CASE CONSTRUCTION

SERVICE MANUAL

HYDRAULIC EXCAVATOR

CX17B

NATN16300~
S5PU0018E01

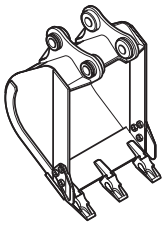
Issued March 2010

Issue	Date of Issue	Applicable Machines	Remarks
↑	↑	CX17B -NAT	(CASE-NA)
↑	↑	CX31B : PW14-45964~ CX36B : PX15-20658~	↑ (CASE-NA)

2. SPECIFICATIONS

Issue	Date of Issue	Applicable Machines	Remarks
First Edition	March 2010	CX17B - NATN16300	NA

2.7 TYPE OF BUCKET

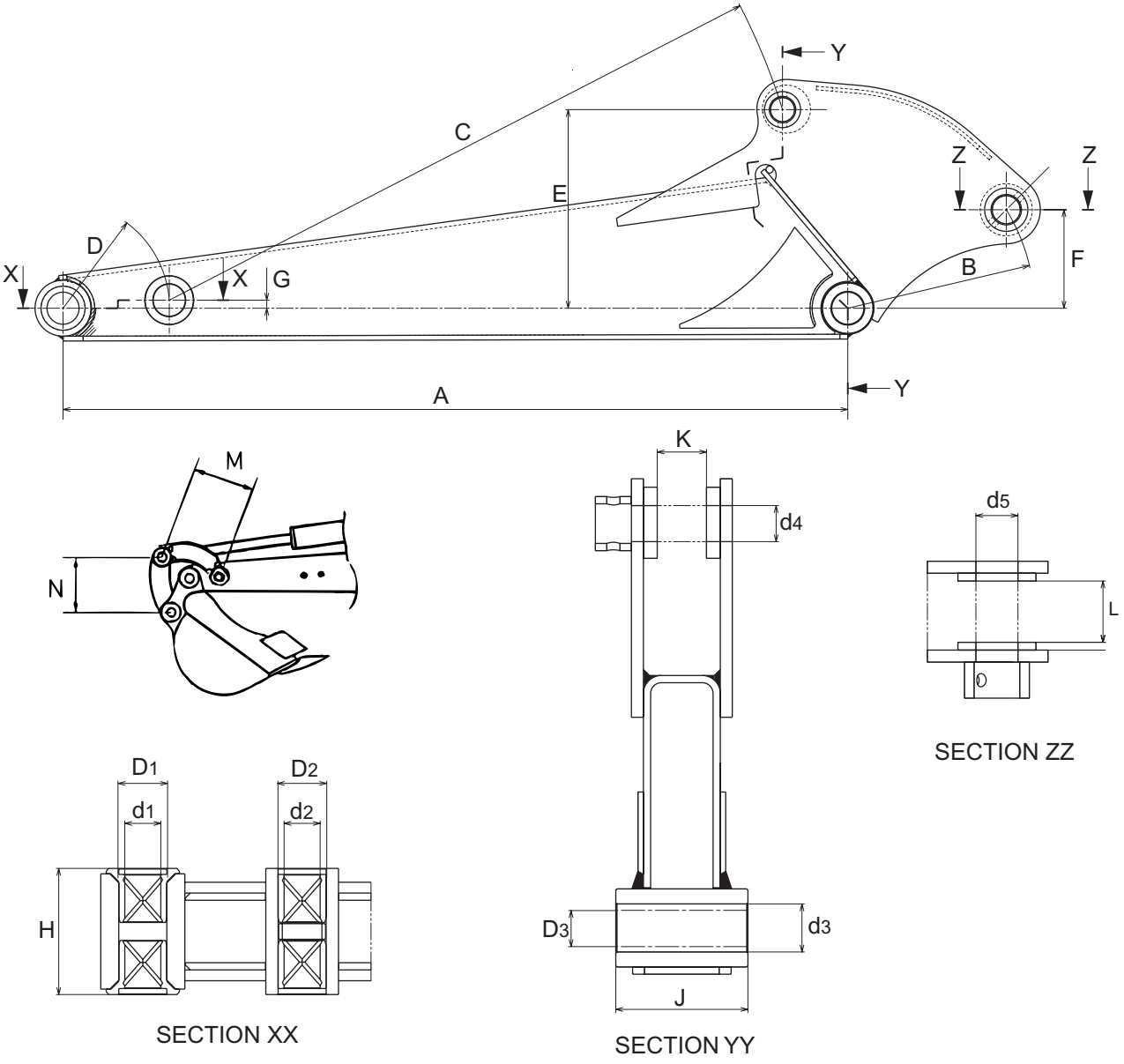
Type	Heaped Capacity m^3 (cu yd)	Outer width mm (in)		Number of tooth	Weight kg (lbs)
		with side cutter	without side cut		
Bucket 	0.044 (0.058)	450 (1 5.7")	420 (1 4.5")	3	35 (77)

Note

this table shows Japanese standard bucket.

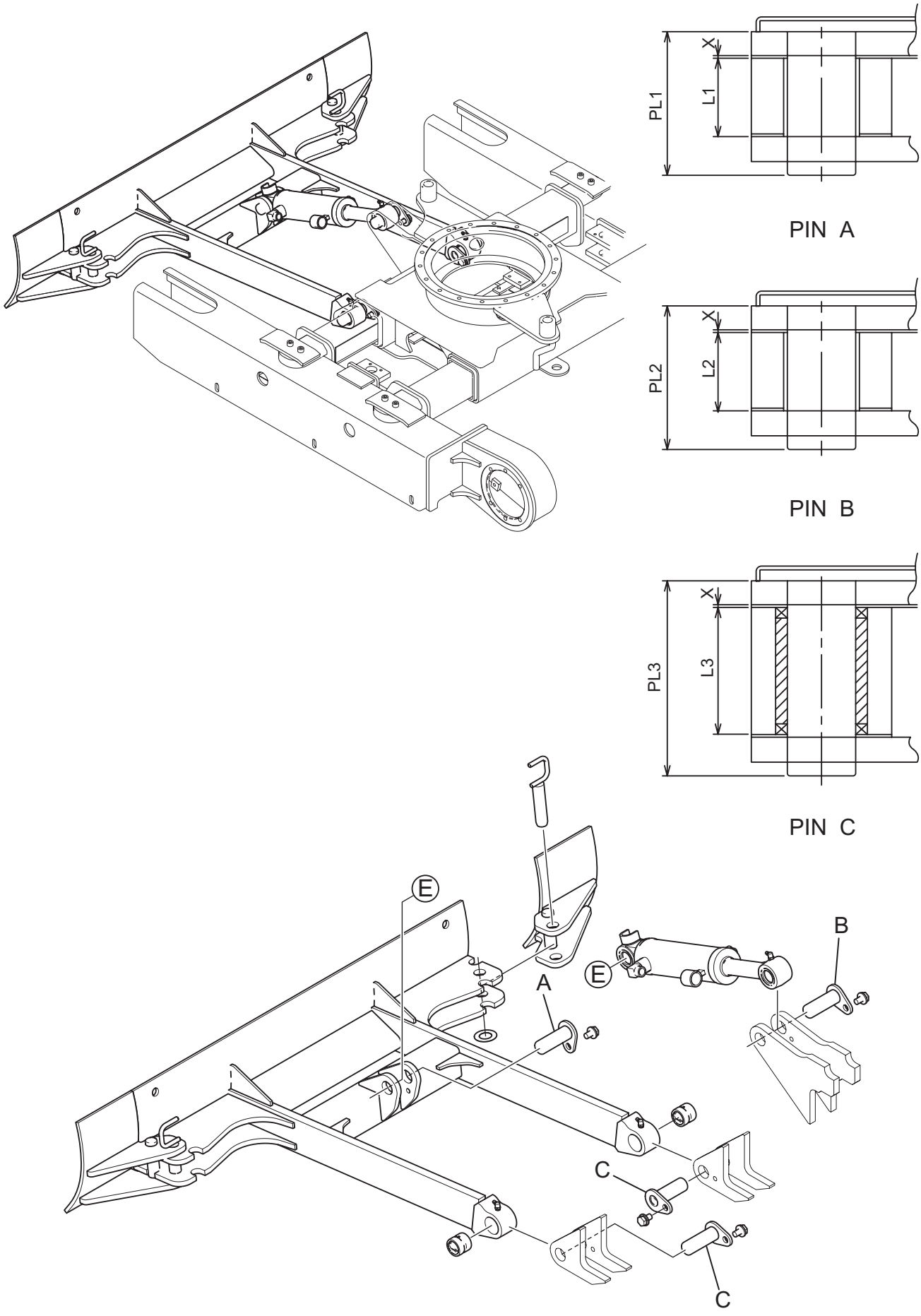
3.2 ARM

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)

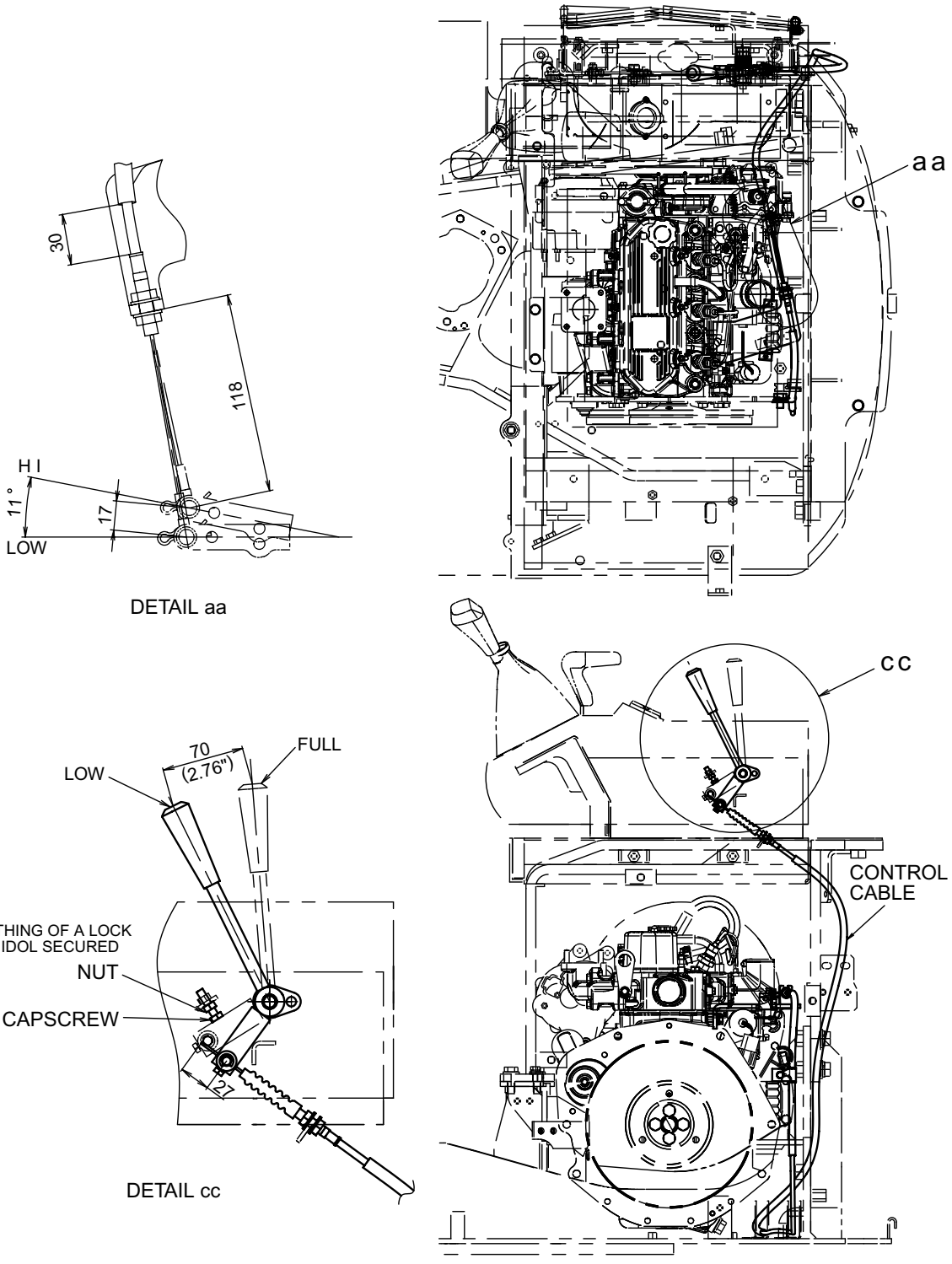
03 Upper structure (4/4)

No.	EQUIPMENT PORTION	WORK TO BE DONE	UNIT	REMARKS	UNIT : HOUR
130	Upper frame portion			Refer to 33.1.22	
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.

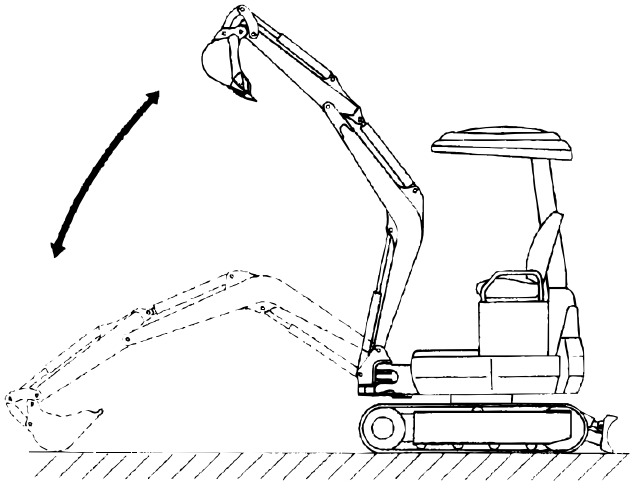
13.7 MEASURING ATTACHMENT OPERATING PERFORMANCES

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

13.7.1 CYLINDER SPEED

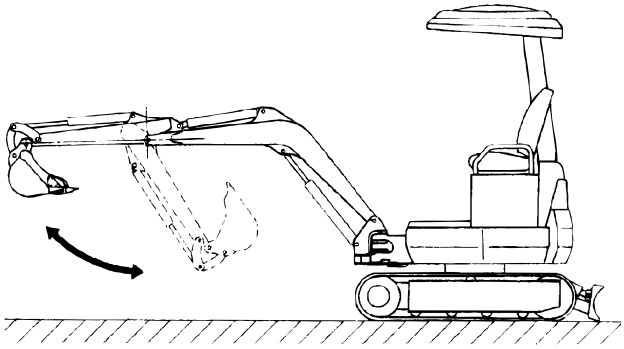
(1) Boom Cylinder Speed

- 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.)



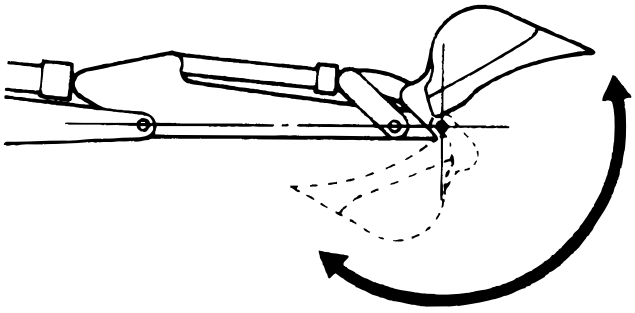
(2) Arm Cylinder Speed

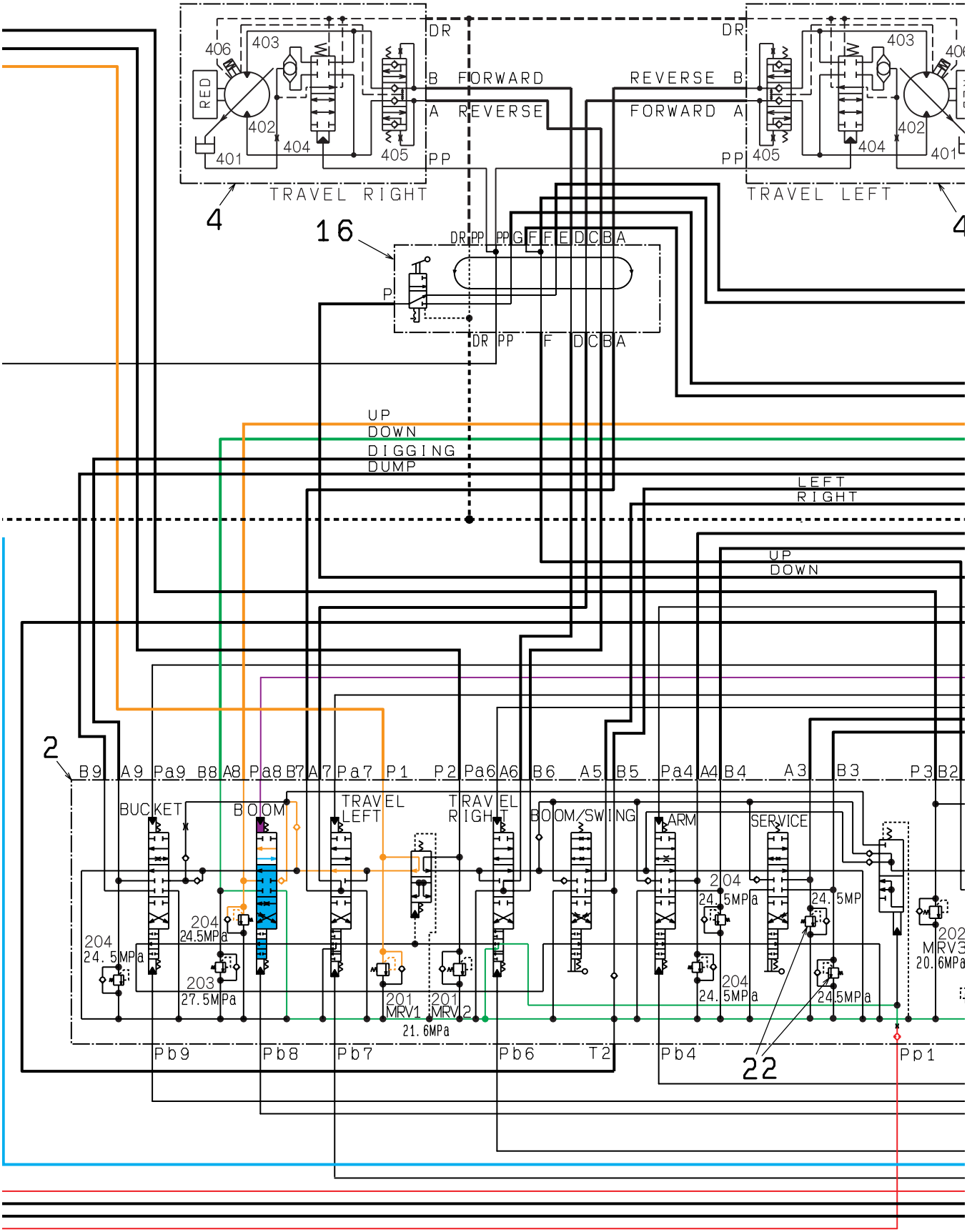
- Engine : High Idle
- Hydraulic Oil Temp. : 50 to 60C degrees (122 to 140F degrees)
- Measurement Posture : Completely retract the arm cylinder, fully extend the bucket cylinder, position the arm horizontally and place the dozer blade on the ground.
- Then measure the time required for the arm cylinder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



(3) Bucket Cylinder Speed

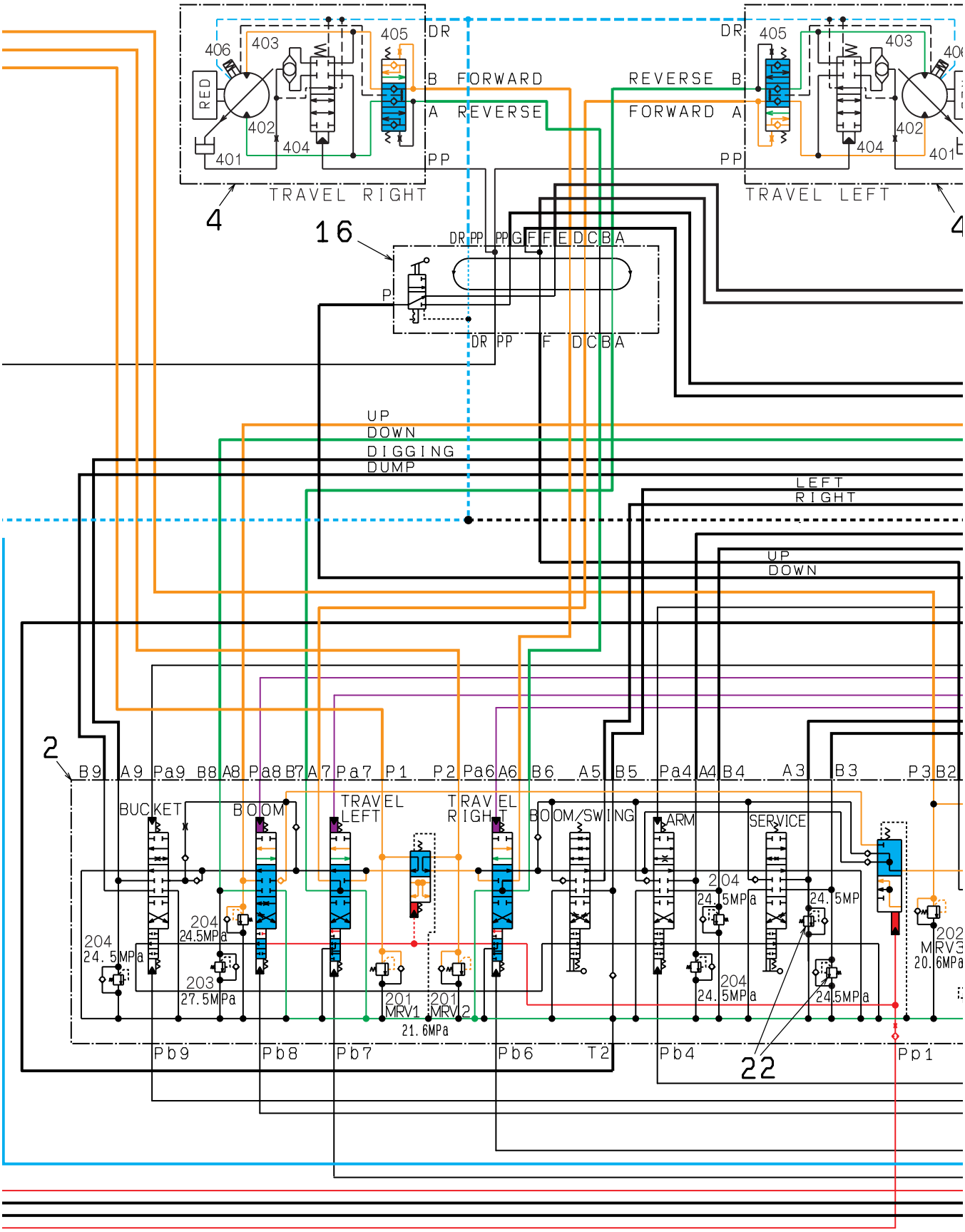
- Engine : High Idle
- Hydraulic Oil Temp. : 50 to 60C degrees (122 to 140F degrees)
- Measurement Posture : Completely retract the arm cylinder, position the arm horizontally and place the dozer blade on the ground.
- Then measure the time required for the bucket cylinder to completely retract (extend)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





No.	NAME	PRESSURE:MPa {psi}	No.	
201	MAIN RELIEF VALVE P1,P2	21.6 {3130}	204 22	OVER
202	MAIN RELIEF VALVE P3	20.6 {2990}	304	SLEW
203	OVER LOAD RELIEF VALVE	27.5 {3990}	13-1	PILOT

