooler hoses (4) and (6), and then plug the inlet/outlet ports of the oil cooler and the openings of the hoses.
(3) Disconnect the hose (A3) of reserve tank by removing the clip (A6).
(4) Remove the radiator hoses (A1) and (A2) fixed by clip (A12) and (A18).
Tools : Cutting pliers and minus screwdriver
(5) Removing radiator
Loosen four M10X25 (B2) sems-bolts to remove the radiator assembly (B1).
Tools: Socket: 17 mm
Weight : 2 kg (4.4 lbs)



Radiator disassembly



Radiator disassembly

(3) Removing engine

CAUTION

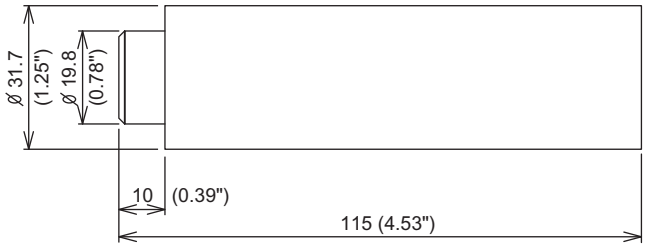
Prepare a worktable capable of enduring the weight of the engine and stably receiving the removed engine.

1. Removing nuts (B9) for mounting engine
   Loosen the nuts (B9) fixing the engine on the rubber mount (B5) and (B6) and remove them with the washer (B10).
   Tools: Spanner, Socket: 17 mm
2. Lifting engine
   Pass a wire rope through the two lifting eyes at the top of the engine and lift the engine.
   Weight : Approx. 71 kg (157 lbs)
3. Place the engine stably on the worktable.

33.2.1.2 DISASSEMBLY AND ASSEMBLY

33.2.1.2.1 Tools and Jig

Tool name	Size	Qty
Hexagon wrench	4.8 mm	1 each
Circlip plyer	For hole	1
Spanner wrench	13 mm	1
Resin hammer		1
Special tooling for oil seal	See below	1
Seal kit		1 Set
Grease		Small amount

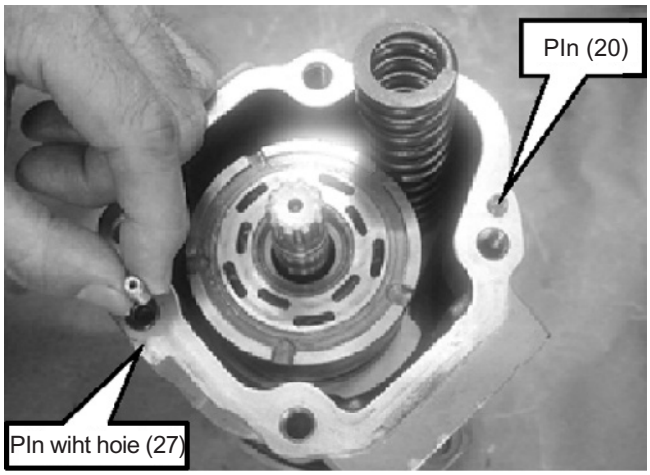


Special tooling for oil seal

33.2.1.2.2 Cautions during Assembling and Dissembling

(1) The disassembling and assembling works are to be carried out in a clean place, providing clean containers to place the disassembled parts in.
(2) Before disassembling, make around the ports clean and remove the paint around each joint with a wire brush.
(3) Clean each of the disassembled parts with a washing oil.
(4) Put a matching mark on each of the mating parts so that they shall be installed to the original positions.
(5) Replace all the seals with new one at every disassembly.
(6) Check each part for abnormal wear and seizure, remove sharp edges and burrs with a sand paper, etc., if any.
(7) Avoid to adjust each adjusting screw, except the necessity.

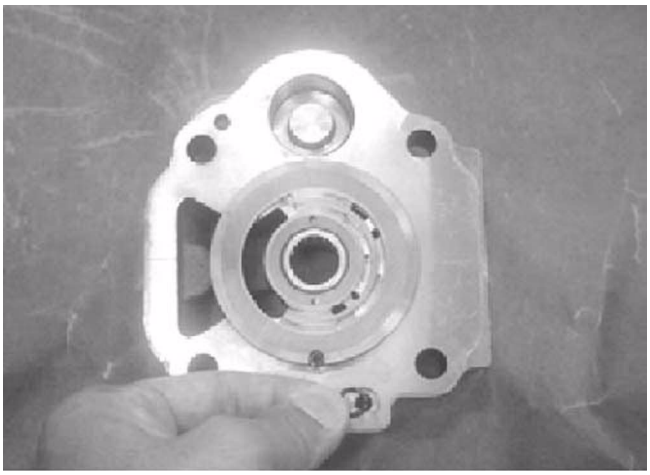
2.
Set pin (20) and pin (27) on body S (1).



CAUTION

Pay attention to the position of each pin. Pin (27) has a hole.

3.
Place O-ring (40) on body H (2).



CAUTION

Use new O-ring for assembling.

(2) Relief valve (Code : RV)

How to remove overload relief valve (Code : ORV)

First, fix the valve on the work bench or ask people to hold down the valve. Then, loosen the hexagonal section (opposing flat, 22) of RV and ORV with spanner of 22 mm. At that time, don't remove the valves applying spanner to the opposing flat, 19.

WARNING

The set pressure of the RV and ORV differs at the position, so tag every valve with respective attaching position. And handle the removed RV and ORV paying attention not to damage the seat section.

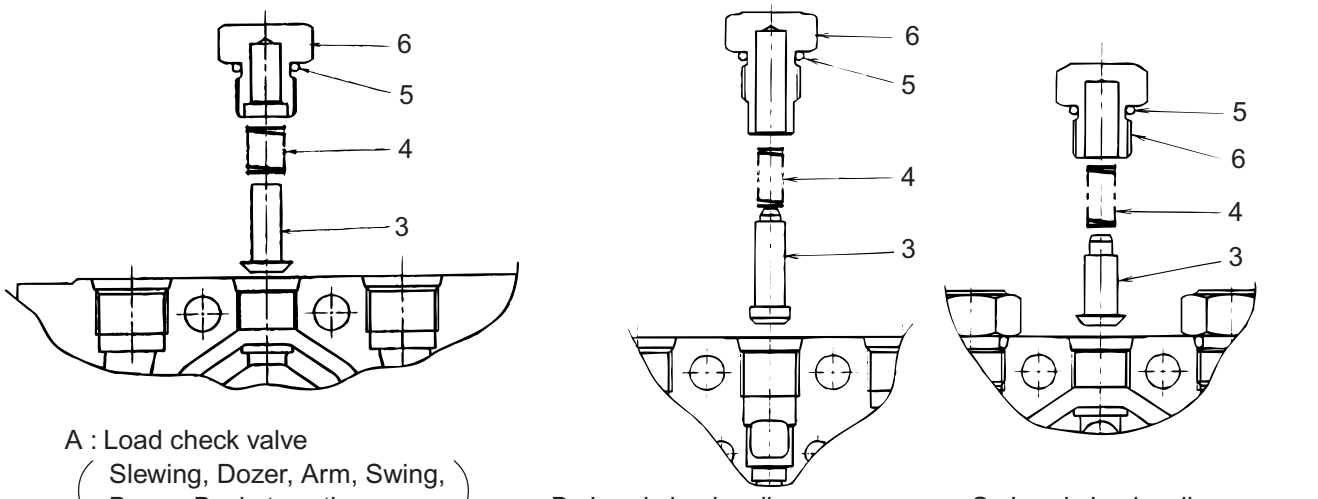
The RV and ORV are essential for the performance and safety, but don't disassemble the RV and ORV because it is very difficult to reset the pressure. When there is a failure, replace the assembly.

(3) How to disassemble load check valve

First, fix the valve on the work bench, or ask people to hold down the valve in order to keep it from moving. Loosen plug (6) at the center of the valve upper surface with spanner of 19 mm (or socket wrench).

It may be difficult to loosen the plug because O-ring gets caught in the thread. Then, don't force it to loosen, but tighten the plug once again and loosen it again. Take out spring (4), load check valve (3) through the hole used to remove the plug with tweezers or magnet.

The item numbers in Fig. "Load check valve" correspond to that of the slewing section in Fig. 33.2.1-2-(2). The travel switching, valve and service switching sections having different forms can be disassembled in the same manner.



A : Load check valve
(Slewing, Dozer, Arm, Swing, Boom, Bucket section)

B : Load check valbe
(Travel right and left switching, P3 supply sections)

C : Load check valbe
(Service switching section)

Load check valve

(5) Assembling relief valve and overload relief valve

The relief valve is essential for the performance and safety, and it is very difficult to reset the pressure. Therefore, in case of the abnormality, replace it with a new assembly.

The assembling procedures described below are only for reference after disassembling to investigate the cause for abnormality.

The figures in parentheses following the part names in the description are the item numbers in the cross-sectional drawing.

First, place spring guide (16) in adjusting screw (7) and then place spring (9) in.

Then, shake the adjusting screw lightly and be sure that the interference of spring guide (16) and spring (9) is sufficiently ensured. If the interference is insufficient, spring (9) pops out or the protrusion from adjusting screw (7) becomes larger. Thereafter fit poppet (6) in plug (4) and tighten adjusting screw (7) {spring guide (16), spring (9) are already fitted.} lightly.

At that time, tighten lock nut M14 (8) lightly. And place spring (10) and piston (3) in poppet (2), and place it in socket (1). And tighten body (5) and plug (4) to the specified torque after checking that piston (3) is inserted in the hole of the top end of plug (4).

T=58.8 N-m (43 lbf-ft)

And adjust the pressure by adjusting screw (7) with Allen wrench of 4 mm, and tighten lock nut M14 (8) to the specified torque.

T=19.6 N-m (14 lbf-ft)

Assemble the relief valves in the reverse procedure of the disassembly paying attention to the direction and order and observing the specified torque. Failure to do so may result in oil leakage or breakage.

(6) Assembling anticavitation valve

The anticavitation valve is essential for the performance and safety, so in case of abnormality replace it with a assembly.

For reference, the procedure for disassembly and assembly is shown below.

The figures in parentheses following the part names in the description are the item numbers in the cross-sectional drawing.

First, place anti cavitation valve (1) in body (2), and place spring (4) in it. Then tighten the plug to the specified torque.

T=58.8 N-m (43 lbf-ft)

Assemble the anti cavitation valve by the reverse procedure of the disassembly paying attention to the direction and order and observing the specified torque.

Failure to do so may result in oil leakage or breakage.

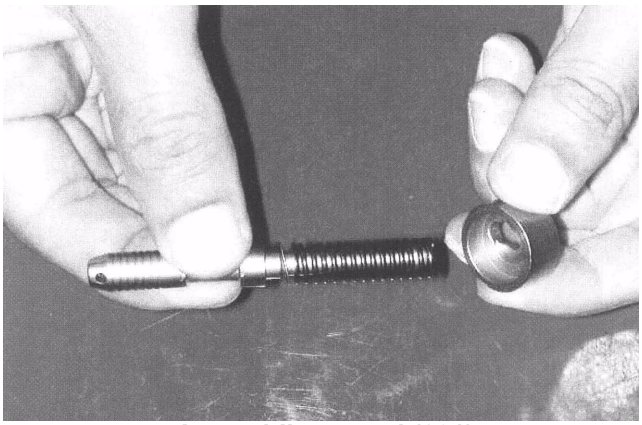
33.2.3.4 Assembling procedures

33.2.3.4.1 General cautions for assembling work

(1) General cautions for assembling work are almost similar to that for disassembling work.
(2) Remove metal chips or foreign substances from all the parts and ensure that the parts have no burrs or flaw prior to assembly. Remove burrs or flaw if any, using oil stone.
(3) Replace the O-rings and back-up rings with new ones in principle.
(4) Be careful not to damage the O-rings and back-up rings when fitting them. (Apply a small amount of grease to fit them smoothly.)
(5) Apply grease to the parts to be installed in order to prevent them from dropping.
(6) Tighten screws at the torque specified in tightening torque tabe. Watch the torque using a torque wrench.
(7) After finishing the assembly, screw blind plugs in all the ports to prevent dust intrusion.

