YANMAR®

SERVICE MANUAL

EXCAVATOR

MODEL ViO45-5, ViO55-5

YANMAR® SERVICE MANUAL

MODEL

ViO45-5

ViO55-5

FOREWORD

This service manual outlines procedures for servicing YANMAR construction machinery. It contains specifications, servicing instructions and handling cautions. To obtain the maximum life and performance from YANMAR construction machinery, read this manual carefully and follow its instructions.
Please note that all dimensions and numerical values in this manual are for service reference, and are not inspection standards. Descriptions and specifications in this manual are subject to change without notice due to design improvements, etc.

⚠ WARNING

California
Proposition 65 Warning

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

⚠ WARNING

California
Proposition 65 Warning

Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
Wash hands after handling.

CONTENTS

CHAPTER 4
ENGINE

CHAPTER 5
HYDRAULIC SYSTEM

CHAPTER 6
HYDRAULIC EQUIPMENT

CHAPTER 7
ADJUSTMENT AND REPAIR

CHAPTER 8
Periodic Inspection and Servicing

CHAPTER 9
FUEL, LUBE OIL AND GREASE RECOMMENDED

CHAPTER 10
TROUBLESHOOTING

CHAPTER 11
REFERENCE DATA

CHAPTER 1

GENERAL CAUTIONS FOR MAINTENANCE WORK

1. GENERAL CAUTIONS FOR MAINTENANCE WORK

1. General Cautions for Maintenance Work

1-1 Correct Work

Correct work means the quickest possible completion of according to the correct procedures and the specified standards.

It is important when conducting certain operations always to bear in mind the equipment, tools, gauges, materials, oil and grease, etc. that you must have ready, as well as items to be checked, adjusted, or disassembled, and cautions to watch out for.

1-2 Safety Precautions

(1) Never attempt servicing while engine is running or immediately after stopping operation.
(2) Wear work cloths, safety shoes and helmet.
(3) Check the equipment and tools before use. Especially, be sure to check the crane, lifting equipment and tools.
(4) When working together with other persons, allocate everyone's share of job, arrange the signals and act in concert with the other persons.
(5) The operation of the crane and slinging work must be performed by qualified persons.
(6) Do not enter or pass under the raised load.
(7) Lift and support the massive parts by crane before removing the installation bolts.
(8) Disconnect cables from battery before repairing the electric system.
(9) Remove the battery when welding the machine.

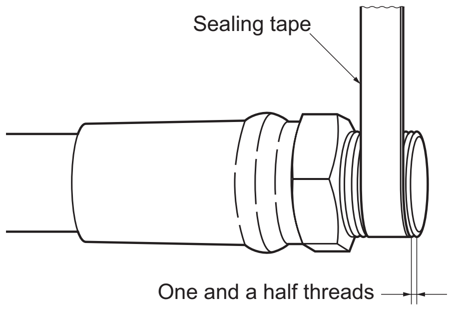
1-3 Preparations

(1) Check the service record of the machine. (That is, check how many months or hours the machine has been used since the preceding overhaul, what was the trouble then and what parts were replaced.)
(2) Have all servicing tools ready, i.e., tools, measuring devices (which have received periodic maintenance), containers, oil & grease, etc.
(3) Have the service literature (operation manual, parts catalog, etc.) ready.

1-4 Cautions for Disassembly and Reassembly

(1) Clean the machine before disassembly.
(2) Check and record the condition of the machine before disassembly :
  - Model, machine number, operation hours
  - Reasons for repair, history of repair
  - Contamination of filters
  - Fuel and oil condition
  - Damage to parts, etc.
(3) Place alignment marks on the necessary parts to facilitate reassembly.
(4) Clean all the removed parts and new replacement parts and put them in order.
(5) Use new seals, split pins, etc. for reassembly.

(6) Keep the parts apt to be damaged by water or oil apart from the oily or wet parts.
e.g.: Electrical parts, rubber parts, V-belts, etc.
(7) Use the jig for press-fitting the bearings, bushes and oil seals. When using a hammer, use a pad block.
(8) Clean the joint surface of all parts and keep them free from dust.
(9) Wind the sealing tape securely, leaving a space of one or two threads from the tip of the male screw. The tape should have an overlap of about 10 mm.

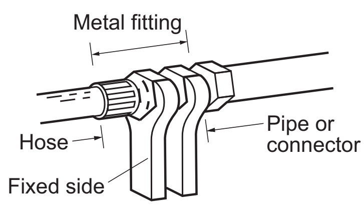


1-5 Cautions for Removal and Installation of Hydraulic Equipment

(1) Check that the hydraulic oil temperature is low enough.
(2) Release air from the hydraulic tank to prevent the hydraulic oil from flowing out.
(3) Be sure to plug open the ends of hydraulic components to prevent dust from entering.
(4) Be sure to wipe hydraulic oil from the hydraulic components so that it will not be mistaken for an oil leak.
(5) Take care not to damage the plating on the cylinder rod.
(6) Remove or install cylinders with rods fully retracted.
(7) Be sure to release air after installing the hydraulic cylinders.
• Run the engine at a low speed. Extend and retract the cylinders 4 to 5 times up to 50 to 100 mm from the end of the stroke. Then, fully extend and retract.
(8) Be sure to pressurize the hydraulic tank after installing the hydraulic components (in the case of the sealed hydraulic tank). Otherwise, hydraulic pumps might suffer cavitation and their life will be shortened.
• To pressurize the hydraulic tank, fully extend each cylinder and tighten the oil filter port plugs.

1-6 Cautions for Removal and Installation of Hydraulic Piping

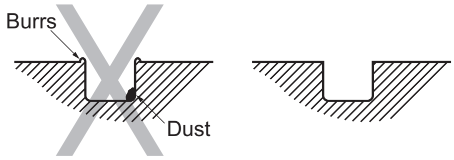
(1) Installation of hydraulic hose
Take care not to twist the hoses. (Judge whether or not the hose is twisted by the hose mark.) For hoses with a metal fitting, use two wrenches to prevent twisting.
Use one to fix the hose, and the other to tighten the fitting to the specified tightening torque. Carefully check that the hoses do not come in contact after tightening. If any contact is found, correct it or use tubes.



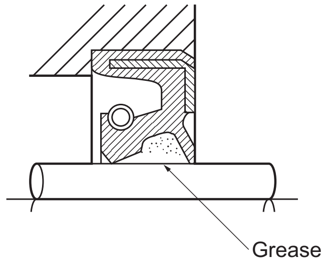
(2) When installing hoses, first tighten to the specified torque and then loosen them a little. Then retighten to the specified torque.
• Break in the installed parts before tightening (except those using seal tapes).
(3) When installing pipes, turn the nuts more 1/4 to 1/2 turn after they reach the sharp torque rise point.
(4) When installing or removing hoses, use two wrenches, one to fasten the hose and the other to tighten or loosen the hose to prevent twisting.
(5) Check for oil leakage by applying max. pressure 5 to 6 times after attaching hydraulic hoses or pipes.

1-7 Cautions for Handling Seals

(1) Clean out grooves of O-rings. Remove burrs or dust if any.



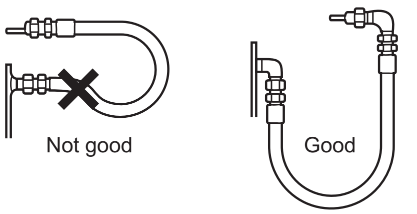
(2) Take care not to twist O-rings. Correct by your finger if it is twisted.
(3) Take care not to damage seals when inserting.
(4) Handling of floating seals :
• Completely wipe off all the oil from the O-ring and housing after detaching the floating seals.
• Before installing, apply a little gear oil to the matching face of the housing.
• Turn the seals two or three times after installation to break them in.
(5) Apply grease to the lip of the oil seals to prevent wear.



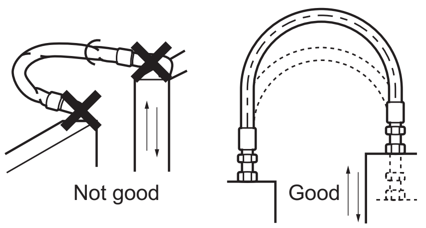
1-8 Correct Installation of Hydraulic Hose

In order to mount the hydraulic hose most effectively and economically, observe the following cautions.

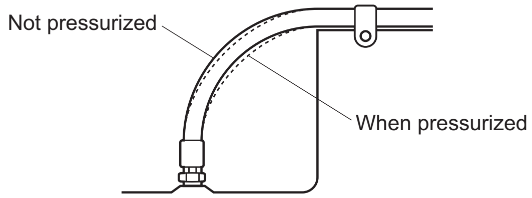
(1) When a hose is used at the minimum bending radius, use elbows to avoid sharp bending.



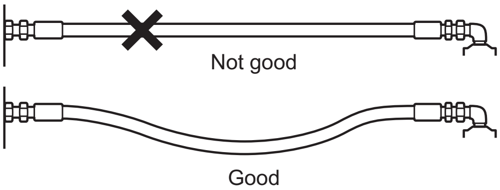
(2) To prevent twisting, the hose should be bent in the same direction as it moves.



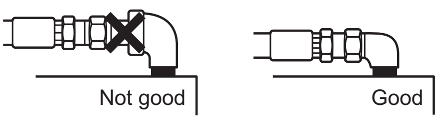
(3) When the hose is pressurized, the hose length varies slightly at the bend. Allow this change to occur and do not try to fasten the bend.



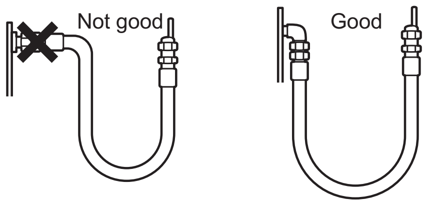
(4) It is necessary for the hose to have ample slackness for elongation and contraction, because its length will change by +2 % to -4 % when used at high pressure.



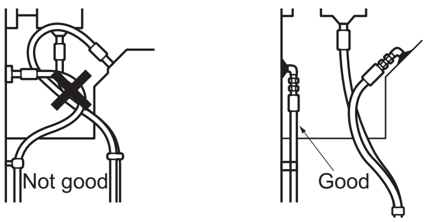
(5) Use the proper adapters, not pipes, in order to reduce the number and length of joints and improve the external appearance.



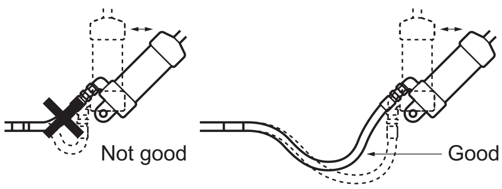
(6) Use an elbow to prevent excessive twisting or bending of the hose.



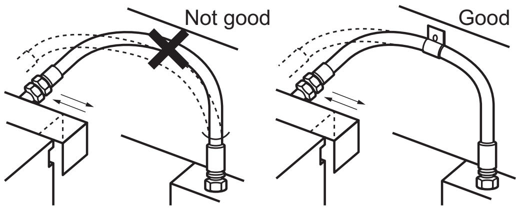
(7) Use adapters to make the hose as straight as possible. The outside appearance can be improved by avoiding the use of hoses that are too long.



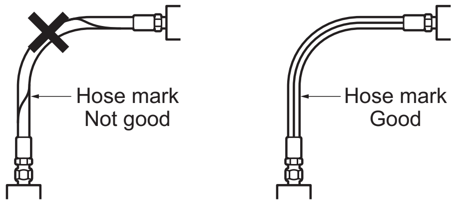
(8) The hose should be slightly longer than is absolutely necessary. The extra allows smoother movement of the hose and prevents sharp bending.



(9) When a bent hose is attached to two different planes, fix as shown in the diagram to prevent twisting.



(10) Use the marking on the hose as a guide to prevent twisting during installation.
Twisting of metal fitting with union nuts should be with a wrench on the hexagonal parts.



1-9 Specifications of Hydraulic Hose

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

(1) Yanmar Standard Type

The part code consists of 11-digit numbers :

○○○○○ — ○○○○○○

Hose material code

Hose type code

Fittings combination code

Nominal length code

Nominal dia. code

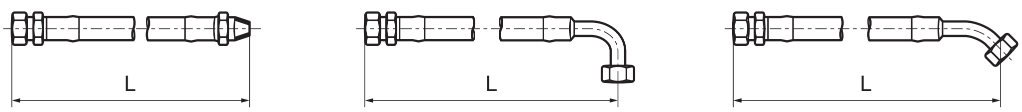
Description / Part code No. / Hose material	Hose material	Type of hose		Hose dia.	Hose length	Combination of fittings
	○○○○	○		○○	○○○	○
Rubber hose (High pressure type)	2320	1	(SAE J517,100R1)	02	Unit : cm	1
						3
				03		4
		2	(SAE J517,100R2)			5
				04		6
Plastic hose (High pressure type)	2327	1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

1. GENERAL CAUTIONS FOR MAINTENANCE WORK

1) Type of Hose (Hose Dia. & Recommended Working Pressure)

Type of hose	Hose dia.	Inner dia. [in. (mm)]	Outer dia. [in. (mm)]	Working pressure [PSI (MPa)]
1 (SAE J517, 100R1)	02	0.25 (6.3)	0.53 (13.5)	2489 (17.2)
	03	0.37 (9.5)	0.69 (17.5)	1991 (13.7)
	04	0.50 (12.7)	0.81 (20.6)	1564 (10.8)
2 (SAE J517,100R7)	02	0.25 (6.3)	0.59 (15.1)	4266 (29.4)
	03	0.37 (9.5)	0.75 (19.1)	3484 (24.0)
	04	0.50 (12.7)	0.87 (22.2)	2986 (20.6)
1 (SAE J517, 100R6)	02	0.25 (6.3)	0.49 (12.5)	2986 (20.6)
	03	0.37 (9.5)	0.65 (16.6)	2489 (17.2)
	04	0.50 (12.7)	0.81 (20.7)	1991 (13.7)
2 (SAE J517,100R7)	03	0.37 (9.5)	0.68 (17.2)	2986 (20.6)
	04	0.50 (12.7)	0.84 (21.4)	2986 (20.6)
1 (SAE J517,100R6)	02	0.25 (6.3)	0.50 (12.7)	427 (2.9)
	03	0.37 (9.5)	0.63 (15.9)	427 (2.9)
	04	0.50 (12.7)	0.78 (19.8)	427 (2.9)
	05	0.63 (15.9)	0.91 (23.0)	427 (2.9)
	06	0.75 (19.0)	1.25 (31.8)	427 (2.9)
	10	1.00 (25.4)	1.50 (38.1)	427 (2.9)
	12	1.25 (31.8)	1.75 (44.5)	427 (2.9)
	14	1.50 (38.1)	2.04 (51.9)	427 (2.9)

2) Total Length of Hose [Unit : in. (cm)]



3 digit indication in cm. ***(Example)*** **Nominal length 065 : Full length 25.6 in. (65 cm)**

3) Hose Dia. (Unit : inch)

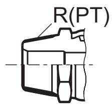
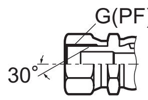
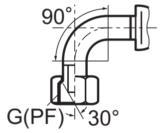
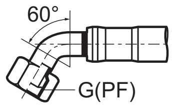
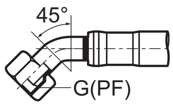
02....1/4"	05....5/8"	12....1 1/4"
03....3/8"	06....3/4"	14....1 1/2"
04....1/2"	10....1	

Note :

Please note that these code numbers are different from those for the equivalent diameters for special parts on the next page.

4) Combination of Fitting

Code No.	Fitting type
1	A·B
3	A·E
4	B·B
5	B·C
6	B·E
7	B·D

Type	Fitting	Description
A		Taper pipe thread R (PT)
B		Straight pipe thread G (PF) with male 30 degrees seat
C		90 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat
D		60 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat
E		45 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat

(Example) Part code 2 3 2 0 2 — 0 3 0 8 5 5

- 2320: Rubber hose, high pressure type
- 2: SAE J517, 100R2
- 03: Nominal dia., 3 / 8"
- 085: Hose length, 33.5 in. (85 cm)
- 5: Straight pipe thread G (PF) with male 30 degrees seat and 90 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat

List of pipe threads	
Symbol	Name
G (PF)	Straight pipe thread
R (PT)	Male taper pipe thread
Rc (PT)	Female taper pipe thread

Note :

All the hoses with fittings other than those listed above are special parts.