Boom circuit : Boom up operation



No.	NAME	PRESSURE:MPa {psi}	No.	
201	MAIN RELIEF VALVE P1,P2	21.6 {3130}	204 22	OVER
202	MAIN RELIEF VALVE P3	20.6 {2990}	304	SLEW
203	OVER LOAD RELIEF VALVE	27.5 {3990}	13-1	PILOT

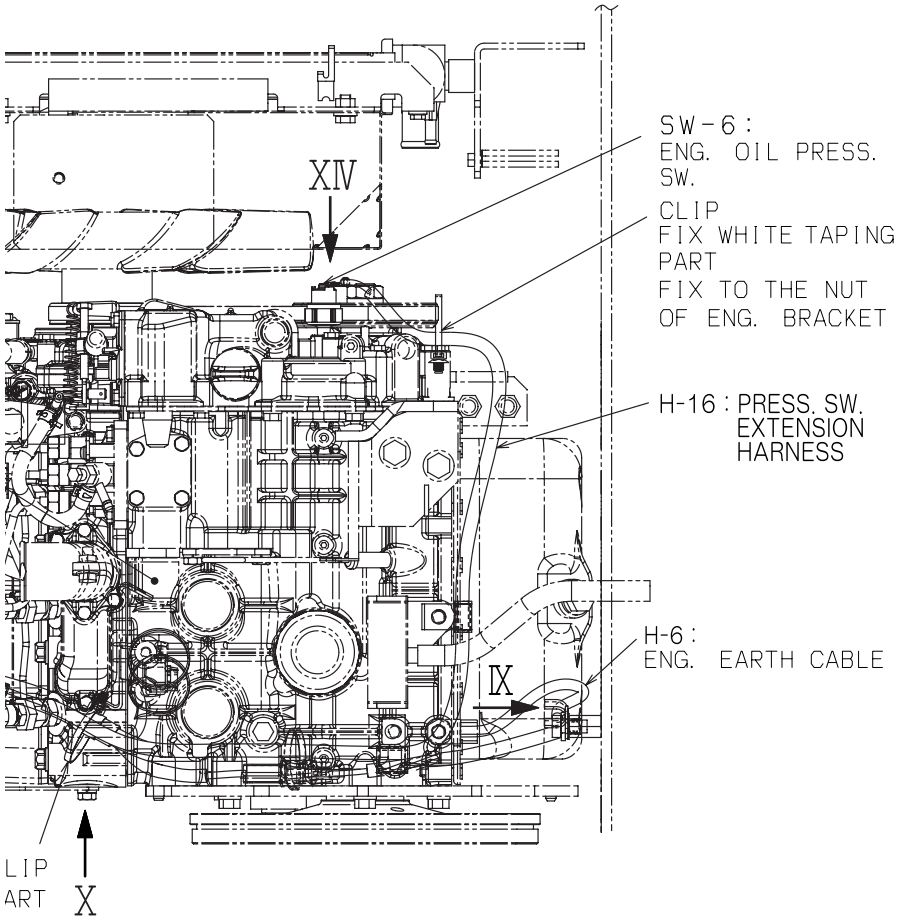
Combined operation circuit : Travel (forward) 1st speed / Boom up operation

23.2.2 HARNESS & CABLE LIST

Code	Name		Part No.	Remarks
H-1	Main Harness		PU13E01046P3	
H-4	Starter Cable (+)		PU13E01049P2	
H-5	Battery Ground Cable (-)		PU13E01050P1	
H-6	Engine Ground Cable		PU13E01051P1	
H-7	Boom Harness	Canopy	PU15E01004P3	
		Cab	PU15E01005P1	(OPT)
H-8	Key Switch Harness		PW50E01002P1	
H-9	Hand Rail Work Light Harness		PU11E01004P1	
H-10	Boom Work Light Extension Harness		PU13E01052P2	
H-11	Connection Harness with Cab		PU13E01061P1	(OPT.)
H-13	Travel Alarm Harness		PW13E01069P1	(OPT.)
H-14	Alarm Extension Harness		PU13E01056P1	(OPT.)
H-15	Heater Harness		PU13E01039P1	(OPT.)
H-16	Pressure SW. Extension Harness		PU13E01059P1	
H-17	Jamper Connector		PW14E01018P1	(OPT.)

Note

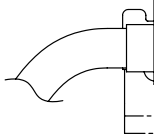
The part number may be changed owing to modification, use them only for reference.



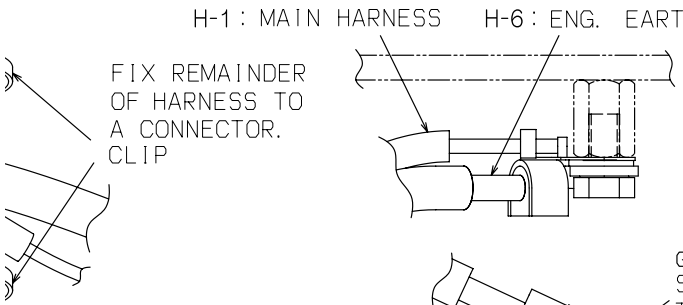
SW-5 :
ENG. WATER

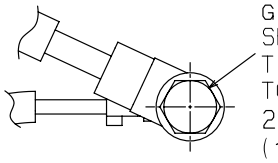
E-8 : GL
TIGHTENI
1.0~1.
(0.74~1.1

SECTION C-C



VI





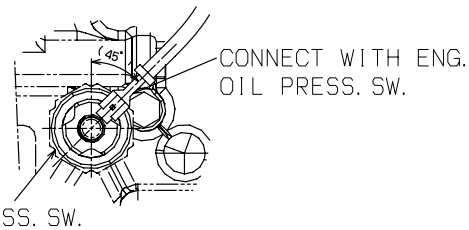
SV-3 :
ENG. STOP SOL.

VIEW IX

CAP SCREW
TIGHTENING
TORQUE
10.7 N·m
(7.9 lbf·ft)

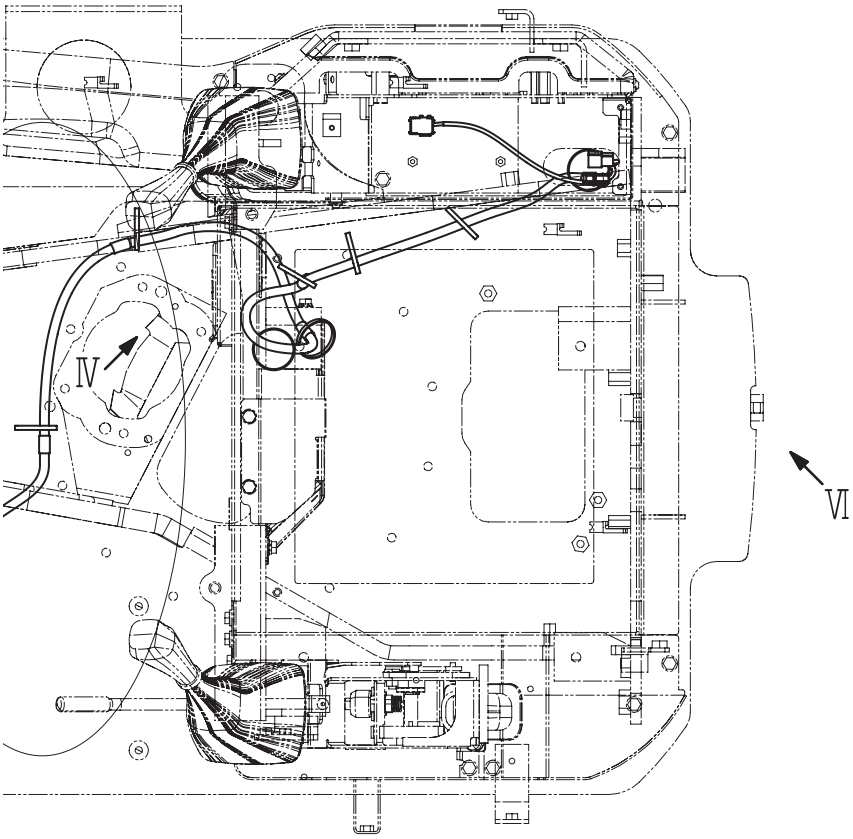
E-3 : HOR

FRONT SIDE OF MACHINE



-6 :
G. OIL PRESS. SW.

VIEW XIV

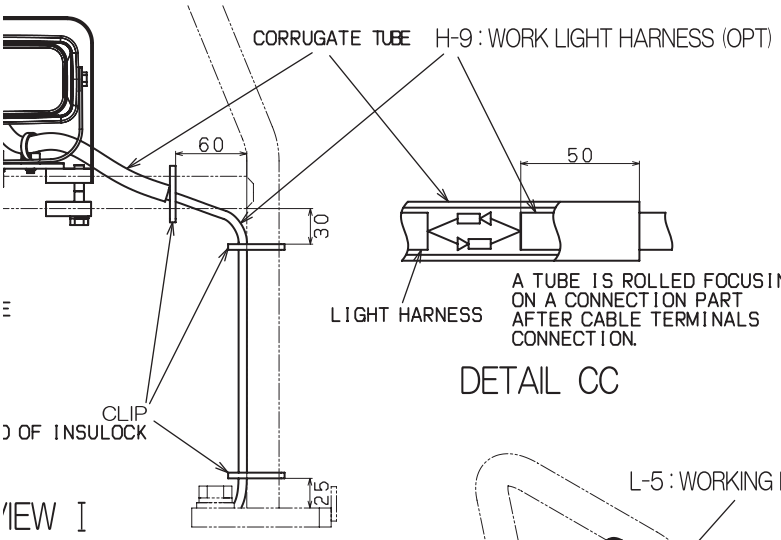


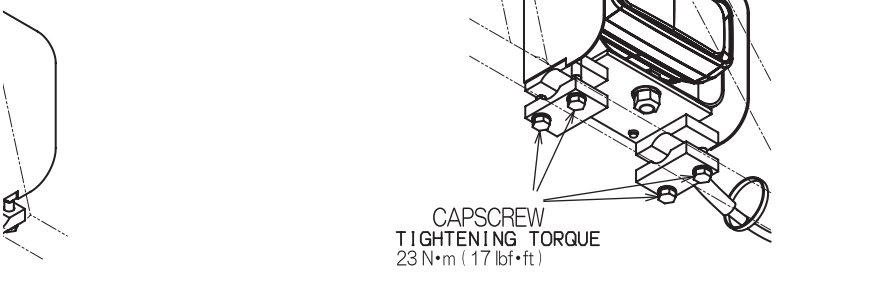
WHITE TAPING
POSITION TO BE A
THIS WHITE TAPIN

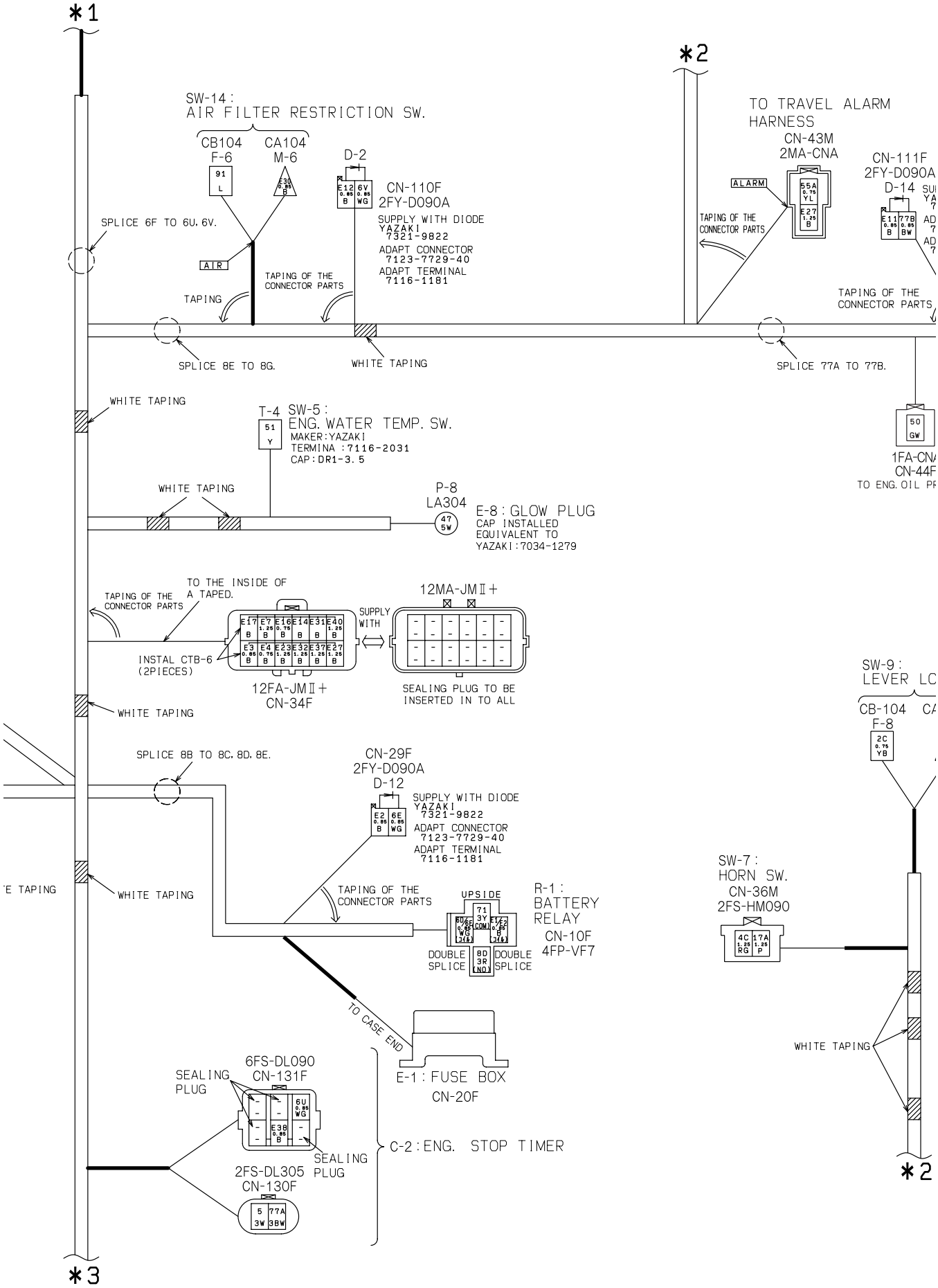
CLIP
FIX A MAIN
HARNESS WITH
CLIP.

FIX WH
TAPIN

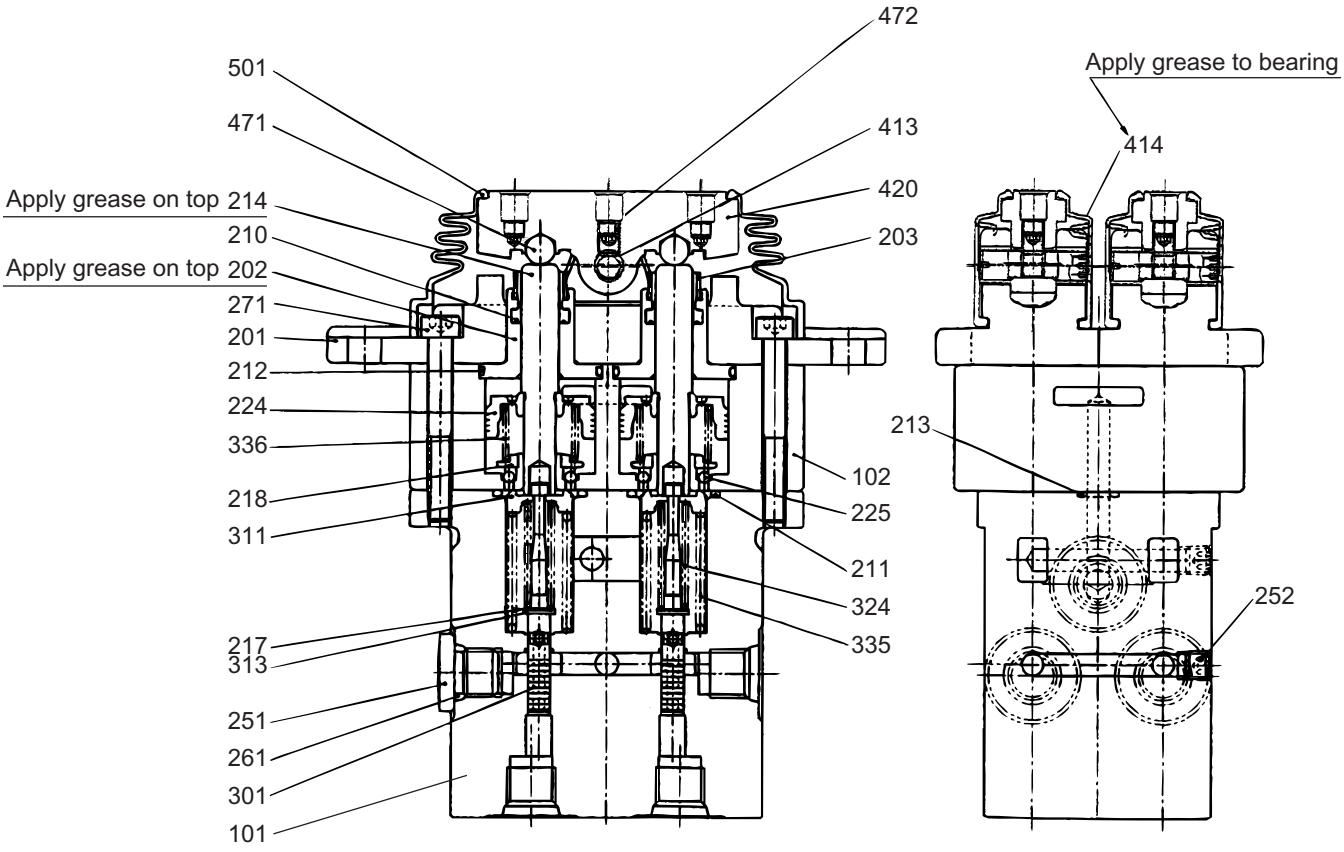
FIX
FOR






*1
*2
*3
SW-14 :
AIR FILTER RESTRICTION SW.
CB104
F-6
CA104
M-6
D-2
CN-110F
2FY-D090A
SUPPLY WITH DIODE
YAZAKI
7321-9822
ADAPT CONNECTOR
7123-7729-40
ADAPT TERMINAL
7116-1181
SPLICE 6F TO 6U. 6V.
AIR
TAPING
TAPING OF THE CONNECTOR PARTS
SPLICE 8E TO 8G.
WHITE TAPING
TO TRAVEL ALARM HARNESS
CN-43M
2MA-CNA
ALARM
CN-111F
2FY-D090A
D-14
TAPING OF THE CONNECTOR PARTS
SPLICE 77A TO 77B.
WHITE TAPING
T-4
SW-5 :
ENG. WATER TEMP. SW.
MAKER:YAZAKI
TERMINA :7116-2031
CAP:DR1-3. 5
WHITE TAPING
P-8
LA304
E-8 : GLOW PLUG
CAP INSTALLED
EQUIVALENT TO
YAZAKI:7034-1279
TO THE INSIDE OF A TAPED.
TAPING OF THE CONNECTOR PARTS
INSTAL CTB-6
(2PIECES)
12FA-JMⅡ+
CN-34F
SUPPLY WITH
12MA-JMⅡ+
SEALING PLUG TO BE INSERTED IN TO ALL
WHITE TAPING
SPLICE 8B TO 8C. 8D. 8E.
CN-29F
2FY-D090A
D-12
SUPPLY WITH DIODE
YAZAKI
7321-9822
ADAPT CONNECTOR
7123-7729-40
ADAPT TERMINAL
7116-1181
WHITE TAPING
TAPING OF THE CONNECTOR PARTS
UPSIDE
R-1 :
BATTERY
RELAY
CN-10F
4FP-VF7
DOUBLE SPLICE
DOUBLE SPLICE
TO CASE END
E-1 : FUSE BOX
CN-20F
6FS-DL090
CN-131F
SEALING PLUG
SEALING PLUG
2FS-DL305
CN-130F
C-2 : ENG. STOP TIMER
SW-9 :
CB-104
F-8
SW-7 :
HORN SW.
CN-36M
2FS-HM090
WHITE TAPING

24.1.3.2 CONSTRUCTION



Pilot valve-Sectional view

Torque N-m (lbf-ft)	No.	NAME	Q'TY	Torque N-m (lbf-ft)	No.	NAME	Q'TY
	101	Casing	1	6.9 (5.1)	252	Plug	2
	102	Casing (Damper)	1		261	O-ring	3
	201	Cover	2	8.8 (6.5)	271	Capscrew	4
	202	Plug			301	Spool	4
	203	Grease cup			311	Spring seat	4
	210	Packing			313	Washer	4
	211	O-ring			324	Spring	4
	212	O-ring			335	Spring	4
	213	O-ring			336	Spring	4
	214	Push rod			413	Cam shaft	2
	217	Shim			414	Bushing	4
	218	Spring seat			420	Cam	2
	224	Piston			471	Steel ball	4
	225	Steel ball	12	6.9 (5.1)	472	Set screw	2
29.4 (21.7)	251	RO Plug	3		501	Boots (Bellows)	2

24.1.4.5 EXPLANATION OF OPERATION

(1) Neutral position

P1:

The oil delivered from the hydraulic pump flows from the P1 port of the control valve (hereafter called a C/V) into the left travel spool section through the passage of the supply section.

At the spool neutral position, the entered oil passes through the by-pass of the spool leading from the left travel to the boom because the spool does not cut off the by-pass and flows out to the tank circuit through the by-pass of the spool for the bucket and the by-pass leading to the tank.

P2:

The oil delivered from the hydraulic pump flows from the P2 port of C/V into the right travel spool section through the passage of the supply section.

At the spool neutral position, the entered oil passes through the by-pass of the spools for the right travel, boom swing and service, and flows out to the tank circuit through the by-pass circuit leading from the by-pass of the spool for service.

P3:

The oil delivered from the hydraulic pump flows from the P3 port into the control valve and then into the parallel passages to the dozer and the swing. The oil having entered the parallel passage flows through the by-pass passages of the slewing and dozer spools to the independent travel spool land portion, then through the P2 side second by-pass passage, and finally from the by-pass passage in the service switching section out into the tank passage.

WARNING

As the flow from the pump is fed into each line (P1, P2, P3), the switching sections of respective line shown below are in operable condition. Therefore, don't operate them except when working.