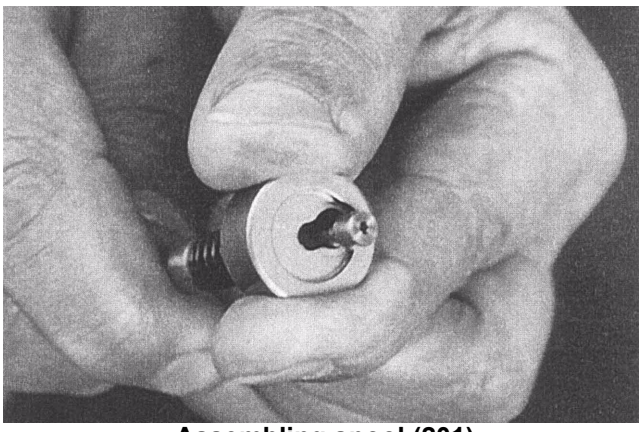
33.2.3.4.2 Assembly

(1)
Insert the washer (217), secondary pressure spring (241), and spring seat (216) to the spool (201) in this order.



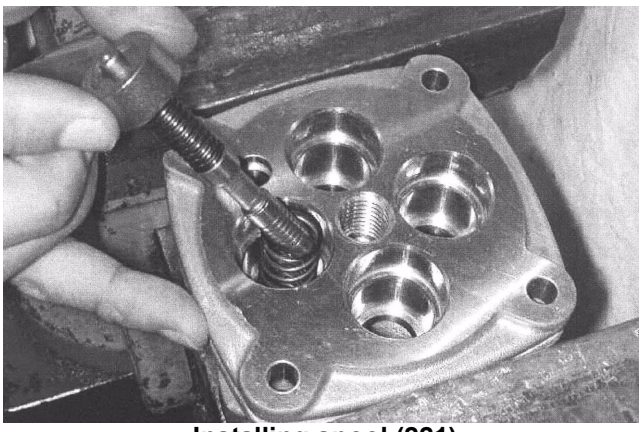
Assembling spool (201)

(2)
Shift the spring seat (216) laterally while pushing in the spring seat (216) to make the secondary pressure spring (241) deflect, and install the valve to the spool (201) through the larger hole.
-Do not push down the spring seat by more than 6 mm (0.24").



Assembling spool (201)

(3)
Install the return spring (211) into the casing (101).
Install the pressure reducing valve assembly into the casing (101).
-Install these parts into the position before disassembling.



Installing spool (221)

33.2.4.4 TROUBLESHOOTING

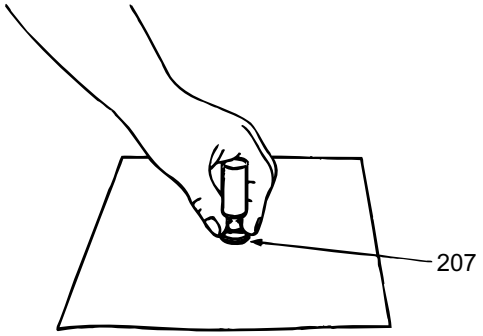
Phenomenon	Cause	Corrective action
Secondary pressure does not rise.	1. Insufficient primary pressure 2. Permanent set in fatigue of spring (324) for setting of secondary pressure. 3. The gap between spool and casing is too large. 4. The control section is loosened.	1. Secure primary pressure. 2. Replace it with new one. 3. Replace it with complete remote control valve. 4. Replace parts of control section.
Secondary pressure is unstable.	1. Sliding part is not smooth. 2. Variation of pressure of tank line 3. Air contamination in piping	1. Repair unsmooth section. 2. Return oil to oil tank directly. 3. Bleed air by operating several times.
Secondary pressure is high.	1. Pressure of tank line is high. 2. Sliding part is not smooth.	1. Return oil to oil tank directly. 2. Repair unsmooth section.
Damping does not work.	1. Air is accumulated in piston chamber. 2. Sliding part is not smooth. 3. Permanent set in fatigue of damping spring (336) 4. Gap between damping piston (224) and casing (damper) (102) is too large. 5. Malfunction of check valve 6. Orifice of damping piston (224) is too large.	1. Bleed air by operating several times. 2. Repair unsmooth section. 3. Replace it with new one. 4. Replace it with complete remote control valve. 5. Disassemble and check on check valve section. 6. Replace damping piston.
Damping torque is heavy.	1. Sliding part is not smooth. 2. Orifice of damping piston (224) is clogged.	1. Repair unsmooth section. 2. Repair or replace damping piston.

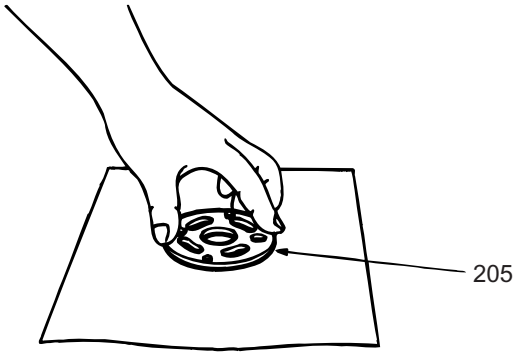
33.2.5.4 ASSEMBLY

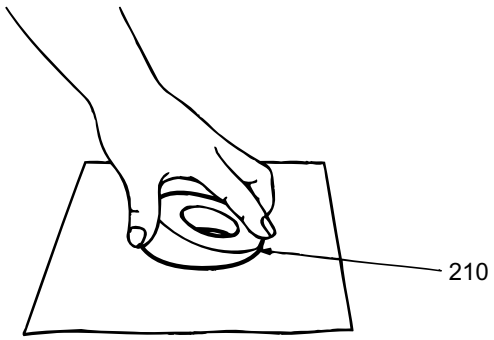
(1) Preparation for Assembly

Perform the following steps before assembly.

1. Inspect each part for damage caused during use or removal. If damaged, remove the damage with an oil stone or sandpaper, clean with light oil and dry with compressed air.
2. Replace all sealing parts with new ones.
3. Using #2000 sandpaper, lap the sliding surfaces of the piston shoe (207), valve plate (205) and swash plate (210) on a surface plate.
   - Apply clean hydraulic oil to each sliding surface before installation.
   - Install each piston assy (206) into the same piston bore in the cylinder barrel (204) from which it was removed.

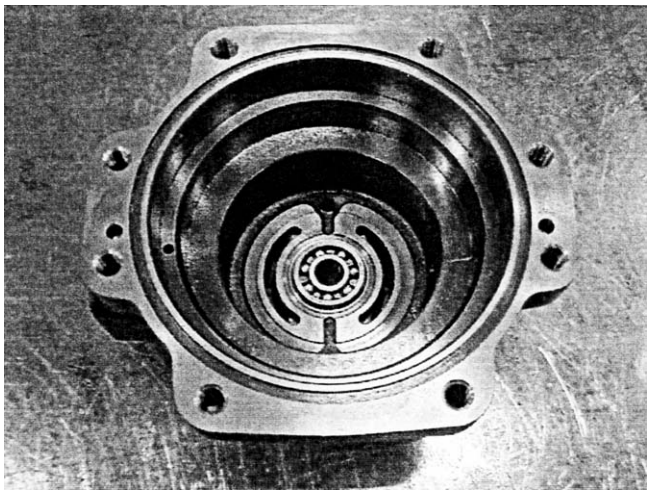




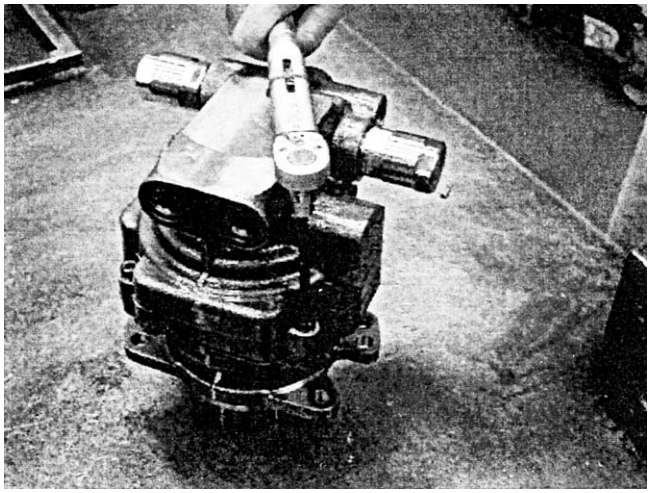


(2) Assembling Hydraulic motor

1. Press-fit the bearing (217) and spring pin (224) into the body H (201).



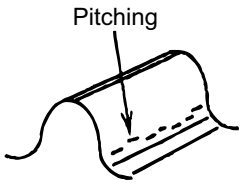
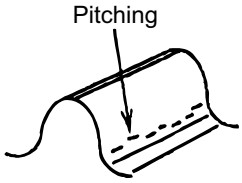
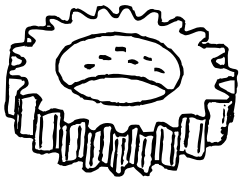
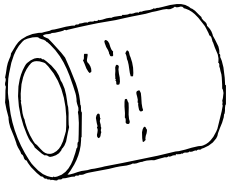
18. Join the hydraulic motor and the body, and them bolt them together with the socket bolts (124).
    Tools: Allen wrench: 6 mm
    Torque wrench : 29.4±2.9 N-m (21.7±2.1 lbf-ft)
    - Alibn the shaft of the motor to the b1 gears.
    - Apply anti-loose adhesive to the screws.



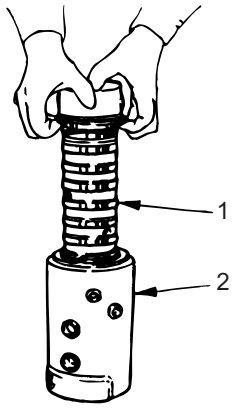
33.2.5.5 MAINTENANCE STANDARD

Replace each part referring to the list shown below.

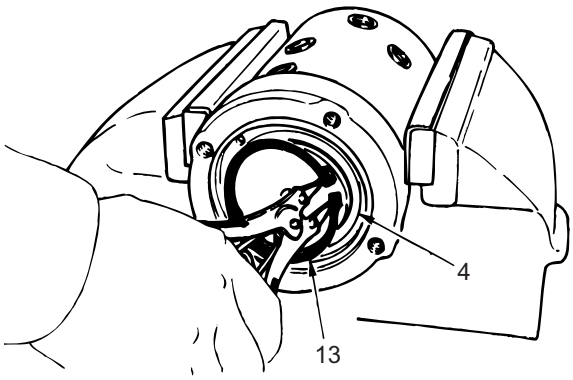
(1) Reduction gear section

Part	Extent of the damage	Inspection standard	Action
a internal gear (Body 101) Pinion gear (Pinion shaft 104)	Excessive wear of the surface	Pitching area 5% or more of the gear surface. 	Replace the pinion kit.
Carrier 1 (102)	Damage to spline section	By visual	Replace the carrier kit.
S1 gear (Shaft 203) b1 gear (106)	Excessive wear of the surface	Pitching area 5% or more of the gear surface. 	Replace the carrier kit.
	Excessive wear of the bearing surface	By visual Pitching, flaking 	
Ring (129)	Excessive wear of the bearing surface	By visual Pitching, flaking 	Replace the carrier kit.
Roller	Excessive wear of the bearing surface	By visual Pitching, flaking 	Replace the carrier kit.
Other (O–ring, screw, ect)	Damage, excessive rust		Replace each part.

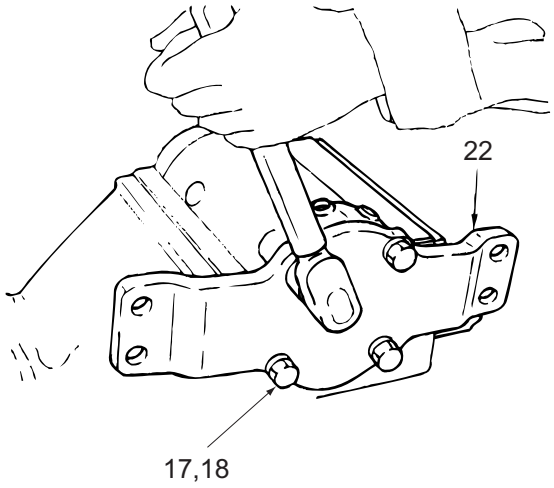
(5) Installing shaft (1) :
Insert the shaft (1) into the body (2) paying attention to the relative positioning of the shaft (1) and body (2).
- Thinly apply grease to outer periphery of the shaft (1).
- For the insertion of the shaft (1), evenly tap the shaft with a plastic hammer, paying attention not to give any damages to the seals.