(2) Special Parts

Description .... Hose P 2 06 AB 075 W __

Hose	P	2	06	AB	075	W	__
1	2	3	4	5	6	7	8

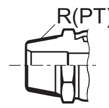
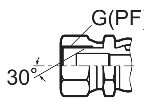
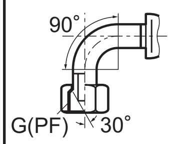
1 Part name

2 Hose material
- Rubber hose .... G
- Wear-resistant high pressure rubber hose .... H
- Plastic hose .... P

3 Recommended working pressure PSI(Mpa)
- Over 2986 (20.6) 1
- 2489 to 2986 (17.2 to 20.6) 2
- 1991 to 2489 (13.7 to 17.2) 3
- 1564 to 1991 (10.8 to 13.7) 4
- 995 to 1564 (6.9 to 10.8) 5
- 427 to 995 (2.9 to 6.9) 6
- 213 to 427 (1.5 to 2.9) 7
- Below 213 (1.5) 8

4 Nominal dia. (inch)
- 1 / 8" 02
- 3 / 16" 03
- 1 / 4" 04
- 3 / 8" 06
- 1 / 2" 08
- 5 / 8" 10
- 3 / 4" 12
- 1" 16

5 Combination of fitting

Fitting type		Code
	Taper pipe thread R (PT)	A
	Straight pipe thread G (PF) with male 30 degrees seat	B
	90 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat	C
	Without fitting	Y

∗ For the combination of fitting, refer to the list on the following page.

6 Total length
(Unit : cm)

7 Hose protector
- Coil spring .... W
- Coil tube .... S
- Wire braid .... B
- Tube (Rubber) .... R
- Tube (Vinyl) V
- Sponge rubber .... P
- Hose cover .... K
- No protection ..... Blank

8 Other accessories
- No accessories...Blank
- O-ring 1

List of pipe threads

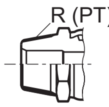
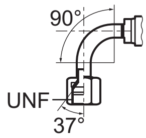
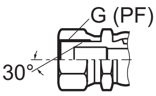
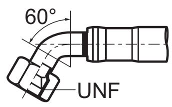
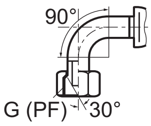
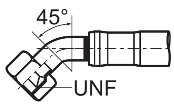
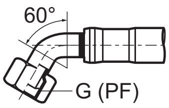
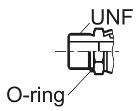
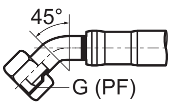
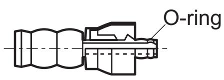
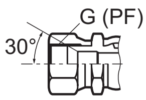
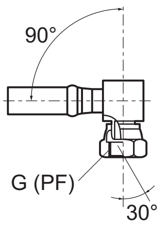
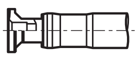
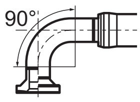
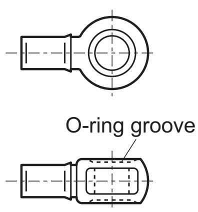
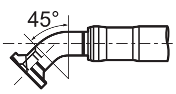
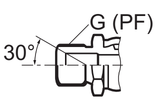
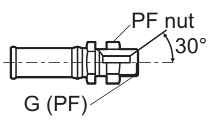
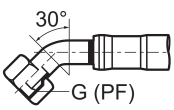
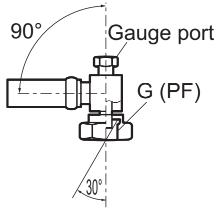
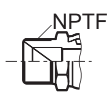
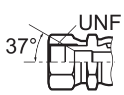
Symbol	Name
G (PF)	Straight pipe thread
R (PT)	Male taper pipe thread
Rc (PT)	Female taper pipe thread

The example hose, P 2 06 AB 075 W stands for :

P	2	06	AB	075	W
2	3	4	5	6	7

2 Material : Plastic
3 Working pressure : 2489 to 2986 PSI (17.2 to 20.6 MPa)
4 Nominal dia. : 3 / 8"
5 Fitting type : Taper pipe thread R (PT) and straight pipe thread G (PF) with male 30 degrees seat.
6 Length : 29.5 in. (75 cm)
7 Hose protector : Coil spring

5 Combination of fitting

Fitting type		Code	Fitting type		Code
	Taper pipe thread R (PT)	A		90 degrees bent type. UNF thread with female 37 degrees seat	P
	Straight pipe thread G (PF) with male 30 degrees seat	B		60 degrees bent type. UNF thread with female 37 degrees seat	Q
	90 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat	C		45 degrees bent type. UNF thread with female 37 degrees seat	R
	60 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat	D		UNF, thread with O-ring groove	S
	45 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat	E		One-touch fitting (male)	T
	Straight pipe thread G (PF) with male 30 degrees seat	F		90 degrees elbow straight pipe thread male 30 degrees seat	V
	O-ring flange type	G			
	90 degrees bent O-ring flange type	H		Eyejoint with O-ring groove	W
	45 degrees bent O-ring flange type	J			
	Straight pipe thread, female 30 degrees seat with O-ring groove	K		Straight pipe thread with jam nut female 30 degrees seat	X
	30 degrees bent type. Straight pipe thread G (PF) with male 30 degrees seat	L		90 degrees elbow straight pipe thread with gauge port plug male 30 degrees seat	Z
	Taper pipe thread NPTF	M			
	UNF, thread with female 37 degrees seat	N	Without fitting		Y

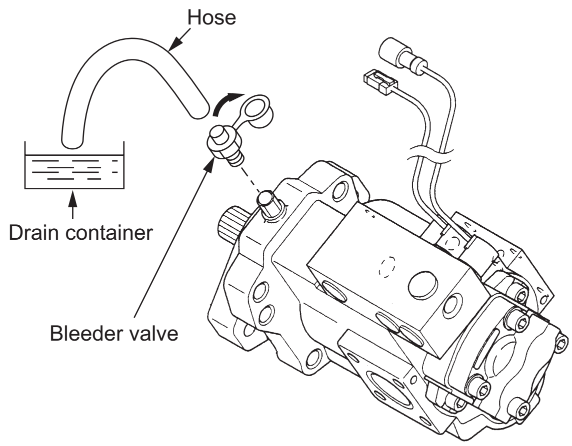
Note :
According to the combination of bending or elbow fittings, some hoses require drawings or original hoses to locally manufacture.

1-10 Air Release of Hydraulic Equipment

When operating the machine after disassembly or parts replacement of the hydraulic equipment, piping, etc., be sure to release air from the hydraulic system. This is necessary to prevent seizure and cavitation of the hydraulic equipment. If the air is left in the hydraulic system, the air is compressed or expanded depending on the load, having an adverse effect on the smooth operation of the hydraulic equipment and shortening the service life.

1. Air Release of Variable Displacement Piston Pumps

1) **Put a Specified Quantity of Hydraulic Oil Into the Hydraulic Oil Tank.**
   Note :
   1. Set the machine at the oil level check position.
   2. Refer to the hydraulic oil supply procedure for how to put hydraulic oil into the tank.
2) **Keep the Oil Supply Cap of the Hydraulic Oil Tank Removed.**
3) **Install the Air Bleeder Hose onto the Bleeder Valve and Loosen the Bleeder Valve Half a Turn. (Inside Diameter of the Hose : 0.20 in. [5 mm])**
   Note :
   Since the top end of the bleeder valve is acting as a seat surface, the air is released only by loosening the bleeder valve.



4) **Check that All the Air has been Released from the Bleeder Valve.**
5) **Tighten the Bleeder Valve, Remove the Hose and Install the Cap on the Bleeder Valve.**

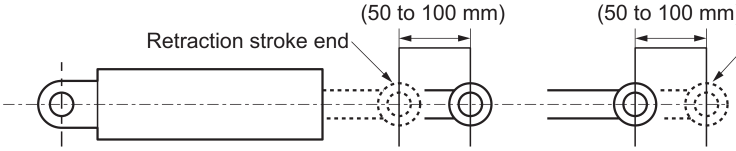
Bleeder valve	Width across flats : 0.40 in. (10 mm)
Tightening torque	3.61 to 5.06 ft·lbf (4.9 to 6.7 N·m)

2. Air Release of Each Hydraulic Component

Run the engine at medium speed and activate the respective circuits for about 10 to 15 minutes.

3. Air Release of Hydraulic Cylinders

1) **Set the Engine Speed at Low Idling Range.**
2) **Extend and Retract the Cylinder Up to 1.97 to 3.9 in. (50 to 100 mm) from Each Stroke End Slowly 4 or 5 Times.**



   Note :
   The extension and retraction stroke is up to 1.97 in. (50 mm) from each stroke end for the blade cylinder.
3) **Then, Fully Extend and Retract the Cylinder 3 or 4 Times.**

CHAPTER 2

TECHNICAL DATA

2. Technical Data

2-1 Specifications

Note : *< > : W/O Quick coupler*

Item				Unit	ViO45-5
Main specifications of machine					
Dimensions					
Overall length (Transportation position)				in. (mm)	207.1 (5260) <202.8 (5150)>
Cabin	Overall height	Transportation position		in. (mm)	103.1 (2620)
		Traveling position		in. (mm)	103.1 (2620)
	Overall width	Full machine width		in. (mm)	77.6 (1970)
Canopy	Overall height	Transportation position		in. (mm)	103.1 (2620)
		Traveling position		in. (mm)	103.1 (2620)
	Overall width	Full machine width		in. (mm)	77.6 (1970)
Tumbler center distance (steel/rubber)				in. (mm)	80.7 (2050)/81.5 (2070)
Track gauge				in. (mm)	65.7 (1670)
Minimum ground clearance				in. (mm)	14.2 (360)
Traveling performance					
Travel speed	Steel track	Low speed (Forward/Reverse)		MPH (km/hr)	1.4 (2.3)
		High speed (Forward/Reverse)		MPH (km/hr)	2.9 (4.6)
	Rubber track	Low speed (Forward/Reverse)		MPH (km/hr)	1.4 (2.3)
		High speed (Forward/Reverse)		MPH (km/hr)	2.9 (4.6)
Permissible water depth limit				in. (mm)	19.7 (500)
Work performance					
Bucket	Width (Standard) *including side cutter			in. (mm)	25.6 (650)
	(Standard. JIS heaped capacity)			cu.ft. (cu.m)	4.94 (0.14) [Old JIS 4.59 (0.13)]
	Number of teeth / Installation method			pcs.	4 / rubber pin lock type
Maximum digging depth	With blade raised			in. (mm)	144.9 (3680) <137.8 (3500)>
	With blade on the ground			in. (mm)	151.6 (3850) <145.7 (3700)>
Maximum depth of vertically digging				in. (mm)	106.3 (2700) <112.2 (2850)>
Maximum dumping height (canopy/cabin)				in. (mm)	153.9 (3910) <157.5 (4000)>
Minimum front swing radius (with boom in front) (canopy/cabin)				in. (mm)	91.3 (2320) <81.1 (2060)>
Minimum front swing radius (at 90 degrees right boom swing)			Cabin	in. (mm)	78.3 (1990) <68.1 (1730)>
			Canopy	in. (mm)	78.3 (1990) <68.1 (1730)>
Rear end swing radius				in. (mm)	38.4 (975)
Boom swing angle		Cabin	Left	degrees	70
			Right	degrees	70
		Canopy	Left	degrees	70
			Right	degrees	70
Maximum digging force		Bucket		lbs. (k•N)	6725 (29.9) <8489 (37.7)>
		Arm		lbs. (k•N)	4631 (20.6) <5292 (23.5)>

2. TECHNICAL DATA

***Note :** < > : W/O Quick coupler*

Item					Unit	ViO45-5
Main specifications of machine						
	Work performance					
		Maximum tractive force (Oil pressure force) (steel/rubber)			lbs. (k•N)	9107 (40.5)/8655 (38.5)
		Maximum swing inclination angle (with standard bucket)			degrees	18
		Swing speed			rpm	10
		Fuel consumption in practical operation			Gals/h (L/h)	1.48 (5.6)
	Blade					
		Blade	Width×Height		in. (mm)	77.6 (1970)×15.7 (400)
			Capacity		cu.ft. (cu.m)	10.9 (0.31)
			Lift above ground level		in. (mm)	19.7 (500) <17.3 (440)>
			Digging depth		in. (mm)	20.5 (520) <16.9 (430)>
	Mean contact pressure					
		JIS	Steel track	Cabin	PSI (KPa)	4.05 (27.9) <3.99 (27.5)>
				Canopy	PSI (KPa)	3.87 (26.7) <3.86 (26.6)>
			Rubber track	Cabin	PSI (KPa)	3.99 (27.5) <3.93 (27.1)>
				Canopy	PSI (KPa)	3.84 (26.5) <3.78 (26.1)>
	Mass					
		Operating mass	Steel track	Cabin	lbs. (kg)	9371 (4250) <9746 (4420)>
				Canopy	lbs. (kg)	8974 (4070) <9393 (4260)>
			Rubber track	Cabin	lbs. (kg)	9217 (4180) <9592 (4350)>
				Canopy	lbs. (kg)	8820 (4000) <9239 (4190)>
		Base machine dry mass	Steel track	Cabin	lbs. (kg)	6461 (2930) <6461 (2930)>
				Canopy	lbs. (kg)	6064 (2750) <6064 (2750)>
			Rubber track	Cabin	lbs. (kg)	6304 (2860) <6304 (2860)>
				Canopy	lbs. (kg)	5909 (2680) <5909 (2680)>
Hydraulic equipment						
	Hydraulic pump					
		Drive method				Engine → CF Coupling → Pump (Direct drive)
		Type of main pump				Variable displacement piston pumps + Gear pumps
		Number of pumps				Piston pump : 2 + Gear pump : 2
		Theoretical discharge volume			cu.in./rev (cu.cm/rev)	1.02 (16.8)×2, 1.02 (16.8), 0.30 (4.9)
		Maximum allowable pressure			PSI (MPa)	3128 (21.6)×2, 3128 (21.6)×1, 427 (2.9)×1
	Control valve					
		Number of connected valves			pcs.	11
		System relief set pressure	P1, P2		PSI (MPa)	3128 (21.6)
			P3		PSI (MPa)	3128 (21.6)
		Circuit relief set pressure	Boom (at rod end)		PSI (MPa)	3555 (24.5)
			Boom (at bottom end)		PSI (MPa)	3555 (24.5)
			Arm (at rod end)		PSI (MPa)	3555 (24.5)
			Arm (at bottom end)		PSI (MPa)	3555 (24.5)

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

Item				Unit	ViO45-5
Hydraulic equipment					
	Control valve				
		Circuit relief set pressure	Bucket (at rod end)	PSI (MPa)	3555 (24.5)
			Bucket (at bottom end)	PSI (MPa)	3555 (24.5)
			Boom swing (at rod end)	PSI (MPa)	3555 (24.5)
			Boom swing (at bottom end)	PSI (MPa)	3555 (24.5)
			Blade (at rod end)	PSI (MPa)	2133 (14.7)
			Blade (at bottom end)	PSI (MPa)	-
	Cylinder				
		Boom	Stroke	in. (mm)	26.0 (660)
			Inside diameter	in. (mm)	∗1 : Ø3.74 (Ø95), ∗2 : Ø3.94 (Ø100)
			Piston rod diameter	in. (mm)	Ø1.97 (Ø50)
			Speed: Up (Ground → Max.)	sec.	∗1 : 2.2, ∗2 : 2.4
			Speed: Down (Max. → Ground)	sec.	∗1 : 2.5, ∗2 : 2.9
		Arm	Stroke	in. (mm)	29.9 (760)
			Inside diameter	in. (mm)	Ø3.3 (Ø85)
			Piston rod diameter	in. (mm)	Ø2.0 (Ø50)
			Speed: Full stroke for digging	sec.	2.5
			Speed: Full stroke for dumping	sec.	3.4
		Bucket	Stroke	in. (mm)	24.8 (630)
			Inside diameter	in. (mm)	Ø2.95 (Ø75)
			Piston rod diameter	in. (mm)	Ø1.95 (Ø50)
			Speed: Full stroke for digging	sec.	4.0
			Speed: Full stroke for dumping	sec.	2.4
		Blade	Stroke	in. (mm)	8.66 (220)
			Inside diameter	in. (mm)	Ø3.54 (Ø90)
			Piston rod diameter	in. (mm)	Ø1.97 (Ø50)
			Speed: Up (Ground → Max.)	sec.	0.9
			Speed: Down (Max. → Ground)	sec.	1.1
		Boom swing	Stroke	in. (mm)	21.8 (553)
			Inside diameter	in. (mm)	Ø3.54 (Ø90)
			Piston rod diameter	in. (mm)	Ø1.77 (Ø45)
			Speed: Full stroke to the right	sec.	6.5
			Speed: Full stroke to the left	sec.	6.5
		Quick coupler	Stroke	in. (mm)	3.39 (86)
			Inside diameter	in. (mm)	Ø2.56 (Ø65)
			Piston rod diameter	in. (mm)	Ø1.38 (Ø35)
	Swivel joint				
		Swivel joint port diameter×Number		inch×pcs.	3/8×4, 1/4×6