- P1 line: Left travel, Boom, Bucket
- P2 line: Right travel, Boom Swing, Service and Arm
- P3 line: Dozer, slewing [Service and Arm]

Pp1:

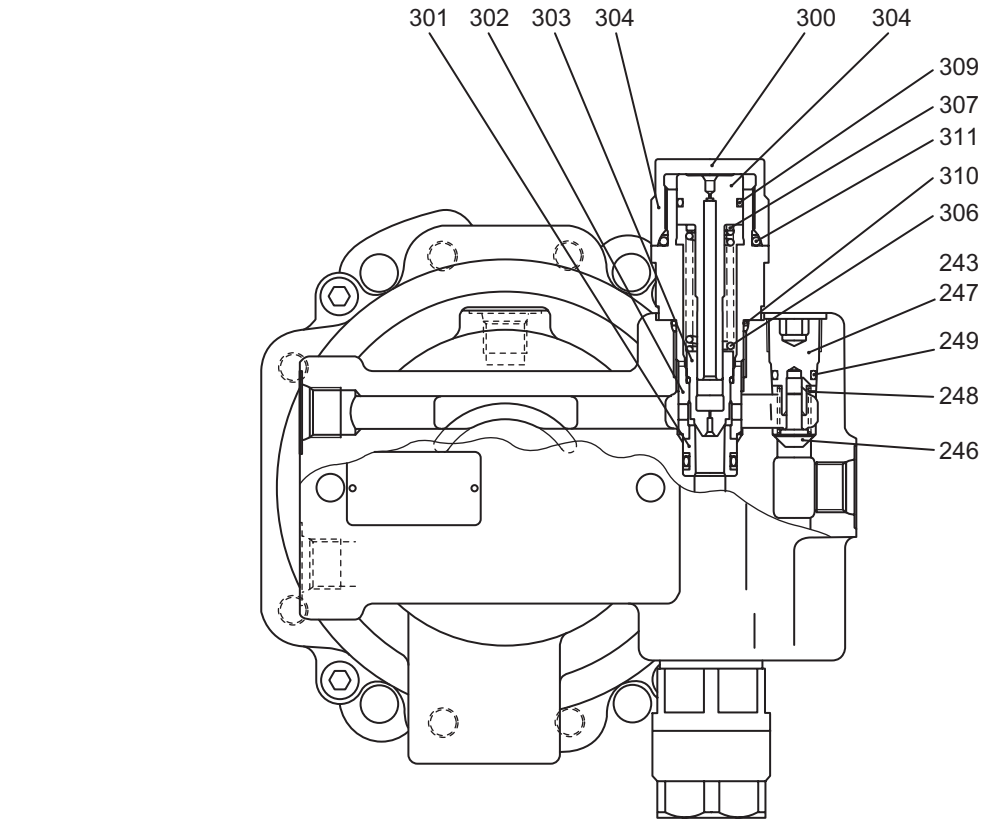
The pilot pressure supplied to the Pp1 port forces the oil to flow out through the orifice into the independent travel signal passage in the control valve.

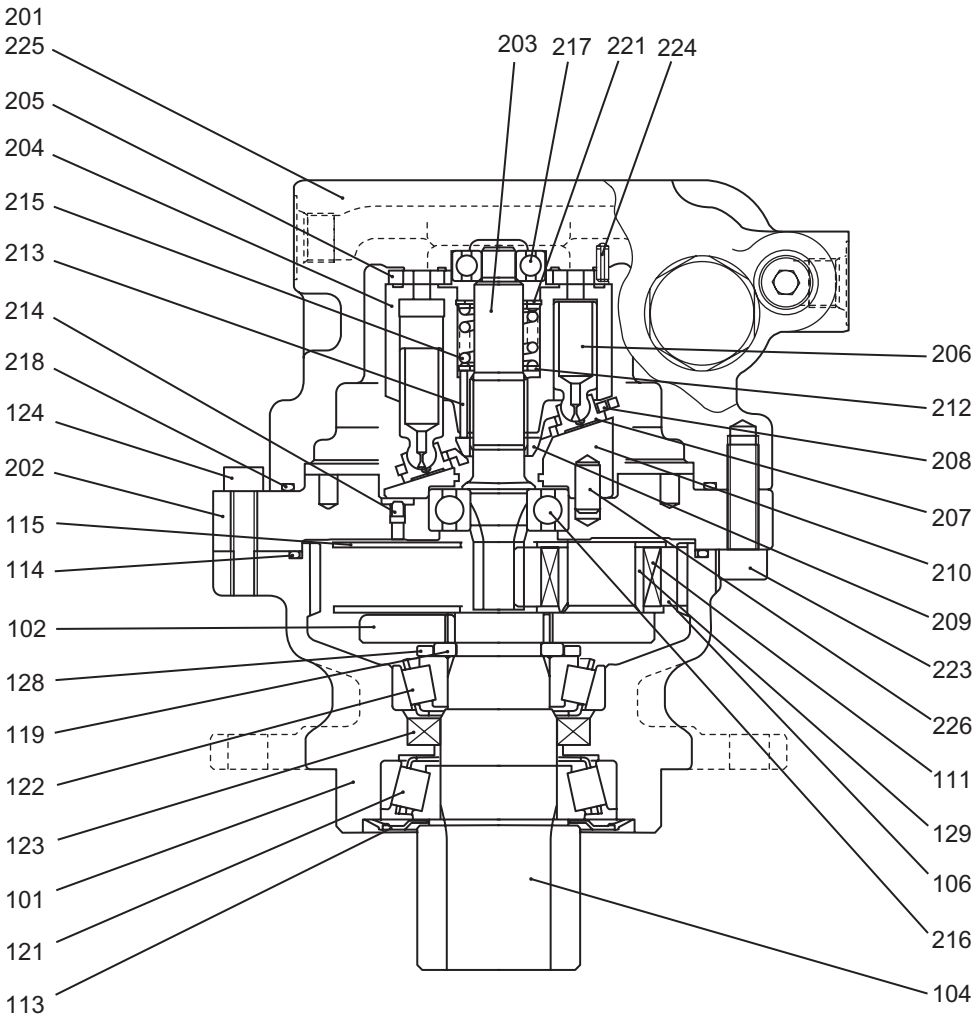
With the spool in the neutral position, the oil passes through the passages provided on the left and right travel spools and on the service spool, and flows out into the tank passage.

WARNING

When the engine is stopped (when each hydraulic pump is stopped), the actuator does not function even when being loaded by the self weight, because the pilot pressure does not act on the pilot control spool (except for the condition where the accumulator, etc. is attached and the pressure remains due to the pipe volume). On the spools of boom swing and dozer which directly actuates the spool, the port on the loaded side is led to the tank circuit with the operating direction making it unable to hold the load, consequently the actuator may be actuated causing danger. Therefore, even if the engine is stopped, when there are people around the machine or it may be in contact with implements, don't use the control lever.

24.1.5.4 CONSTRUCTION





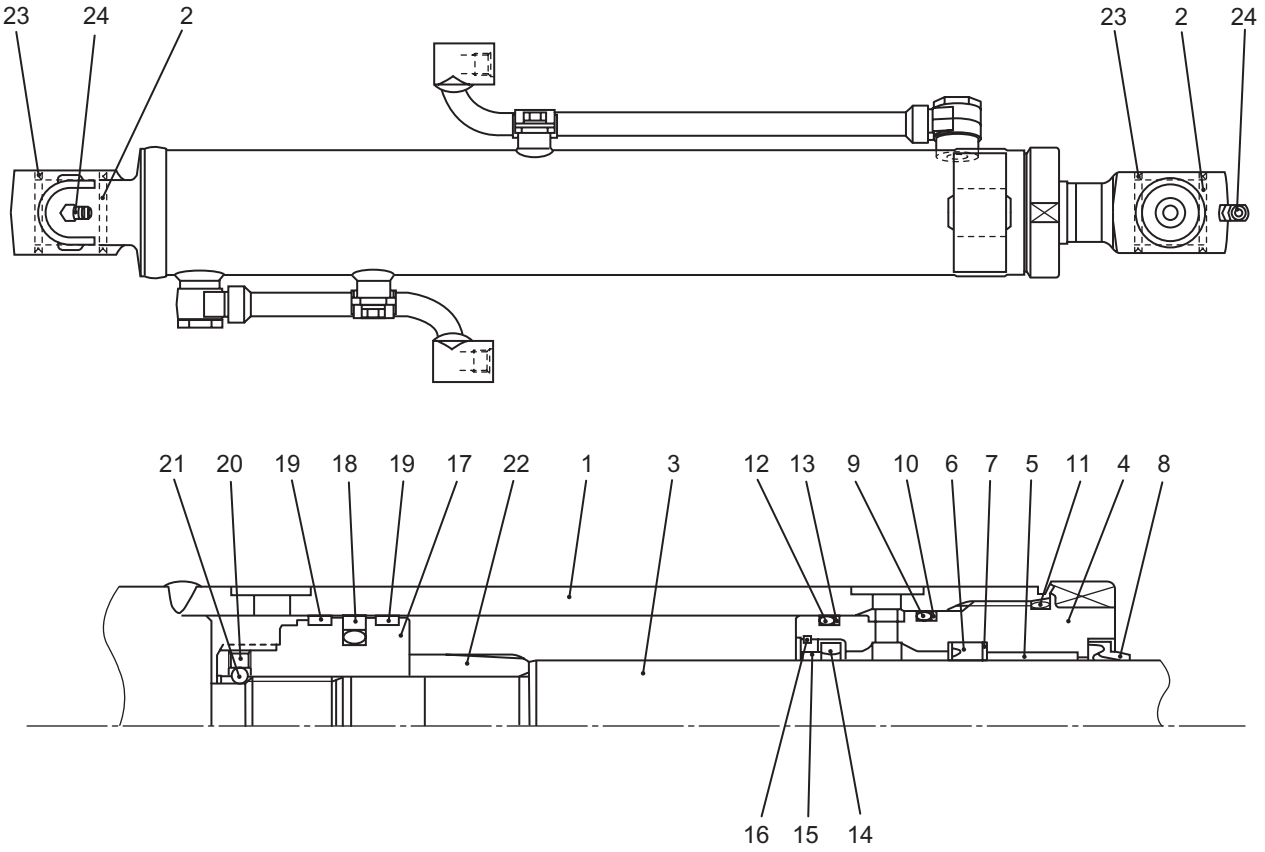
Body 1 sub assy group

No.	NAME	Q'TY	No.	NAME	Q'TY
301	BODY 1	1	312	PLUG	2
302	SPOOL	1	313	CHOKE	5
303	CHECK VALVE	2	314	RING	2
304	SPRING GUIDE	2	315	PLUG	8
305	SPOOL	1	316	PLUG	2
306	SHUTTLE SPOOL	1	317	O-RING	2
307	SPRING V1	2	318	O-RING	2
308	SPRING V2	2	319	O-RING	2
309	SPRING V3	1	320	CHOKE	2
310	PLUG	2	321	PIN	2
311	PLUG	2	322	PLUG	6

24.1.8.2 CONSTRUCTION AND FUNCTION

24.1.8.2.1 CONSTRUCTION

(1) Boom cylinder



Construction of boom cylinder

No.	NAME	Q'TY	No.	NAME	Q'TY	No.	NAME	Q'TY
1	CYLINDER TUBE ASSY	1	9	O-RING	2	17	PISTON	1
2	PIN BUSHING	2	10	BACK-UP RING	1	18	SEAL RING ASSY	1
3	PISTON ROD ASSY	1	11	O-RING	1	19	SLIDE RING	2
4	CYLINDER HEAD	1	12	O-RING	1	20	SETSCREW	1
5	BUSHING	1	13	BACK-UP RING	1	21	STEEL BALL	1
6	U-RING	1	14	CUSHION SEAL	1	22	CUSHION BEARING	1
7	BACK-UP RING	1	15	SPACER	1	23	DUST SEAL	4
8	WIPER RING	1	16	STOPPER	1	24	GREASE NIPPLE	2

Group	Code	Part Name	Part No.
Relay	R-1	BATTERY RELAY	PH24S00001P1
	R-2	SAFETY RELAY	E/G accessory (VA30L74-00100)
	R-3	STARTER RELAY	E/G accessory (VAMM431-28201)
	R-6	GLOW TIMER	E/G accessory (VAMM436-811)
	R-8	CHARGE INDICATOR RELAY	PA24E01001P1
	R-9	WORKING LIGHT RELAY (CAB SPEC.)	PM24S00001P1
	R-13	GLOW RELAY	E/G accessory (VAMM431-28201)
Sensor	SE-1	FUEL SENSOR	PU52S00013F1
Solenoid	SV-1	LEVER LOCK SOL.	PX35V00003F1
	SV-2	2-SPEED SELECT SOL.	
	SV-3	E/G STOP SOL.	E/G accessory (VA31A87-01050)
Switch	SW-1	KEY SWITCH	PW50S00007F1
	SW-2	WORKING LIGHT SW. (CAB)	PV24E01001P2
	SW-3	2-SPEED SELECT SW.	YN03M01286S002
	SW-4	WIPER WASHER SW. (CAB)	PY50S00004P2
	SW-5	E/G COOLANT TEMP. SW.	E/G accessory (VAMM432-104)
	SW-6	E/G OIL PRESSURE SW.	E/G accessory (VA31A90-00600)
	SW-7	HORN SW.	YN50E01001P2
	SW-9	LEVER LOCK SW.	PA50S00001P1
	SW-10	HEATER SW. (CAB)	PY50S00003P2
	SW-14	AIR FILTER RESTRICTION SW.	FILTER accessory
	SW-24	TRAVEL RIGHT (FORWARD) PRESSURE SW. (OPT)	GB50S00049F2
	SW-25	TRAVEL RIGHT (REVERSE) PRESSURE SW. (OPT)	↑
	SW-26	TRAVEL LEFT (FORWARD) PRESSURE SW. (OPT)	↑
	SW-27	TRAVEL LEFT (REVERSE) PRESSURE SW. (OPT)	↑

Note

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

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

SV-3

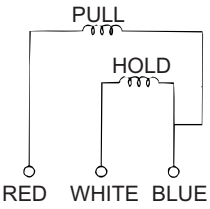
Solenoid

VA31A87-01050

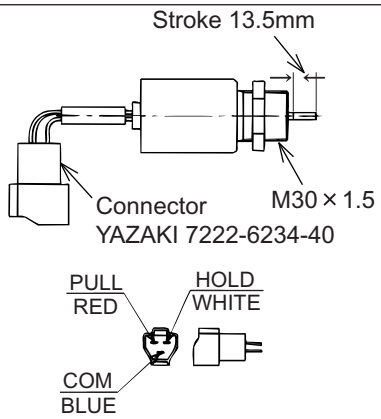
E/G stop

PU08-05001~
PU09-08001~

MITSUBISHI Part No.	VA31A87-01050
Rated voltage	12VDC
Rated current	Pull coil : 50A Hold coil : 1A



Circuit diagram



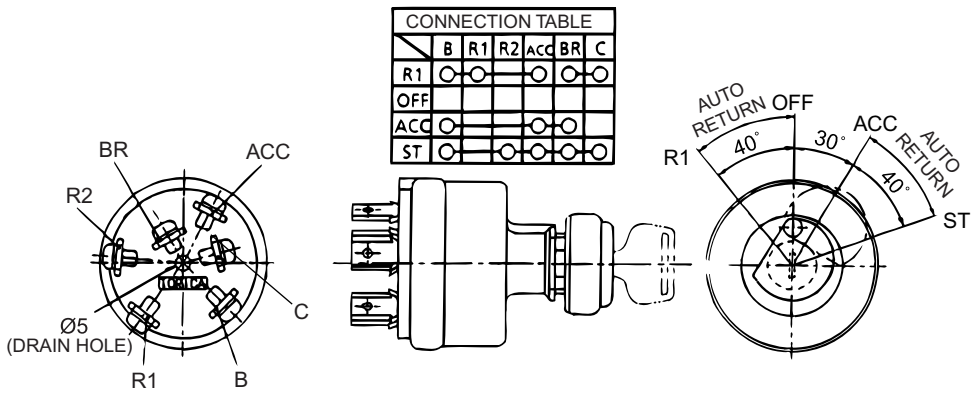
SW-1

Switch

PW50S00004F1

Key switch

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



SW-2

Switch

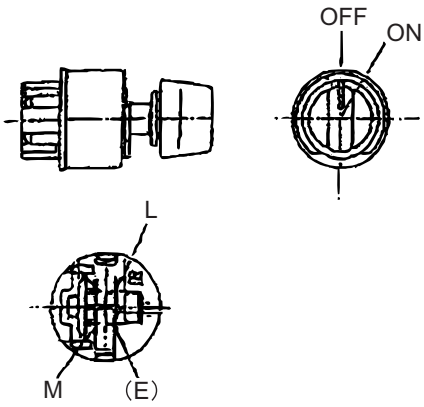
PV24E01001P2

Working light

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

Connection table				
	M	L	(E)	
OFF		○—○		
↕		○—○		
ON	○—○		○	L:70WX2 lamps

(Unconnected)



SW-3

Switch

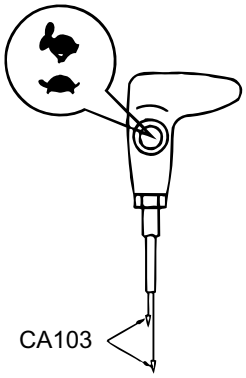
YN03M01286S002
(Right travel lever)

Trvel 1, 2 speed

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

Type	Buried in right travel lever

Switch & Marks

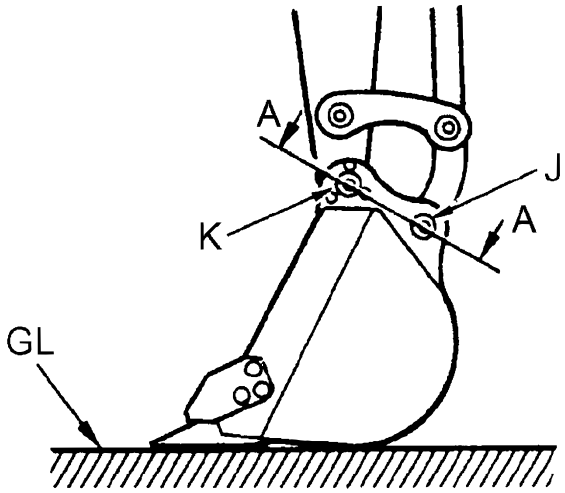


32.1.2 BUCKET

32.1.2.1 REMOVAL OF BUCKET

(1) Operate the operating lever and place the bucket on the ground, so the bucket and arm connecting pins are not loaded.

(2) Move the O-rings (3) toward the bucket bosses using a spatula.



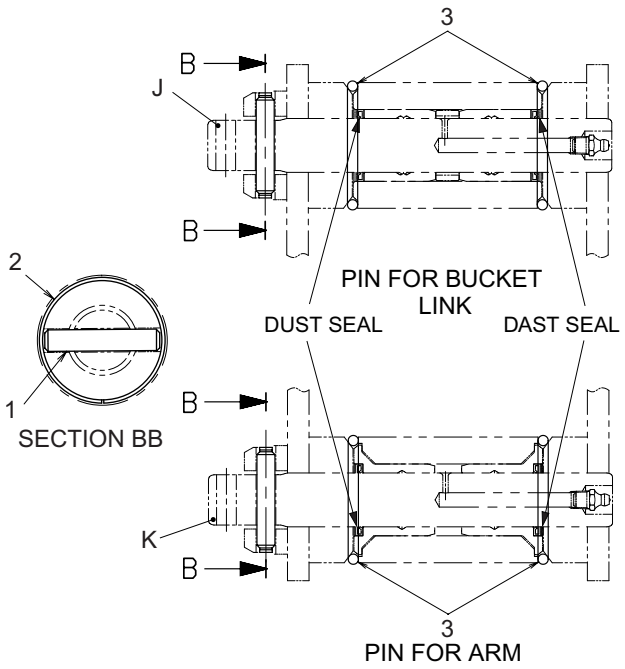
To place Bucket on ground

(3) In order to remove pin (K) which links arm and bucket, remove the ring (2) and the pin (1) by means of straight driver, and draw out pin (K).
- If the pin does not come off easily, the pin is loaded. Take off the load by manipulating the operating lever.
- Take care so the dust seal between the arm and the bucket bosses is not damaged.

(4) Adjust the bucket by manipulating the operating lever so the pin (J) between the bucket link and the bucket is not loaded.

(5) Remove the ring (2) and pin (1) then pull out the pin (J).

(6) Remove bucket assembly.
Weight :35kg (77 lbs)

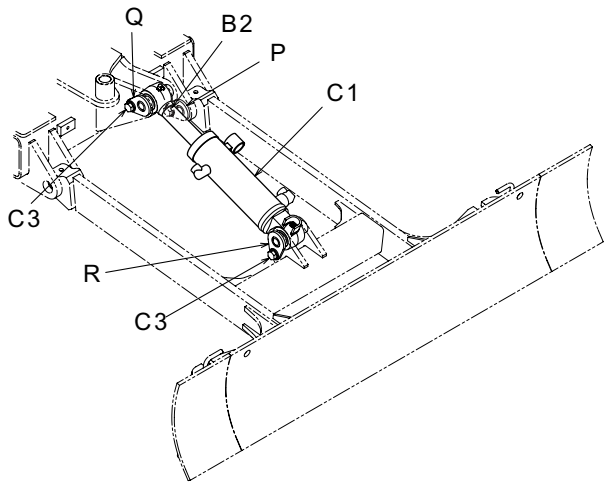


Assembly of pin (SECTION A-A)

32.1.6 DOZER

32.1.6.1 REMOVAL

(1) Put a support of appropriate height under the mounting side of dozer body, and make the dozer at a stable condition not to exert any load to the pin (P).
(2) Disconnect the hydraulic hoses and apply a plug to the connecting portions.
Tools: Spanner: 19mm
(3) Apply a nylon sling to the dozer cylinder (C1), and lift it up slightly not to exert any load to the pin (Q) of rod side.
(4) Remove the capscrew (C3) that are preventing the pin (Q) from coming out, of rod side. Remove the pin (Q), and support the cylinder (C1) with a wood block, etc.
Tools: Spanner: 19mm
(5) Remove the capscrew (B2) that are preventing the dozer body fixing pin (P) from coming out, and remove the two pins (P).
(6) Gradually move the machine to backward to remove the dozer.
Weight of dozer assembly : 90kg (198 lbs)
(7) If necessary, remove the dozer cylinder by means of removing the pin (R) of head side.
Weight of dozer cylinder :10kg (22 lbs)

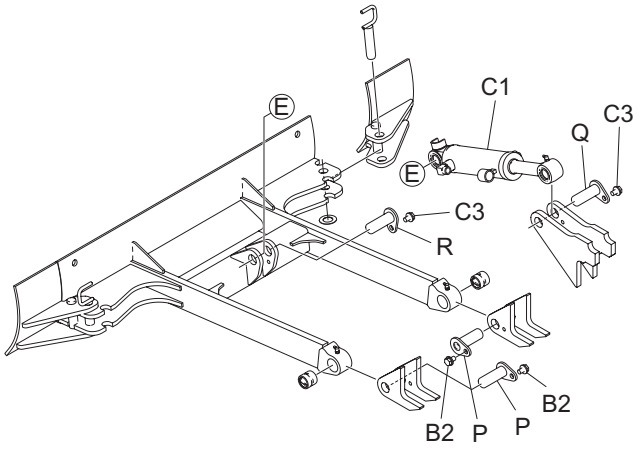


Removing/Installing Dozer

32.1.6.2 INSTALLATION

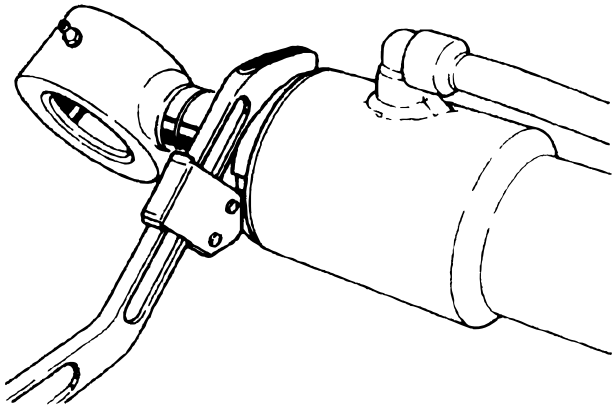
The installation is carried out with the reverse order of the removal paying attention for the following.