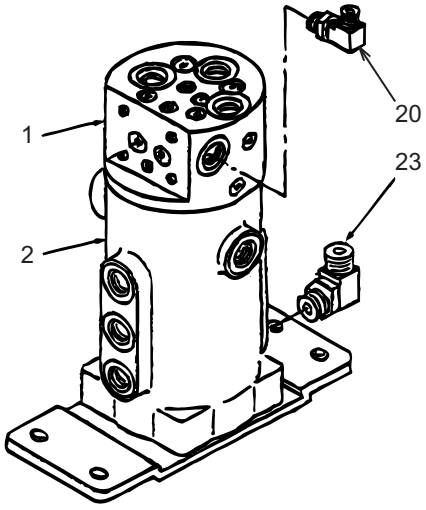
(6) Install the thrust ring (4) and snap ring (13).
- Ensure the fact that the snap ring (13) is securely positioned into the groove on the shaft (1).



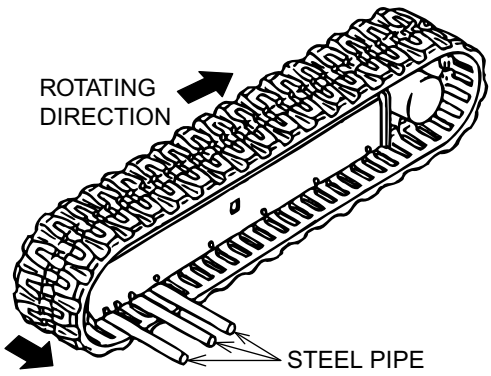
(7) Installing O-ring (10) and flange (22) :
1. Attach the O-ring (10) to the face of gasket on the body (2).
2. Install the flange (22) to the body (2) with the spring washer (18) and bolt (17).
Tools: Socket: 13 mm, T=27.4 N-m (20 lbf-ft)



(8) Installing hose adapters (20) and (23) :
When the hose adapters has been removed, install them to the shaft (1) and body (2) respectively with the specified tightening torque.
Tools: Spanner: 17 mm, T=29.4 N-m (22 lbf-ft)



3. Put steel pipes in the rubber crawler, turn the sprocket in the reverse direction slowly and when the rubber crawler has floated off the idler stop the rotating.
4. Slide the rubber crawler sideways, and remove it.

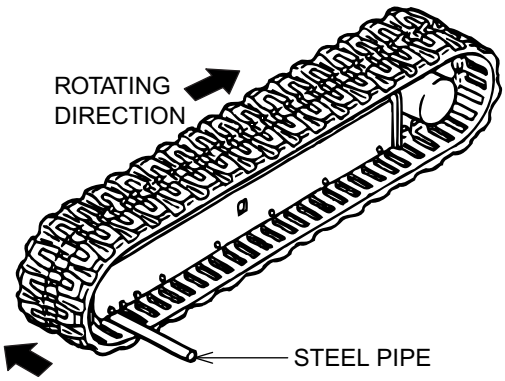


Removing rubber crawler

34.1.2.1.2 INSTALLING RUBBER CRAWLER

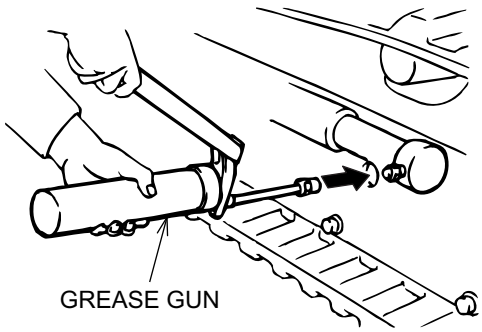
Installation work is performed in the reverse order of removal.

1. Engage the rubber crawler with the sprocket and mount it on the idler.
2. Put steel pipes in the rubber crawler, turn the sprocket in the reverse direction slowly and then the rubber crawler has floated off the idler, stop the rotating.
3. Slide the rubber crawler to the position to be set on idler exactly.



Installing rubber crawler

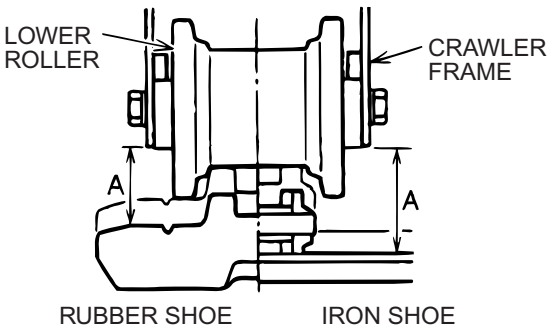
4. Confirm that the rubber crawler is engaged securely with the sprocket, idler and lower roller.
5. Tighten the grease nipple for the crawler adjuster, and adjust tension by feeding grease.
   Tools : Socket : 19mm,
   T=59 N-m (44 lbf-ft)



Feeding grease

Rubber shoe
Appropriate tension A : 45~50 mm (1.77~1.97 in)

Steel shoe
Appropriate tension A : 90~95mm (3.54~3.74 in)



Crawler tension

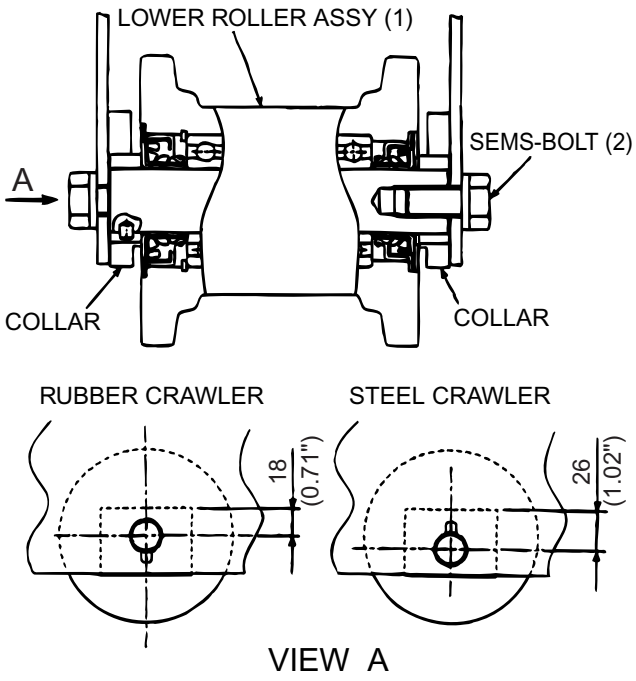
34.1.4.1.2 Installing

(1) Coat the mounting sems-bolt (2) with Loctite #262 in advance.

(2) Place the roller assembly (1) between the crawler and lower frame.
Fasten the sems-bolt (2) temporarily.
Tools : Socket : 19mm

(3) Lower the machine in full contact with the ground and tighten the sems-bolt (2) as specified.
Tools : Socket : 19mm, T=115 N-m (85 lbf-ft)

(4) Tighten the grease nipple of the crawler adjuster.
Lift the machine, and adjust the crawler tension by feeding grease.
Tools : Socket : 19mm, T=59 N-m (44 lbf-ft)



Installing lower roller

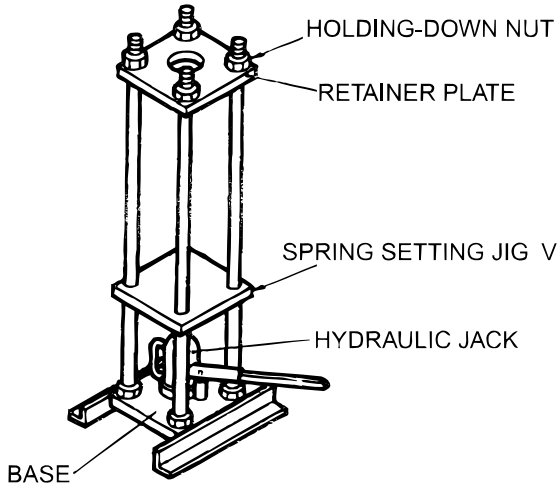
CAUTION

Select the position of collars according to kind of crawlers.

34.1.6.3 DISASSEMBLY AND ASSEMBLY

34.1.6.3.1 Disassembly

(1) Before disassembling and assembling the idler adjuster assembly, prepare spring setting jig (V).
Capacity of hydraulic jack : more than 5 tons (11000 lbf)

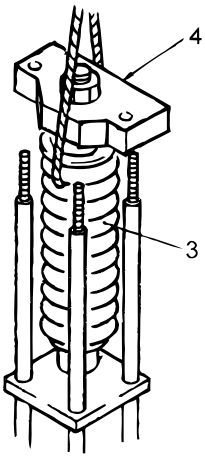


Spring set special jig (V)

WARNING

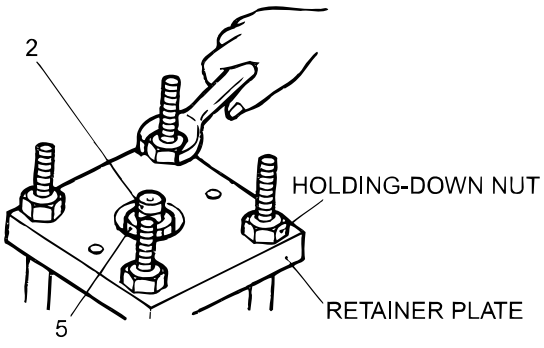
Large power is needed to set the spring. Prepare a special jig before disassembly and assembly.

(2) Place a hydraulic jack between the jig base and the stand.
(3) Loosen the holding-down nuts of the jig and draw out the retainer upward.
(4) Draw out piston (1) from grease cylinder (2) of the idler adjuster assembly.
(5) Taken out oil seal (10), O-ring (11) and back up ring (12) from grease cylinder (2).



Slinging work of idler adjuster

(6) Set the idler adjuster assembly on the stand of the jig (V), with its braket (4) side facing up.
(7) Fit retainer plate to braket (4) tighten holdingdown nuts alternately, and secure idler adjuster assembly.



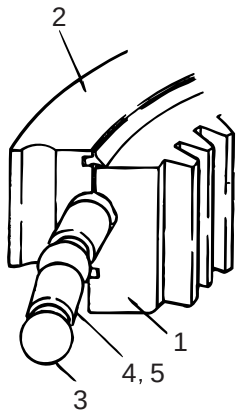
Fixing Holding-down nut

34.1.9.3.2 Assembling

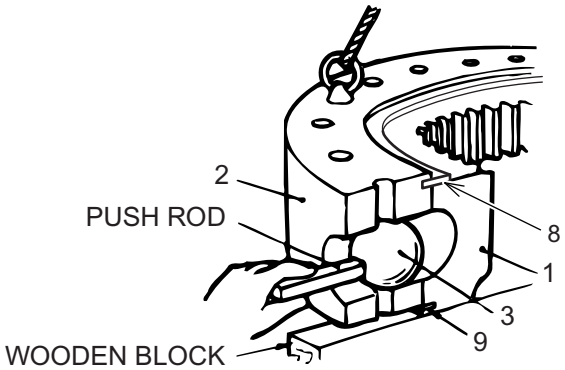
(1) Degrease thoroughly the groove for seal A (8) located in the inner circumference of outer race (2) and the groove for seal B (9) located in the outer circumference of inner race (1). Coat the grooves with adhesive Cyano Bond PO-1, fit seal B (9), and place inner race (1) on a surface table.

(2) Lift and lower outer race (2) slowly till the top surface of inner race (1) matches the bottom of the sealing groove of outer race (2). Place an adjusting washer under outer race (2) in order to support the outer race so the track surface of ball (3) is aligned.

(3) Insert balls (3) and spacers (4) (5) coating with grease (NLGI No.2 Lithium bace with MoS2) alternately through the hole for plug (6) on outer race (2).



Removing balls / spacers



Installing balls

WARNING

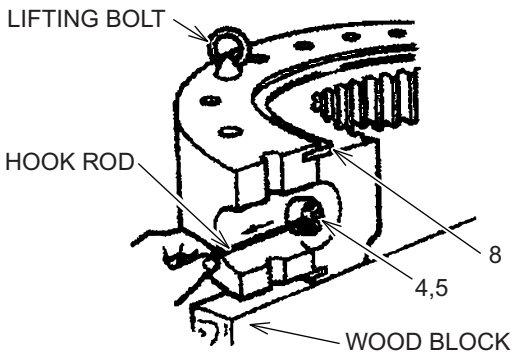
When forwarding balls (3) and spacers (4) (5), the raceways must be aligned completely. To achieve it, outer race (2) should be adjusted. It is very dangerous to put your finger into the plug bore directly ; always use a push rod or a hooked rod.