∗1 : S/N 50501 to 50591, ∗2 : S/N 50592 and after

2. TECHNICAL DATA

***Note :** < > : W/O Quick coupler*

Item					Unit	ViO45-5
Hydraulic equipment						
	Motor					
		Swing motor	Type			Fixed displacement piston motor
			Displacement		cu.in./rev (cu.cm/rev)	23.9 (391)
			Brake valve	Type		Cross relief valve
				Relief set pressure	PSI (MPa)	3128 (21.6)
		Travel motor	Type			Variable displacement piston motor
			Displacement (Low/High)		cu.in./rev (cu.cm/rev)	1.89 (31)/0.95 (15.5)
			Brake valve	Type		Counter balance valve
				Relief set pressure	PSI (MPa)	-
			Type of reduction gear			Planetary gear (with double-reduction mechanism)
	Hydraulic oil tank					
		Tank capacity			Gals (L)	16.9 (64) [tank : 10.0 (38), others : 6.9 (26)]
		Suction filter	Type			CT-12W
			Filtration area		sq.in. (sq.cm)	108 (697)
			Filtration accuracy		Meshes	150
		Return filter	Type			Y2502
			Filtration area		sq.in. (sq.cm)	706.8 (4560)
			Filtration accuracy		μ	10
			By-pass valve opening pressure		PSI (MPa)	21.3 (0.147)
	Locking device					
		Lever lock				Oil pressure controlled
		Boom swing lock				Pedal guard
		Swing lock				Mechanical brake
Swing device						
		Swing bearing				Spur gear
		Power transmission				Swing motor → Reduction gear → Pinion → Internal gear
		Type of brake				Oil pressure controlled + Mechanical brake
		Brake mounting position				Swing motor
Undercarriage						
		Steel track	Shoe width		in. (mm)	13.8 (350)
			Grouser	Type		Triple grouser
				Height	in. (mm)	0.55 (14)
			Shoe and link mounting method			Bolt
			Link pitch		in. (mm)	5.31 (135)
			Number of shoes (One side)		pcs.	40
			Track drive method			Link driving

Note : *< > : W/O Quick coupler*

Item			Unit	ViO45-5
Undercarriage				
	Rubber track	Shoe width	in. (mm)	13.8 (350)
		Lug height	in. (mm)	0.98 (25)
		Core metal pitch	in. (mm)	2.97 (75.5)
	Carrier roller (Upper roller)	Manner of support		Overhang type
		Quantity (One side)	pcs.	1
		Bearing		Bearing
		Sealing		Shaft seal
	Number of shoe slide plates (One side)		pcs.	-
	Track roller (Lower roller)	Quantity (One side)	pcs.	4
		Bearing		Bush
		Sealing		Floating seal
	Idler	Quantity (One side)	pcs.	1
		Bearing		Bush
		Sealing		Floating seal
	Number of sprocket teeth	Steel track	pcs.	19
		Rubber track	pcs.	19
	Track tension adjustment			Grease adjuster

2. TECHNICAL DATA

***Note :** < > : W/O Quick coupler*

Item				Unit	ViO55-5
Main specifications of machine					
Dimensions					
Overall length (Transportation position)				in. (mm)	218.9 (5560) <216.1 (5560)>
Cabin	Overall height	Transportation position		in. (mm)	103.1 (2620)
Cabin	Overall height	Traveling position		in. (mm)	103.1 (2620)
Cabin	Overall width	Full machine width		in. (mm)	78.3 (1990)
Canopy	Overall height	Transportation position		in. (mm)	103.1 (2620)
Canopy	Overall height	Traveling position		in. (mm)	103.1 (2620)
Canopy	Overall width	Full machine width		in. (mm)	78.3 (1990)
Tumbler center distance (steel/rubber)				in. (mm)	80.7 (2050)/81.5 (2070)
Track gauge				in. (mm)	65.7 (1670)
Minimum ground clearance				in. (mm)	14.1 (360)
Traveling performance					
Travel speed	Steel track	Low speed (Forward/Reverse)		MPH (km/hr)	1.4 (2.3)
Travel speed	Steel track	High speed (Forward/Reverse)		MPH (km/hr)	2.7 (4.4)
Travel speed	Rubber track	Low speed (Forward/Reverse)		MPH (km/hr)	1.4 (2.3)
Travel speed	Rubber track	High speed (Forward/Reverse)		MPH (km/hr)	2.7 (4.4)
Permissible water depth limit				in. (mm)	19.7 (500)
Work performance					
Bucket	Width (Standard) *including side cutter			in. (mm)	27.6 (700)
Bucket	(Standard. JIS heaped capacity)			cu.ft. (cu.m)	5.65 (0.16) [Old JIS 4.94 (0.14)]
Bucket	Number of teeth / Installation method			pcs.	4 (rubber pin lock type)
Maximum digging depth	With blade raised			in. (mm)	156.7 (3980) <149.6 (3800)>
Maximum digging depth	With blade on the ground			in. (mm)	163.8 (4160) <156.7 (3980)>
Maximum depth of vertically digging				in. (mm)	114.2 (2900) <122.0 (3100)>
Maximum dumping height (canopy/cabin)				in. (mm)	173.2 (4400) <177.2 (4500)>
Minimum front swing radius (with boom in front) (canopy/cabin)				in. (mm)	91.3 (2320) <79.5 (2020)>
Minimum front swing radius (at 90 degrees right boom swing)			Cabin	in. (mm)	77.2 (1960) <65.4 (1660)>
Minimum front swing radius (at 90 degrees right boom swing)			Canopy	in. (mm)	77.2 (1960) <65.4 (1660)>
Rear end swing radius				in. (mm)	39.2 (995)
Boom swing angle		Cabin	Left	degrees	70
Boom swing angle		Cabin	Right	degrees	70
Boom swing angle		Canopy	Left	degrees	70
Boom swing angle		Canopy	Right	degrees	70
Maximum digging force		Bucket		lbs. (k•N)	7607 (33.8) <9592 (42.7)>
Maximum digging force		Arm		lbs. (k•N)	5579 (24.8) <5292 (23.5)>

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

Item				Unit	ViO55-5
Main specifications of machine					
Work performance					
	Maximum tractive force (Oil pressure force) (steel/rubber)			lbs. (k•N)	10760 (47.9)/12039 (53.5)
	Maximum swing inclination angle (with standard bucket)			degrees	18 (at loading)
	Swing speed			rpm	10
	Fuel consumption in practical operation			Gals/h (L/h)	1.48 (5.6)
Blade					
	Blade	Width×Height		in. (mm)	77.6 (1970)×15.7 (400)
		Capacity		cu.ft. (cu.m)	10.9 (0.31)
		Lift above ground level		in. (mm)	19.7 (500) <17.3 (440)>
		Digging depth		in. (mm)	20.5 (520) <16.9 (430)>
Mean contact pressure					
	JIS	Steel track	Cabin	PSI (KPa)	3.97 (27.4) <3.93 (27.1)>
			Canopy	PSI (KPa)	3.83 (26.4) <3.78 (26.1)>
		Rubber track	Cabin	PSI (KPa)	3.92 (27.0) <3.87 (26.7)>
			Canopy	PSI (KPa)	3.77 (26.0) <3.73 (25.7)>
Mass					
	Operating mass	Steel track	Cabin	lbs. (kg)	11201 (5080) <11069 (5020)>
			Canopy	lbs. (kg)	10849 (4920) <10716 (4860)>
		Rubber track	Cabin	lbs. (kg)	11047 (5010) <10915 (4950)>
			Canopy	lbs. (kg)	10694 (4850) <10562 (4790)>
	Base machine dry mass	Steel track	Cabin	lbs. (kg)	8379 (3800) <8379 (3800)>
			Canopy	lbs. (kg)	8026 (3640) <8026 (3640)>
		Rubber track	Cabin	lbs. (kg)	8225 (3730) <8225 (3730)>
			Canopy	lbs. (kg)	7872 (3570) <7872 (3570)>
Hydraulic equipment					
Hydraulic pump					
	Drive method				Engine → CF Coupling → Pump (Direct drive)
	Type of main pump				Variable displacement piston pumps + Gear pumps
	Number of pumps				Piston pump : 2 + Gear pump : 2
	Theoretical discharge volume			cu.in./rev (cu.cm/rev)	1.02 (16.8)×2, 1.02 (16.8), 0.30 (4.9)
	Maximum allowable pressure			PSI (MPa)	3555 (24.5)×2, 3555 (24.5)×1, 427 (2.9)×1
Control valve					
	Number of connected valves			pcs.	11
	System relief set pressure	P1, P2		PSI (MPa)	3555 (24.5)
		P3		PSI (MPa)	3555 (24.5)
	Circuit relief set pressure	Boom (at rod end)		PSI (MPa)	3982 (27.5)
		Boom (at bottom end)		PSI (MPa)	3982 (27.5)
		Arm (at rod end)		PSI (MPa)	3982 (27.5)
		Arm (at bottom end)		PSI (MPa)	3982 (27.5)

Note : *< > : W/O Quick coupler*

Item				Unit	ViO55-5
Hydraulic equipment					
	Control valve				
		Circuit relief set pressure	Bucket (at rod end)	PSI (MPa)	3982 (27.5)
			Bucket (at bottom end)	PSI (MPa)	3982 (27.5)
			Boom swing (at rod end)	PSI (MPa)	3982 (27.5)
			Boom swing (at bottom end)	PSI (MPa)	3982 (27.5)
			Blade (at rod end)	PSI (MPa)	2133 (14.7)
			Blade (at bottom end)	PSI (MPa)	-
	Cylinder				
	Boom	Stroke		in. (mm)	26.0 (660)
		Inside diameter		in. (mm)	∗1 : Ø3.74 (Ø95), ∗2 : Ø3.94 (Ø100)
		Piston rod diameter		in. (mm)	Ø1.97 (Ø50)
		Speed	Up (Ground → Max.)	sec.	∗1 : 2.2, ∗2 : 2.6
			Down (Max. → Ground)	sec.	∗1 : 2.5, ∗2 : 3.2
	Arm	Stroke		in. (mm)	29.9 (760)
		Inside diameter		in. (mm)	Ø3.35 (Ø85)
		Piston rod diameter		in. (mm)	Ø1.97 (Ø50)
		Speed	Full stroke for digging	sec.	2.5
			Full stroke for dumping	sec.	3.4
	Bucket	Stroke		in. (mm)	24.8 (630)
		Inside diameter		in. (mm)	Ø2.95 (Ø75)
		Piston rod diameter		in. (mm)	Ø1.95 (Ø50)
		Speed	Full stroke for digging	sec.	4.0
			Full stroke for dumping	sec.	2.4
	Blade	Stroke		in. (mm)	8.66 (220)
		Inside diameter		in. (mm)	Ø3.54 (Ø90)
		Piston rod diameter		in. (mm)	Ø1.97 (Ø50)
		Speed	Up (Ground → Max.)	sec.	1.0
			Down (Max. → Ground)	sec.	1.2
	Boom swing	Stroke		in. (mm)	21.8 (553)
		Inside diameter		in. (mm)	Ø3.54 (Ø90)
		Piston rod diameter		in. (mm)	Ø1.77 (Ø45)
		Speed	Full stroke to the right	sec.	6.5
			Full stroke to the left	sec.	6.5
	Quick coupler	Stroke		in. (mm)	3.39 (86)
		Inside diameter		in. (mm)	Ø2.56 (Ø65)
		Piston rod diameter		in. (mm)	Ø1.38 (Ø35)
	Swivel joint				
		Swivel joint port diameter×Number		inch×pcs.	3/8×4, 1/4×6

∗1 : S/N 50501 to 50800, ∗2 : S/N 50801 and after

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

Item					Unit	ViO55-5
Hydraulic equipment						
	Motor					
		Swing motor	Type			Fixed displacement piston motor
			Displacement		cu.in./rev (cu.cm/rev)	23.9 (391)
			Brake valve	Type		Cross relief valve
				Relief set pressure	PSI (MPa)	3128 (21.6)
		Travel motor	Type			Variable displacement piston motor
			Displacement (Low/High)		cu.in./rev (cu.cm/rev)	2.06 (33.8)/1.03 (16.9)
			Brake valve	Type		Counter balance valve
				Relief set pressure	PSI (MPa)	-
			Type of reduction gear			Planetary gear (with double-reduction mechanism)
	Hydraulic oil tank					
		Tank capacity			Gals (L)	16.9 (64) [tank : 10.0 (38), others : 6.9 (26)]
		Suction filter	Type			CT-12W
			Filtration area		sq.in. (sq.cm)	108 (697)
			Filtration accuracy		Meshes	150
		Return filter	Type			Y2502
			Filtration area		sq.in. (sq.cm)	706.8 (4560)
			Filtration accuracy		μ	10
			By-pass valve opening pressure		PSI (MPa)	21.3 (0.147)
	Locking device					
		Lever lock				Oil pressure controlled
		Boom swing lock				Pedal guard
		Swing lock				Mechanical brake
Swing device						
		Swing bearing				Spur gear
		Power transmission				Swing motor → Reduction gear → Pinion → Internal gear
		Type of brake				Oil pressure controlled + Mechanical brake
		Brake mounting position				Swing motor
Undercarriage						
		Steel track	Shoe width		in. (mm)	15.7 (400)
			Grouser	Type		Triple grouser
				Height	in. (mm)	0.55 (14)
			Shoe and link mounting method			Bolt
			Link pitch		in. (mm)	5.31 (135)
			Number of shoes (One side)		pcs.	40
			Track drive method			Link driving

***Note :** < > : W/O Quick coupler*

Item			Unit	ViO55-5
Undercarriage				
	Rubber track	Shoe width	in. (mm)	15.7 (400)
		Lug height	in. (mm)	0.98 (25)
		Core metal pitch	in. (mm)	2.97 (75.5)
	Carrier roller (Upper roller)	Manner of support		Overhung type
		Quantity (One side)	pcs.	1
		Bearing		Bearing
		Sealing		Shaft seal
	Number of shoe slide plates (One side)		pcs.	-
	Track roller (Lower roller)	Quantity (One side)	pcs.	4
		Bearing		Bush
		Sealing		Floating seal
	Idler	Quantity (One side)	pcs.	1
		Bearing		Bush
		Sealing		Floating seal
	Number of sprocket teeth	Steel track	pcs.	19
		Rubber track	pcs.	19
	Track tension adjustment			Grease adjuster