(1) Referring to the Section "ATTACHMENT DIMENSIONS" of Specifications, replace the worn-out bushings and dust seals to new ones.
(2) Before installing pin (P), (Q) and (R), apply grease to their shaft area.
(3) Applying loctite #262 to the stopper capscrews tighten them up.
Tools: Spanner: 19mm, T=115 N-m (254 lbf-ft)



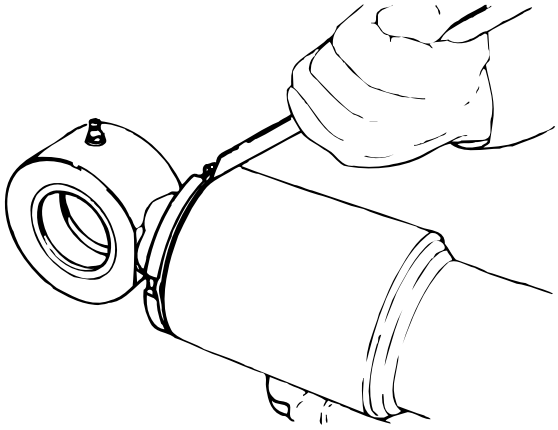
Installing Dozer

2. Install the cylinder head (4).
   - Apply hydraulic oil on the packings (seals) prior to install
   - Tightening torque for cylinder head ;See Table 32.2.1.6.(1)



Installing cylinder head

3. Bend the locking, fin on the tube to lock the cylinder head.



Assembling cylinder assembly

33. UPPER SLEWING STRUCTURE

Issue	Date of Issue	Applicable Machines	Remarks
	03-2010	CX17B NATN16300	(CASE - NA)

(7) Removing rod of N&B pedal

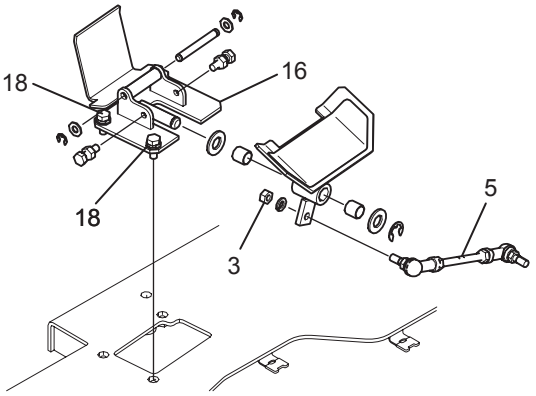
1.

Loosen three M8X20 sems-bolts (18) to pull out the support (16) upward.

Tools: Spanner: 13 mm

2.

Loosen M8 nut (3) and disconnect the control rod (5).



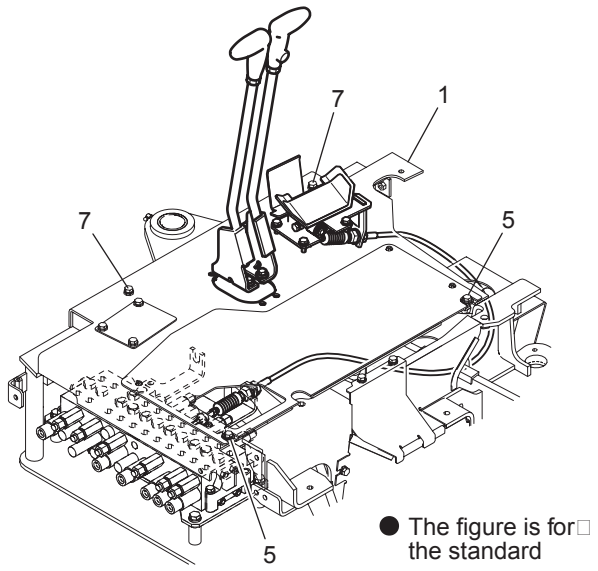
N&B rod disconnection

33.1.5.2 FLOOR PLATE REMOVAL

(1) Remove the two M8X20 sems-bolts (5) and two M8X70 capscrews (7).

Tools: Spanner: 13 mm

(2) Remove the floor plate assembly (1).



Floor plate (1) removal

33.1.5.3 ASSEMBLING FLOOR PLATE

(1) Assemble the floor plate in reverse order of the disassembly.

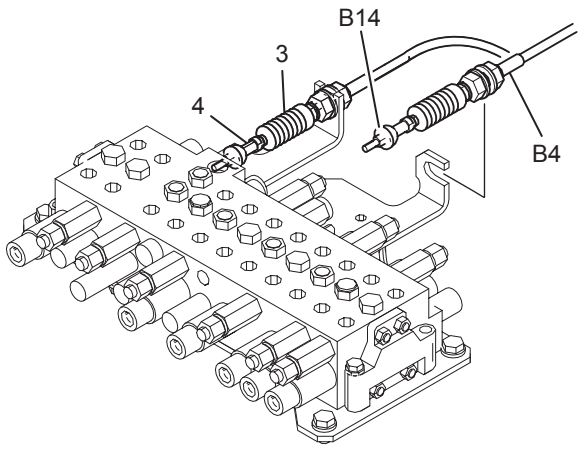
Sems-bolt (6) M8 :

Tools: Socket: 13 mm

Tightening torque : 23.5 N-m (17 lbf-ft)

(2) Disconnecting cables

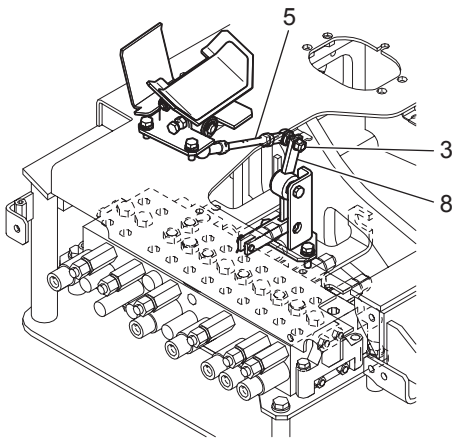
1. After loosening the lock nut, turn the rod end (4) to disconnect the dozer cable (3).
2. After loosening the lock nut, turn the rod end (B14) to disconnect the swing cable (B4).



Cable disconnection

(3) Removing rod

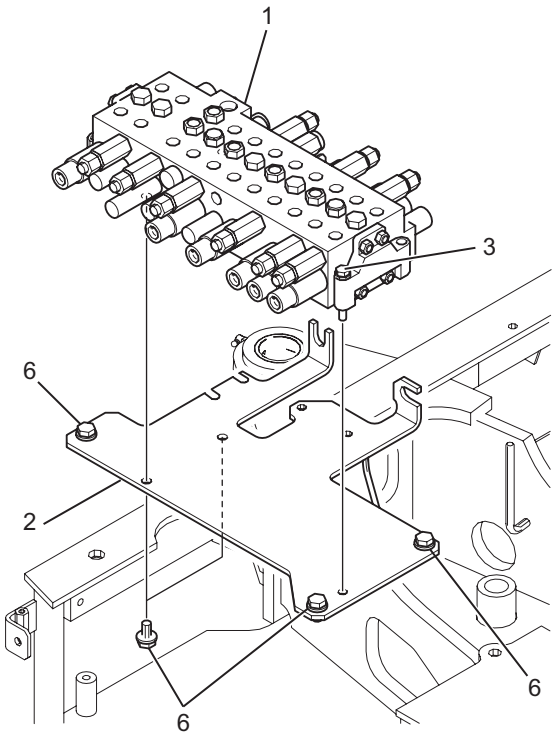
Remove the nut (3) to disconnect the rod (5) from the lever (8).
Tools: Spanner: 13 mm



Rod disconnection

(4) Removing control valve

1. Loosen three M10X20 sems-bots (6) to remove the control valve (1) with the bracket (2).
   Tools: Socket: 17 mm
   Weight of removed parts : Approx. 27 kg (60 lbs)
2. Loosen one M8X60 capscrew (3) and two M10X20 sems-bolts (6) to remove the control valve (1).
   Tools: Socket: 13, 17 mm
   Weight : Approx. 23 kg (51 lbs)



Control valve removal

33.1.17.3 INSTALLATION

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

1.

Attaching sems-bolts (14 : T=2.7 N-m (2.0 lbf-ft)).

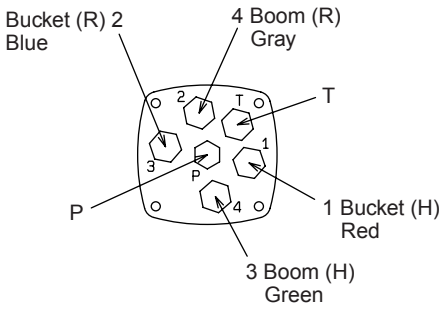
Attaching capscrew (B22) and (B26) : T=9.7 N-m (7.21 lbf-ft)

Tools: Torx driver (T25)

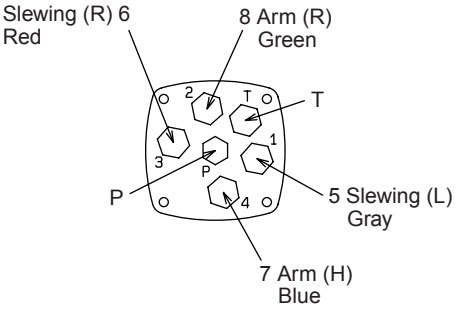
2.

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)



Right side



Left side

Pilot valve port location(View lower side)

Note

Take care of the tightening torque as the pilot valve is made of aluminum.

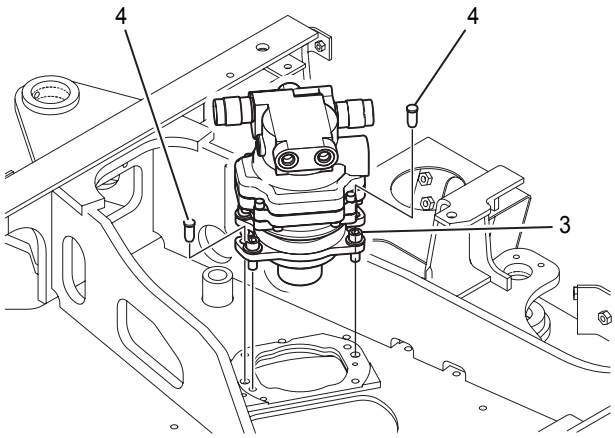
(2) Pressurize the hydraulic tank (See Section 33.1.7.3).

(3) Operate the attachment to check the performance.

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

(3) Remove two pins (4).

(4) (4) Loosen four M12X45 capscrews (3) to remove the slewing motor.
Tools: Allen wrench: 10 mm [a long type approx. 300 mm (11.8") in length required].
Weight : about 23 kg (51 lbs)



Slewing motor removal

33.1.20.3 INSTALLATION

(1) Install the motor in reverse order of the removal according to the tightening torque shown below.
1.
Apply Loctite #515 on the entire circumferential surface for mounting the slewing motor (1).
2.
Attach two pins (4).
3.
Install the capscrews (3) for fixing the motor.
Tools: Allen wrench: 10 mm
T=115 N-m (85 lbf-ft)
Apply Loctite #262 to the capscrew.
4.
Connect the hoses
- Fill the casing with hydraulic oil through the motor drain port prior to connecting drain piping.

		Tightening torque N•m (lbf•ft)	
Thread size (PF)	Spanner used (mm)	O-ring type fitting	30º flare type fitting
1/4	19	36.3 (27)	29.4 (22)
3/8	22	73.5 (54)	49 (36)
1/2	27	108 (80)	78.5 (58)

(2) Feed grease to the pinion gear of the slewing motor.

(3) Check the hydraulic oil tank for the oil level. Supply oil if necessary.

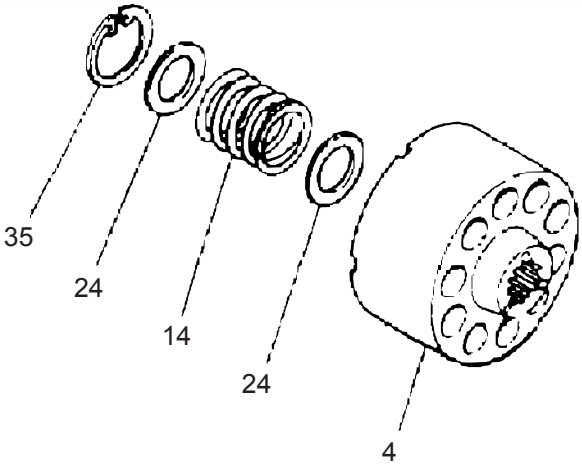
(4) At the start, run the motor in the low idling condition of the engine for a few minutes to check for oil leakage and abnormal noise.

(6) Disassembling of Cylinder barrel (4) kit

1.
Remove shoe holder (8) on which piston shoe assemblies (6) and (7) are set and disassemble it in the order of barrel holder (9).

2.
Remove needle (11) from cylinder barrel (4).

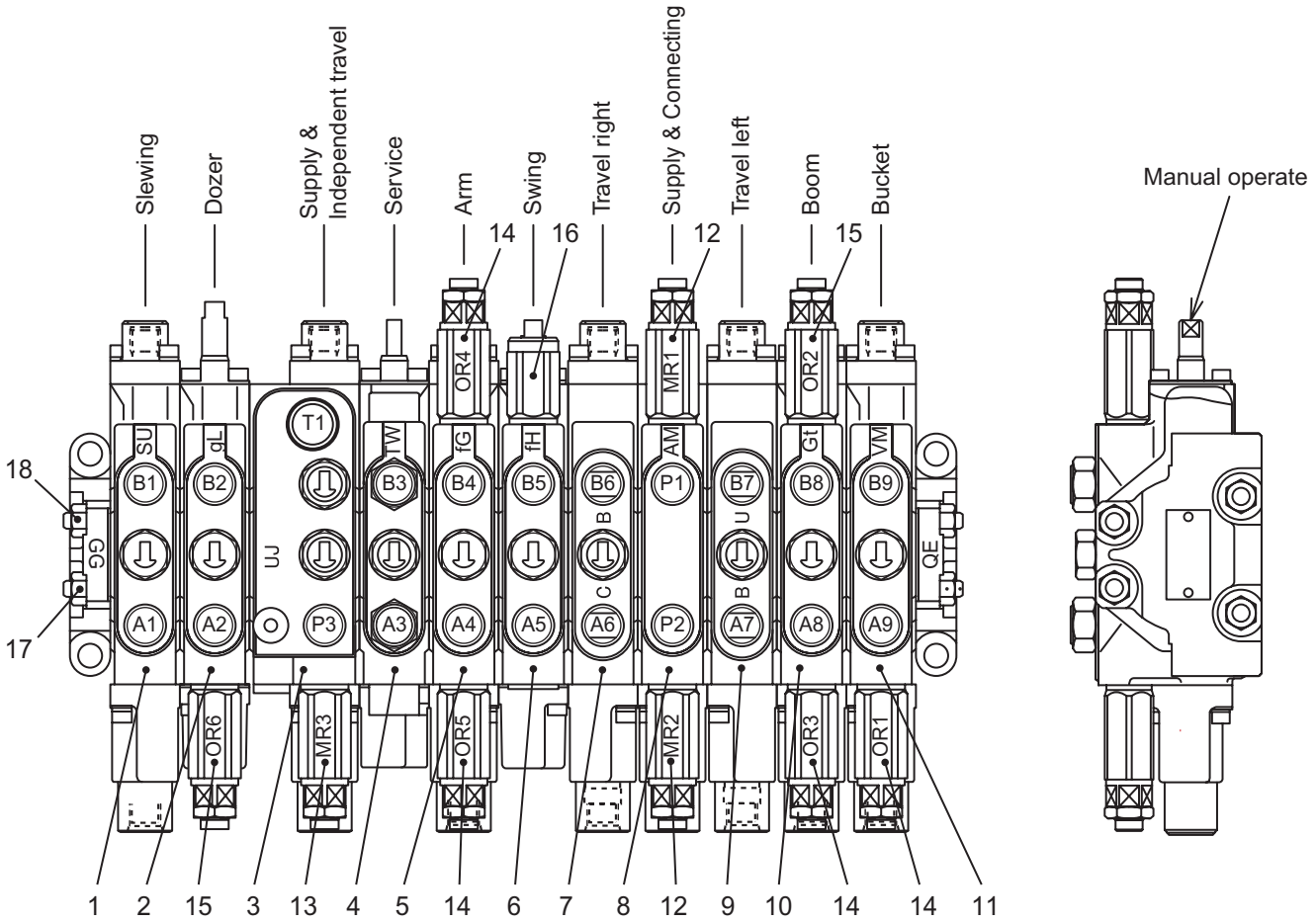
3.
Tank off snap ring (35), retainer (24), spring C (14) and retainer (24), which are set in the cylinder barrel (4) in this order.



33.2.2 CONTROL VALVE

33.2.2.1 CONTROL VALVE

(1) Outside view



No.	NAME	Q'TY	No.	NAME	Q'TY
1	Slewing section	1	10	Boom section	1
2	Dozer section	1	11	Bucket section	1
3	P3 inlet, independent travel & conflux section	1	12	P1, P2 Main relief valve	2
4	Service section	1	13	P3 Main relief valve	1
5	Arm section	1	14	Over load relief valve	4
6	Swing section	1	15	Over load relief valve	2
7	Travel (right) section	1	16	Anti cavitation valve	1
8	P1, P2 inlet straight	1	17	Tie bolt	4
9	Travel (left) section	1	18	Nut	8

33.2.2.5 PRECAUTIONS WHEN ASSEMBLING

CAUTION

Precautions (Observe the following for safety.)

(1) The unevenness of tightening torque and the contamination by dust during assembly may cause a failure. And observe the tightening torque specified in the description.
(2) When assembling, check up on the valve construction drawing, identify the number of part, and ensure that there is no installation error and omission of part, etc.
(3) After cleaning the parts required to use with cleaning solvent, immerse them in hydraulic oil as required and reassemble them.
(4) Before applying Loctite, clean and decrease the surface sufficiently, and apply it to two threads.
(Over application may cause a malfunction due to the squeezing out.)

33.2.2.6 PRECAUTIONS WHEN FITTING SEALS

CAUTION

Precautions (Observe the following for safety.)

(1) Replace seals with new ones when assembling.
(2) Ensure that seals are free from deformation and flaw coming about when handling them.
(3) Apply grease or hydraulic oil to the seals and seal fitting section to make the sliding smooth, unless otherwise specified.
(4) Do not stretch the seals too much. Otherwise they may be permanently deformed.
(5) Pay attention not to roll the O-ring when fitting. Because it is difficult for the twisted O-ring to be restored naturally after fitting, and it may cause oil leakage.

33.2.2.7 ASSEMBLY WORK

(1) Assembling main frame of switching section

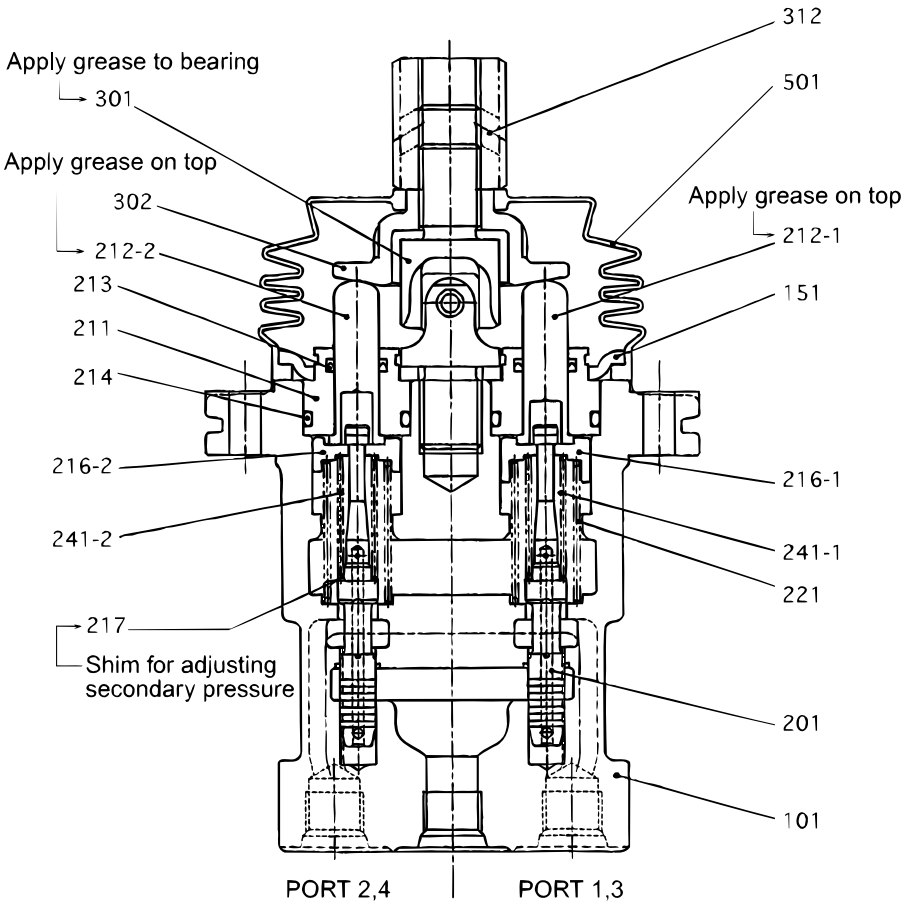
1. On a surface plate with clean rubber plates on it, place Comp. Bodies with actuator port machined surface facing downward in the order shown in "Orders of Assembling Bodies" on the next page.
   At this time, set in the main body of identification sign VM in order of poppet valve (12) --> spring of poppet valve (13) --> plug of poppet valve (14), and tighten the plug of poppet valve (14) with the specified torque with spanner or a socket wrench of 14 mm.

CAUTION

- Then, check the mating surfaces in each Comp. Body for dust or the like and check whether O-rings shown in the delivery specifications are surely put in each groove for O-ring.
- Kinked O-rings could cause the leakage of hydraulic fluid to the outside due to the malfunction of sealing performance.
- If O-rings are not installed surely in O-ring grooves, there would be the nip of O-ring, resulting in the leakage of hydraulic fluid to the outside when assembling the Bodies.

33.2.3 PILOT VALVE (Attachment)

33.2.3.1 CONSTRUCTION

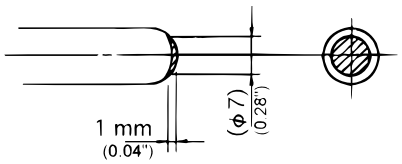


Pilot valve (Attachment)

Item	Thread size	Tightening Torque Table N-m (lbf-ft)
301	M14	47.1 (34.7)
302, 312	M14	68.6 (50.6)

Item	NAME	Q'TY	Item	NAME	Q'TY	Item	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

33.2.3.5 Maintenance standard

Maintenance item	Standard	Remarks
Amount of leakage	Replace with a complete set of pilot valve when the amount of leakage reaches more than 1000 cc/min (61 cu•in/min) or 2000 cc/min (122 cu•in/min) at the neutral position of the handle or during operation, respectively.	Condition : Primary pressure : 2.94MPa (427 psi) Oil viscosity : 23 mm^2/s
Spool	Replace with a complete set of pilot valve when an amount of wear at the sliding section is more than 10 μm (0.0004") in comparison with the non-sliding section.	The wear condition to the left is considered to correspond to the above amount of leakage.
Push rod	Replace when a wear amount of the tip is more than 1 mm (0.04"). 	
Unnecessary play in operation section	Replace when a play more than 2 mm(0.079") due to wear and so on is found on the disk (302) or joint section (301) of the operation section.	A play generated by loosening of tightening portion should be adjusted.
Action stability	Replace with a complete set of pilot valve when abnormal noise, hunting or primary pressure drop is generated during operation and the trouble cannot be remedied according to Section 33.2.3.6 TROUBLESHOOTING.	

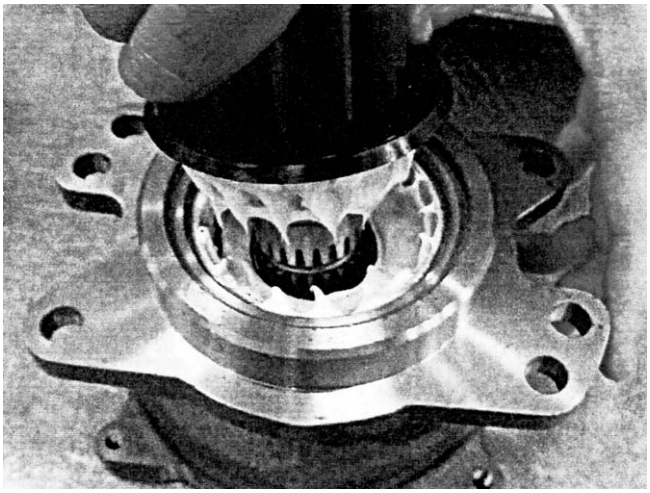
Note

Replace seal such as O-ring with new ones after every disassembly.