(4) Install plug (6) to outer race (2), confirming the direction and the position of the bore for taper pin (7).

(5) Push taper pin (7) into bore, and caulk the head of the taper pin with a punch.

(6) Coat seal A (8) with adhesive (Cyano Bond PO-1) and place it into groove of outer race (2).

(7) Confirm that grease nipple (10) is useful. Apply grease (NLGI-2 Ep type) and confirm that the outer race rotates smootkly and that the lip of the seal is not scored.
Grease amount : Approx. 50 g (1.8 oz)

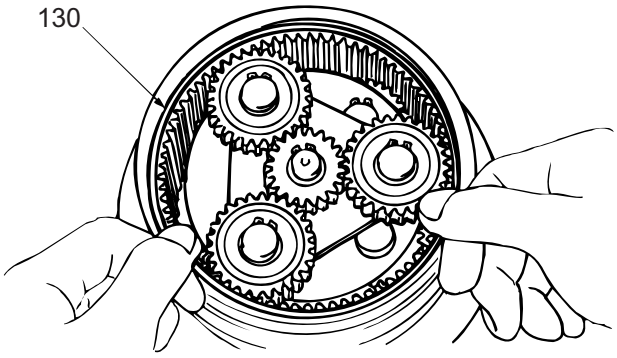


Installing spacer

34.1.9.4 MAINTENANCE STANDARDS

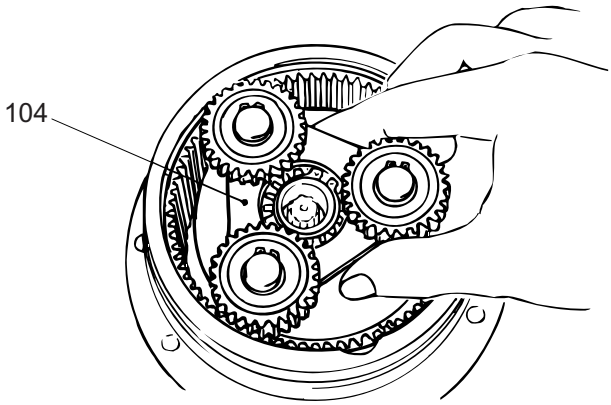
Regarding the maintenance standards for the wear of the slewing bearing, refer to the Article Measuring Slewing Performances in PM13 Maintenance Standards and Test Procedures.

5. Remove the O-ring (130).



O-ring (130) removal

6. Remove the carrier 2 (104) assy.



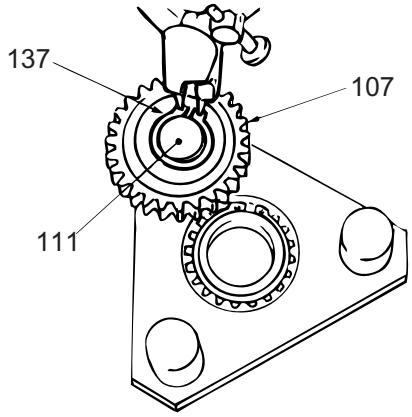
Removing carrier 2 (104) assy

7. Disassembling carrier 2

a. Remove the snap ring (137) from the B2 pin (111).

b. Remove the thrust washer (121), the B2-gear (107), the needle (117) and the thrust washer (121) one after another.

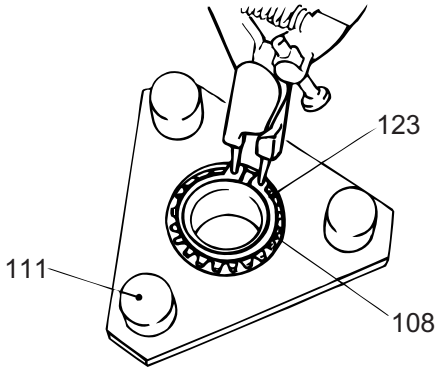
   - Quantity
   Needle (117): 13/B2-gear: 1



Snap ring (137) removal

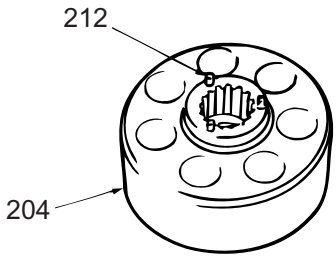
c. Remove the snap ring (123), and then the S1 gear (108).

   - The B2 pin (111) is pressed in. Unnecessary disassembly should be avoided.



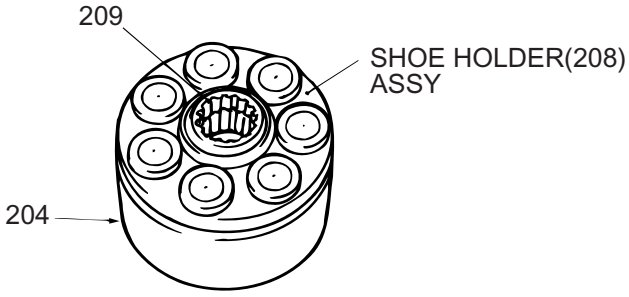
Snap ring (123) removal

15.Assembling cylinder barrel (204)
a. Insert three pins (212) to the cylinder barrel (204).



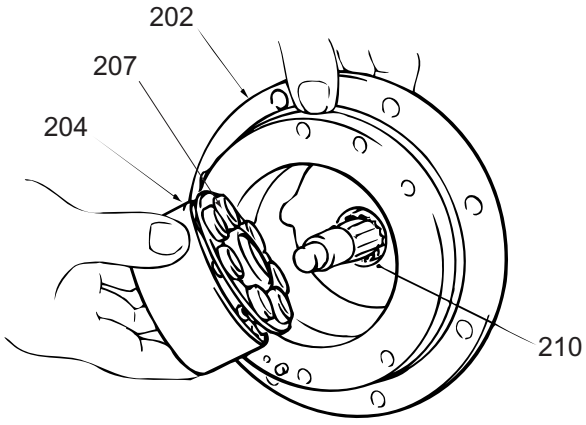
Pin (212) installation

b. Install the barrel holder (209).
c. Further install the shoe holder assy (208) to complete the cylinder barrel assy (204).
- Apply hydraulic oil on the 7-bore of cylinder barrel.



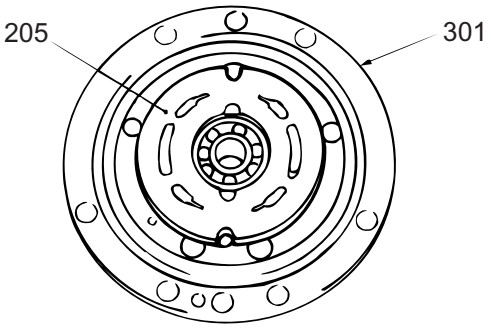
Cylinder barrel (204) assy

16.Insert the cylinder barrel (204) assy into the body 2 (202) till the shoe (207) contacts with the swash plate (210).



Installing cylinder barrel (204) assy

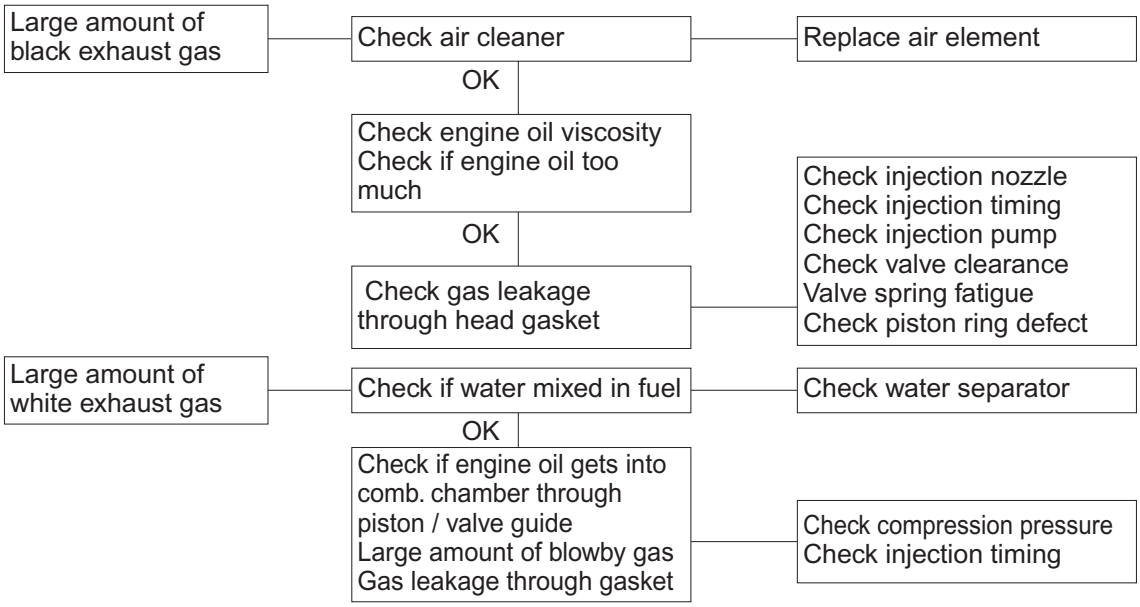
17.Install the valve plate (205) to the body 1 (301).
- Install so that the copper surface of the valve plate (205) is directed upward [cylinder barrel (204) side].
- Apply hydraulic oil on the slide surface (copper surface) of the valve plate (205).
- Apply grease on the reverse side of the valve plate (steel surface) to prevent it from dropping.



Valve plate (205) installation

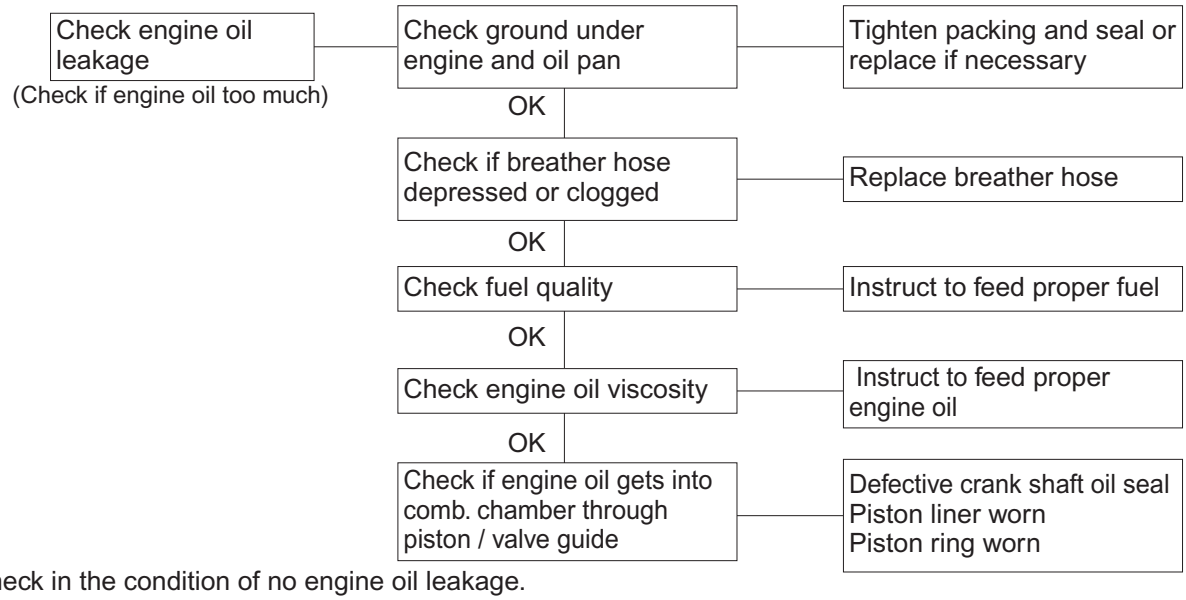
44.2.4 OTHER TROUBLE

44.2.4.1 EXHAUS TROUBLE



Note: Check in the condition at engine coolant temperature of more than 50ºC. (122ºF)

44.2.4.2 EXCESSIVE OIL CONSUMPTION



Note: Check in the condition of no engine oil leakage.

Terms Used in This Manual

Nominal

means the rated (design) size or magnitude of a part to be measured.

Standard

means the quantitative requirement for dimension of a part, clearance between parts and performance. This is given in a form of tolerance. Therfore, the values shown are not in agreement with the design values.

Limit

means that, if this value is reached, the part must be repaired or replaced with a new part.