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

Item					Unit	ViO45-5, ViO55-5
Engine						
	Main specifications					
		Engine model				4TNV88-PBV
		Type				Vertical type series water-cooled 4 cycle diesel engine
		Combustion system				Direct injection
		Number of cylinders - Bore×Stroke			pcs. - in.×in. (mm×mm)	4 - 3.46×3.54 (88×90)
		Total displacement			cu.in. (cu.cm)	133.5 (2189)
		Rated output / engine speed			HP/rpm (KW/rpm)	38.7/2400 (28.8/2400)
		Maximum torque / engine speed			ft•lbf/rpm (N•m/rpm)	30.9 to 32.6/1300 (139.3 to 145.1/1300)
		Specific fuel consumption			lbs./HP•h (g/PS•h)	0.540 (245)
		Maximum idling speed			rpm	2510
		Minimum idling speed (engine unit)			rpm	1150
		Engine dry mass (excluding air cleaner and silencer)			lbs. (kg)	375 (170)
		Lubricating method				Forced lubrication by trochoid pump
		Specific lubricating oil consumption			lbs./HP•h (g/PS•h)	0.0012 or less (0.544 or less)
		Compression pressure			PSI (MPa)	497.7 (3.4) at 250 rpm
	Cylinder head					
		Intake valve	Open	bTDC	degrees	10 to 20
			Close	aBDC	degrees	40 to 50
		Exhaust valve	Open	bBDC	degrees	51 to 61
			Close	aTDC	degrees	13 to 23
		Intake valve clearance (Cold engine)			in. (mm)	0.0059 to 0.0098 (0.15 to 0.25)
		Exhaust valve clearance (Cold engine)			in. (mm)	0.0059 to 0.0098 (0.15 to 0.25)
		Intake valve seat angle			degrees	120
		Exhaust valve seat angle			degrees	90
	Piston					
		First compression ring	Ring shape			Barrel face (chrome-plated)
			Ring quantity		pcs.	4
		Second compression ring	Ring shape			Taper face (inner cut)
			Ring quantity		pcs.	4
		Oil-ring	Ring shape			Bevel cutter (with coil expander)
			Ring quantity		pcs.	4
	Governor					
		Name				Mechanical all speed type
		Type				Centrifugal type

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

Item			Unit	ViO45-5, ViO55-5
Engine				
	Fuel feed system			
		Fuel filter		Filter paper with automatic air release device
		Fuel filter filtration area	sq.in. (sq.cm)	310 (2000)
		Oil/water separator		Mesh filter
		Feed pump		Mechanical diaphragm type
	Lubrication system			
		Lubrication pump		Trochoid pump
		LO pressure regulating valve opening pressure	PSI (kPa)	42.7 to 56.9 (294.2 to 392.2)
		LO filter		Full flow filter
		LO filter filtration area	sq.in. (sq.cm)	186 (1200)
		Filter valve opening pressure	PSI (kPa)	11.4 to 17.1 (78.5 to 117.7)
		Operating pressure of alarm switch	PSI (kPa)	5.7 to 8.5 (39.2 to 58.8)
	Cooling device			
		Cooling system		Water-cooling (Radiator)
		Fan belt size		A38
		Thermostat opening temperature	ºF (ºC)	159.8 (71)
		Thermostat full-open temperature	ºF (ºC)	185.0 (85)
		Radiator cap pressure	PSI (kPa)	12.8 (88.3)
		Radiator fan	pcs.× Øin. (mm)	6×Ø13.2 (Ø335)
		Operating temperature of water temperature alarm switch	ºF (ºC)	224.6 to 235.4 (107 to 113)
	Air cleaner			
		Type		Cyclone type
		Filtration area	sq.ft. (sq.m)	11.8 (1.1)
	Fuel injection pump			
		Injection pump type		YPD-4MP2
		Injection pump plunger diameter	in. (mm)	Ø0.35 (Ø9)
		Injection pump cam lifting height	in. (mm)	0.28 (7.0)
		Fuel injection timing (FID)	degrees	16
		Firing order		1→3→4→2
	Nozzle			
		Type		Hall valve
		Nozzle hole diameter×Number of holes	Øin. (mm) ×pcs.	Ø0.0071 (Ø0.18)×4
		Spray angle	degrees	159
		Fuel injection pressure	PSI (MPa)	2844 to 2986 (19.6 to 20.6)
	Turbocharger			
		Type		-
		Revolution speed	rpm	-
		Turbocharging pressure	PSI (MPa)	-

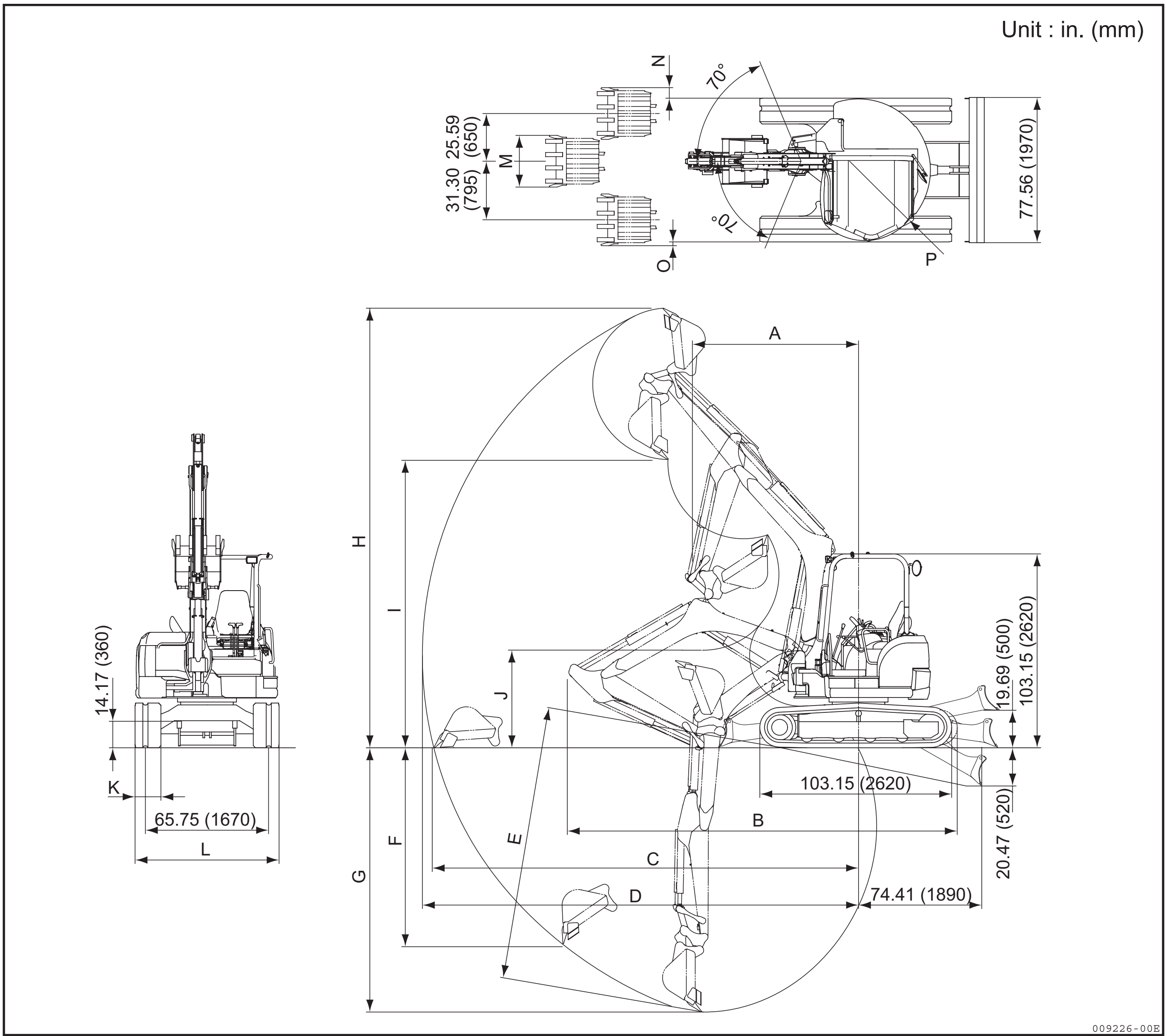
2. TECHNICAL DATA

***Note :** < > : W/O Quick coupler*

Item		Unit	ViO45-5, ViO55-5
Engine			
Starting device			
Cold starting aids			Air heater
Starting aids capacity		V-W	12-400
Battery type			115D31R
Battery voltage - 5 hrs rate capacity		V-Ah	12-72
Electrical equipment			
Alternator	Type		Magnet
	Nominal output	V-A	12-40
	Rated speed	rpm	5000
Regulator	Type		IC type
	Regulation voltage	V	14.2 to 14.8
Starter motor	Type		Reduction type
	Nominal output	V-kW	12-2.3
	Engagement		Magnet shift
Stop motor	Type	-	-
	Nominal output	V-A	-
Hour meter		V-W	12-12
Horn		V-W	12-30
Fuse		A×pcs.	30×1, 15×5, 5×1
Monitor lamps	Battery charge alarm lamp	V-W	12-2
	Engine oil pressure alarm lamp	V-W	12-2
	Water temperature alarm lamp	V-W	12-2
Headlight		V-W	12-55
Boom light		V-W	12-55
Room lamp (for cabin)		V-W	12-5
Wiper motor (for cabin)		V-W	12-48
Cabin heater (for cabin)		V-W	12-35
External energizer socket		V-W	12-120

2-2 Outline Drawing and Working Area

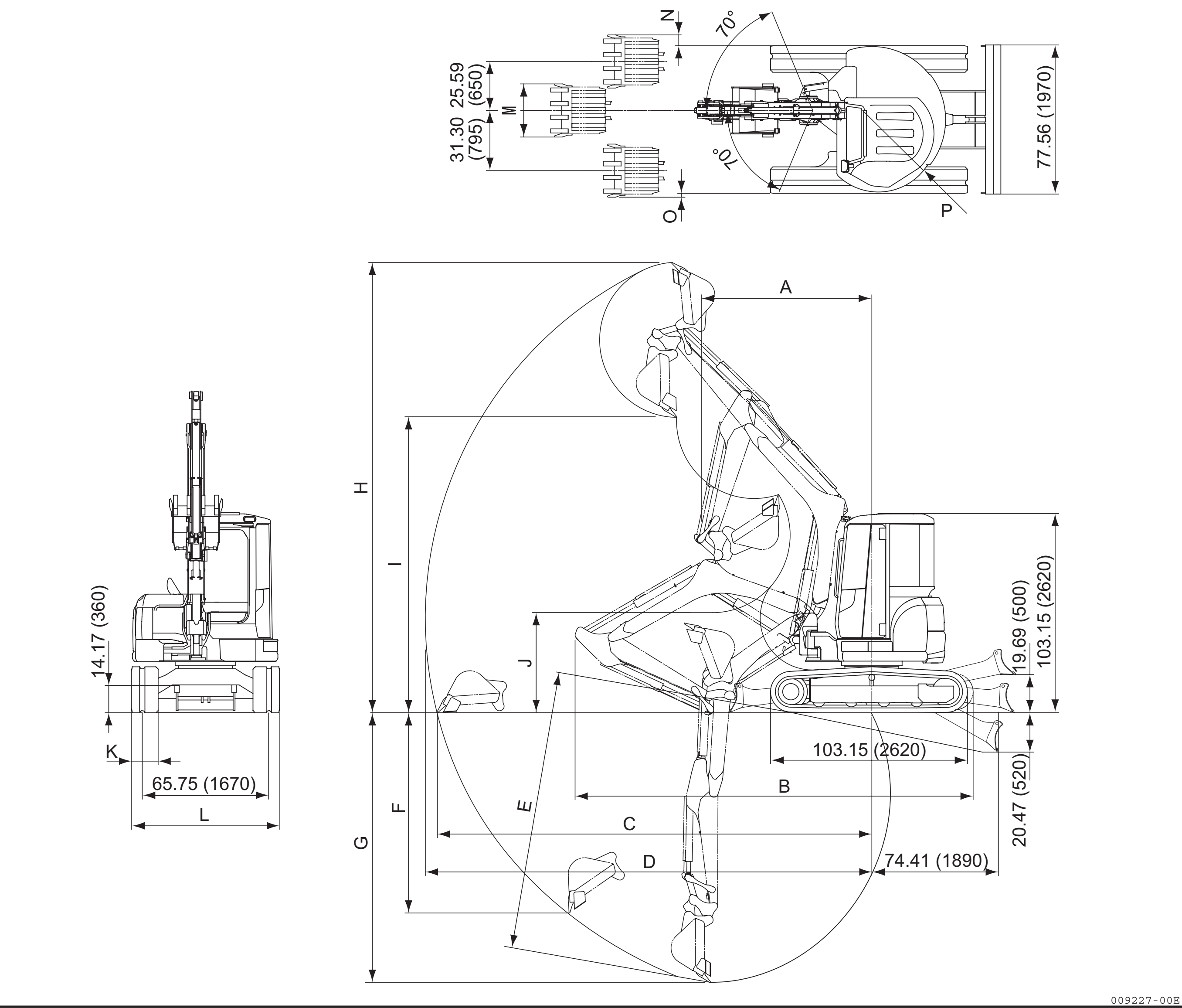
2-2-1 Canopy type



	A <at boom swing>	B	C	D	E	F	G	H	I	J
ViO45-5	92.13 <78.35> (2340 <1990>)	207.09 (5260)	226.38 (5750)	232.28 (5900)	151.57 (3850)	106.30 (2700)	144.88 (3680)	234.25 (5950)	153.94 (3910)	52.36 (1330)
ViO55-5	91.34 <77.17> (2320 <1960>)	218.90 (5560)	244.09 (6200)	250.00 (6350)	163.78 (4160)	114.17 (2900)	156.69 (3980)	253.54 (6440)	173.23 (4400)	59.84 (1520)

	K	L	M	N	O	P
ViO45-5	13.78 (350)	76.77 (1950)	25.59 (650)	5.12 (130)	1.57 (40)	R38.39 (R975)
ViO55-5	15.75 (400)	78.35 (1990)	27.56 (700)	5.31 (135)	1.77 (45)	R39.17 (R995)

2-2-2 Cabin type



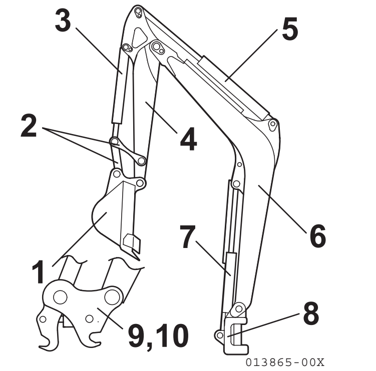
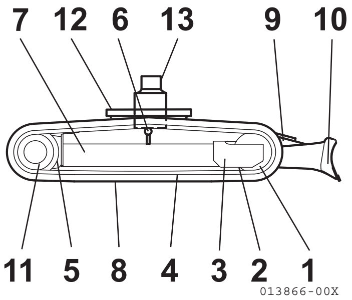
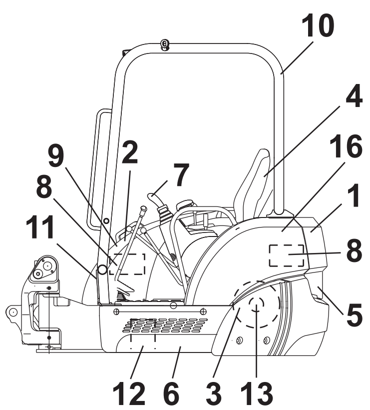
	A <at boom swing>	B	C	D	E	F	G	H	I	J
ViO45-5	92.13 <78.35> (2340 <1990>)	207.09 (5260)	226.38 (5750)	232.28 (5900)	151.57 (3850)	106.30 (2700)	144.88 (3680)	234.25 (5950)	153.94 (3910)	52.36 (1330)
ViO55-5	91.34 <77.17> (2320 <1960>)	218.90 (5560)	244.09 (6200)	250.00 (6350)	163.78 (4160)	114.17 (2900)	156.69 (3980)	253.54 (6440)	173.23 (4400)	59.84 (1520)

	K	L	M	N	O	P
ViO45-5	13.78 (350)	76.77 (1950)	25.59 (650)	5.12 (130)	1.57 (40)	R38.39 (R975)
ViO55-5	15.75 (400)	78.35 (1990)	27.56 (700)	5.31 (135)	1.77 (45)	R39.17 (R995)

2-3 Weight List of Main Parts

Note : *< > : W/O Quick coupler*

[Unit : lbs. (kg)]