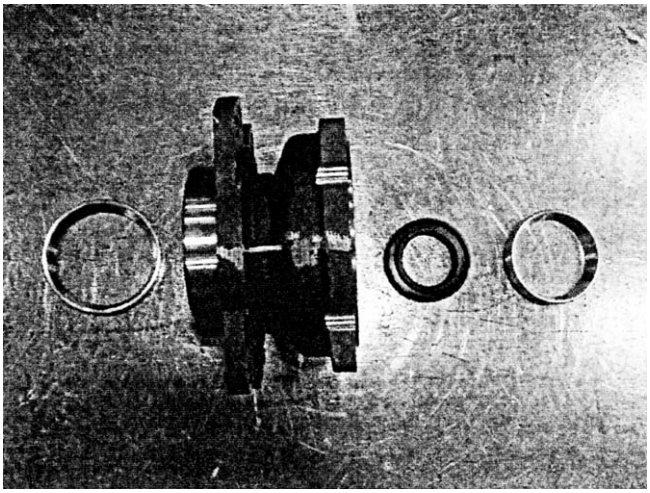
33.2.3.6 TROUBLESHOOTING

Phenomenon	Possible Cause	Corrective action
Secondary pressure does not rise.	1. Primary pressure is insufficient. 2. Springs (241-1, 241-2) are broken or fatigued. 3. Clearance between spool (201-1, 201-2) and valve body (101) is abnormally large. 4. Play of handle portion is too much.	1. Secure primary pressure. 2. Replace with new ones. 3. Replace assembly. 4. Disassembly and reassembly or replace handle portion.
Secondary pressure is unstable.	1. Sliding parts are caught. 2. Tank line pressure varies. 3. Air has contained into pipeline.	1. Correct. 2. Return directly to oil tank. 3. Release air.
Secondary pressure is high.	1. Tank line pressure is high. 2. Sliding parts are caught.	1. Return directly to oil tank. 2. Correct.

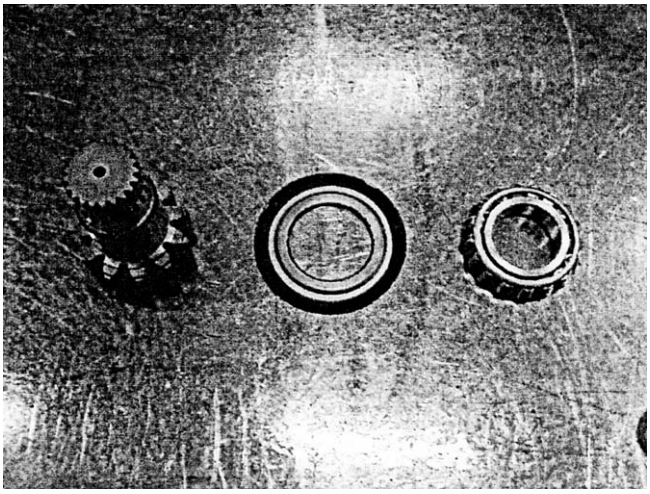
4. Take out the pinion shaft (104).
   - To secure the drawing space of the pinion shaft, attach the approximate 100 mm pad to the flange part, and push out the pinion shaft (104) by the press.
   - As pre-adjusted the gap with the bearing, do not disassemble unless it is necessary.



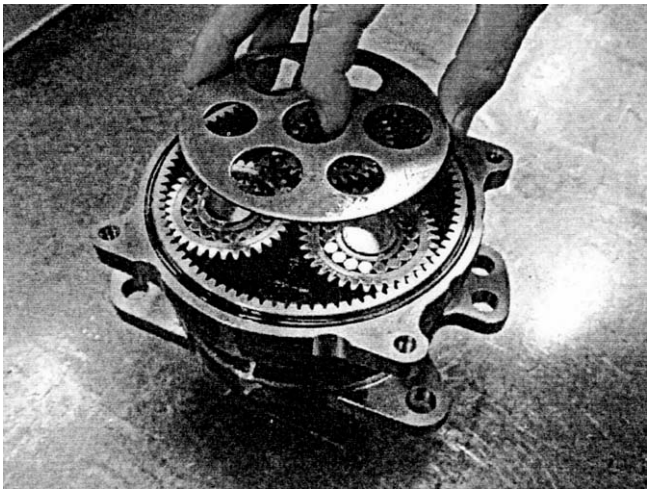
5. Take out the outer ring of the bearing (121, 122), and the oil seal (123).
   - As it is difficult to take put the outer ring of the bearing (121, 122), do not disassemble unless it is necessary.
   - Do not use again the oil seal.



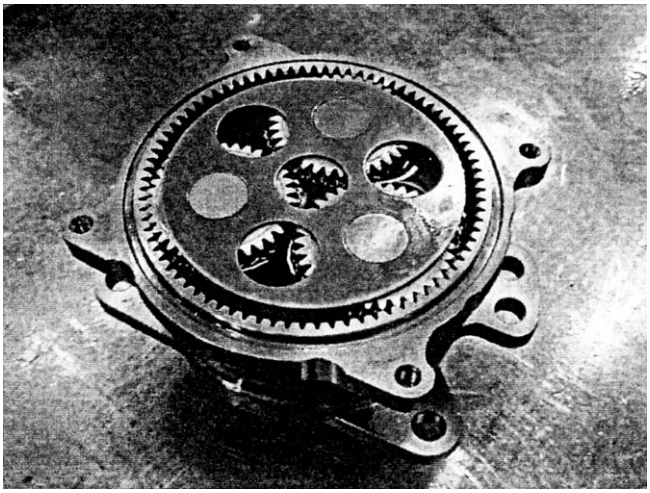
6. Take out the inner ring of the bearing (121) and the ring seal (113).
   - As the inner ring of the bearing (121) is press-fitting one, do not disassemble unless it is necessary.
   - Do not use again the ring seal (113).



15.Place the thrust plate (115) onto the carrier 1.
- Smaller size holes are aligned to the pins.



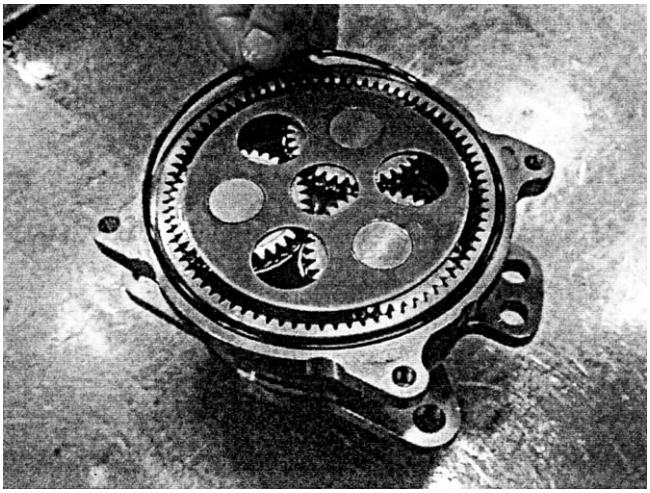
16.Fill the body with hydraulic oil.



CAUTION

Oil : ISO VG46 or equivalent.
Oil amount : 3 to 4 mm below the top thrust plate.
Wipe the oil off the flange surface if it is spilled.

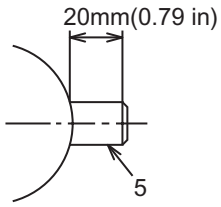
17.Place the O-ring (114) onto the body.



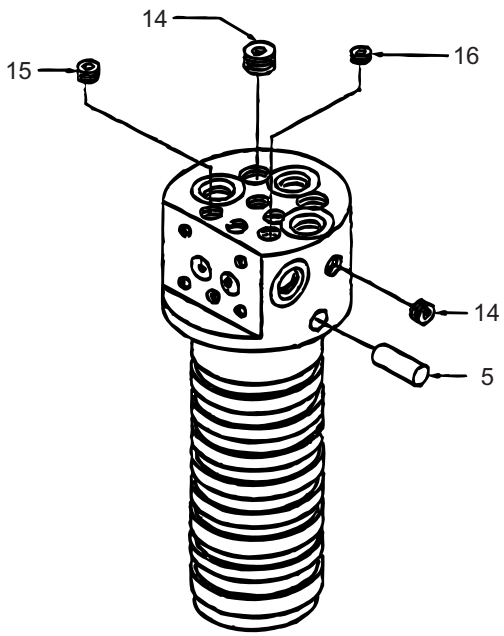
33.2.6.4 Assembly

33.2.6.4.1 Assembling Swivel Joint

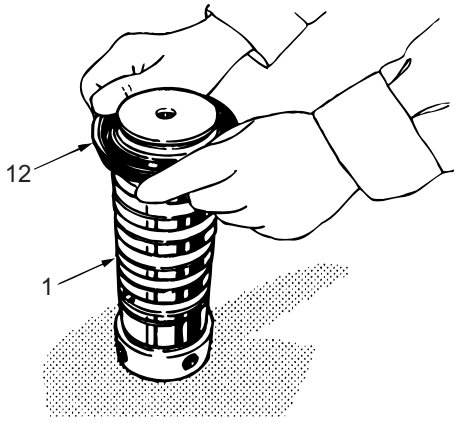
(1) Installing pin (5) :
When the pin (5) has been removed, tap it into the shaft (1) with a plastic hammer paying attention to the installing length.



(2) Installing plugs :
When plugs (14), (15) and (16) have been remover, install them with each specified tightening torque.
Plug (14) : Tools: Allen wrench: 6 mm, T=29.4 N-m (22 ft-lbs)
Plug (15) : Tools: Allen wrench: 5 mm, T=18.6 N-m (14 ft-lbs)
Plug (16) : Tools: Allen wrench: 4 mm, T=9.8 N-m (7.8 ft-lbs)

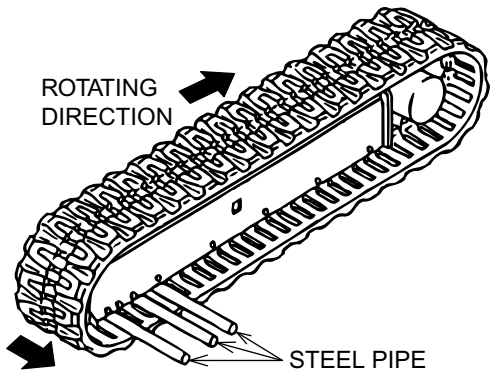


(3) Install the dust seal (12) to the shaft (1).
- Apply grease in plenty to the lip portion of dust seal (12).



(4) Installing seals :
Install the O-ring (7), backup ring (11) and slipper seal (6) into each groove on the body (2).
- Ensure each positioning of the seals referring to the structural drawing.
- Pay attention not to give any damages, scores and twisting to the seals.

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.

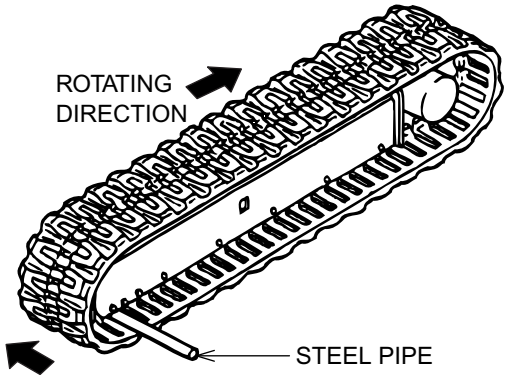


Removing rubber crawler

34.1.2.1.2 INSTALLING RUBBER CRAWLER

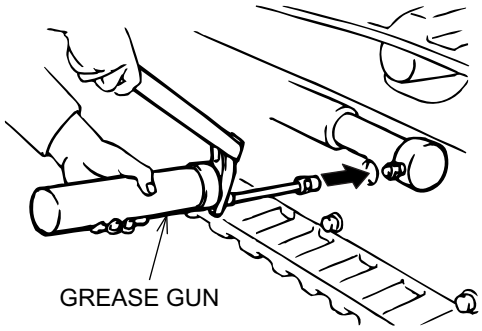
Installation work is performed in the reverse order of removal.

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

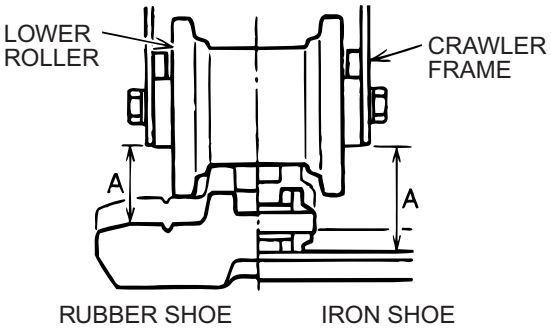
4. Confirm that the rubber crawler is engaged securely with the sprocket, idler and lower roller.
5. Tighten the grease nipple for the crawler adjuster, and adjust tension by feeding grease.
   Tools : Socket : 19mm,
   T=59 N-m (44 lbf-ft)



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

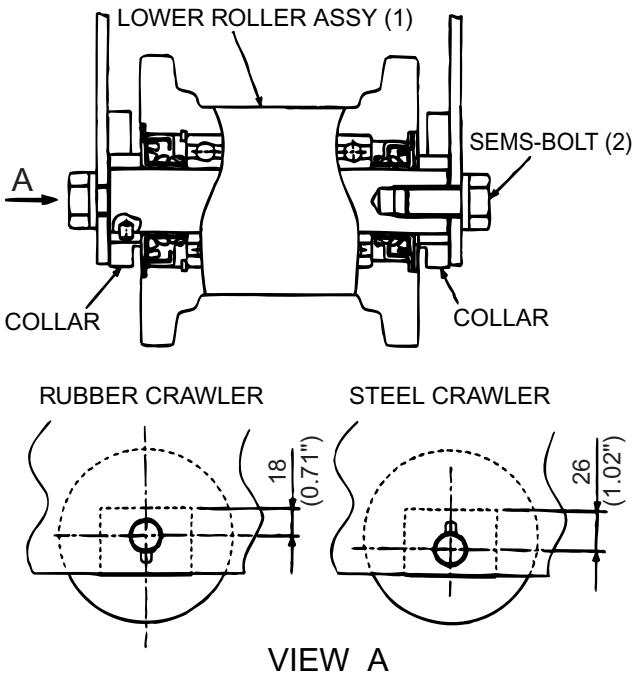
34.1.4.1.2 Installing

(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

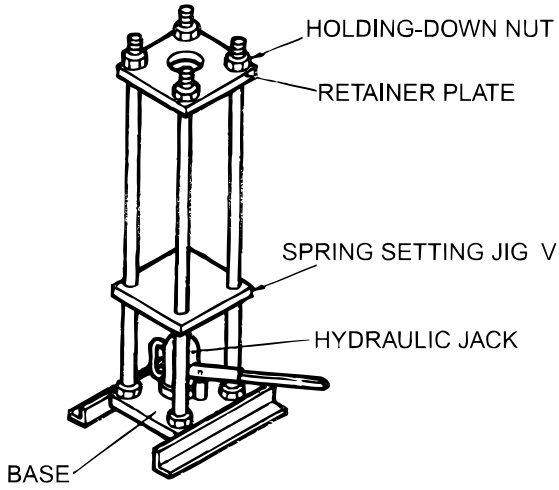
CAUTION

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)

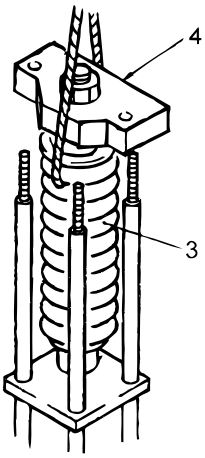


Spring set special jig (V)

WARNING

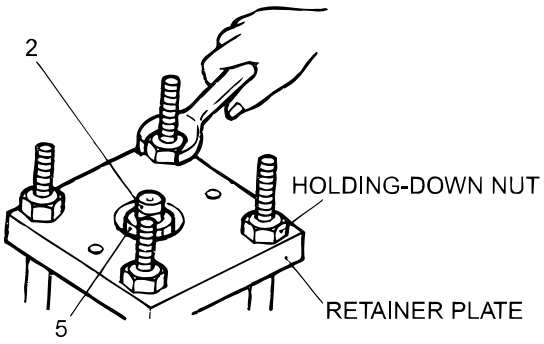
Large power is needed to set the spring. Prepare a special jig before disassembly and assembly.

(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.



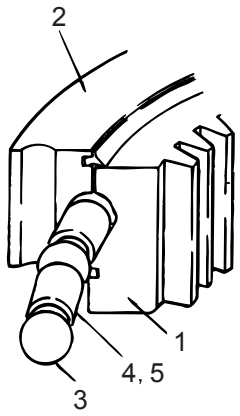
Fixing Holding-down nut

34.1.9.3.2 Assembling

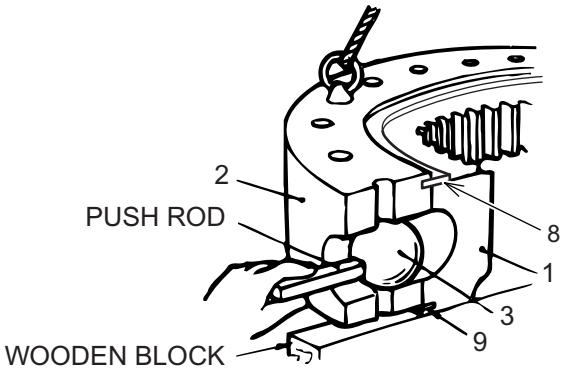
(1) Degrease thoroughly the groove for seal A (8) located in the inner circumference of outer race (2) and the groove for seal B (9) located in the outer circumference of inner race (1). Coat the grooves with adhesive Cyano Bond PO-1, fit seal B (9), and place inner race (1) on a surface table.

(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

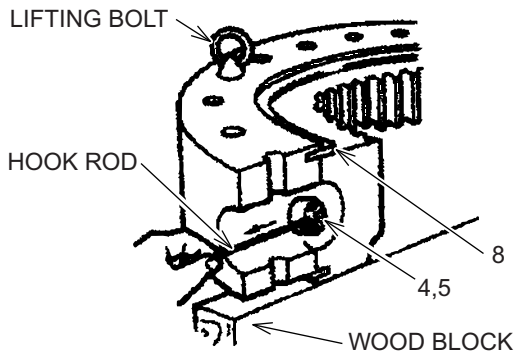
When forwarding balls (3) and spacers (4) (5), the raceways must be aligned completely. To achieve it, outer race (2) should be adjusted. It is very dangerous to put your finger into the plug bore directly ; always use a push rod or a hooked rod.

(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)

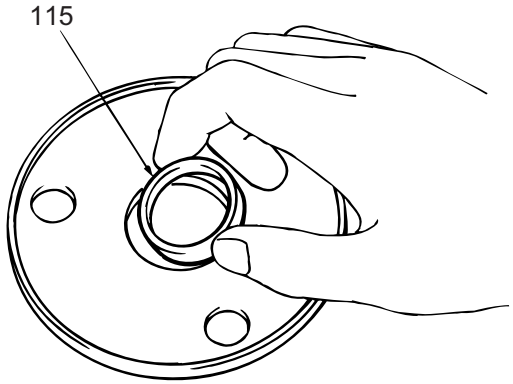


Installing spacer

34.1.9.4 MAINTENANCE STANDARDS

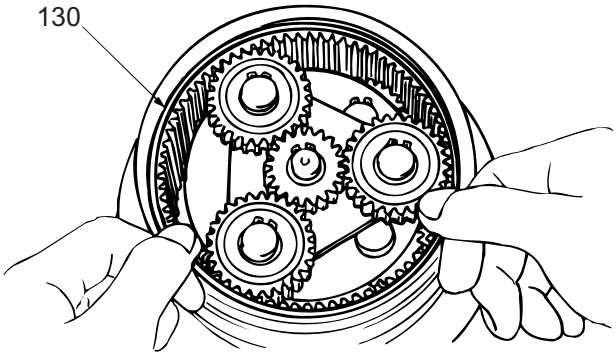
Regarding the maintenance standards for the wear of the slewing bearing, refer to the Article Measuring Slewing Performances in PM13 Maintenance Standards and Test Procedures.

4. Remove the slide ring (115) from the cover (102).



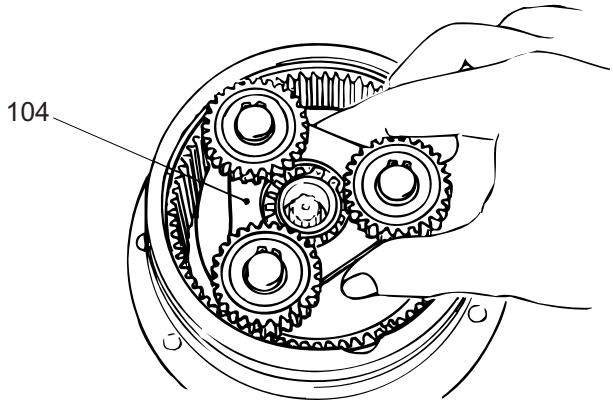
Slide ring (115) removal

5. Remove the O-ring (130).



O-ring (130) removal

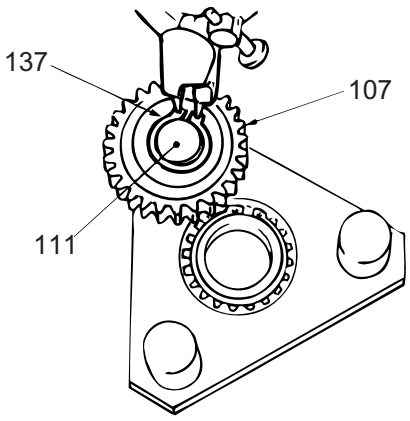
6. Remove the carrier 2 (104) assy.



Removing carrier 2 (104) assy

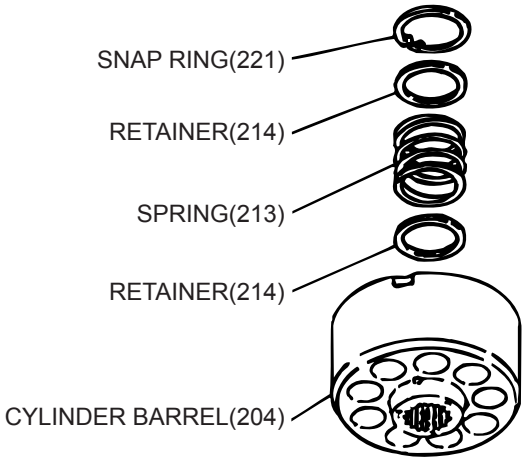
7. Disassembling carrier 2
a. Remove the snap ring (137) from the B2 pin (111).
b. Remove the thrust washer (121), the B2-gear (107), the needle (117) and the thrust washer (121) one after another.

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

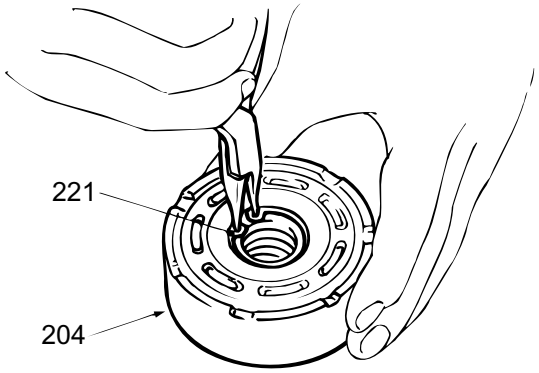


Snap ring (137) removal

13.Install the retainer (214), the spring (213) and the retainer (214) to the cylinder barrel (204) in this order, and fix by the snap ring (221).