Abbreviations

- BTDC: Before Top Dead Center
- ATDC: After Top Dead Center
- BBDC: Before Bottom Dead Center
- ABDC: After Bottom Dead Center
- TIR: Total Indicated Runout
- API: American Petroleum Institute
- ASTM: American Society for Testing and Materials
- JIS: Japanese Industrial Standards
- LLC: Long Life Coolant
- MIL: Military Specifications and Standards (U.S.)
- MSDS: Material Safety Data Sheet
- SAE: Society of Automotive Engineers (U.S.)

Units of Measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in parentheses {}. For metric conversion, the following rates are used.

- Pressure: 1 MPa ＝ 10.197 kgf/cm^2
- Torque: 1 N·m ＝ 0.10197 kgf·m
- Force: 1 N = 0.10197 kgf
- Horsepower: 1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury: 1 kPa = 0.7 cmHg
- Meter of water: 1 kPa ＝ 10.197 cmH_2O (cmAq)
- Rotational speed: 1min^{-1} ＝ 1 rpm

1. Maintenance service data

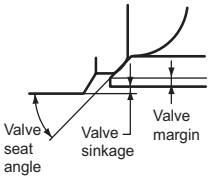
1.1 General

Table 2-1 Maintenance service data table - General Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Maximum rotation speed (rated rotation speed used as reference)		$2350\ ^{+50}_{+0}$ min^{-1}			Adjust governor setting.
Minimum rotation speed					
Compression pressure (at 280 min^{-1})			2.7 MPa {28 kgf/cm²} [398 psi]	Not acceptable at or below 2.2 MPa {22 kgf/cm²} [313 psi]	When oil and water temperatures at 20 to 30 C [68 to 86 F]
Lubricating oil pressure	Rotated speed		0.29 to 0.39 MPa {3 to 4 kgf/cm²} [42.7 to 56.9 psi]		Oil temperature at 60 to 70 C [140 to 158 F]
	Low idling		0.10 MPa {1.0 kgf/cm²} [14.2 psi]		
Valve timing	Inlet Open		BTDC 18		Values for checking valve timing Different from actual valve opening and closing timing
	Inlet Close		ABDC 46		
	Exhaust Open		BBDC 46		
	Exhaust Close		ATDC 18		
Valve clearance	Inlet		0.25 [0.0098]		When engine is cold
	Exhaust		0.25 [0.0098]		
Fuel injection timing (before TDC)			BTDC 15		

1.2 Engine main part

Table 2-2 Maintenance service data table - Engine main part (1 / 3) Unit: mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Rocker	Rocker arm inside diameter		ø 12 [0.47]	12.013 to 12.035 [0.4730 to 0.4738]		
	Rocker shaft outside diameter		ø 12 [0.47]	11.470 to 11.984 [0.4516 to 0.4718]		
	Clearance betweenrocker arm and rocker shaft			0.029 to 0.065 [0.0011 to 0.0026]	0.2 [0.0079]	Replace rocker arm
Valve	Valve stem outside diameter	Inlet	ø 6.6 [0.259]	6.565 to 6.580 [0.2587 to 0.2593]	6.500 [0.2561]	
		Exhaust	ø 6.6 [0.259]	6.530 to 6.550 [0.2573 to 0.2581]	6.500 [0.2561]	
	Valve guide inside diameter	Inlet	ø 6.6 [0.259]	6.600 to 6.615 [0.2601 to 0.2606]		
		Exhaust				
	Clearance between valve stem and valve guide	Inlet		0.020 to 0.050 [0.0008 to 0.0020]	0.10 [0.0040]	Replace valve and valve guide
		Exhaust		0.050 to 0.085 [0.0020 to 0.0034]	0.15 [0.0059]	
Valve seat and valve	Valve seat angle		44			
	Valve sinkage		0.5 [0.020]	0.4 to 0.6 [0.016 to 0.024]		
	Valve margin			1.0 [0.040]	0.5 [0.020]	
	Valve guide mounting length		14 [0.55]	13.5 to 14.5 [0.532 to 0.552]		

1. Basic tools

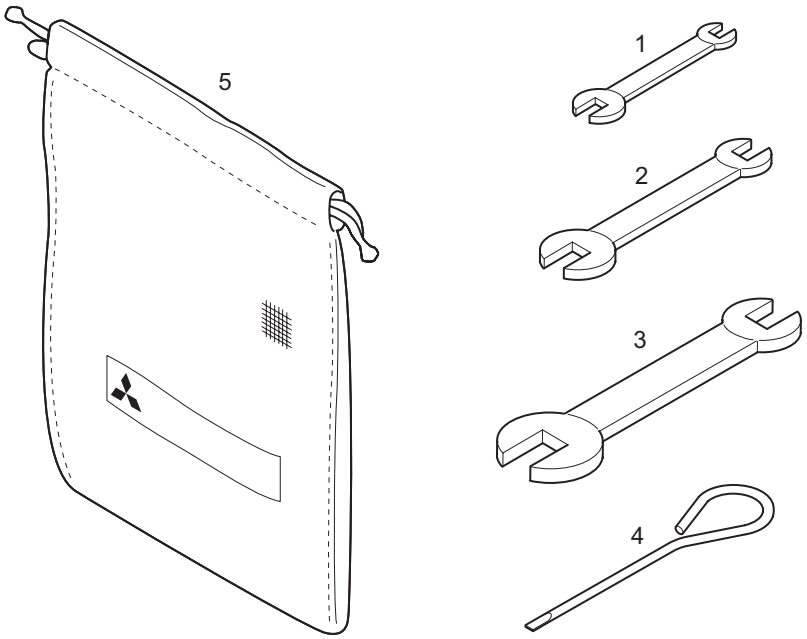


Table 3-1 Basic tools

No.	Tool name	Part No.	Remark
-	Tool set	MM413900	Includes 1 to 5
1	Spanner	MK96008010	Width across flats (8 mm × 10 mm) [0.32 × 0.39 in.]
2	Spanner	MK96012014	Width across flats (12 mm × 14 mm) [0.47 × 0.55 in.]
3	Spanner	MK96017019	Width across flats (17 mm × 19 mm) [0.69 × 0.75 in.]
4	Screwdriver	MM300110	(-)
5	Tool bag	MM300783	

1.4 Removing cylinder head assembly

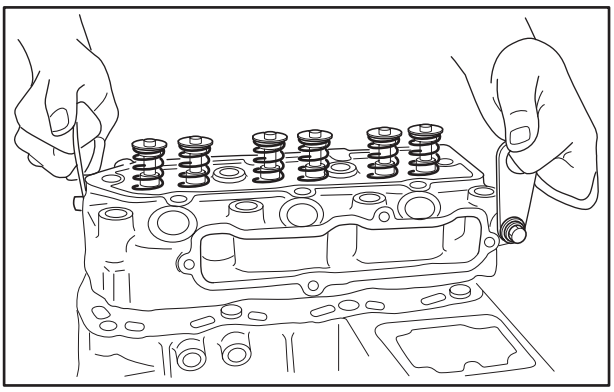
(1) Lift up the cylinder head assembly to remove.

Note: If the cylinder head assembly cannot be removed due to crimping of the cylinder head gasket, tap the thick area on the side of the cylinder head to give a shock.

(2) Remove the gasket from the cylinder head.

Note: (a) Be careful not to damage the fitting surfaces of the gasket when removing the gasket from the cylinder head.

(b) Before removing the cylinder head bolts, check the cylinder head components for any defects or faults. If any of them is faulty or defective, check the bolts for tightness with a torque wrench.



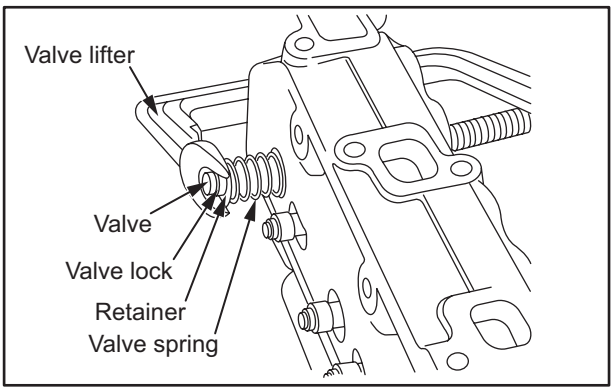
Removing cylinder head assembly

1.5 Removing valves and valve spring

(1) Use the valve lifter to compress the valve spring and remove the valve lock.

(2) Remove the retainer, valve spring and valve.

Note: Put match marks for easy identification of the installing position if the valve is to be reused. When reassembling, do not change the combination of the valve and valve seat.

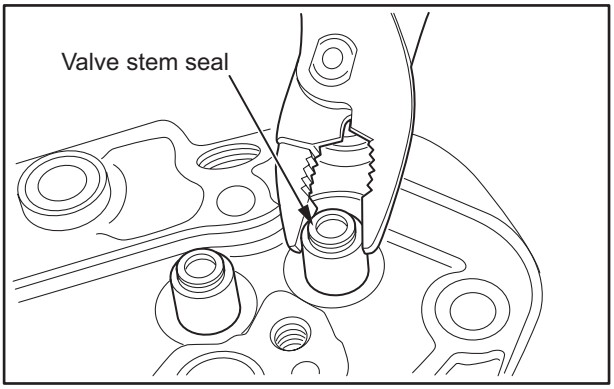


Removing valve

1.6 Removing valve stem seal

Grab the stem seal with pliers and remove.

Note: Be sure to replace the stem seal when reassembling the valve and valve spring.



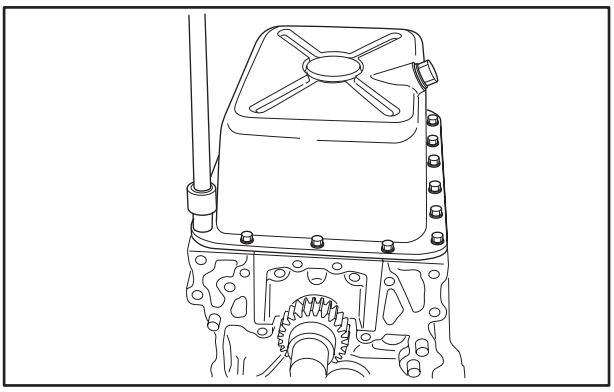
Removing valve stem seal

4.1 Removing oil pan

CAUTION

Do not insert a chisel or screwdriver between the oil pan and crankcase to remove the oil pan. It will deform the oil pan flange.

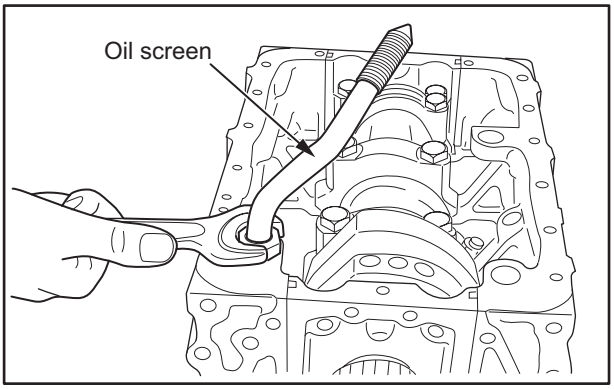
(1) Turn the engine around.
(2) Remove bolts from the oil pan.
(3) To remove oil pan, tap bottom corners of the oil pan with a plastic hammer.



Removing oil pan

4.2 Removing oil screen

Loosen the nut to remove the oil screen and gasket.

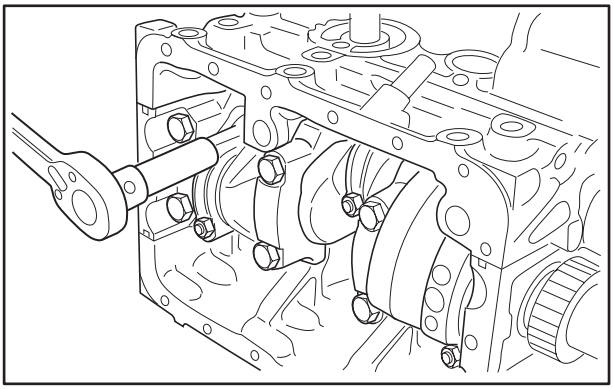


Removing oil screen

4.3 Removing connecting rod cap

(1) Lay the engine by its side.
(2) Mark the cylinder number on the connecting rod and connecting rod cap so that their combination is not changed when reassembling.
(3) Remove the connecting rod caps.