Equipment	No.	Part	ViO45-5 Canopy Steel track	ViO45-5 Canopy Rubber track	ViO45-5 Cabin Steel track	ViO45-5 Cabin Rubber track
Front implement						
	1	Bucket Ass'y	271.2 (123)			
	2	Bucket arm & link Ass'y	61.7 (28)			
	3	Bucket cylinder Ass'y	70.6 (32)			
	4	Arm Ass'y	196.2 (89)			
	5	Arm cylinder Ass'y	94.8 (43)			
	6	Boom Ass'y	374.9 (170)			
	7	Boom cylinder Ass'y	∗1 : 90.4 (41), ∗2 : 113.0 (52)			
	8	Boom bracket Ass'y	209.5 (95)			
	9	Quick coupler cylinder Ass'y	19.4 (8.8)			
	10	Quick coupler Ass'y	103.2 (46.8)			
Undercarriage						
	1	Idler Ass'y	81.6 (37)			
	2	Track guard Ass'y	9.26×2 [(4.2)×2]	–	9.26×2 [(4.2)×2]	–
	3	Track adjuster Ass'y	44.1 (20) × 2			
	4	Track roller Ass'y	27.6 (12.5) × 8			
	5	Sprocket Ass'y	28.7 (13) × 2			
	6	Carrier roller Ass'y	22.1 (10) × 2			
	7	Track frame Ass'y	1125 (510)			
	8	Steel track & Rubber track Ass'y	560.1×2 [(254)×2]	518.2×2 [(235)×2]	560.1×2 [(254)×2]	518.2×2 [(235)×2]
	9	Blade cylinder Ass'y	70.6 (32)			
	10	Blade Ass'y	555.7 (252) <507.2 (230)>			
	11	Travel motor Ass'y	121.3 (55) × 2			
	12	Swing bearing Ass'y	196.2 (89)			
	13	Swivel & hose or fitting Ass'y	66.2 (30)			
Upperstructure						
	1	Engine hood Ass'y	66.2 (30)			
	2	Hydraulic oil tank with filter Ass'y	83.8 (38)			
	3	Engine	551.3 (250)			
	4	Operator's seat & mount Ass'y	123.5 (56)			
	5	Counter weight Ass'y	258 (117)			
	6	Turning frame Ass'y	1226 (556)			
	7	Controls (4 cables) Ass'y	66.2 (30)			
	8	Battery Ass'y	48.5 (22)			
	9	Fuel tank & piping Ass'y	83.8 (38)			
	10	Canopy (& pole) or cabin Ass'y	132.3 (60)		507.2 (230)	
	11	Swing lock, covers, steps and panels	136.7 (62)			
	12	Swing motor Ass'y	92.6 (42)			
	13	Pump & mount and hoses Ass'y	88.2 (40)			
	14	Control valve & fitting and hoses Ass'y	143.3 (65)			
	15	Boom swing cylinder Ass'y	70.6 (32)			
	16	Engine mount Ass'y	224.9 (102)			

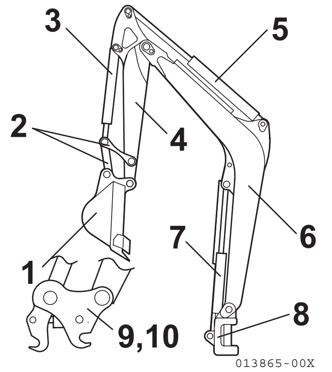
∗1 : S/N 50501 to 50591, ∗2 : S/N 50592 and after

2. TECHNICAL DATA

Note : *< > : W/O Quick coupler*

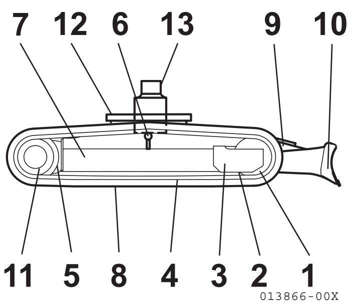
[Unit : lbs. (kg)]

Front implement



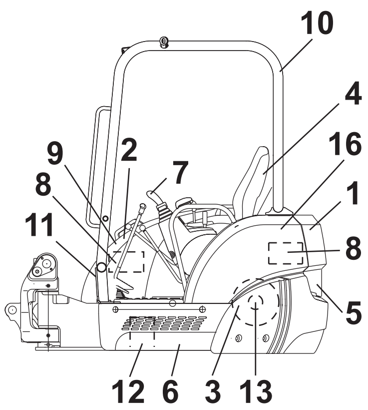
No.	Part		ViO55-5 Canopy Steel track	ViO55-5 Canopy Rubber track	ViO55-5 Cabin Steel track	ViO55-5 Cabin Rubber track
1	Bucket	Ass'y	277.8 (126)			
2	Bucket arm & link	Ass'y	61.7 (28)			
3	Bucket cylinder	Ass'y	70.6 (32)			
4	Arm	Ass'y	235.9 (107)			
5	Arm cylinder	Ass'y	94.8 (43)			
6	Boom	Ass'y	502.7 (228)			
7	Boom cylinder	Ass'y	∗1 : 90.4 (41), ∗2 : 113.0 (52)			
8	Boom bracket	Ass'y	209.5 (95)			
9	Quick coupler cylinder	Ass'y	19.4 (8.8)			
10	Quick coupler	Ass'y	103.2 (46.8)			

Undercarriage



No.	Part		ViO55-5 Canopy Steel track	ViO55-5 Canopy Rubber track	ViO55-5 Cabin Steel track	ViO55-5 Cabin Rubber track
1	Idler	Ass'y	81.6 (37)			
2	Track guard	Ass'y	9.26×2 [(4.2)×2]	–	9.26×2 [(4.2)×2]	–
3	Track adjuster	Ass'y	44.1 (20) × 2			
4	Track roller	Ass'y	27.6 (12.5) × 8			
5	Sprocket	Ass'y	28.7 (13) × 2			
6	Carrier roller	Ass'y	22.1 (10) × 2			
7	Track frame	Ass'y	1125 (510)			
8	Steel track & Rubber track	Ass'y	626.2×2 [(284)×2]	577.7×2 [(262)×2]	626.2×2 [(284)×2]	577.7×2 [(262)×2]
9	Blade cylinder	Ass'y	70.6 (32)			
10	Blade	Ass'y	555.7 (252) <507.2 (230)>			
11	Travel motor	Ass'y	121.3 (55) × 2			
12	Swing bearing	Ass'y	196.2 (89)			
13	Swivel & hose or fitting	Ass'y	66.2 (30)			

Upperstructure

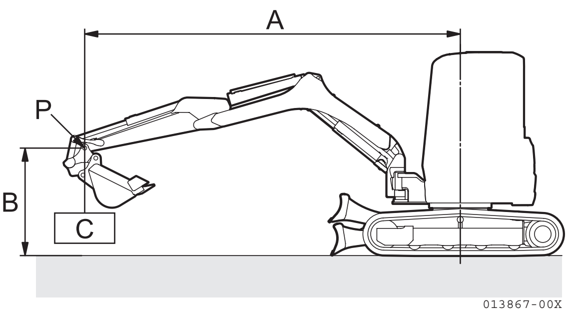


No.	Part		ViO55-5 Canopy Steel track	ViO55-5 Canopy Rubber track	ViO55-5 Cabin Steel track	ViO55-5 Cabin Rubber track
1	Engine hood	Ass'y	66.2 (30)			
2	Hydraulic oil tank with filter	Ass'y	83.8 (38)			
3	Engine		551.3 (250)			
4	Operator's seat & mount	Ass'y	123.5 (56)			
5	Counter weight	Ass'y	1292 (586)			
6	Turning frame	Ass'y	1226 (556)			
7	Controls (4 cables)	Ass'y	66.2 (30)			
8	Battery	Ass'y	48.5 (22)			
9	Fuel tank & piping	Ass'y	83.8 (38)			
10	Canopy (& pole) or cabin	Ass'y	132.3 (60)		507.2 (230)	
11	Swing lock, covers, steps and panels		136.7 (62)			
12	Swing motor	Ass'y	92.6 (42)			
13	Pump & mount and hoses	Ass'y	88.2 (40)			
14	Control valve & fitting and hoses	Ass'y	143.3 (65)			
15	Boom swing cylinder	Ass'y	70.6 (32)			
16	Engine mount	Ass'y	224.9 (102)			

∗1 : S/N 50501 to 50800, ∗2 : S/N 50801 and after

2-4 Lifting Capacity List

1) ViO45-5



With:
(☐ Cabin■ Canopy) Type
(☐ Steel ■ Rubber) Track
Quick coupler
W/O Bucket

A : Reach from swing center line [in. (m)]
B : Load point height [in. (m)]
C : Lifting load [lbs. (kg)]
P : Load point
: Rating over front
: Rating over side or 180 degrees

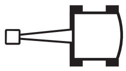
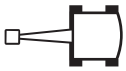
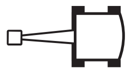
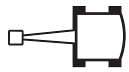
Blade on ground

Unit : lbs. (kg)

A [in. (m)]	Max.		157.5 (4.0)		118.1 (3.0)		98.43 (2.5)	
B [in. (m)]								
157.5 (4.0)	*2088 (947)		–		–		–	
118.1 (3.0)	*2145 (973)		*2029 (920)		–		–	
78.7 (2.0)	*2220 (1007)		*2395 (1086)		*2796 (1268)		*3354 (1521)	
39.4 (1.0)	*2298 (1042)		*2778 (1260)		*3947 (1790)		*5272 (2391)	
0 (0)	*2432 (1103)		*3008 (1364)		*4350 (1973)		*5541 (2513)	
-39.4 (-1.0)	*2604 (1181)		*2778 (1260)		*4159 (1886)		*5232 (2373)	
-78.7 (-2.0)	*2432 (1103)		–		*3105 (1408)		*4081 (1851)	

Blade above ground

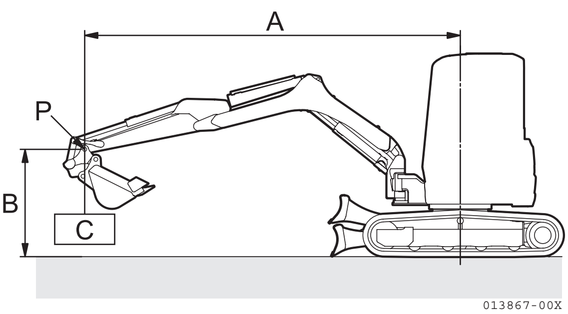
Unit : lbs. (kg)

A [in. (m)]	Max.		157.5 (4.0)		118.1 (3.0)		98.43 (2.5)	
B [in. (m)]								
157.5 (4.0)	*1991 (903)	1652 (749)	–	–	–	–	–	–
118.1 (3.0)	1321 (599)	1255 (569)	*1934 (877)	1502 (681)	–	–	–	–
78.7 (2.0)	1122 (509)	1056 (479)	1585 (719)	1486 (674)	*2664 (1208)	*2664 (1208)	*3257 (1477)	*3371 (1529)
39.4 (1.0)	1072 (486)	1023 (464)	1552 (704)	1420 (644)	2461 (1116)	2280 (1034)	3122 (1416)	2875 (1304)
0 (0)	1171 (531)	1072 (486)	1502 (681)	1402 (636)	2328 (1056)	2097 (951)	3074 (1394)	2792 (1266)
-39.4 (-1.0)	1387 (629)	1288 (584)	1469 (666)	1387 (629)	2148 (974)	2346 (1064)	3122 (1416)	2792 (1266)
-78.7 (-2.0)	2088 (947)	1916 (869)	–	–	2379 (1079)	–	3288 (1491)	2891 (1311)

Note :

The lifting load with the asterisk (*) mark is limited by hydraulic lifting capacity rather than tipping. The lifting capacity shown in the above list is based on the ISO Standard No. 10567 and represents either 87 % of hydraulic lifting capacity or 75 % of tipping load, which is smaller.

2) ViO55-5



With:
(☐ Cabin■ Canopy) Type
(☐ Steel ■ Rubber) Track
Quick coupler
W/O Bucket

A : Reach from swing center line [in. (m)]
B : Load point height [in. (m)]
C : Lifting load [lbs. (kg)]
P : Load point
: Rating over front
: Rating over side or 180 degrees

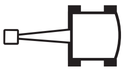
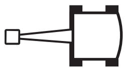
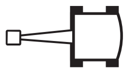
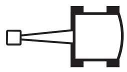
Blade on ground

Unit : lbs. (kg)

A [in. (m)]	Max.		157.5 (4.0)		118.1 (3.0)		98.43 (2.5)	
B [in. (m)]								
157.5 (4.0)	*2176 (987)		*1985 (900)		–		–	
118.1 (3.0)	*2159 (979)		*2196 (996)		–		–	
78.7 (2.0)	*2216 (1005)		*2600 (1179)		*3405 (1544)		*4172 (1892)	
39.4 (1.0)	*2254 (1022)		*3061 (1388)		*4421 (2005)		–	
0 (0)	*2311 (1048)		*3233 (1466)		*4747 (2153)		*5956 (2701)	
-39.4 (-1.0)	*2311 (1048)		*3078 (1396)		*4478 (2031)		*5420 (2458)	
-78.7 (-2.0)	*2196 (996)		–		*3596 (1631)		–	

Blade above ground

Unit : lbs. (kg)

A [in. (m)]	Max.		157.5 (4.0)		118.1 (3.0)		98.43 (2.5)	
B [in. (m)]								
157.5 (4.0)	*2062 (935)	*2062 (935)	*1910 (866)	*1910 (866)	–	–	–	–
118.1 (3.0)	1413 (641)	1398 (634)	*2062 (935)	*2062 (935)	–	–	–	–
78.7 (2.0)	1314 (596)	1248 (566)	1810 (821)	1910 (866)	*3405 (1544)	*3405 (1544)	*4403 (1997)	*4172 (1892)
39.4 (1.0)	1248 (566)	1215 (551)	2009 (911)	1910 (866)	3034 (1376)	2919 (1324)	–	–
0 (0)	1281 (581)	1248 (566)	1927 (874)	1843 (836)	2935 (1331)	2769 (1256)	*5955 (2701)	3596 (1631)
-39.4 (-1.0)	1464 (664)	1413 (641)	1861 (844)	1795 (814)	2853 (1294)	2736 (1241)	*5420 (2458)	3596 (1631)
-78.7 (-2.0)	1927 (874)	1876 (851)	–	–	2986 (1354)	2853 (1294)	–	–

Note :

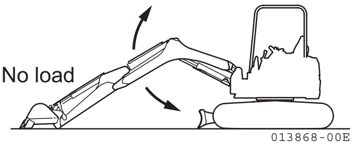
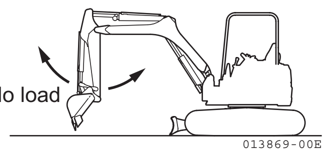
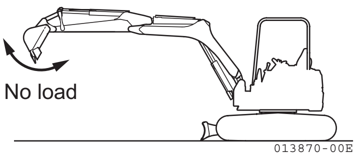
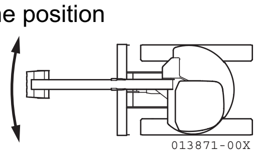
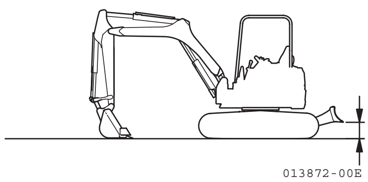
The lifting load with the asterisk (*) mark is limited by hydraulic lifting capacity rather than tipping. The lifting capacity shown in the above list is based on the ISO Standard No. 10567 and represents either 87 % of hydraulic lifting capacity or 75 % of tipping load, which is smaller.