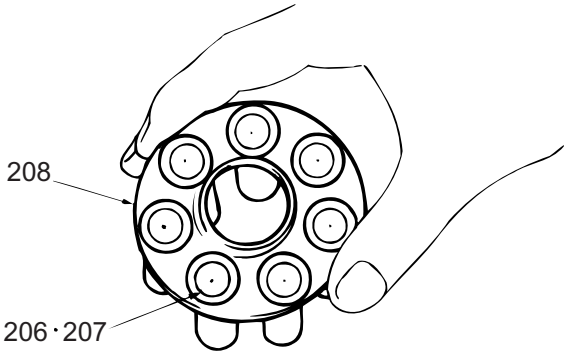


Installing parts to cylinder barrel (204)



Snap ring (221) installation

14.Assembling shoe holder (208) install the piston (206) and the shoe (207) assy to the shoe holder (208) to complete the shoe holder assy.



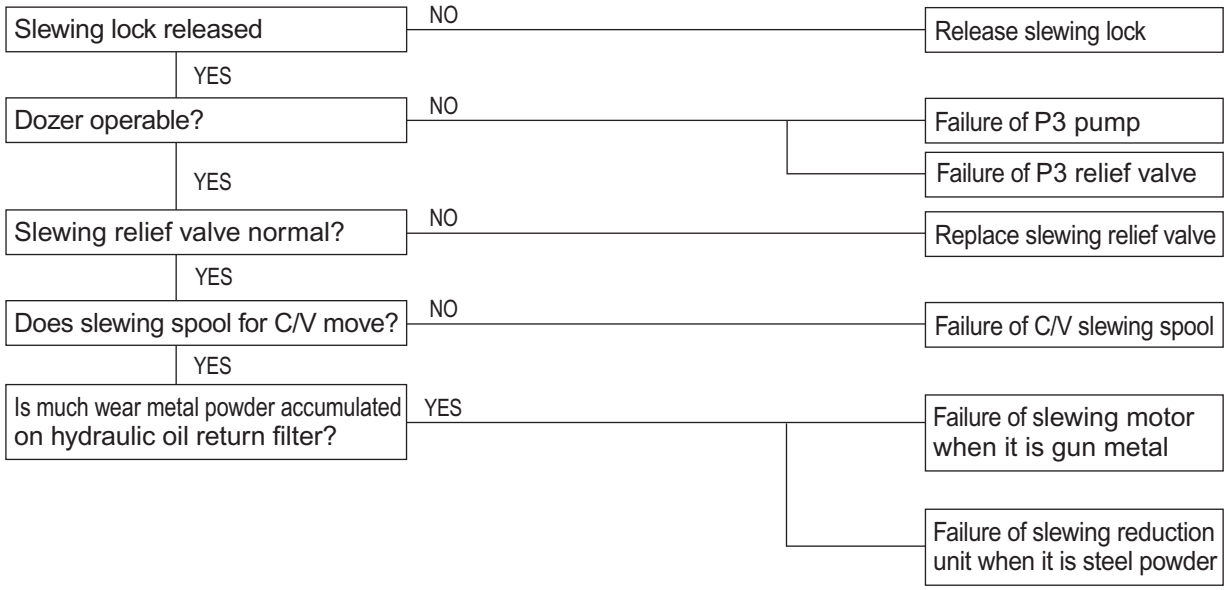
Shoe holder (208) assembly

(4) General precautions

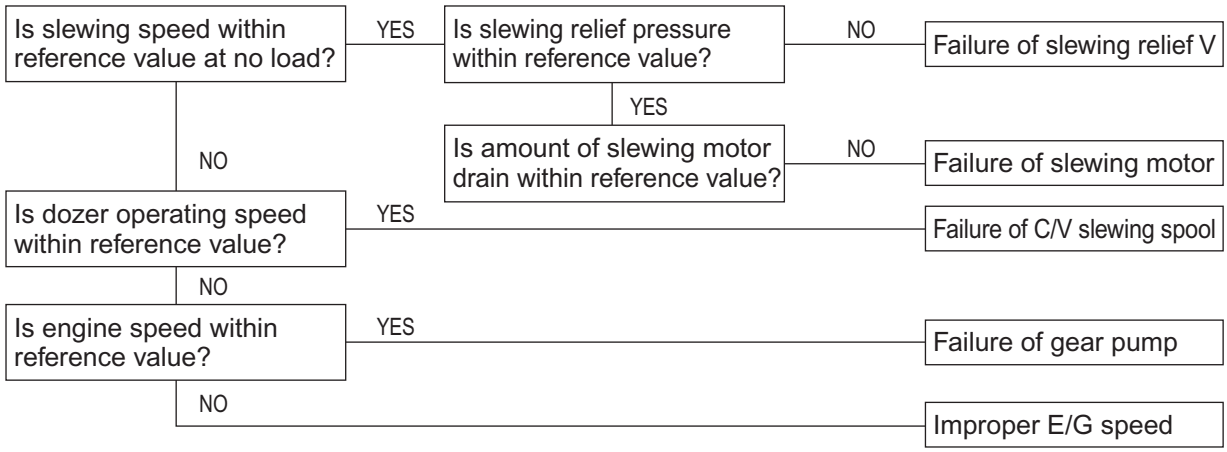
We recommend the user to prepare a check sheet for lubricating oil. Check oil leakage and loose bolts periodically to prevent trouble.

42.3.3 SLEWING OPERATION

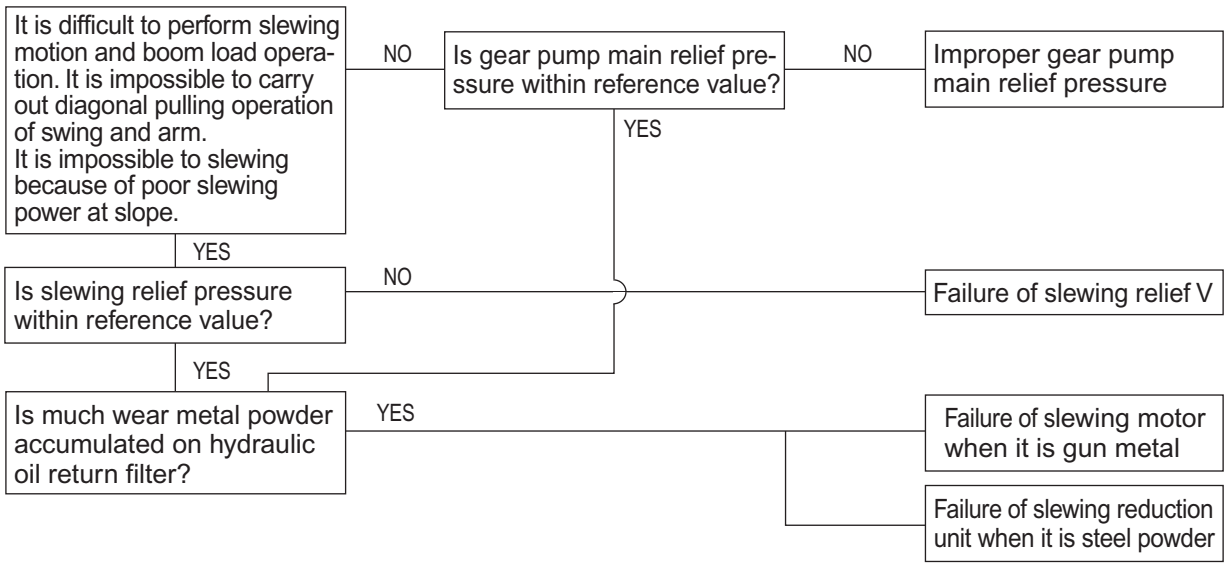
42.3.3.1 SLEWING OPERATIONAL FAILURE



42.3.3.2 SLEWING SPEED IS SLOW

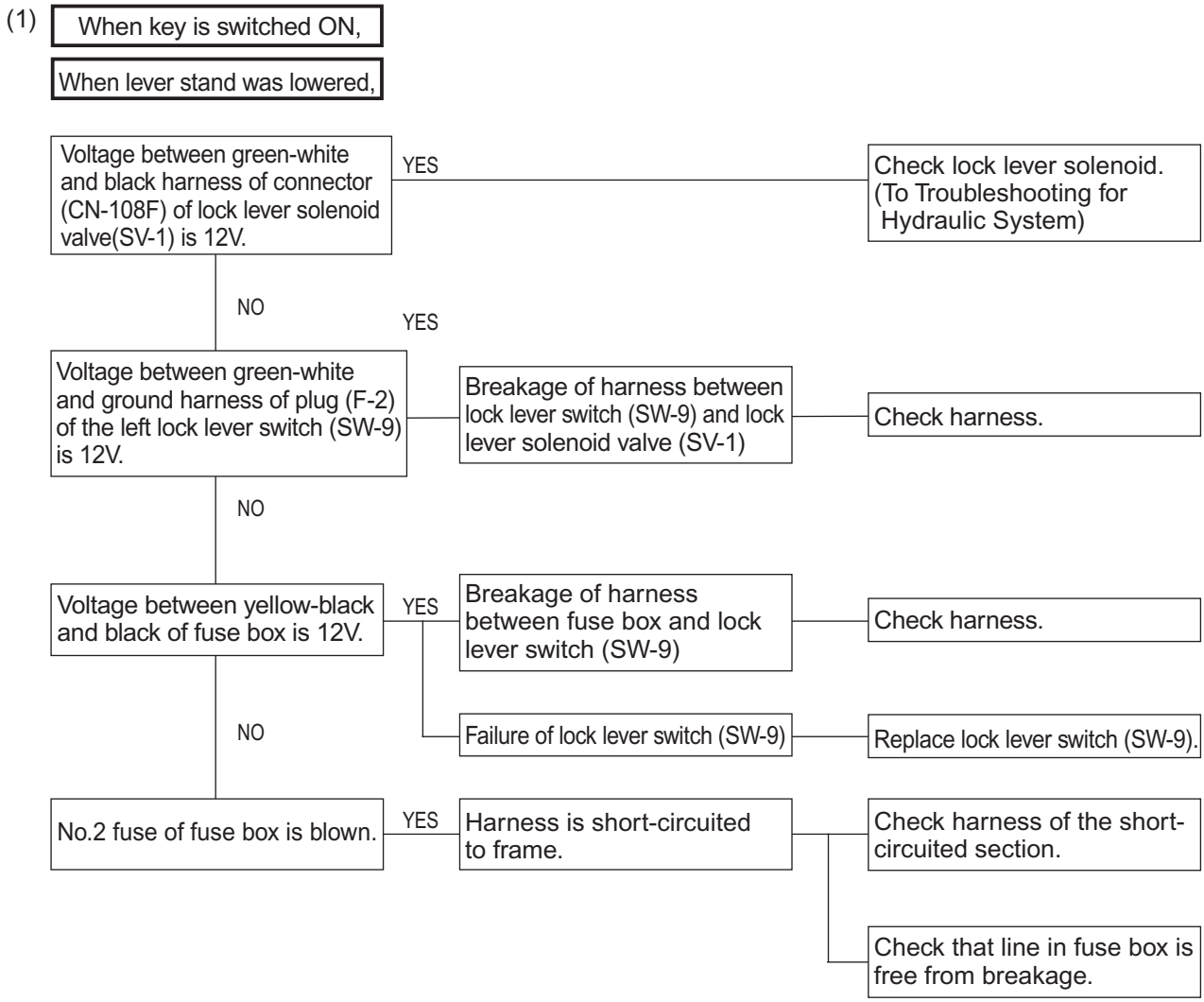


42.3.3.3 SLEWING POWER IS LOW

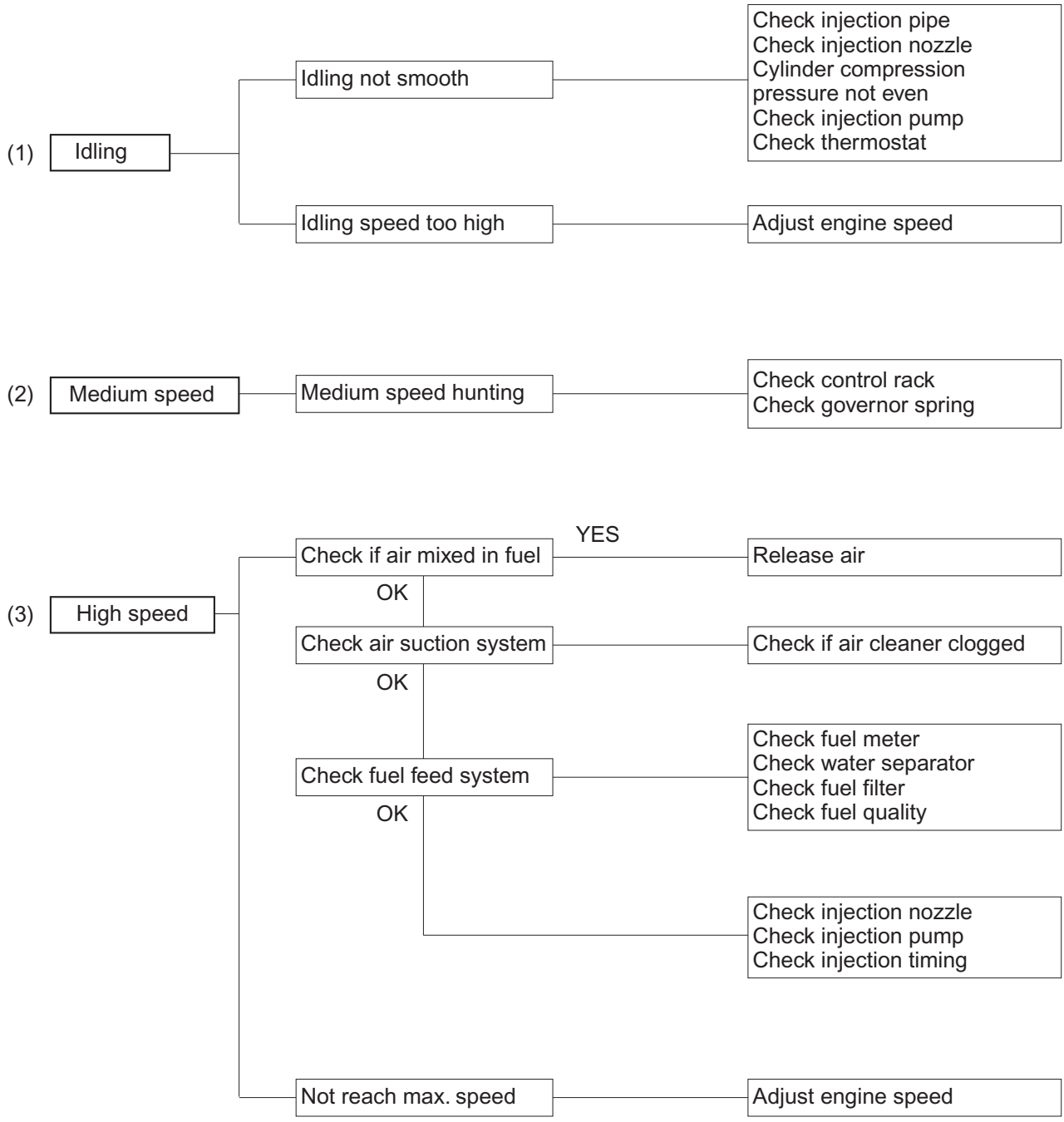


43.2.2 ATTACHMENT OPERATION

43.2.2.1 ALL CONTROLS DO NOT FUNCTION (Excluding swing, dozer and crawler width operations)



44.2.2 E/G ROTATION TROTUBLE



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

⚠ CAUTION

About warning labels

Maintenance of warning labels

Make sure all warning/caution labels are legible.

Clean or replace the warning/caution labels the description and/or illustration of which cannot be seen clearly.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.

To obtain replacement warning labels, contact a Mitsubishi dealer.

Warning labeles

6. Tips on disassembling and reassembling

This service manual specifies the recommended procedures to be followed when servicing Mitsubishi engines. The manual also specifies the special tools that are required for the work, and the basic safety precautions to follow when working.

Note that this manual does not exhaustively cover potential hazards that could occur during maintenance, inspection and service work of engine.

When working on an engine, follow the relevant directions given in this manual and observe the following instructions:

6.1 Disassembling

(1) Use correct tools and instruments. Serious injury or damage to the engine will result from using the wrong tools and instruments.

(2) Use an overhaul stand or work bench if necessary, and follow the disassembling procedures described in this manual.

(3) Keep the engine parts in order of removal to prevent losing them.

(4) Pay attention to assembling marks. Put your marks on the parts , if necessary, to ensure correct reassembling.

(5) Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be detected after disassembling or cleaning.

(6) When lifting or carrying heavy parts, excercise utmost caution to ensure safety. Pay attention to blance of heavy parts when handling. (Get help, and use jacks, chain blocks and guide bolts as necessary.)

6.2 Reassembling

(1) Wash all engine parts, except such parts as oil seals, O-rings and rubber sheets, in cleaning oil and dry them with compressed air.

(2) Use correct tools and instruments.

(3) Use only high-quality lubricating oils and greases of appropriate types. Be sure to apply oil, grease or adhesive to the part wherever specified.

(4) Use a torque wrench to tighten parts correctly when their tightening torques are specified.
Refer to "List of Tightening Torque."

(5) Replace all gaskets and packings with new ones unless specified otherwise. Apply adhesive if necessary. Use only the proper amount of adhesive.

2.3 Standard eyebolt tightening torque

Table 2-15 Standard eyebolt tightening torque

Threads Dia × Pitch (mm)	Width across flats (mm) [in.]	Strength classification		
		4T		
		N·m	kgf·m	lbf·ft
M8 × 1.25	12 [0.47]	8 ± 1	0.8 ± 0.1	5.8 ± 0.7
M10 × 1.25	14 [0.55]	15 ± 2	1.5 ± 0.2	11 ± 1.5
M12 × 1.25	17 [0.67]	25 ± 3	2.5 ± 0.3	18 ± 2.2
M14 × 1.5	19 [0.75]	34 ± 4	3.5 ± 0.4	25 ± 2.9
M16 × 1.5	22 [0.87]	44 ± 5	4.5 ± 0.5	33 ± 3.6
M18 × 1.5	24 [0.94]	74 ± 5	7.5 ± 0.5	54 ± 3.6
M20 × 1.5	27 [1.06]	98 ± 10	10.0 ± 1.0	72 ± 7.2
M24 × 1.5	32 [1.26]	147 ± 15	15.0 ± 1.5	109 ± 11
M27 × 1.5	41 [1.61]	226 ± 20	23.0 ± 2.0	166 ± 15

(Dry)

2.4 Standard union nut tightening torque

Table 2-16 Standard union nut tightening torque

Nominal diameter	Cap nut size M (mm)	Width across flats (mm) [in.]	N·m	kgf·m	lbf·ft
63	M14 × 1.5	19 [0.75]	39	4	29
80	M16 × 1.5	22 [0.87]	49	5	36
100	M20 × 1.5	27 [1.06]	78	8	58
120	M22 × 1.5	30 [1.18]	98	10	72
150	M27 × 1.5	32 [1.26]	157	16	116
180	M30 × 1.5	36 [1.42]	196	20	145
200	M30 × 1.5	36 [1.42]	196	20	145
220	M33 × 1.5	41 [1.61]	245	25	181
254	M36 × 1.5	41 [1.61]	294	30	217

(Maximum tolerance value: ± 10 %, dry)

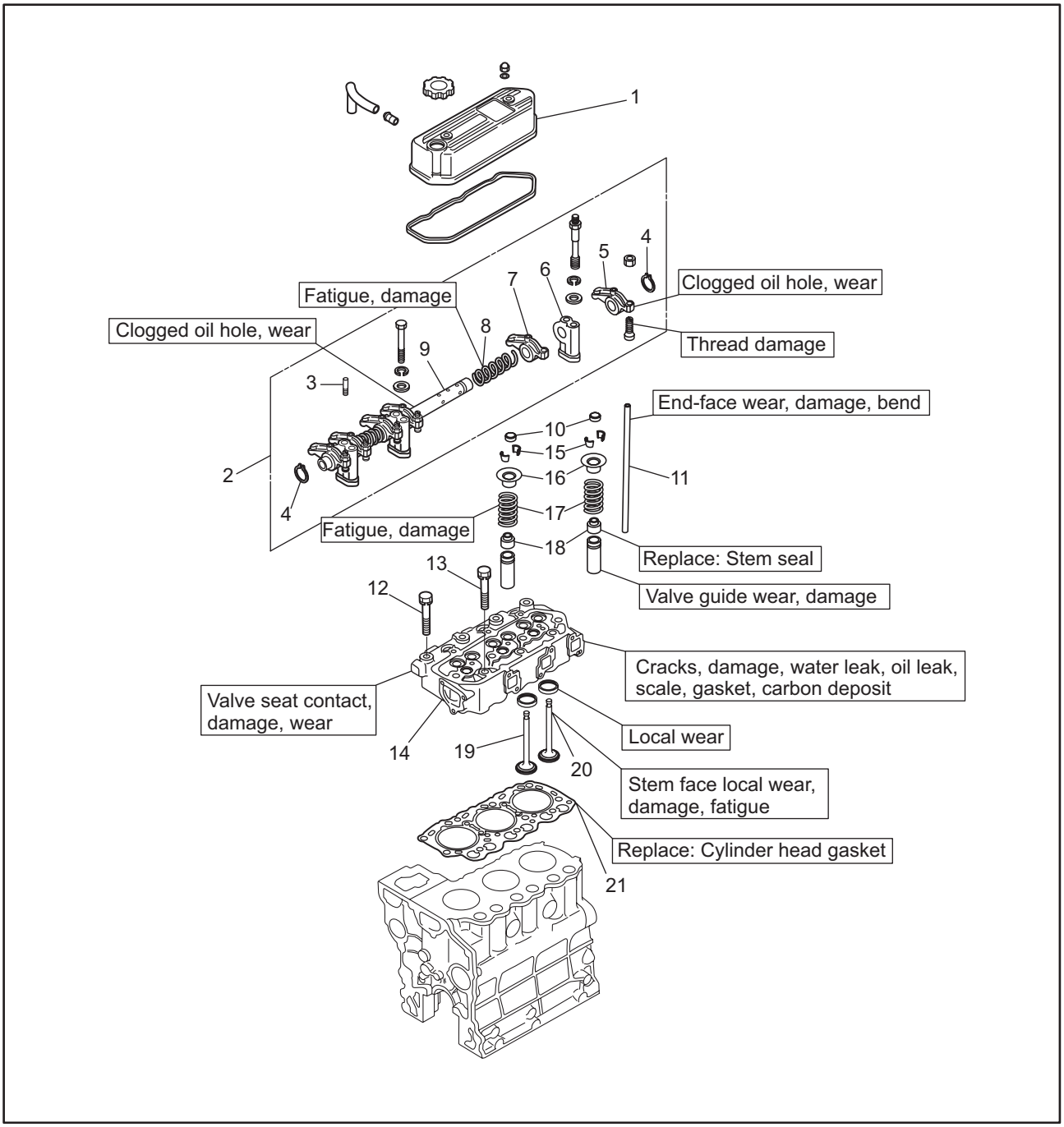
2.5 High-pressure fuel injection pipe tightening torque

Table 2-17 High-pressure fuel injection pipe tightening torque

Cap nut size (mm)	N·m	kgf·m	lbf·ft
M12 × 1.5	39 ± 5	4 ± 0.5	29 ± 3.6
M14 × 1.5	49 ± 5	5 ± 0.5	36 ± 3.6
M18 × 1.5	59 ± 1	6 ± 1.0	43 ± 7.2

(Dry)

1. Disassembling and inspecting cylinder head and valve mechanism



Disassembling and inspecting cylinder head and valve mechanism

Disassembling sequence

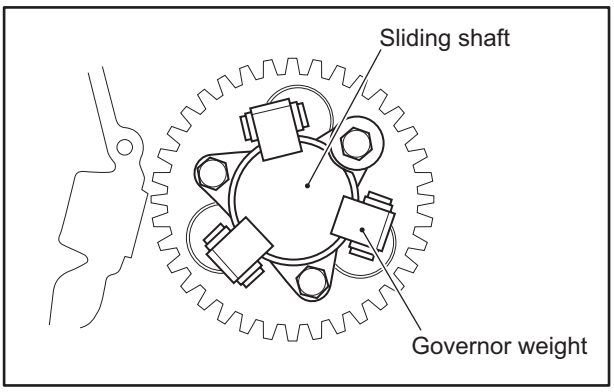
1	Rocker cover	8	Rocker shaft spring	15	Valve lock
2	Rocker shaft assembly (incudes 3 - 9)	9	Rocker shaft	16	Retainer
3	Grooved pin	10	Valve cap	17	Valve spring
4	Snap ring	11	Pushrod	18	Valve stem seal
5	Exhaust rocker arm	12	Cylinder head bolt (main)	19	Intake valve
6	Rocker stay	13	Cylinder head bolt (sub)	20	Exhaust valve
7	Intake rocker arm	14	Cylinder head	21	Cylinder head gasket

3.11 Removing fuel injection pump camshaft

CAUTION

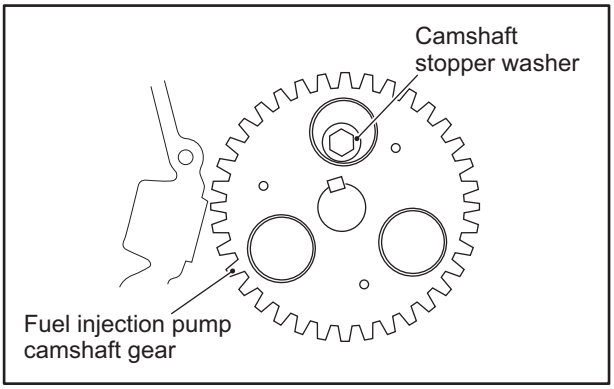
When pulling out the fuel injection pump camshaft, be careful not to cause damage to the cam portion of the fuel injection pump camshaft and the cam hole of the cylinder block.