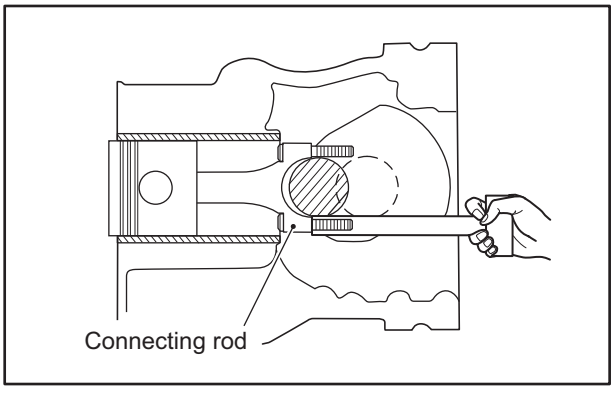
Note: Mark the cylinder No. and upper/lower on connecting rod bearings to ensure correct reassembling.



Removing connecting rod cap

4.4 Pulling out piston

(1) Turn the crankshaft and place the piston to top dead center.
(2) Push the mating surface of the connecting rod cap with a piece of wood such a handle of a hammer and push out the piston and connecting rod upward of the cylinder.



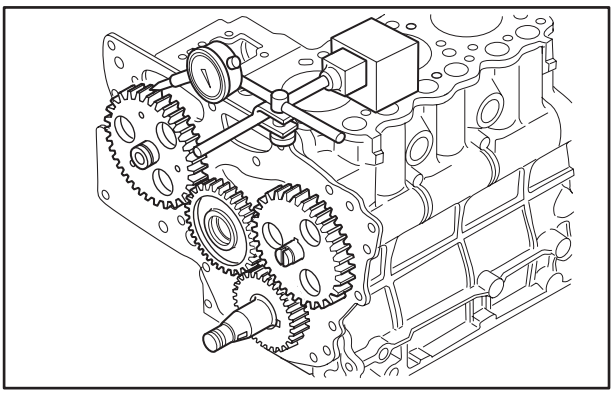
Pulling out piston

3. Inspecting and repairing gear case, timing gears and camshaft

3.1 Measuring backlash of timing gear

Measure the backlash of the timing gears by using one of the following two methods; measure the gear play with the dial gauge plunger applied to a tooth flank on the pitch circle at a right angle to the tooth axis, or measure the clearance between gears by inserting a feeler gauge between the gears at the tooth-to-tooth contacting area. Replace the faulty gear pair if the limit is exceeded.

Item		Standard	Limit
Timing gear backlash	Between crankshaft gear and idler gear	0.010 to 0.141 mm [0.0004 to 0.0056 in.]	0.30 mm [0.0118 in.]
	Between idler gear and valve camshaft gear	0.010 to 0.136 mm [0.0004 to 0.0054 in.]	
	Between idler gear and pump camshaft gear		

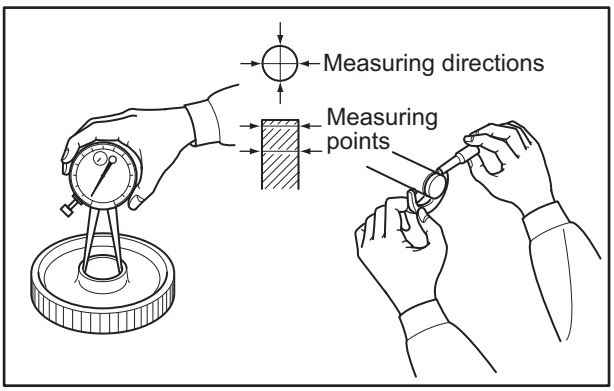


Measuring backlash of timing gears

3.2 Measuring clearance between idler gear and idler shaft

Measure the inside diameter of the idler gear and outside diameter of the idler shaft. Replace the idler gear or idler shaft if the clearance exceeds the limit.

Item	Standard	Limit
Clearance between idler gear and idler shaft	0.030 to 0.066 mm [0.0012 to 0.0026 in.]	0.200 mm [0.0079 in.]



Measuring idler gear inside diameter and idler shaft outside diameter

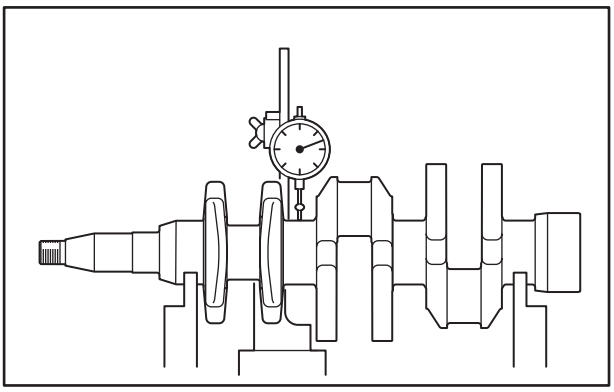
4.10 Measuring crankshaft runout

Support the crankshaft at the front and rear journals with V-blocks, and measure the crankshaft deflection (radial runout at the center journal) with a dial gauge. If the runout deviates from the standard only slightly, correct it by grinding the crankshaft. If the runout is a little large, straighten the crankshaft using a press.

Replace the crankshaft if the limit is exceeded.

If the crankshaft has been repaired by grinding or pressing, inspect its various parts for cracks and other harmful damage with a magnetic particle examination.

Item	Standard	Remark
Crankshaft runout	0.06 mm [0.0024 in.]	TIR



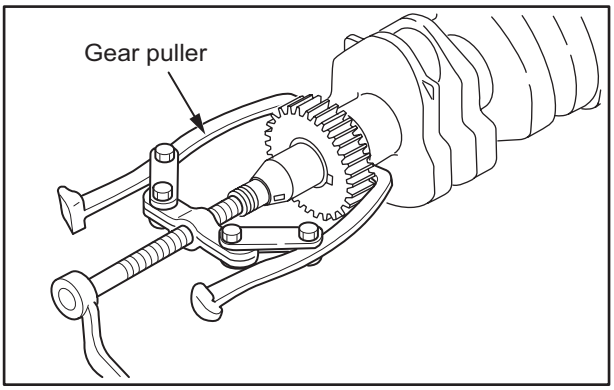
Measuring runout of crankshaft

4.11 Replacing crankshaft gear

4.11.1 Removing crankshaft gear

Using the gear puller, remove the gear from the crankshaft.

Note: Do not remove the gear by hitting it with a hammer.

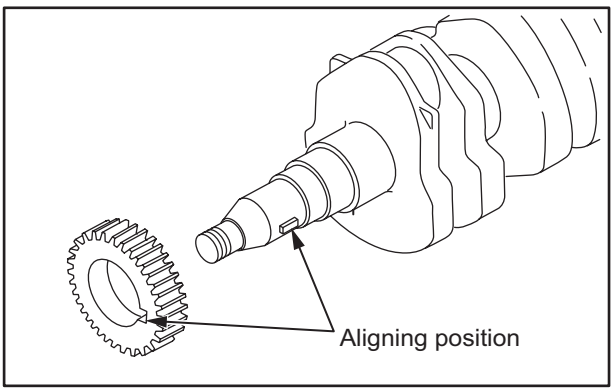


Removing crankshaft gear

4.11.2 Installing crankshaft gear

(1) Install the key on the crankshaft.

(2) Press-fit the gear fully in alignment with the key.

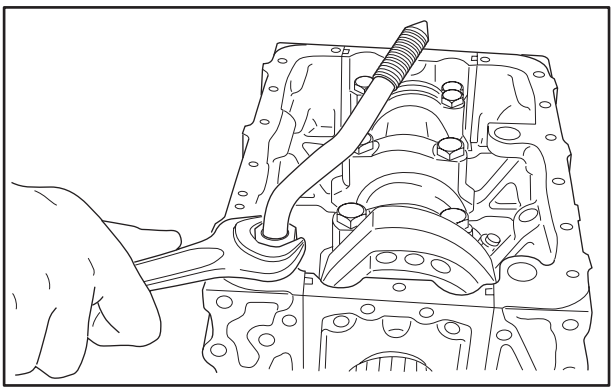


Installing crankshaft gear

1.11 Installing oil screen

(1) Turn the engine upside down to face up the oil pan mounting surface.

(2) Install the oil screen so that the tip of the screen does not contact the oil pan.

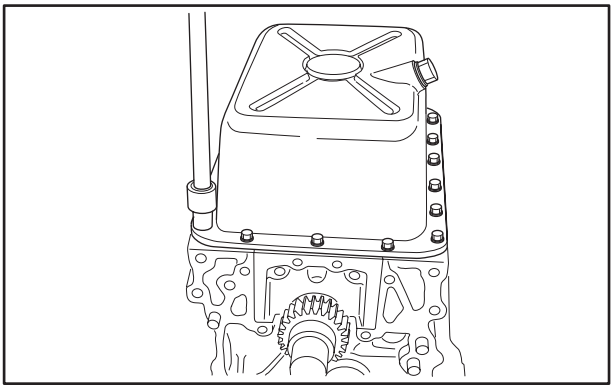


Installing oil screen

1.12 Installing oil pan

(1) Install new oil pan gasket.

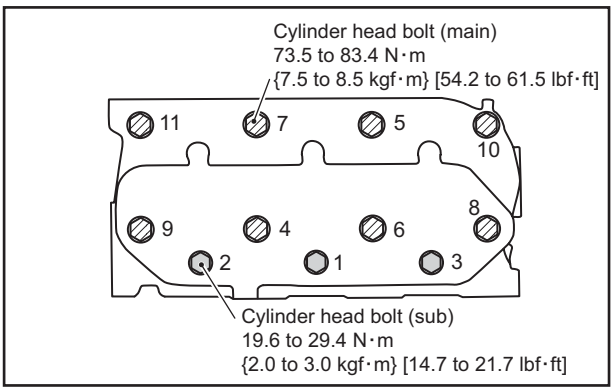
(2) Tighten oil pan bolts evenly and diagonally.



Installing oil pan

4.7 Tightening cylinder head bolts

In the numerical order as shown in the illustration, tighten cylinder head bolts progressively to the specified torque.

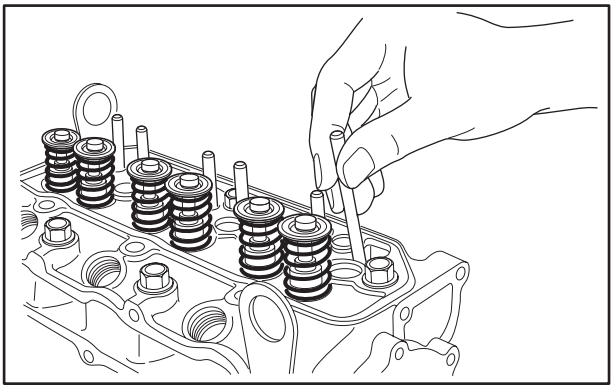


Tightening order of cylinder head bolts

4.8 Inserting pushrod

(1) Insert each pushrod into its hole in the cylinder head.

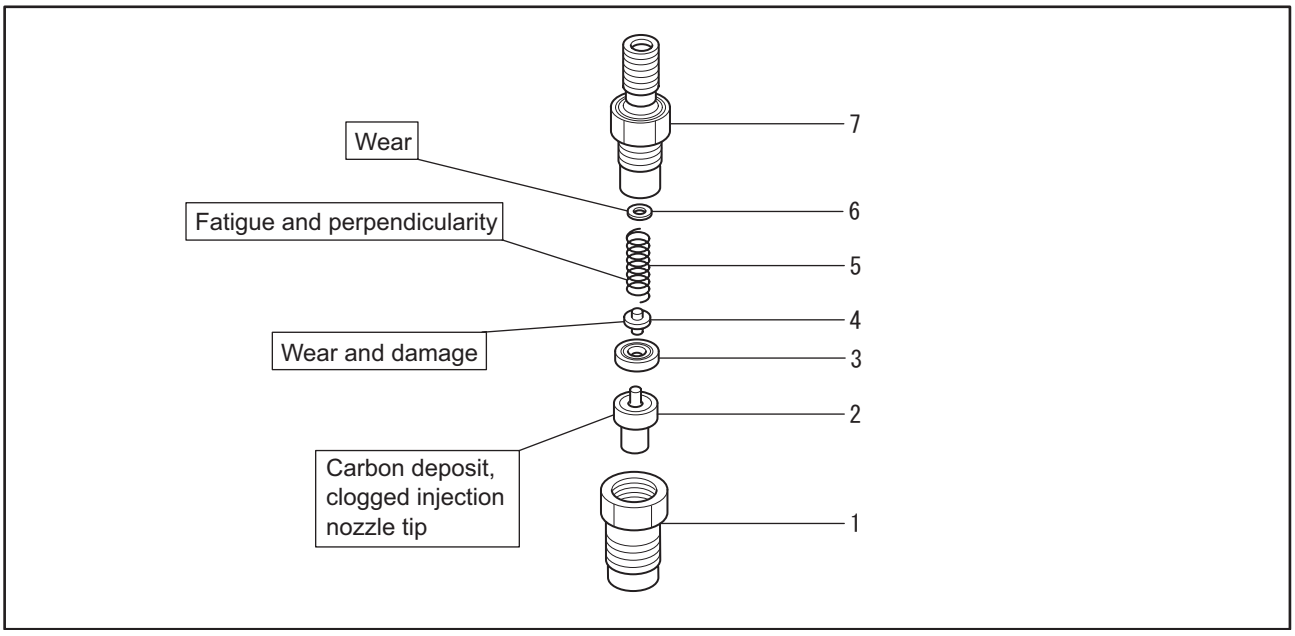
(2) Make sure that the ball end of each pushrod is placed correctly on the tappet cup.