CHAPTER 3

SERVICE STANDARDS

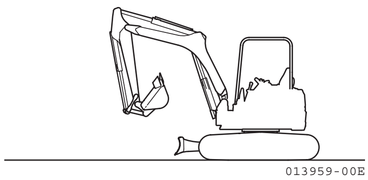
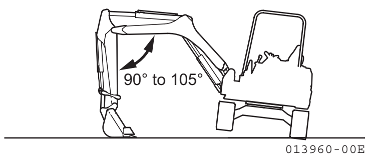
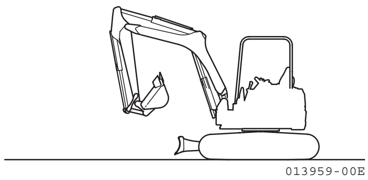
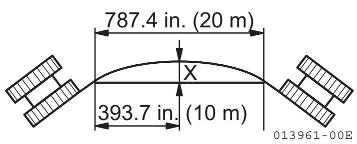
3. Service Standards

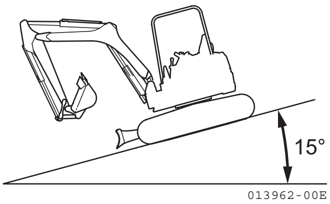
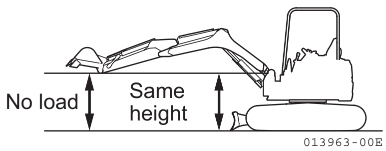
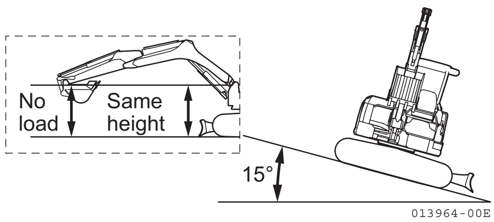
3-1 Machine Performance

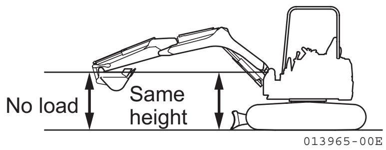
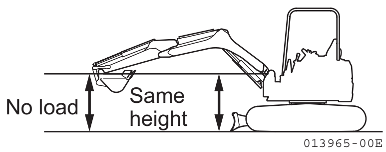
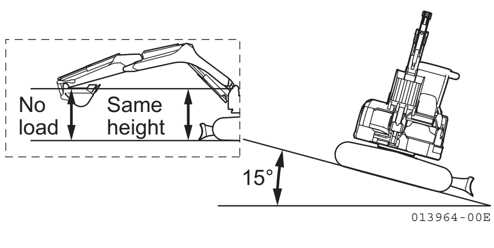
Applicable model				ViO45-5		ViO55-5	
Item	Measuring condition		Unit	Standard	Allowance	Standard	Allowance
Machine performance							
Working speed							
Boom speed Max. cylinder extension ↕ Bucket teeth grounded	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground	Up	sec.	∗1 : 2.2 ∗2 : 2.4	∗1 : 2.5 ∗2 : 2.7	∗1 : 2.2 ∗2 : 2.6	∗1 : 2.5 ∗2 : 2.9
		Down		∗1 : 2.5 ∗2 : 2.9	∗1 : 2.8 ∗2 : 3.2	∗1 : 2.5 ∗2 : 3.2	∗1 : 2.8 ∗2 : 3.5
Arm speed Max. cylinder retraction ↕ Max. cylinder extension	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground	Extend	sec.	2.5	2.8	2.5	2.8
		Retract		3.4	3.7	3.4	3.7
Bucket speed Max. cylinder retraction ↕ Max. cylinder extension	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground	Dump	sec.	2.4	2.7	2.4	2.7
		Curl		4.0	4.3	4.0	4.3
Boom offset speed Max. cylinder retraction ↕ Max. cylinder extension	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground	Right swing	sec.	6.5	8.0	6.5	8.0
		Left swing		6.5	8.0	6.5	8.0
Blade speed Max. cylinder retraction ↕ Blade grounded	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C)	Up	sec.	0.9	1.2	1.0	1.3
		Down		1.1	1.4	1.2	1.5

ViO45-5 : ∗1 : S/N 50501 to 50591, ∗2 : S/N 50592 and after
ViO55-5 : ∗1 : S/N 50501 to 50800, ∗2 : S/N 50801 and after

3. SERVICING STANDARDS

Applicable model				ViO45-5		ViO55-5	
Item		Measuring condition	Unit	Standard	Allowance	Standard	Allowance
Machine performance							
	Travel speed	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Traveling time for 787.4 in. (20 m) after an approach run of 196.9 in. (5 m) or more.	sec./ 787.4 in. (20 m)	High speed 15.6	17.1	16.4	18.0
				Low speed 32.0	35.0	32.0	35.0
	Track speed	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Travel lever : Full throttle (Floating track side) • Float one side of the track. Make a mark on the track. After turning the floating track side more than once, measure the time needed for 3 turns of the track.	sec./ 3 rev.	High speed 12.6	15.6	13.3	16.3
				Low speed 26.1	30.0	25.0	29.0
	Track deviation	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Measure the deviation (χ) in a travel distance of 787.4 in. (20 m) after an approach run of 196.9 in. (5 m) or more. 	in. (mm)/ 787.4 in. (20 m)	11.8 (300) or less	14.2 (360)	11.8 (300) or less	14.2 (360) or less

Applicable model			ViO45-5		ViO55-5	
Item	Measuring condition	Unit	Standard	Allowance	Standard	Allowance
Machine performance						
Traveling drift	Machine position  • Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Drift of the machine after 5 min. on a slope with an inclination of 15 degrees.	in. (mm) / 5 min.	7.87 (200) or less	11.8 (300)	7.87 (200) or less	11.8 (300)
Drift of cylinders						
Boom drift (Cylinder rod retraction)	Machine position  • Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Make the boom and bucket pins the same height. • Measure the retraction or extension of each cylinder rod after leaving the machine at the above position for 10 min. • Lift the blade to the highest position, and measure the cylinder rod extension after 10 min.	in. (mm) / 10 min.	0.39 (10) or less	0.59 (15)	0.39 (10) or less	0.59 (15)
Arm drift (Cylinder rod extension)			0.39 (10) or less	0.59 (15)	0.39 (10) or less	0.59 (15)
Bucket drift (Cylinder rod extension)			0.24 (6) or less	0.35 (9)	0.24 (6) or less	0.35 (9)
Blade drift (Cylinder rod extension)			0.24 (6) or less	0.35 (9)	0.24 (6) or less	0.35 (9)
Boom offset drift (Cylinder rod extension)	Machine position  • Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Make the boom and bucket pins the same height. • Park the machine on a slope with an inclination of 15 degrees and turn the upperstructure 90 degrees to the track and engage the swing lock. • Measure the cylinder rod extension after 10 min.	in. (mm) / 10 min.	0.24 (6) or less	0.35 (9)	0.24 (6) or less	0.35 (9)

Applicable model			ViO45-5		ViO55-5	
Item	Measuring condition	Unit	Standard	Allowance	Standard	Allowance
Machine performance						
Swing drift at stopping	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Make the boom and bucket pins the same height. • Make match marks on the outer race and the inner race of the swing bearing (or the track frame). • Measure shifted distance between both marks after making one turn with no load.	in. (mm) or degrees	12.4 (315) or less, 45 or less	12.3 (490) 70	12.4 (315) or less, 45 or less	12.3 (490) 70
Swing time	Machine position  • Engine : rated speed • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Site : Firm, flat ground • Make one idling turn with no load, then measure the time necessary to make 5 turns.	sec. / 5 turns	27.5	31.5	27.5	31.5
Swing drift	Machine position  • Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Make the boom and bucket pins the same height. • Park the machine on a slope with an inclination of 15 degrees and turn the upperstructure 90 degrees to the track. • Make match marks on the outer race and the inner race of the swing bearing (or the track frame). • Measure shifted distance or angle between both marks after 5 min.	in. (mm)	0	-	0	-

3. SERVICING STANDARDS

3-2 Engine

1) Nominal and Allowable Values

Applicable model					4TNV88-PBV	
Item				Unit	Standard	Wear limit
Cylinder head						
	Cylinder head distortion			in. (mm)	0.0020 (0.05) or less	0.0059 (0.15)
	Valve seat angle	Intake		degrees (°)	120	–
		Exhaust			90	–
	Valve seat width	Intake		in. (mm)	–	
		Exhaust			–	
	Intake valve	Stem outside dia.		in. (mm)	0.3132 to 0.3140 (7.955 to 7.975)	0.3110 (7.9)
		Guide inside dia.			0.3154 to 0.3159 (8.010 to 8.025)	0.3189 (8.1)
		Oil clearance			0.0014 to 0.0028 (0.035 to 0.070)	0.0071 (0.18)
	Exhaust valve	Stem outside dia.		in. (mm)	0.3132 to 0.3138 (7.955 to 7.970)	0.3110 (7.9)
		Guide inside dia.			0.3155 to 0.3161 (8.015 to 8.030)	0.3189 (8.1)
		Oil clearance			0.0018 to 0.0030 (0.045 to 0.075)	0.0071 (0.18)
	Valve guide projection			in. (mm)	0.5787 to 0.5906 (14.7 to 15.0)	–
	Valve sinkage	Intake		in. (mm)	0.0118 to 0.0197 (0.30 to 0.50)	0.0315 (0.8)
		Exhaust			0.0118 to 0.0197 (0.30 to 0.50)	
	Valve head thickness	Intake		in. (mm)	0.0488 to 0.0567 (1.24 to 1.44)	0.0315 (0.8)
		Exhaust			0.0531 to 0.0610 (1.35 to 1.55)	
	Intake valve operating timing	Open	b. TDC	degrees (°)	–	–
		Close	a. BDC		–	–
	Exhaust valve operating timing	Open	b. BDC	degrees (°)	–	–
		Close	a. TDC		–	–
	Valve spring	Free length		in. (mm)	1.6535 (42.0)	1.6339 (41.5)
		Inclination		in. (mm)	–	0.0551 (1.4)
		Tension [0.0394 in. (1 mm) compressed]		lbs. (kg)	–	–
	Intake / exhaust valve clearance			in. (mm)	0.0077 to 0.0081 (0.195 to 0.205)	–
Cylinder block						
	Cylinder bore dia.			in. (mm)	3.4646 to 3.4657 (88.000 to 88.030)	3.472 (88.200)
	Cylinder bore dia.		L mark		–	
			M mark		–	
			S mark		–	
	Roundness of cylinder				0.0004 (0.01) or less	0.0012 (0.03)
	Cylindricity of cylinder				0.0004 (0.01) or less	0.0012 (0.03)

3. SERVICING STANDARDS

Applicable model				4TNV88-PBV	
Item			Unit	Standard	Wear limit
Valve					
	Intake / exhaust valve rocker arm	Shaft outside dia.	in. (mm)	0.6286 to 0.6293 (15.966 to 15.984)	0.6276 (15.94)
		Bush inside dia.		0.6299 to 0.6307 (16.000 to 16.020)	0.6327 (16.07)
		Oil clearance		0.0006 to 0.0021 (0.016 to 0.054)	0.0051 (0.13)
	Push rod bend			–	0.0012 (0.03)
	Tappet	Stem outside dia.		0.4715 to 0.4721 (11.975 to 11.990)	0.4707 (11.955)
		Guide hole inside dia.		0.4724 to 0.4734 (12.000 to 12.025)	0.4742 (12.045)
		Oil clearance		0.0004 to 0.0020 (0.010 to 0.050)	0.0035 (0.090)
Piston					
	Piston outside dia.		in. (mm)	3.4624 to 3.4636 (87.945 to 87.975)	3.4606 (87.900)
	Piston outside dia.	L mark		–	
		ML mark		–	
		MS mark		–	
		S mark		–	
	Minimum clearance between piston and cylinder			0.0016 to 0.0028 (0.040 to 0.070)	–
	Top clearance			0.0268 to 0.0315 (0.68 to 0.80)	–
	Piston pin	Outside dia.		1.0234 to 1.0236 (25.995 to 26.000)	1.0222 (25.965)
		Bush inside dia.		1.0236 to 1.0240 (26.000 to 26.009)	1.0252 (26.039)
		Oil clearance		0 to 0.0006 (0 to 0.014)	0.0029 (0.074)
Piston ring					
	Top ring	Ring groove width	in. (mm)	0.0811 to 0.0817 (2.060 to 2.075)	–
		Ring width		0.0776 to 0.0783 (1.970 to 1.990)	0.0768 (1.950)
		Clearance between groove and ring		0.0028 to 0.0041 (0.070 to 0.105)	–
		End gap		0.00787 to 0.0158 (0.200 to 0.400)	0.0193 (0.490)
	Second ring	Ring groove width		0.0797 to 0.0803 (2.025 to 2.040)	0.0843 (2.140)
		Ring width		0.0776 to 0.0784 (1.970 to 1.990)	0.0768 (1.950)
		Clearance between groove and ring		0.0014 to 0.0028 (0.035 to 0.070)	0.0075 (0.190)
		End gap		0.0079 to 0.0157 (0.200 to 0.400)	0.0193 (0.490)

3. SERVICING STANDARDS

Applicable model				4TNV88-PBV	
Item			Unit	Standard	Wear limit
Piston ring					
	Oil ring	Ring groove width	in. (mm)	0.1581 to 0.1587 (4.015 to 4.030)	0.1626 (4.130)
		Ring width		0.1563 to 0.1571 (3.970 to 3.990)	0.1555 (3.950)
		Clearance between groove and ring		0.0010 to 0.0024 (0.025 to 0.060)	0.0071 (0.180)
		End gap		0.0079 to 0.0157 (0.200 to 0.400)	0.0193 (0.490)
Connecting rod					
	Crank pin side	Crank pin metal inside dia.	in. (mm)	1.8898 to 1.8908 (48.000 to 48.026)	–
		Crank pin metal thickness		0.0587 to 0.0591 (1.492 to 1.500)	–
		Crank pin outside dia.		1.8879 to 1.8883 (47.952 to 47.962)	1.8859 (47.902)
		Oil clearance		0.0015 to 0.0029 (0.038 to 0.074)	0.0059 (0.150)
	Piston pin side	Bush inside dia.		1.0246 to 1.0251 (26.025 to 26.038)	1.0263 (26.068)
		Piston pin outside dia.		1.0234 to 1.0236 (25.995 to 26.000)	1.0223 (25.967)
		Oil clearance		0.0010 to 0.0017 (0.025 to 0.043)	0.0040 (0.101)
	Twist and parallelism			0.0012 (0.03) or less for 3.94 (100)	0.0031 (0.08)
Cam					
	Gear side	Bush inside dia.	in. (mm)	1.7713 to 1.7738 (44.990 to 45.055)	1.7768 (45.130)
		Cam shaft outside dia.		1.7687 to 1.7697 (44.925 to 44.950)	1.7673 (44.890)
		Oil clearance		0.0016 to 0.0051 (0.040 to 0.130)	0.0094 (0.24)
	Intermediate	Bearing inside dia.		1.7717 to 1.7726 (45.000 to 45.025)	1.7756 (45.100)
		Cam shaft outside dia.		1.7681 to 1.7691 (44.910 to 44.935)	1.7667 (44.875)
		Oil clearance		0.0026 to 0.0045 (0.065 to 0.115)	0.0089 (0.225)
	Flywheel side	Bearing inside dia.		1.7717 to 1.7726 (45.000 to 45.025)	1.7756 (45.100)
		Cam shaft outside dia.		1.7687 to 1.7697 (44.925 to 44.950)	1.7673 (44.890)
		Oil clearance		0.0020 to 0.0039 (0.050 to 0.100)	0.0083 (0.210)
	Bend			0.0008 (0.02) or less	0.0020 (0.05)
	Cam height	Intake cam		1.5197 to 1.5276 (38.600 to 38.800)	1.5098 (38.350)
		Exhaust cam		1.5197 to 1.5276 (38.600 to 38.800)	1.5098 (38.350)