(1) Remove the sliding shaft and governor weight.



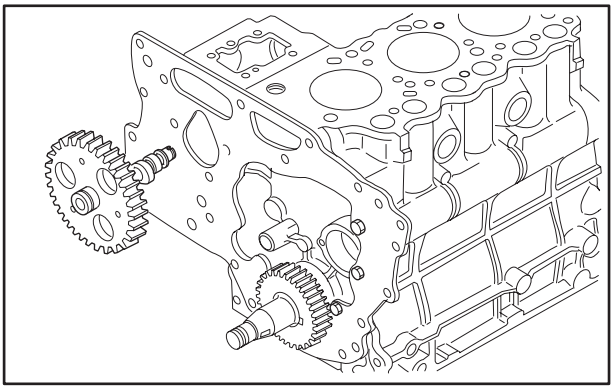
Removing sliding shaft and governor weight

(2) Remove camshaft stopper washer.



Removing fuel injection pump camshaft (1)

(3) Remove the fuel injection pump camshaft with the fuel injection pump camshaft gear and ball bearings as a unit.



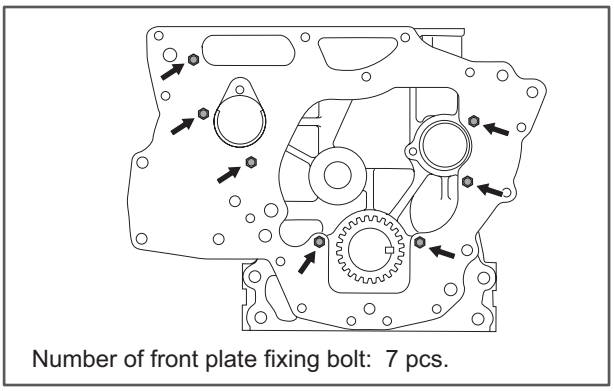
Removing fuel injection pump camshaft (2)

3.12 Removing front plate

(1) Remove the front plate bolts.

(2) Remove the front plate from the crankcase.

Note: If it is difficult to remove the front plate, lightly tap it with a plastic hammer.



Removing front plate

1.8 Measuring distortion of cylinder head bottom face

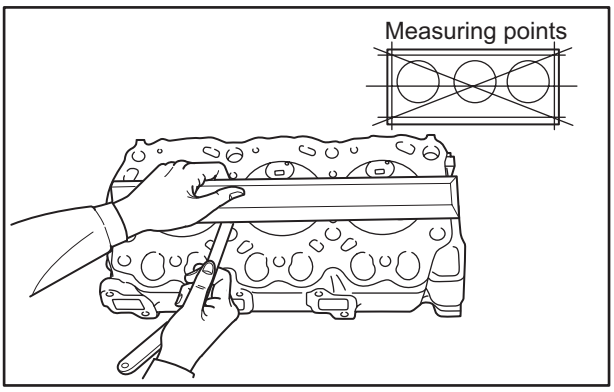
CAUTION

Limit the depth of surface grinding of cylinder head to a necessary minimum.

If the surface of cylinder head is ground more than specified, it may result in defects such as defective combustion and stamping (contact between piston and valve).

With a straight edge placed on the bottom face of the cylinder head, measure the bottom face distortion with a feeler gauge. If the measurement exceeds the limit, grind the bottom face with a surface grinder.

Item	Standard	Limit
Distortion of head bottom surface	0.05 mm [0.0020 in.]	0.10 mm [0.0039 in.]

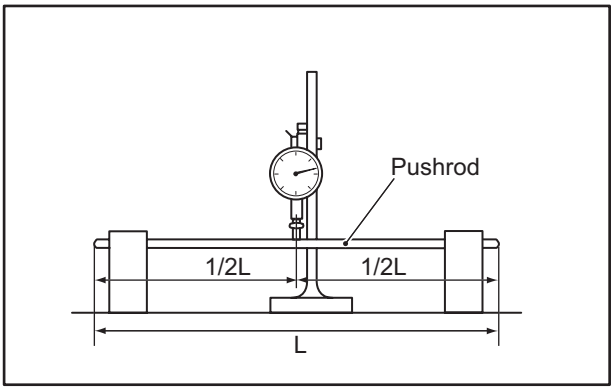


Measuring distortion of cylinder head bottom surface

1.9 Measuring pushrod runout

Measure the runout of each pushrod. Replace if the limit is exceeded.

Item	Standard	Limit	Remark
Pushrod runout	Less than 0.3 mm [0.012 in.]	0.3 mm [0.012 in.]	Total indicated reading (TIR)



Measuring runout of pushrod

4.8 Measuring clearance between connecting rod bearing and crankpin

CAUTION

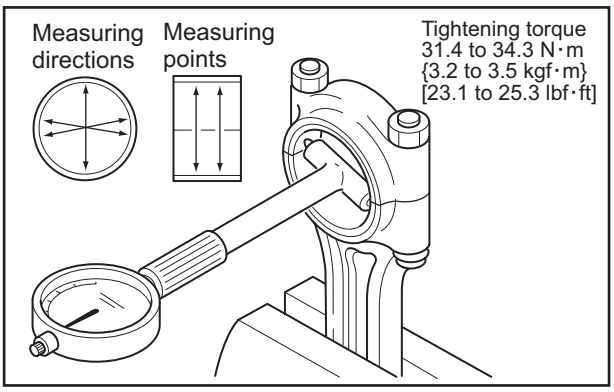
When grinding crank pins, be sure to grind all the pins to the same size.

Finish the fillet radius to the specified dimension.

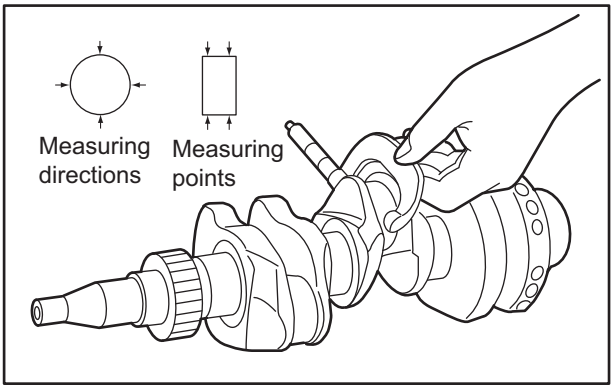
(1) Reassemble the bearing into the big end of the connecting rod.
(2) Tighten the connecting rod cap bolts to the specified torque.
(3) Measure the inside diameter of the connecting rod bearing.
(4) Measure the outside diameter of the crank pin.
(5) Calculate the clearance from the difference between the inside diameter of the connecting rod bearing and outside diameter of the crank pin.
(6) Replace the connecting rod bearing if the clearance exceeds the limit.
(7) Measure the clearance between the connecting rod bearing and the crank pin again. Use the undersize bearing if the limit is exceeded.
(8) If an undersize bearing is used, grind the crank pin to the specified undersize.

Item	Nominal	Standard	Limit
Crankpin outside diameter (STD)	ø 40 mm [1.57 in.]	39.965 to 39.980 mm [1.5734 to1.5740 in.]	-0.70 mm [-0.0276 in.]
Clearance between crankpin and connecting rod bearing	-	0.028 to 0.071 mm [0.0011 to 0.0028 in.]	0.150 mm [0.0059 in.]

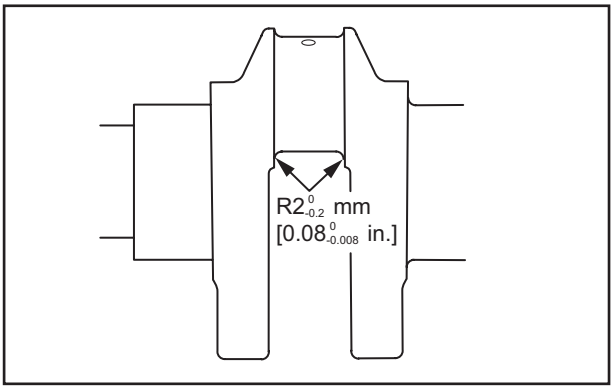
Undersize grinding dimensions of crankshaft		
Item	Undersize	Finish dimension
Crankpin undersize	0.25 mm [0.0098 in.]	ø 39.75 $^{-0.020}_{-0.035}$ mm [1.5650 $^{-0.0008}_{-0.0014}$ in.]
	0.50 mm [0.0197 in.]	ø 39.50 $^{-0.020}_{-0.035}$ mm [1.5551 $^{-0.0008}_{-0.0014}$ in.]



Measuring inside diameter of connecting rod bearing



Measuring crank pin outside diameter



Finish dimension of fillet radius

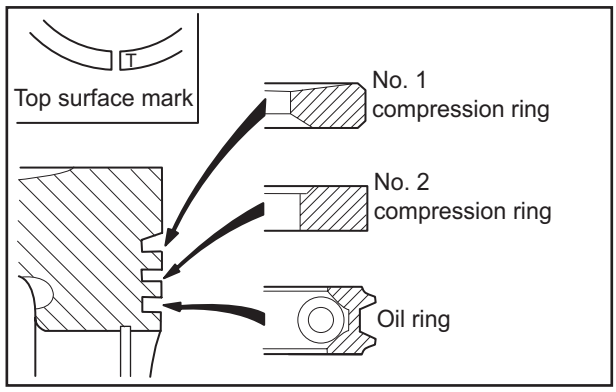
1.8 Installing piston ring

CAUTION

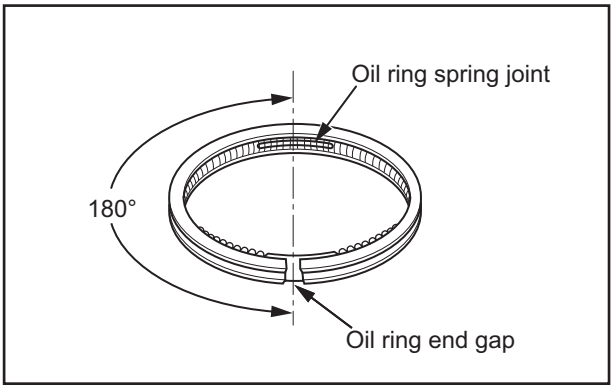
A marking such as "R" is stamped near the end gap to indicate the top face of piston ring. Install all piston rings with the mark faced upward.
If piston rings are assembled wrong side up, it will cause malfunctions such as increase of oil consumption or engine seizure.

(1) Install the piston rings to the piston with a ring expander.

(2) Install the oil ring spring so that its joint is 180° away from the oil ring end gap as shown in the illustration.



Reassembling pistons and piston rings



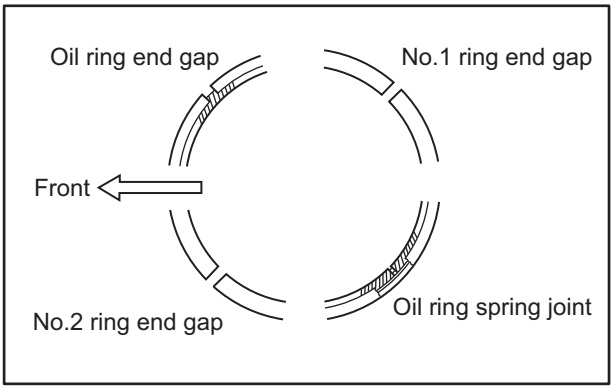
Positioning of oil ring end gap and spring joint

1.9 Installing piston and connecting rod

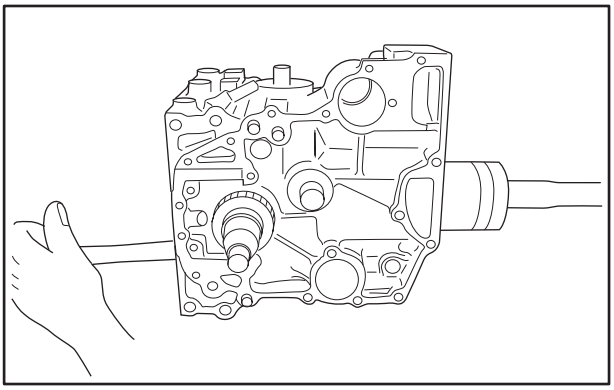
CAUTION

Do not drive in the piston strongly. It may cause damage to the piston rings and crank pin.

(1) Apply engine oil to the circumference of the piston and piston rings.
(2) Place the ring end gaps in diagonal positions avoiding the piston pin direction and its right angle direction.
(3) Fit the connecting rod bearing (upper) to the connecting rod aligning the lug and lug groove.
(4) Turn the crankshaft to place the crank pin of the assembling cylinder to the top dead center.
(5) Face the front mark (arrow) stamped on the piston top toward the timing gear case side (forward of the engine).
(6) Insert the piston from the top face of cylinder block using a piston guide (commercially available).



Orienting piston ring end gaps



Installing pistons and connecting rods

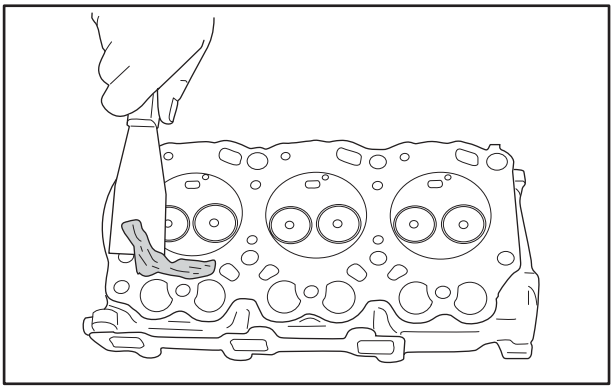
4. Reassembling cylinder head and valve mechanism

Reassemble the cylinder head and valve mechanisms in the reverse order of the disassembly procedures.

4.1 Cleaning cylinder head bottom surface

Taking care not to damage the cylinder head bottom surface, remove gasket residue.

Note: First, roughly scrape off the residue using a scraper. Then, grind off remaining residue using an engine-oil immersed oil stone.



Scraping gasket

4.2 Installing valve stem seal

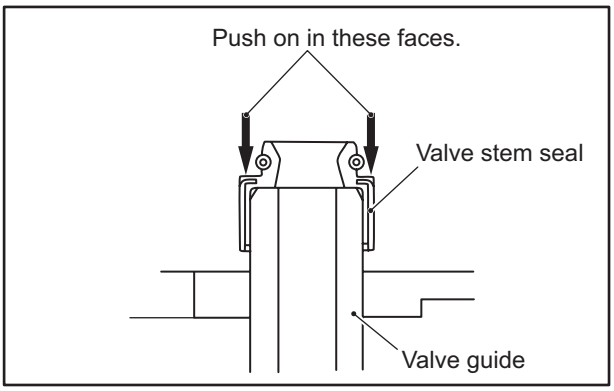
CAUTION

Do not apply oil or liquid gasket to the inner side of stem seal that comes in contact with the valve guide.

(1) Apply engine oil to the lip of the valve stem seal.

(2) Push the shoulder of the valve stem seal and fit the valve stem steal into the valve guide.

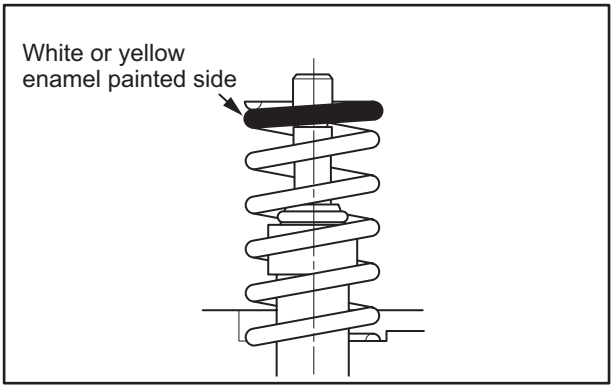
(3) Make sure the valve stem steal is fully inserted into the valve guide.



Installing valve stem seal

4.3 Installing valve spring

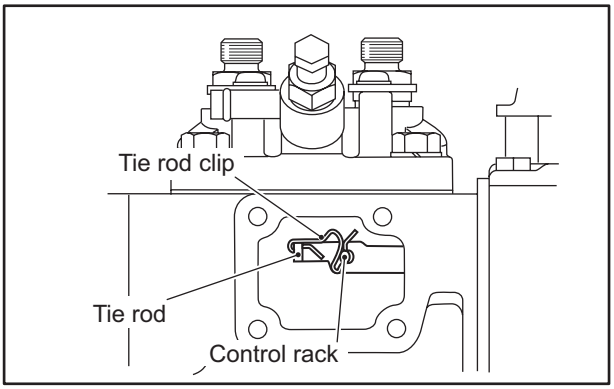
Install the valve spring with its white or yellow enamel painted side faced upward.



Installing valve spring

1.3.1 Disconnecting tie rod from control rack

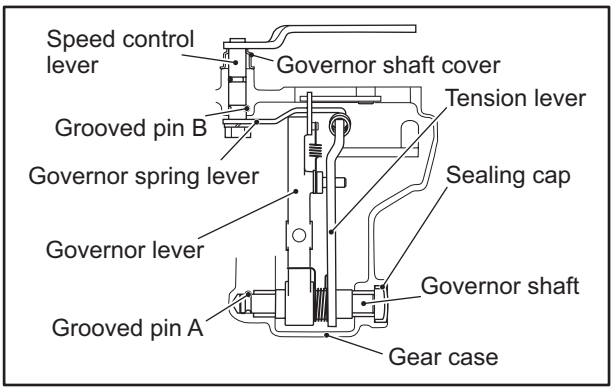
(1) Remove the tie rod cover.
(2) Remove the tie rod clip and disconnect the tie rod from the control rack.



Disconnecting tie rod from control rack

1.3.2 Removing governor shaft and speed control lever

(1) Remove the sealing cap from the side of the gear case.
(2) Pull out the grooved pin A.
(3) Remove the governor shaft, and remove tension lever and governor lever.
(4) Remove the governor spring lever.
(5) Remove the grooved pin B and remove speed control lever.
(6) Remove the governor cover.



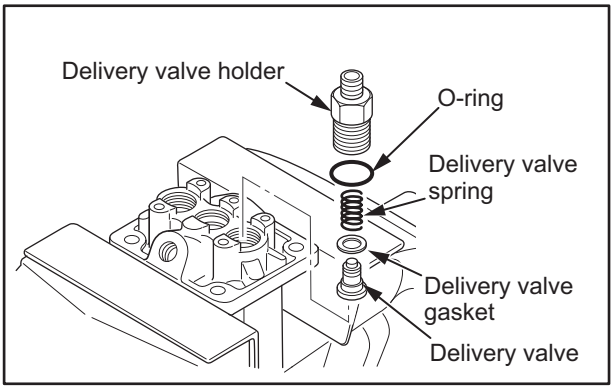
Removing governor shaft and speed control lever

2.5.2 Assembling delivery valve

CAUTION

(a) Do not reuse the O-ring.
(b) Install a new O-ring so that it is not cut with threads of the valve holder.

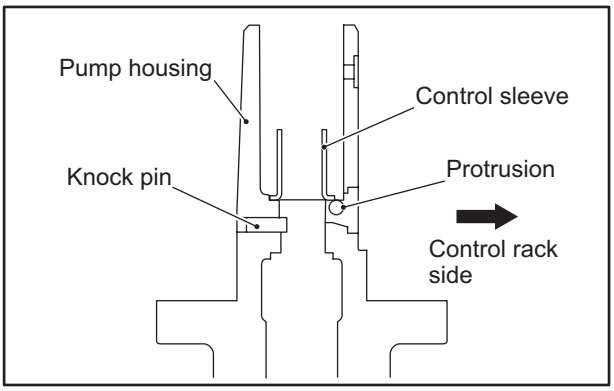
Assemble the delivery valve, delivery valve gasket and delivery valve spring. Then with the O-ring installed, temporarily tighten the delivery valve holder.



Assembling delivery valve

2.5.3 Assembling control sleeve

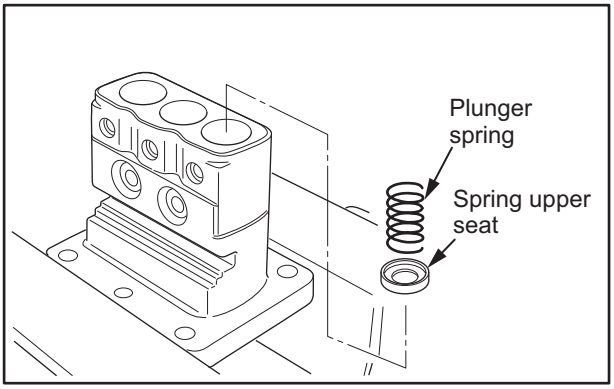
(1) Reverse the pump housing and grab the housing with a vise.
(2) Install the sleeve with the protrusion of the control sleeve the control rack side (opposite side to the knock pin). The protrusion can be seen through the housing hole.



Assembling control sleeve

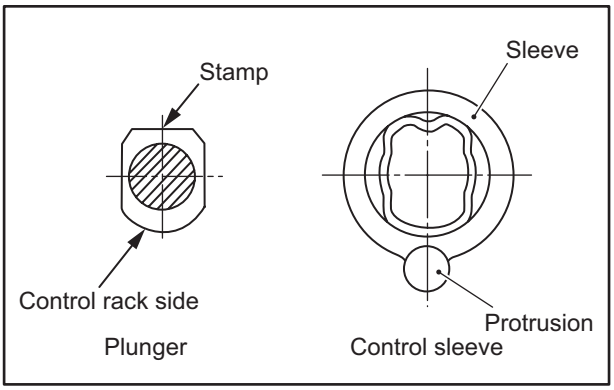
2.5.4 Assembling plunger

(1) Assemble the spring upper seat and plunger spring.