Inserting pushrods

2. Disassembling, inspecting and reassembling fuel system

2.1 Disassembling and inspecting fuel injection nozzles



Disassembling and inspecting fuel injection nozzles

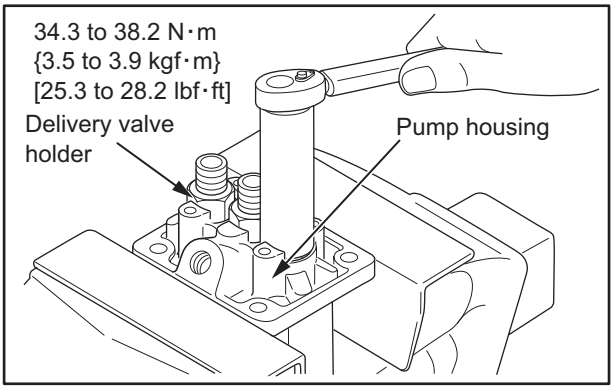
Disassembling sequence

1 Nozzle retaining nut
2 Nozzle tip assembly
3 Piece
4 Pin
5 Spring
6 Washer
7 Nozzle holder

2.5.7 Tightening delivery valve holder

(1) Place the pump housing upright, and grab the housing with a vise.

(2) Tighten the delivery valve holder to the specified torque.

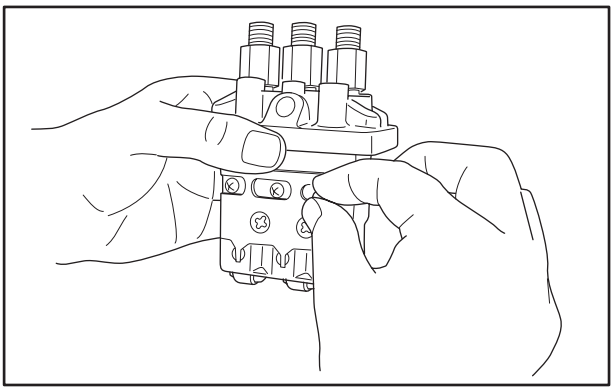


Tightening delivery valve holder

2.5.8 Inspecting control rack for smooth operation

(1) Remove the pump housing from the vise and check the control rack for smooth movement.
If the movement is not smooth, the following defects are suspected:
· Sliding of the element is poor.
· A foreign substance is present in the teeth of rack or sleeve.
· The valve holder is overtightened.

(2) Check the injection timing.



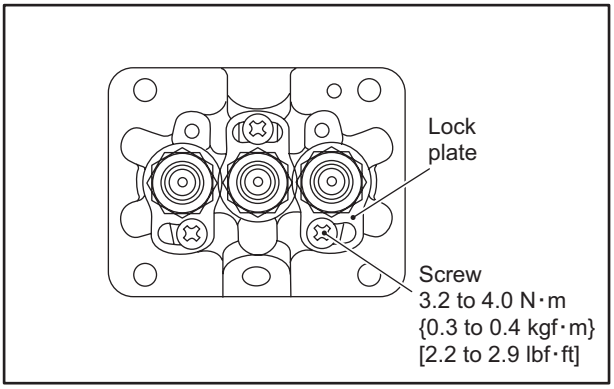
Checking sliding of control rack

2.5.9 Installing lock plate

(1) Grab the pump housing with a vise.

(2) Install the center lock plate first and then side lock plates later.

(3) Tighten the screws to the specified torque.

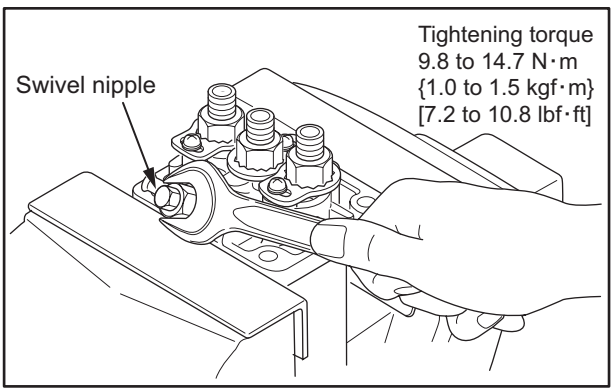


Installing lock plate

2.5.10 Installing swivel nipple

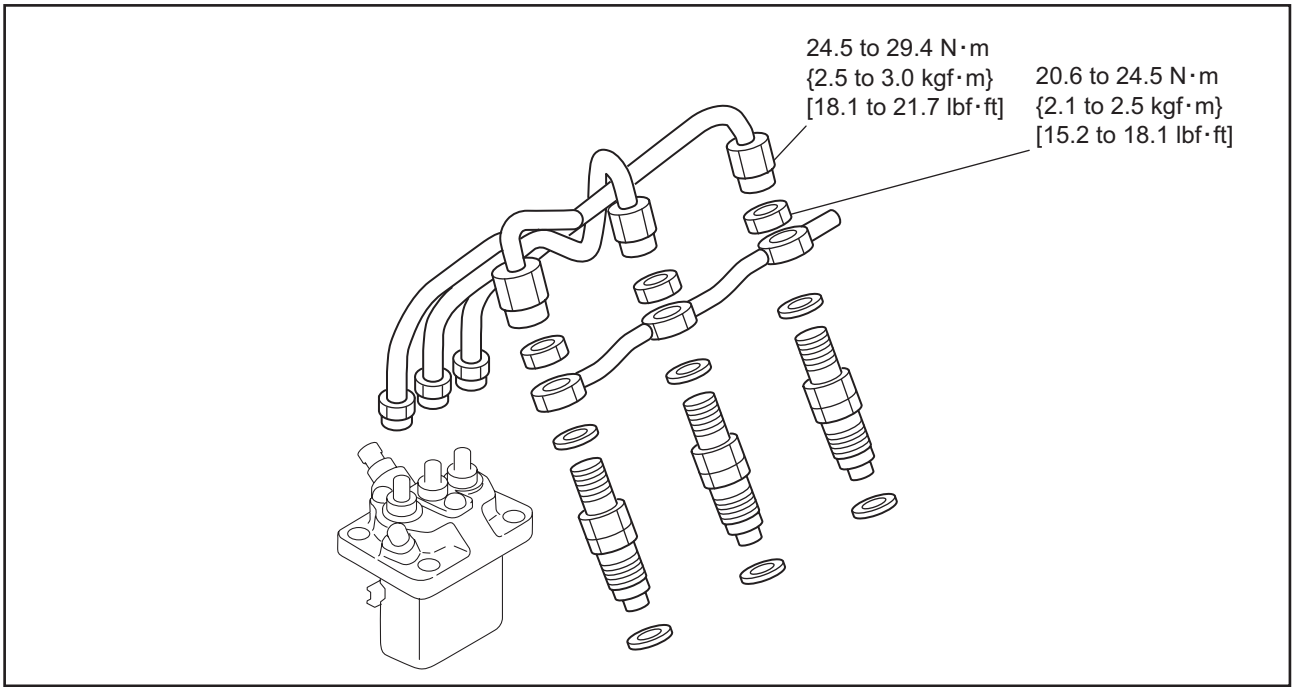
(1) Install the swivel nipple on the pump housing

(2) Tighten the hollow screw to the specified torque.



Installing swivel nipple

3.4 Installing fuel pipe and fuel injection nozzles

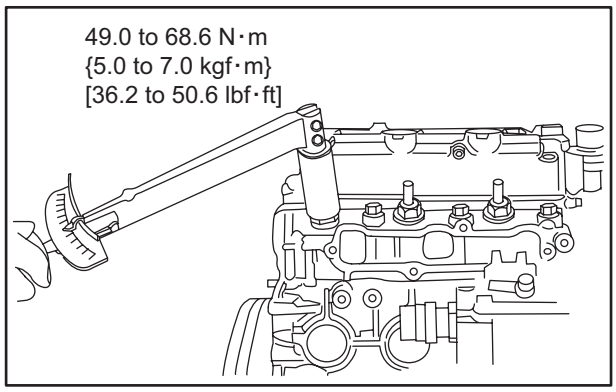


Installing fuel pipe and fuel injection nozzles

3.4.1 Installing fuel injection nozzle

(1) Clean the nozzle holder hole of cylinder head.

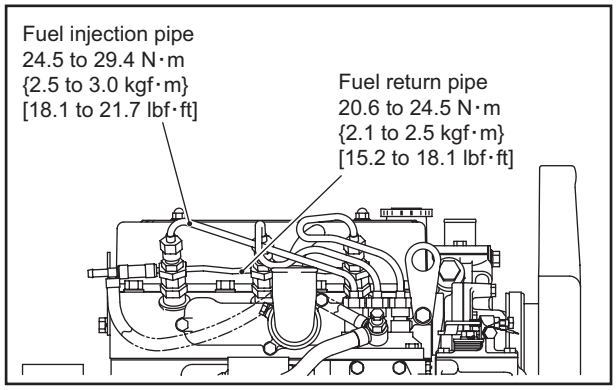
(2) Install the gasket to the nozzle tip and tighten the fuel injection pump.



Installing fuel injection nozzles

3.4.2 Installing fuel return pipe and fuel injection pipe

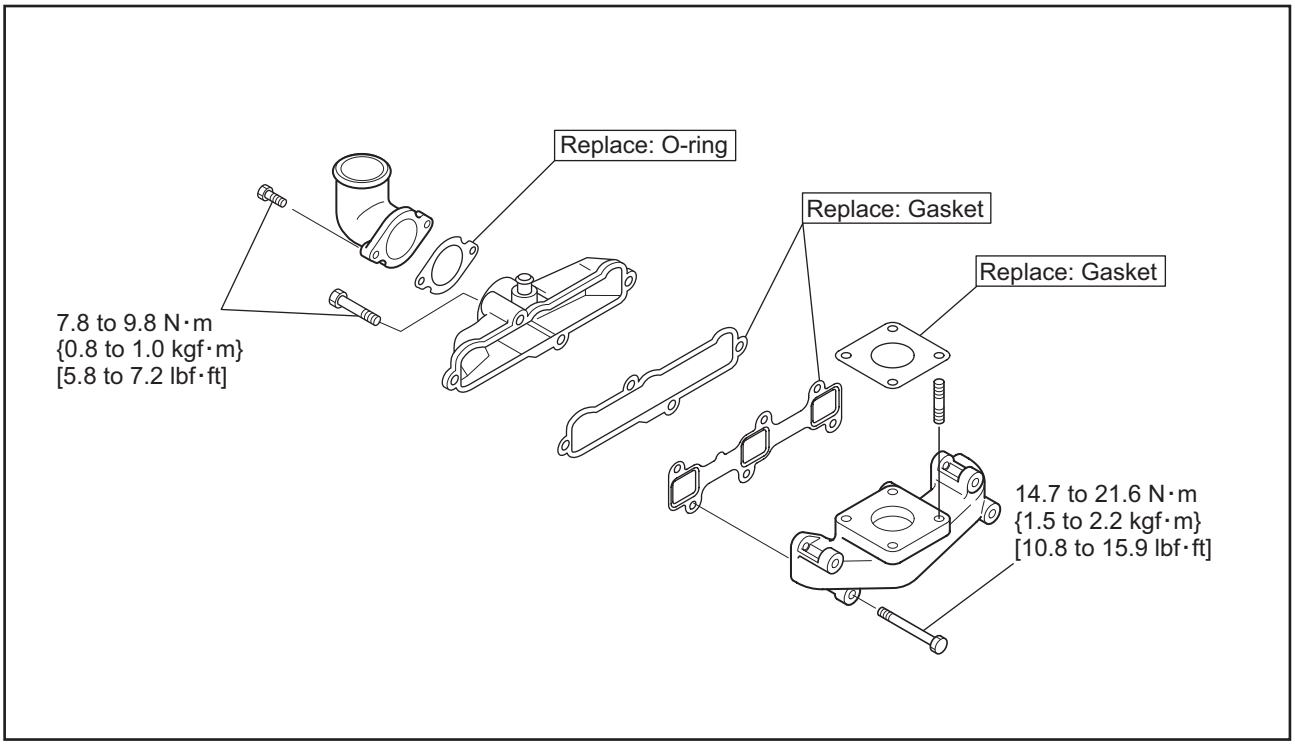
Install the fuel return pipe and fuel injection pipe.