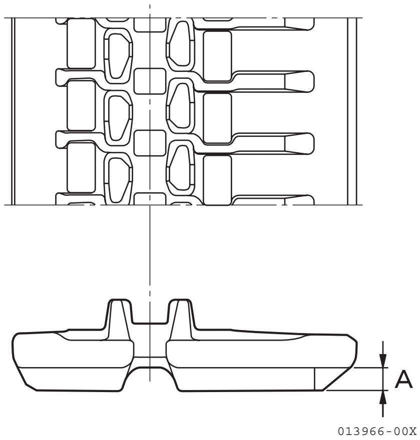
3. SERVICING STANDARDS

Applicable model				4TNV88-PBV	
Item			Unit	Standard	Wear limit
Crank shaft					
	Journal	Outside dia.	in. (mm)	2.1241 to 2.1245 (53.952 to 53.962)	2.1221 (53.902)
		Main metal inside dia.		2.1260 to 2.1268 (54.000 to 54.020)	–
		Main metal thickness		0.0785 to 0.0783 (1.995 to 1.990)	–
		Oil clearance		0.0015 to 0.0027 (0.038 to 0.068)	0.0059 (0.150)
	Bend			–	0.0008 (0.02) or less
Idle gear		Shaft outside dia.	in. (mm)	1.8091 to 1.8100 (45.950 to 45.975)	1.8071 (45.900)
		Bush inside dia.		1.8110 to 1.8120 (46.000 to 46.025)	1.8140 (46.075)
		Oil clearance		0.0010 to 0.0030 (0.025 to 0.075)	0.0069 (0.175)
Trochoid pump		Outside clearance of outer rotor	in. (mm)	0.0047 to 0.0083 (0.12 to 0.21)	0.0118 (0.30)
		Side clearance of outer rotor		0.0008 to 0.0028 (0.02 to 0.07)	0.0047 (0.12)
		Inside clearance of inner rotor		0.0118 to 0.0197 (0.3 to 0.5)	0.0236 (0.6)
		Width across flat clearance of inner rotor		0.0079 to 0.0236 (0.2 to 0.6)	0.0276 (0.7)
Side gap		Crank shaft	in. (mm)	0.0051 to 0.0091 (0.13 to 0.23)	0.0110 (0.28)
		Cam shaft		0.0020 to 0.0079 (0.05 to 0.20)	0.0118 (0.30)
		Connecting rod		0.0079 to 0.0157 (0.20 to 0.40)	–
		Idle gear		–	–
Backlash		Crank gear, Cam gear, Idle gear and Fuel injection pump drive gear	in. (mm)	0.00276 to 0.00591 (0.07 to 0.15)	–
		Lubricating oil pump gear		–	–
Others					
	Lube oil pump discharge volume	High speed	GPM (L/min)	6.6 (25) at 3000 min^{-1} (rpm)	–
		Low speed		2.1 (8) at 800 min^{-1} (rpm)	–
	Oil pressure regulating valve opening pressure		PSI (kPa)	42.66 to 56.88 (294.2 to 392.3)	–
	Oil pressure switch operating pressure		PSI (kPa)	5.69 to 8.53 (39.2 to 58.8)	–
	Cooling water pump discharge volume		GPM (L/min)	9.2 (35) at 3250 min^{-1} (rpm)	–
	Thermostat valve opening temperature	Temperature	°F (°C)	157.1 to 162.5 (69.5 to 72.5)	–
		Lift at opening	in. (mm)	0.315 (8.0) or more at 185°F (85°C) or higher	–
	Thermo-switch operating temperature	ON	°F (°C)	224.6 to 235.4 (107 to 113)	–
		OFF		212 (100) or more	–

3-3 Undercarriage

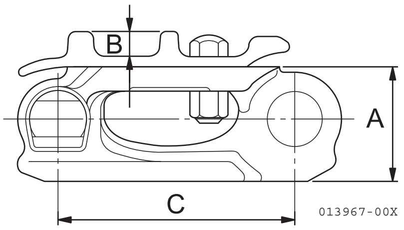
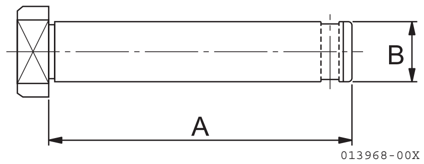
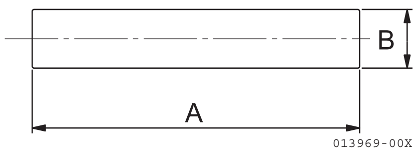
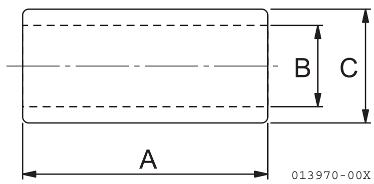
3-3-1 Rubber Track Specifications

[Unit : in. (mm)]

Applicable model	ViO45-5, ViO55-5		
Part	Measuring position	Standard	Wear limit
Rubber track specifications			
(1) Rubber track 	A	0.98 (25)	0.39 (10)

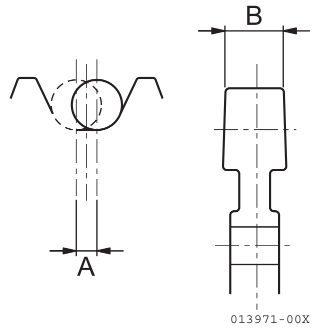
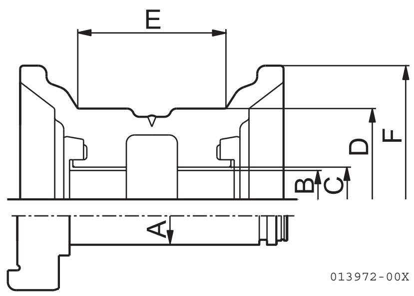
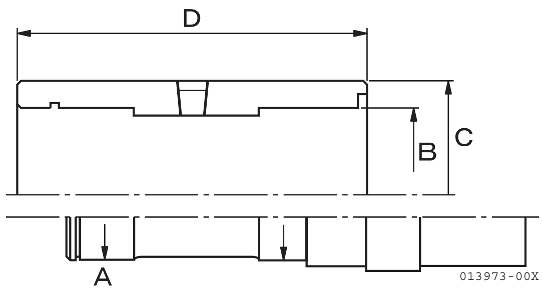
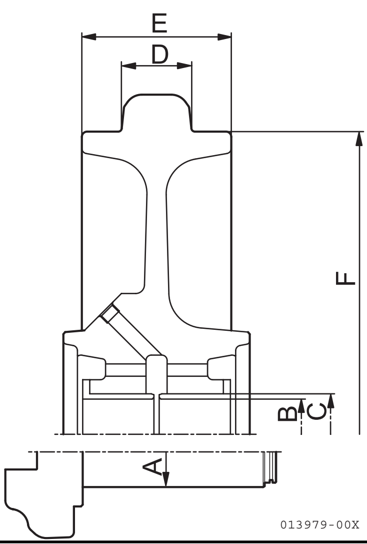
3-3-2 Steel Track Specifications

[Unit : in. (mm)]

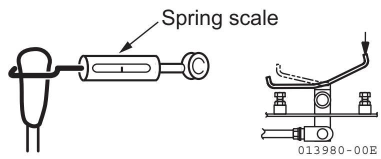
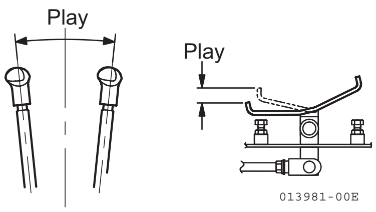
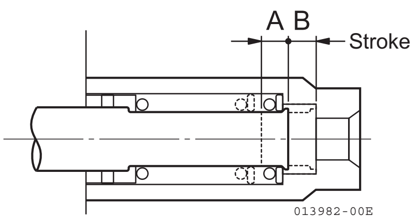
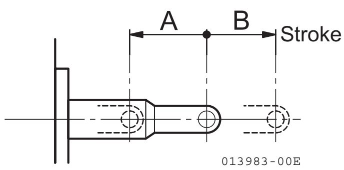
Applicable model	ViO45-5, ViO55-5		
Part	Measuring position	Standard	Wear limit
Steel track specifications			
(1) Track link (Triple grouser)  ***Note :*** *For the link pitch, measure 5 links at three places and obtain the*	A	2.64 (67)	2.52 (64)
	B	0.55 (14.0)	0.35 (9.0)
	C	5.32 (135.0)	5.37 (136.5)
(2) Master pin 	A	4.49 (114)	–
	B	Ø0.87 (Ø22.16)	Ø0.77 (Ø19.63)
(3) Pin 	A	4.73 (120.2)	–
	B	Ø0.88 (Ø22.3)	Ø0.79 (Ø20.1)
(4) Bush & master bush 	A	2.89 (73.5)	–
	B	Ø0.89 (Ø22.5)	Ø0.95 (Ø24.1)
	C	Ø1.38 (Ø35)	Ø1.31 (Ø33.2)

3-3-3 Common Specifications of Steel & Rubber Tracks

[Unit : in. (mm)]

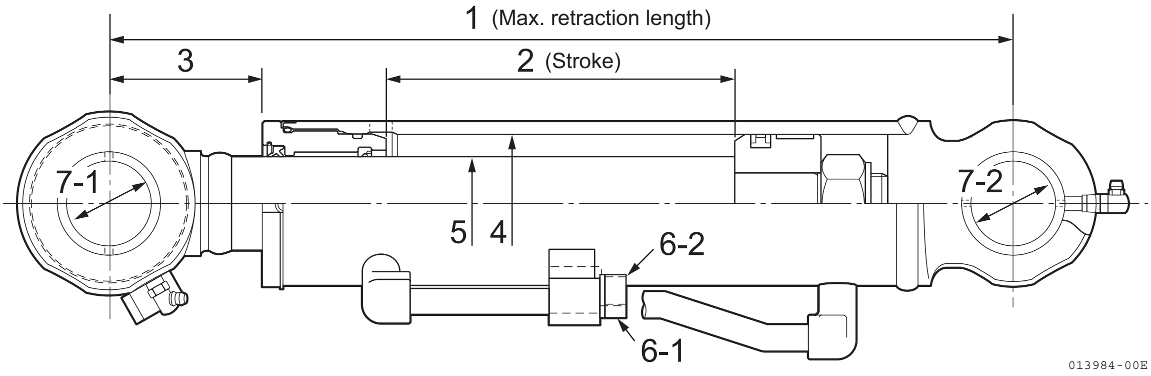
Applicable model	ViO45-5, ViO55-5		
Part	Measuring position	Standard	Wear limit
Common specifications of steel & rubber tracks			
(1) Sprocket 	A	0.20 (5)	0.39 (10)
	B	1.38 (35)	1.14 (29)
(2) Track roller & shaft 	A	Ø1.38 (Ø35)	Ø1.36 (Ø34.5)
	B	Ø1.38 (Ø35)	Ø1.39 (Ø35.4)
	C	Ø1.61 (Ø41)	–
	D	Ø4.33 (Ø110)	Ø4.09 (Ø104)
	E	3.54 (90)	3.78 (96)
	F	Ø6.38 (Ø162)	Ø6.14 (Ø156)
(3) Carrier roller & shaft 	A	Ø1.18 (Ø30)	–
	B	Ø2.44 (Ø62)	–
	C	Ø3.15 (Ø80)	Ø2.99 (Ø76)
	D	4.72 (120)	–
(4) Idler & shaft 	A	Ø1.57 (Ø40)	Ø1.56 (Ø39.5)
	B	Ø1.57 (Ø40)	Ø1.59 (Ø40.4)
	C	Ø1.81 (Ø46)	–
	D	1.50 (38)	1.26 (32)
	E	3.35 (85)	3.15 (80)
	F	Ø13.54 (Ø344)	Ø13.31 (Ø338)

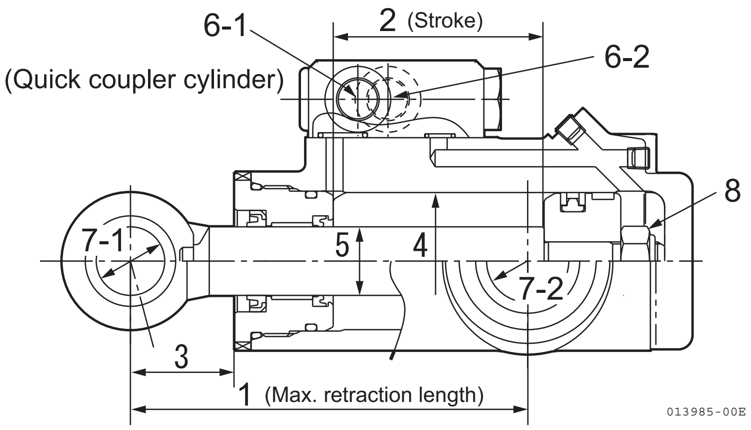
3-4 Controls

Applicable model		ViO45-5, ViO55-5		
Item	Measuring conditions	Unit	Standard	Allowable limit
Controls				
Operating force				
Right control lever (Boom & Bucket)	• Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Lever operating force : Measure the force by hanging the spring scale on the lever grip. • Pedal operating force : Measure the force by applying load as shown below. 	lbs. (kg)	3.09 (1.4)	4.63 (2.1)
Left control lever (Arm & Swing)			3.09 (1.4)	4.63 (2.1)
Blade lever			4.41 (2.0)	6.62 (3.0)
Travel levers			3.31 (1.5)	4.41 (2.0)
			–	–
Boom swing lever			–	–
Boom swing pedal			14.33 (6.5)	17.64 (8.0)
P.T.O. pedal			–	–
Play of control lever & pedal				
Right control lever (Front & rear / left & right)	• Engine : stopped • Hydraulic oil temp. : 122 to 140 °F (50 to 60 °C) • Play of each control lever and pedal : Measure the total play (front & rear and left & right) at the lever grip end or the pedal end. 	in. (mm)	0.79 (20)	–
Left control lever (Front & rear / left & right)			0.79 (20)	–
Blade lever			0.59 (15)	–
Travel levers			0.79 (20)	–
Boom swing pedal			0.16 (4)	–
P.T.O. pedal			–	–
Control valve				
Spool stroke				
Boom		in. (mm)	0.28 (7.0)	–
Bucket				
Arm				
Swing				
Blade				
Parallel-flow divider				
Inlet				
Right travel		in. (mm)	0.28 (7.0)	–
Left travel				
Boom swing				
Offset			–	

3-5 Hydraulic Equipment

3-5-1 Hydraulic Cylinders





Unit : in. (mm)

No. / Cylinder	1	2	3	4	5	6-1 / 6-2	7-1 / 7-2		8	
							Standard	Allowable limit	Thread size (mm)	Tightening torque ft•lbf (N•m)
Boom ∗1	40.6 (1031)	26.0 (660)	3.31 (84)	Ø3.74 (Ø95)	Ø1.97 (Ø50)	G3/8	Ø1.97(Ø50)	Ø1.99 (Ø50.5)	M39	1374 to 1447 (1860 to 1960)
Boom ∗2	40.6 (1031)	26.0 (660)	3.31 (84)	Ø3.94 (Ø100)	Ø2.17 (Ø55)	G3/8	Ø1.97(Ø50)	Ø1.99 (Ø50.5)	M39	1374 to 1447 (1860 to 1960)
Arm	45.6 (1159)	29.9 (760)	3.35 (85)	Ø3.35 (Ø85)	Ø1.97 (Ø50)	G3/8 / G1/2	Ø1.97(Ø50)	Ø1.99 (Ø50.5)	M36	1049 to 1121 (1420 to 1520)
Bucket	36.6 (930)	24.8 (630)	3.35 (85)	Ø2.95 (Ø75)	Ø1.97 (Ø50)	G3/8	Ø1.77 (Ø45)	Ø1.79 (Ø45.5)	M33	1013 to 1085 (1370 to 1470)
Boom swing	33.4 (848)	21.8 (553)	2.95 (75)	Ø3.54 (Ø90)	Ø1.77 (Ø45)	G1/4	Ø1.57 (Ø40)	Ø1.59 (Ø40.5)	M33	1013 to 1085 (1370 to 1470)
Blade	33.5 (850)	8.66 (220)	8.03 (204)	Ø3.54 (Ø90)	Ø1.97 (Ø50)	R3/8	Ø1.77 (Ø45)	Ø1.79 (Ø45.5)	M33	1013 to 1085 (1370 to 1470)
Quick coupler	7.40 (188)	3.39 (86)	1.81 (46)	Ø2.56 (Ø65)	Ø1.38 (Ø35)	G1/4	Ø1.38 (Ø35) / Ø1.57 (Ø40)	Ø1.40 (Ø35.5)/ Ø1.59 (Ø40.5)	M20	217 to 253 (294 to 343)