Assembling plunger spring

(2) Place the stamped side of the collar of the plunger to the opposite side to the protrusion of the control sleeve (opposite side to the control rack side). Assemble the spring lower seat to the plunger and insert the plunger into the control sleeve.



Assembling direction of plunger

3.2.3 Installing torque spring set

CAUTION

Torque spring set comes in 2 types: single type and double type. These torque spring sets are properly adjusted at the factory before shipment. Do not change the setting of the adjusting screw unless absolutely necessary.

Adjust and reassemble the torque spring set as described in the following.

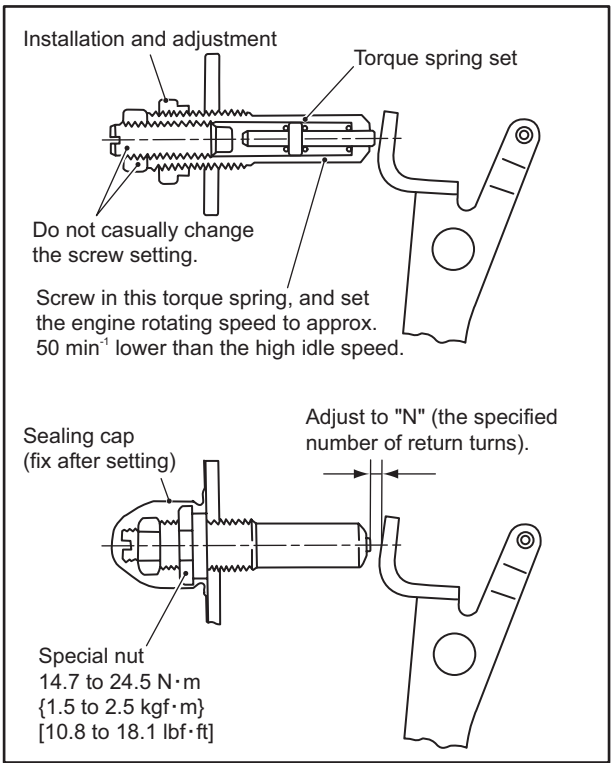
(1) Adjust the speed control lever with the high speed set bolt, and set it to the high idle speed.

(2) Screw in the torque spring set and check the position at which the engine speed drops approx. 50 min^{-1} lower than the high idle speed.

(3) In this condition, loosen the torque spring set by the specified number of turns (N), and fix it with the special nut.

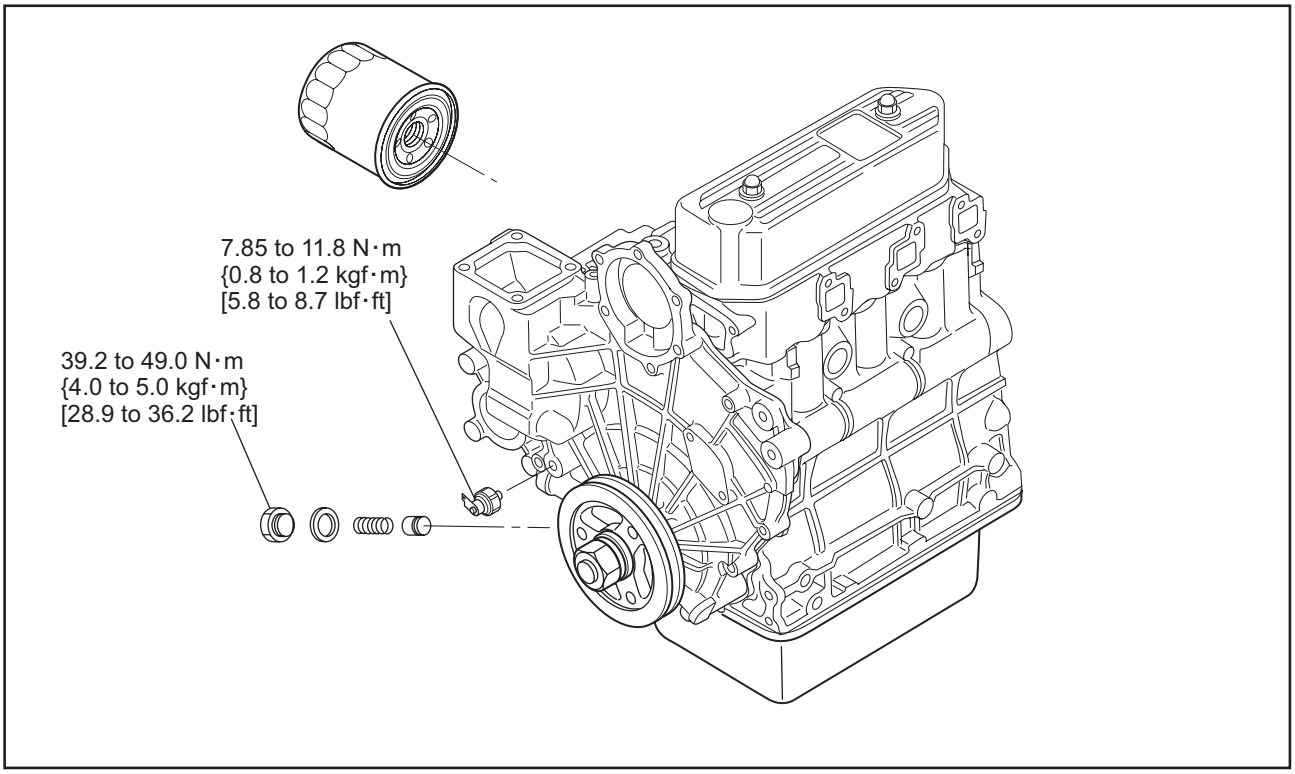
Note: The number of return turns (N) differs depending on specifications. Consult your dealer.

(4) Put a torque spring sealing cap on the torque spring and firmly tighten the sealing cap to prevent it from becoming loose.



Installing torque spring set

3.2 Installing oil filter, relief valve and oil pressure



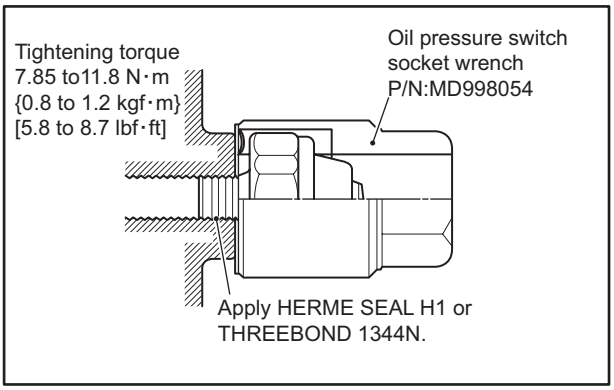
Installing oil filter, relief valve and oil pressure

3.2.1 Installing oil pressure switch

CAUTION

Do not allow sealant to squeeze out at the thread end.
Do not overtighten.

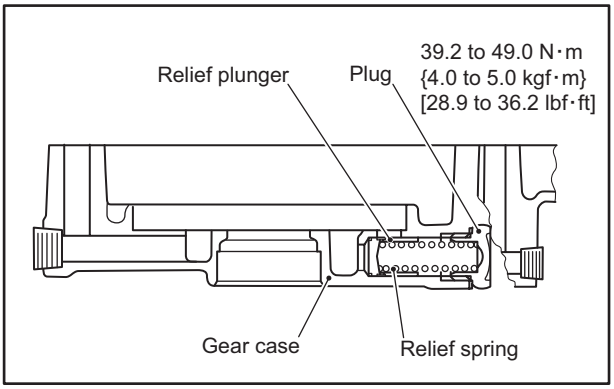
(1) Using an oil pressure switch socket wrench, tighten the oil pressure switch to the specified torque.
(2) Apply a sealant to the threaded portion when installing the switch.



Installing oil pressure switch

3.2.2 Installing relief valve

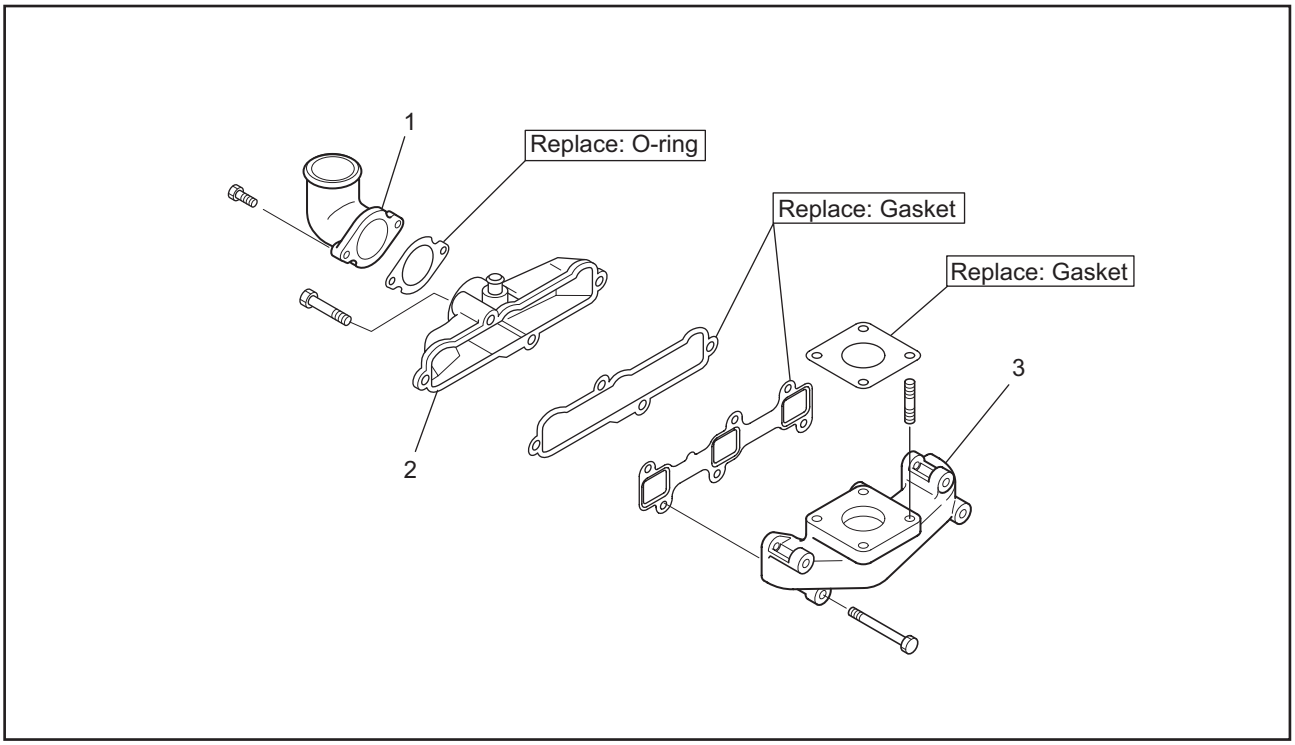
Insert the relief plunger and relief spring into the gear case and tighten the plug to the specified torque.



Installing relief valve

1. Removing inlet and exhaust systems

1.1 Removing intake cover and exhaust manifold



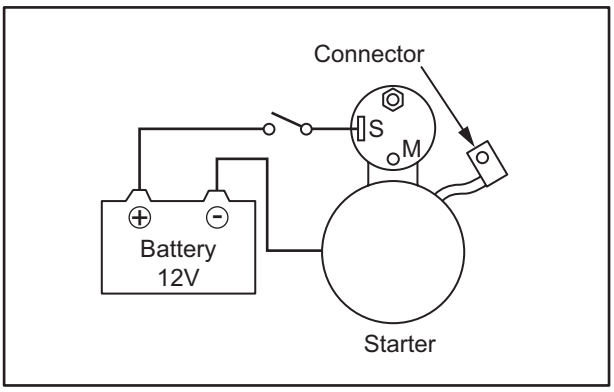
Removing intake cover and exhaust manifold

Removing sequence

1 Intake pipe
2 Intake cover
3 Exhaust manifold

(3) Holding test

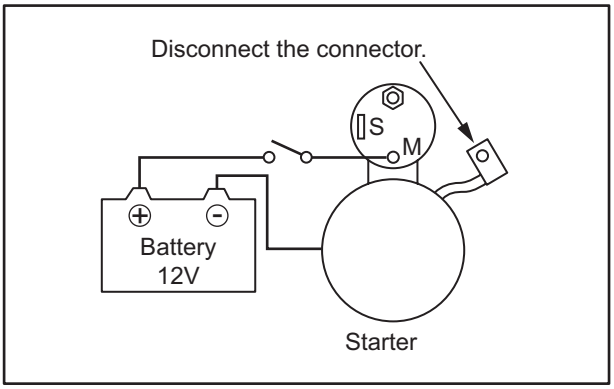
Connect the starter to the circuit as shown in the illustration. Pull out the pinion fully by hand. The magnet switch is normal if the pinion does not return when it is released.



Holding test

(4) Return test

Connect the starter to the circuit as shown in the illustration. Pull out the pinion fully by hand. The magnet switch is normal if the pinion returns immediately when it is released.



Return test

2.1.3 No load test

CAUTION

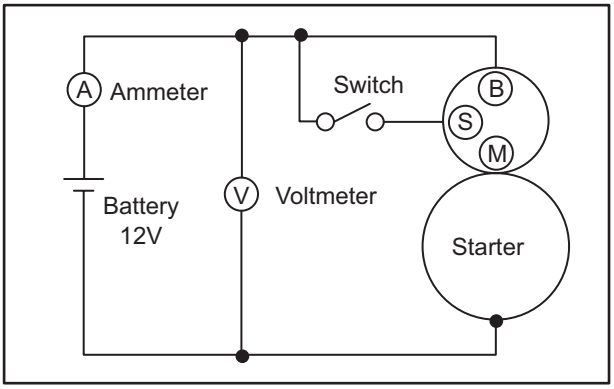
Use as thick a wire as possible and firmly tighten each terminal.

When detecting the rotation at the tip of the pinion, be careful, as the pinion pops out during operation.

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

(2) In normal condition, the pinion pops out when the switch is turned ON, and the starter rotates at or above the specified rotation speed.

If the terminal voltage, current or rotation speed does not meet the standard, disassemble, inspect and repair the starter.



Test at no load

Item		Standard
Starter model name		M001T68381
Nominal output V-kW		12 - 1.7
No-load characteristics	Terminal voltage V	11
	Current A	110 or less
	Rotation speed min^{-1}	2400 or more

2.5.2 Installing pinion

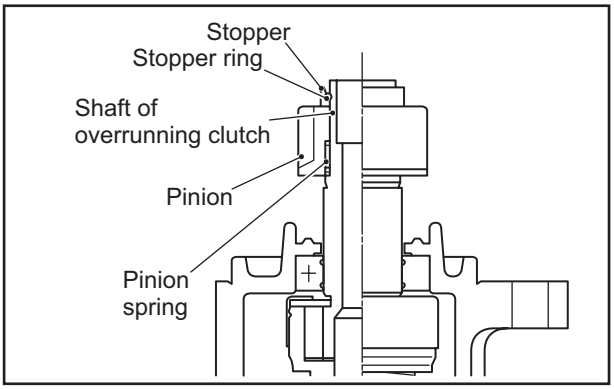
CAUTION

Before assembling, apply grease to the inner race groove of the front bracket bearing.

Be sure to use a new stopper ring. Do not reuse the stopper ring that has been removed.

(1) Put the overrunning clutch through the front bracket.
(2) Fit the internal gear into the gear shaft.
(3) Put the gear shaft through the overrunning clutch and install the stopper on it.
(4) Fit the stopper ring into the groove if the stopper ring and firmly pinch it.
(5) Using a gear puller, firmly draw the pinion and fit the stopper into the stopper ring.

Note: The adjustment of play in the axial direction of the gear shaft is not necessary because its required amount is automatically secured.



Installing pinion

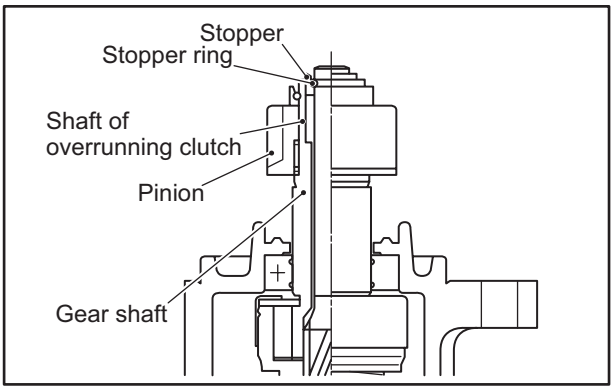
2.5.3 Installing gear shaft

CAUTION

Be sure to use a new stopper ring. Do not reuse a removed one.

(1) Reassemble the lever to the overrunning clutch.
(2) Fit the internal gear into the gear shaft.
(3) Put the gear shaft through the overrunning clutch and install the stopper on it.
(4) Fit the stopper ring into the groove of the stopper ring and firmly pinch it.
(5) Using a gear puller, firmly pull the pinion and fit the stopper into the stopper ring.

Note: The adjustment of play in the axial direction of the gear shaft is not necessary because its required amount is automatically secured.

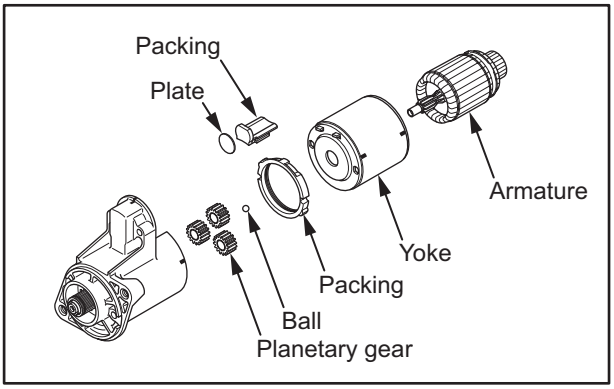


Installing gear shaft

2.5.4 Installing yoke and armature

(1) Install the planetary gears on the gear shaft.
(2) Install the packing on the internal gear.
(3) Install the plate and packing.
(4) Install the yoke on the front bracket.
(5) Apply grease to the armature shaft end and install a ball on it.
(6) Install the armature.

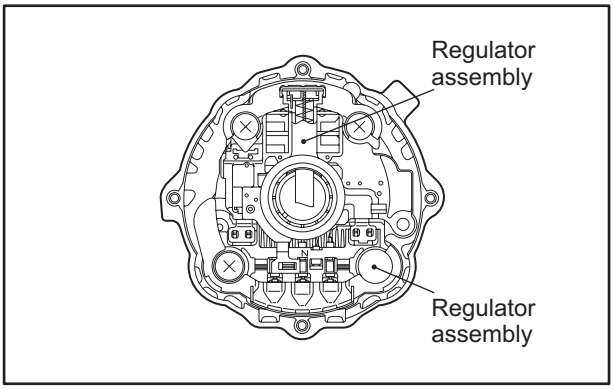
Note: The adjustment of play in the axial direction of the armature shaft is not necessary.



Installing yoke and armature

2.8.1 Installing rectifier assembly and regulator assembly

Install the rectifier assembly and regulator assembly on the rear bracket.



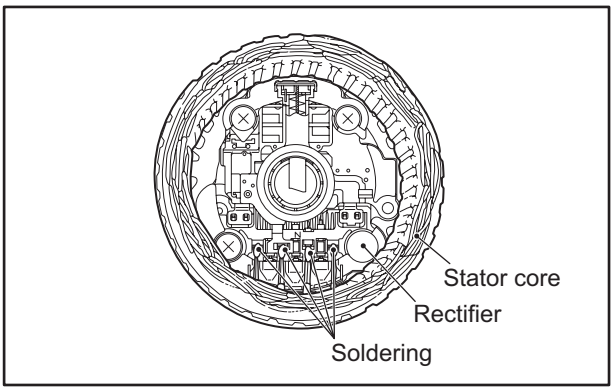
Installing rectifier assembly and regulator assembly

2.8.2 Installing stator

CAUTION

Soldering must be finished as quickly as possible.
Extended heating will damage the diodes.

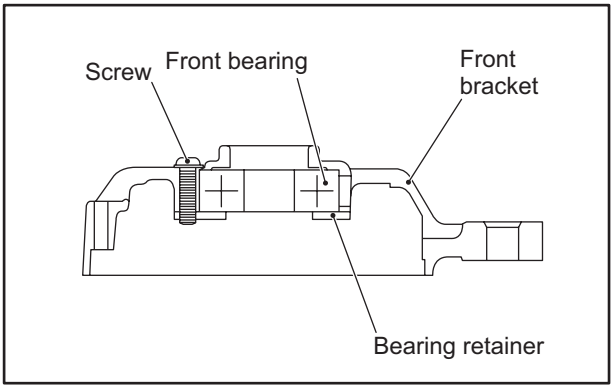
Install the stator and solder the leads of the stator to the rectifier.



Installing stator

2.8.3 Installing front bearing

Drive the front bearing into the front bracket and secure the bearing retainer with a screw.



Installing front bearing

1.3 Adjusting fuel injection timing

(1) Check that the fuel injection timing meets the specified fuel injection timing at the position where the injection timing mark on the crank pulley is aligned with the mark on the gear case.

(2) If the fuel injection timing does not meet the specified value, increase or decrease the thickness of the fuel injection pump adjusting shim to adjust the timing.

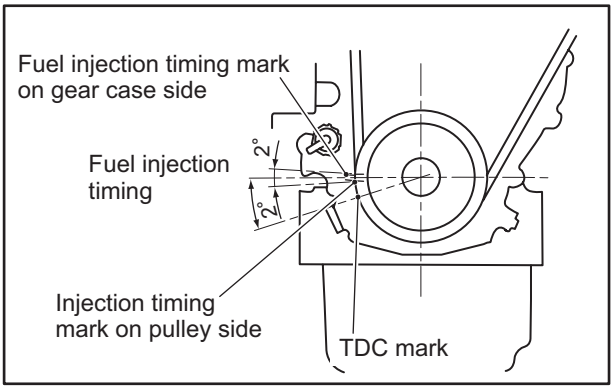
Note: A change in thickness of the shim by 0.1 mm [0.004 in.] results in a change in the fuel injection timing by approx 1°.
There are nine kinds of shims from 0.2 to 1.0 mm [0.008 to 0.039 in.].

Adjusting value	Standard value ± 1.5°

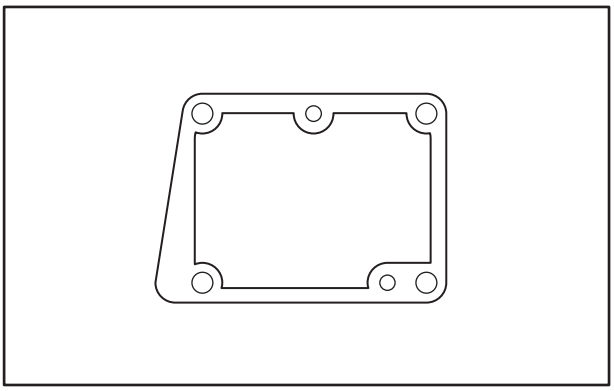
(3) With the delivery valve installed, check the fuel injection timing as follows:

(4) Remove the tie rod cover and disconnect the tie rod from the control rack.

(5) Set the control rack to the medium position in the operating range and then remove the No. 1 fuel injection pipe on the nozzle side.
When the crankshaft is gradually rotated, fuel begins to swell at the tip of the pipe. This timing is the fuel injection timing. In this case, the timing is delayed by 1° as compared to the normal fuel injection timing.



Fuel injection timing



Adjusting shim