Installing fuel return pipe and fuel injection pipe

3. Installing inlet and exhaust systems

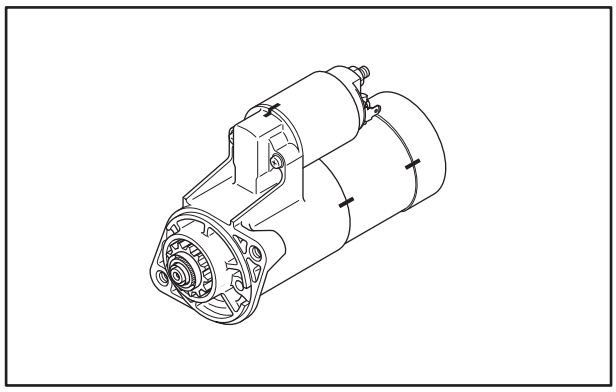
3.1 Installing intake cover and exhaust manifold



Installing intake cover and exhaust manifold

2.3 Preparation before disassembling

Mark the mating marks on magnet switch, front bracket, center bracket, yoke and rear bracket to each other for reassembly.



Preparatory work before disassembly

2.3.1 Removing pinion set

CAUTION

The starter generates heat if it is left with current being applied. Remove the pinion within 10 seconds.

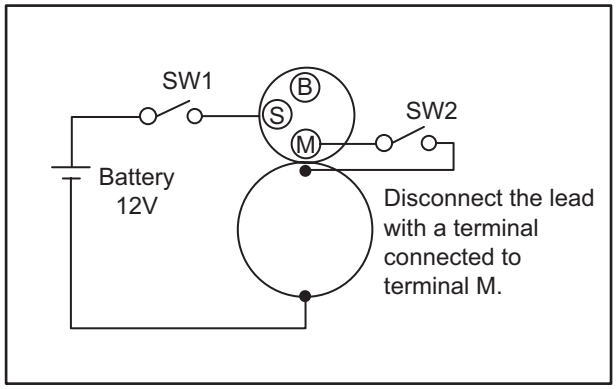
(1) Connect the starter to the circuit as shown in the illustration.

(2) Turn the switches SW1 and SW2 ON to move the pinion out and then turn the SW2 OFF to stop the rotation of the armature and the pinion.

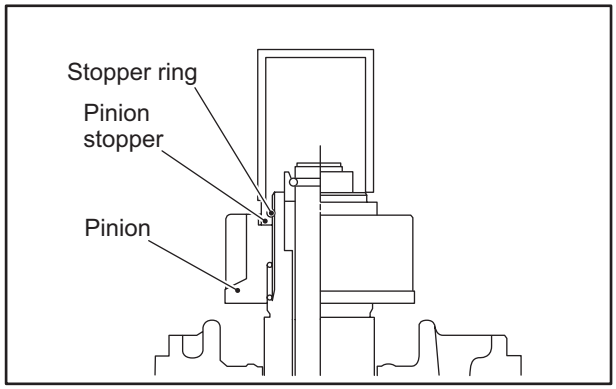
(3) Place an appropriate tube on the pinion stopper.
Tap the tube with a hammer to drop the pinion stopper to the clutch side. This will expose the stopper ring.

(4) Remove the stopper ring with pliers and remove the pinion.

Note: Do not reuse the stopper ring for reassembly.



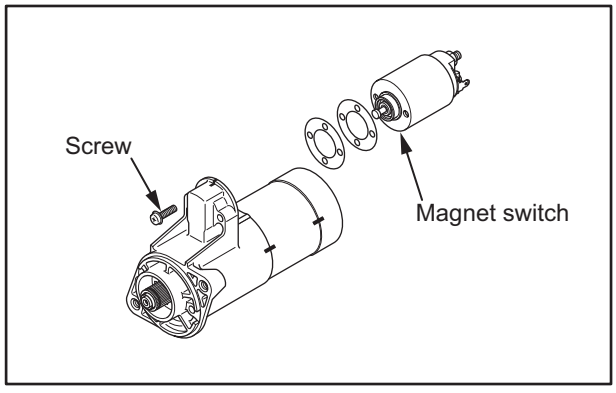
Connection to move the pinion forward



Removing pinion

2.3.2 Removing magnet switch

Disconnect the leads, and remove the magnet switch.



Removing magnet switch

2.5.8 Inspecting pinion clearance

CAUTION

Do not apply current continuously for longer than 10 seconds.

(1) Connect the starter to the circuit as shown in the illustration.

(2) When the switches SW1 and SW2 are turned ON, the pinion springs out to the cranking position and the armature rotates.

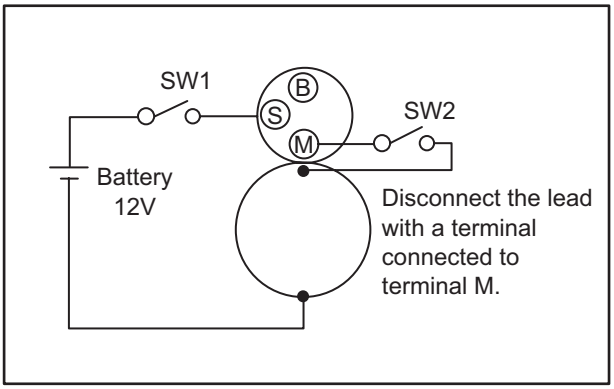
(3) Turn the switch SW2 OFF to stop the rotation of the armature.

(4) Gently push back the pinion in the out position with a finger and measure the distance over which the pinion has returned (movement amount).

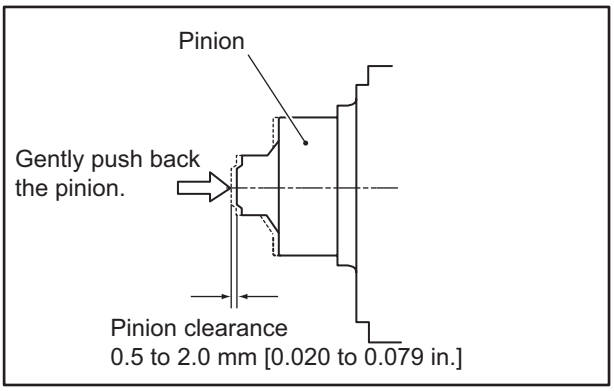
(5) If the measured value is out of the standard, increase or decrease the number of packings between the magnet switch and the front bracket for adjustment, or replace the lever with a new one.

Note: When the number of packings is increased, the pinion clearance becomes small.

Item	Standard
Pinion clearance	0.5 to 2.0 mm [0.020 to 0.079 in.]



Wiring during inspection of pinion clearance

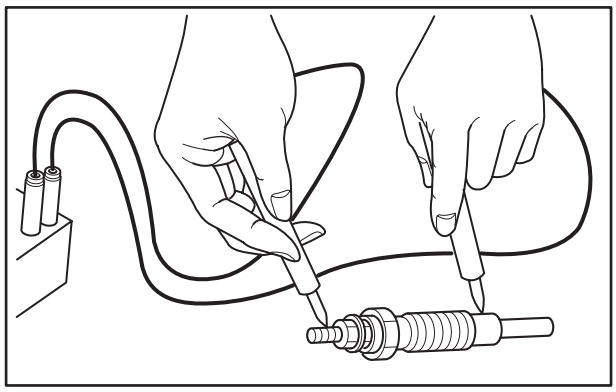


Inspecting pinion clearance

2.9 Inspecting glow plug

Check continuity between the terminal and the body as shown in the illustration. If no continuity is indicated, or the resistance is large, replace the glow plug with a new one.

Item	Standard
Resistance value	0.8 Ω



Inspecting glow plug

1.5 Bleeding fuel system

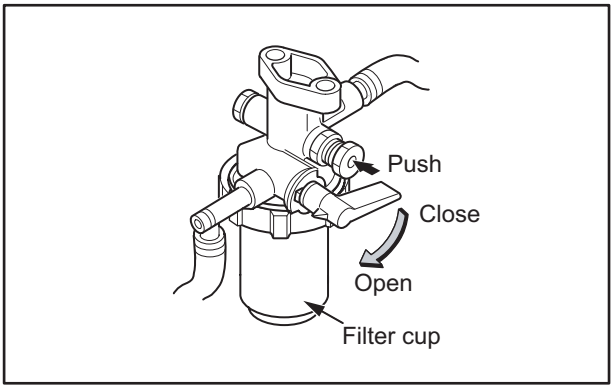
⚠ WARNING

Completely wipe off any spilled fuel from air vent screws with a cloth or the like, as spilled fuel can cause a fire.

Bleeding of the fuel system must be started from the place closest to the fuel tank: the fuel filter the first and the fuel injection pump the last.

1.5.1 Bleeding fuel filter

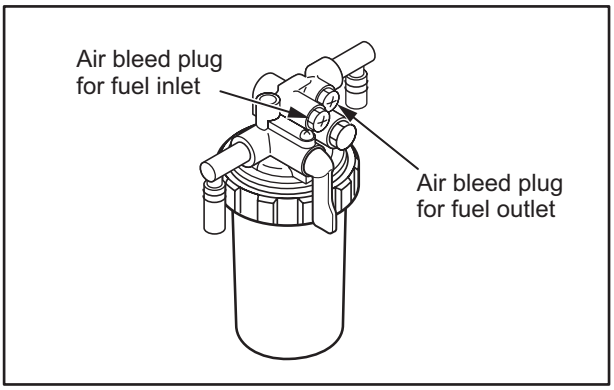
(1) Deliver fuel by solenoid pump.
(2) Place the cock of fuel filter in the "OPEN" position.
(3) Push and hold the button until the filter cup is filled with fuel.
(4) Stop the fuel delivery.



Bleeding fuel filter

1.5.2 Bleeding water sedimenter

(1) Loosen the water sedimenter's air bleed plug for fuel inlet.
(2) Deliver fuel by solenoid pump.
(3) Tighten air bleed plug for fuel inlet when the fuel flow from the air bleed plug becomes free of bubbles.
(4) Loosen air bleed plug for fuel outlet.
(5) Tighten air bleed plug for fuel outlet when the fuel flow from the air bleed plug becomes free of bubbles.
(6) Stop the fuel delivery.

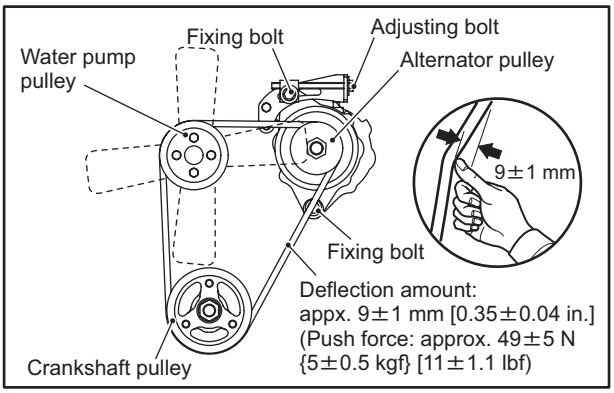


Bleeding water sedimenter

1.5.3 Adjusting V-belt tension

(1) Loosen the adjusting bolt and fixing bolt of the alternator. Loop the V-belt over the water pump pulley, alternator pulley and crankshaft pulley.
(2) Adjust the adjusting bolt so that the V-belt tension meets the specified value.

Belt tension (with pushing force of approx. 49 ± 5 N {5 ± 0.5 kgf} [11 ± 1.1 lbf])	Approx. 10 mm [0.39 in.]



Adjusting V-belt tension