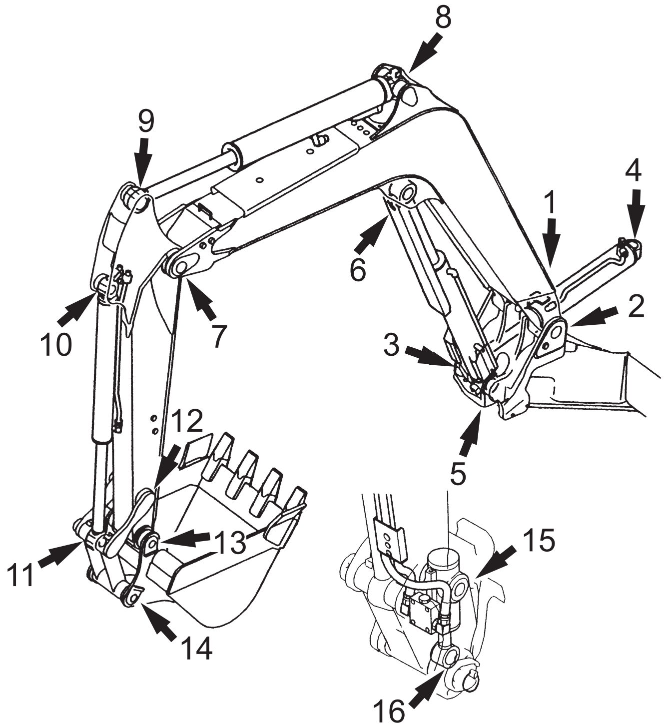
Nut for pipe

Symbol	Name
G (BSPP)	Straight pipe thread
R (BSPT)	Taper pipe thread (male)
Rc (BSPT)	Taper pipe thread (female)

ViO45-5 : ∗1 : S/N 50501 to 50591, ∗2 : S/N 50592 and after
ViO55-5 : ∗1 : S/N 50501 to 50800, ∗2 : S/N 50801 and after

3-6 Implement

3-6-1 Front Attachments

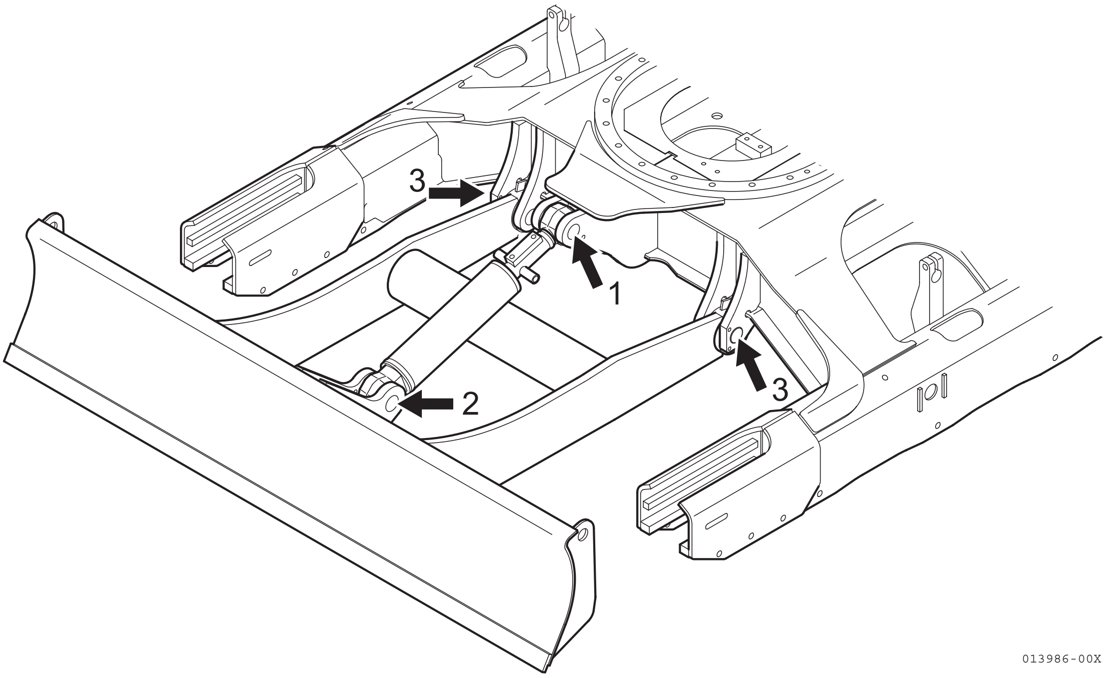


Unit : in. (mm)

No.	Applicable model : ViO45-5, ViO55-5	Standard	Wear limit	
	Measuring point		Pin	Bore of bush or hole
1	Boom swing fulcrum	Ø2.76 (Ø70)	-0.02 (-0.5)	+0.02 (+0.5)
2	Boom fulcrum	Ø2.36 (Ø60)		
3	Boom swing cylinder, rod	Ø1.57 (Ø40)		
4	Boom swing cylinder, bottom	Ø1.57 (Ø40)		
5	Boom cylinder, bottom	Ø1.97 (Ø50)		
6	Boom cylinder, rod	Ø1.97 (Ø50)		
7	Arm fulcrum	Ø2.36 (Ø60)		
8	Arm cylinder, bottom	Ø1.97 (Ø50)		
9	Arm cylinder, rod	Ø1.97 (Ø50)		
10	Bucket cylinder, bottom	Ø1.77 (Ø45)		
11	Bucket cylinder, rod	Ø1.77 (Ø45)		
12	Link “A” arm	Ø1.77 (Ø45)		
13	Bucket fulcrum	Ø1.77 (Ø45)		
14	Bucket “link A”	Ø1.77 (Ø45)		
15	Quick coupler cylinder, bottom	Ø1.57 (Ø40)		
16	Quick coupler cylinder, rod	Ø1.38 (Ø35)		

Note : *Allowable clearance is 0.04 in. (1.0 mm).*

3-6-2 Blade Moving Device



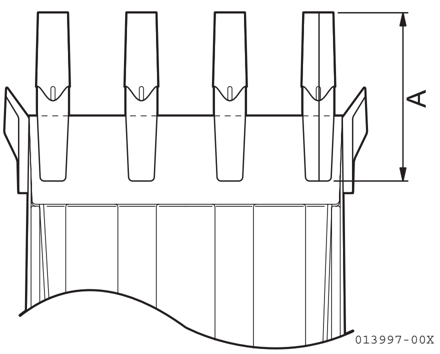
Unit : in. (mm)

No.	Applicable model : ViO45-5, ViO55-5	Standard	Wear limit	
	Measuring point		Pin	Bore of bush or hole
1	Blade cylinder, rod	Ø1.77 (Ø45)	-0.02 (-0.5)	+0.02 (+0.5)
2	Blade cylinder, bottom	Ø1.77 (Ø45)		
3	Blade fulcrum	Ø1.77 (Ø45)		

Note : *Allowable clearance between pin and bore of bush or hole is 0.04 in. (1.0 mm).*

3-6-3 Bucket Teeth

Unit : in. (mm)

Measuring point	Standard	Wear limit	Measure
	9.17 (233.0)	7.05 (179.0)	Replace

3-7 List of Tightening Torque

3-7-1 Machine

Unit : ft•lbf (N•m)

Applicable model:			ViO45-5, ViO55-5		
Equipment			Thread size	Tightening torque	Adhesive
	No.	Tightening part			
Engine / Electrical equipment					
	1	Engine mount vibroisolating rubber	M16	155.0 to 170.0 (206 to 235)	Three Bond 1324
	2	Engine × Engine mount (Flywheel side)	M10 (10.9T)	47.0 to 54.3 (63.7 to 73.6)	Three Bond 1324
	3	Engine × Engine mount (Radiator side)	M10 (10.9T)	47.0 to 54.3 (63.7 to 73.6)	Three Bond 1324
	4	Hose clip 70 (Air cleaner intake side)	–	0.9 to 1.1 (1.2 to 1.5)	
	5	Hose clip 70 (Intake hose installation)	–	2.2 to 2.9 (2.5 to 3.4)	
	6	Hose clip (Resonator)	–	1.8 to 2.5 (2.5 to 3.4)	
	7	Fuel gauge hose	Hose band 14	0.7 to 1.1 (1.0 to 1.5)	
	8	Fuel gauge unit	Pan head screw M5	0.9 to 1.1 (1.2 to 1.5)	
	9	Fuel tank	M14	86.8 to 108.5 (118 to 147)	Three Bond 1324
	10	Battery holding rod	Nut M8	2.2 (2.9)	Lock nut 9.4 to 12.3 ft•lbf (12.7 to 16.7 N•m)
	11	CW hose clip 41, 48	–	1.8 to 2.5 (2.5 to 3.4)	
	12	Air cleaner	M8	14.5 to 16.6 (19.6 to 22.6)	
	13	Heater hose	Hose clip 22	1.6 to 1.8 (2.2 to 2.5)	
	14	Drain plug	M14	43.0 (59.0)	
	15	Safety switch (2-speed, cut-off)	Lock nut M18 (Fine)	21.7 to 25.3 (29.4 to 34.3)	
Driving system					
	1	Sprocket	M14	137.4 to 151.9 (186.3 to 205.9)	Loctite 262
Travel device					
	1	Plugs (Idler)	R (PT) 1/8	6.5 to 7.2 (8.8 to 9.8)	Loctite 572
	2	Idler seal cover × Track spring	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324
	3	Track roller tightening nut	Cap nut M16	151.9 to 180.8 (205.9 to 245.2)	Loctite 262
	4	Track guard × Track frame (Steel track spec. only)	M16	123.0 to 151.9 (166.7 to 205.9)	Loctite 262
	5	Track tensioner valve	M16	36.2 (49.0)	

Unit : ft•lbf (N•m)

Applicable model:			ViO45-5, ViO55-5		
Equipment	No.	Tightening part	Thread size	Tightening torque	Adhesive
Controls					
	1	Blade lever × Pilot valve	M8	12.0 to 13.5 (15.2 to 18.2)	
	2	Grips (L, R) × Levers (L, R)	Binding head screw M4	1.3 to 1.9 (1.8 to 2.5)	Three Bond 1324
Frame					
	1	Swing bearing × Lower frame	M16	195.3 to 224.2 (264.8 to 304.0)	Loctite 262
	2	Swing bearing × Turning frame	M16	195.3 to 224.2 (264.8 to 304.0)	Loctite 262
	3	Counter weight × Turning frame	M24	354.4 to 441.3 (480.5 to 598.2)	Three Bond 1324
Hydraulic equipment					
	1	CF Coupling	Hexagon socket head bolt M12	61.5 to 68.0 (83.4 to 92.2)	Three Bond 1324
	2	Swivel joint × Track frame	M10	32.6 to 43.4 (44.1 to 58.8)	Loctite 262
	3	Swing motor × Turning frame	M16	195.3 to 224.2 (264.8 to 304.0)	Three Bond 1324
	4	Travel motor × Track frame	M14	86.8 to 108.5 (117.7 to 147.1)	Loctite 262
	5	Hydraulic oil tank × Turning frame	M14	86.8 to 108.5 (117.7 to 147.1)	Three Bond 1324
	6	Drain plug 24 × Hydraulic oil tank	M24	78.0 (108.0)	
	7	Oil level gauge × Hydraulic oil tank	M10	10.9 to 11.6 (14.7 to 15.7)	
	8	Hose clip 13	–	1.6 to 1.8 (2.2 to 2.5)	
	9	Hose clip 25	–	2.9 to 3.6 (3.9 to 4.9)	
	10	Hose clip 60, 70	–	3.6 to 4.3 (4.9 to 5.9)	
Rigging					
	1	Canopy pole × Canopy mount A (canopy type)	M16 (10.9T)	123.0 to 151.9 (166.7 to 205.9)	Three Bond 1324
	2	Canopy comp. × Frame (canopy type)	M12 (10.9T)	58.0 to 72.0 (78.4 to 98.0)	Three Bond 1324
	3	Track frame × Motor cover	M10	32.6 to 43.4 (44.1 to 58.8)	Three Bond 1324
	4	Track frame × Under cover	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324

Unit : ft•lbf (N•m)

Applicable model:			ViO45-5, ViO55-5		
Equipment			Thread size	Tightening torque	Adhesive
	No.	Tightening part			
Implements					
	1	Side cutter × Bucket	M16	191.7 to 217.0 (259.9 to 294.2)	Loctite 262
	2	Lock plate (Boom bracket fulcrum pin)	M14	86.8 to 108.5 (117.7 to 147.1)	Three Bond 1324
	3	Lock plate (Arm fulcrum pin)	M14	86.8 to 108.5 (117.7 to 147.1)	Three Bond 1324
	4	Lock plate (Boom cylinder rod end pin)	M14	86.8 to 108.5 (117.7 to 147.1)	Three Bond 1324
	5	Lock plate (Boom swing cylinder rod end pin)	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324
	6	Lock plate (Boom swing cylinder bottom end pin)	M10	32.6 to 43.4 (44.1 to 58.8)	Three Bond 1324
	7	Lock plate (Arm cylinder bottom end pin)	M14	86.8 to 108.5 (117.7 to 147.1)	Three Bond 1324
	8	Lock plate (Arm cylinder rod end pin)	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324
	9	Lock plate (Bucket cylinder bottom end pin)	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324
	10	Lock plate (Blade fulcrum pin)	M10	32.6 to 43.4 (44.1 to 58.8)	Three Bond 1324
	11	Lock plate (Blade cylinder pin)	M12	57.9 to 72.3 (78.5 to 98.1)	Three Bond 1324
	12	Protector × Cylinder	M10	32.6 to 43.4 (44.1 to 58.8)	Three Bond 1324
	13	Protector × Cylinder	M10 (10.9T)	47.0 to 54.0 (63.7 to 73.5)	Three Bond 1324

3-7-2 Engine

Tightening torque for major bolts and nuts

No.	Item	Thread size × Pitch	Tightening torque Unit : ft•lbf (N•m)	Lubricating oil
1	Cylinder head bolt	M10 × 1.25	62.9 to 67.3 (85.3 to 91.1)	Yes
2	Connecting rod bolt	M9 × 1.0	32.6 to 36.2 (44.1 to 49.0)	Yes
3	Flywheel mounting bolt	M10 × 1.25	61.5 to 65.1 (83.3 to 88.2)	Yes
4	Metal cap mounting bolt	M12 × 1.5	68.7 to 76.0 (93.2 to 98.0)	Yes
5	Crankshaft pulley fastening bolt	M14 × 1.5	83.2 to 90.4 (112.7 to 122.7)	Yes
6	Fuel injection valve tap bolt	M8 × 1.25	18.1 to 21.0 (24.4 to 28.4)	No
7	Fuel injection pump gear nut	M14 × 1.5	57.9 to 65.1 (78 to 88)	No
8	Fuel injection pipe fastening nut	M12 × 1.5	21.7 to 25.3 (29.4 to 34.3)	No

3-7-3 Tightening Torque for General Bolts and Nuts

Item		Thread size × Pitch	Tightening torque [Unit : ft•lbf (N•m)]	Remarks
Hexagon head bolt (7T) Nut	Coarse thread	M6 × 1	7.23 to 8.68 (9.8 to 11.8)	1) Apply 80% of tightening torque when tightened to aluminum. 2) Apply 60% of tightening torque for 4T bolts and lock nuts. 3) Use fine screw threads for engine only.
		M8 × 1.25	16.6 to 21.0 (22.5 to 28.4)	
		M10 × 1.5	32.6 to 43.4 (44.1 to 58.8)	
		M12 × 1.75	57.9 to 72.3 (78.4 to 98.0)	
		M14 × 2	86.8 to 108.5 (117.6 to 147.0)	
		M16 × 2	123.0 to 151.9 (166.6 to 205.8)	
		M18 × 2.5	173.6 to 209.8 (235.2 to 284.2)	
		M20 × 2.5	238.7 to 296.6 (323.4 to 401.8)	
	Fine thread	M14 × 1.5	94.0 to 108.5 (127.4 to 147.0)	
		M16 × 1.5	155.5 to 177.2 (210.7 to 240.1)	
PT plug		1/8	7.23 (9.8)	
		1/4	14.5 (19.6)	
		3/8	21.7 (29.4)	
		1/2	43.4 (58.8)	
Pipe joint bolt		M8	9.4 to 12.3 (12.7 to 16.7)	
		M12	18.1 to 25.3 (24.5 to 34.3)	
		M14	28.9 to 36.2 (39.2 to 49.0)	
		M16	36.2 to 43.4 (49.0 to 58.8)	

CHAPTER 4

ENGINE

4. Engine

4-1 General

4-1-1 How to Read This Manual

1) Range of Operation Explanation

This manual explains the troubleshooting, installation / removal, replacement, disassemble / reassembly, inspection, adjustment and adjusting operation procedures for the 4TNV88-PBV engine.

Refer to the manufacturer's manual for each of the fuel injection pump, governor, starting motor and alternator except for their installation.

2) How to Read the Explanations

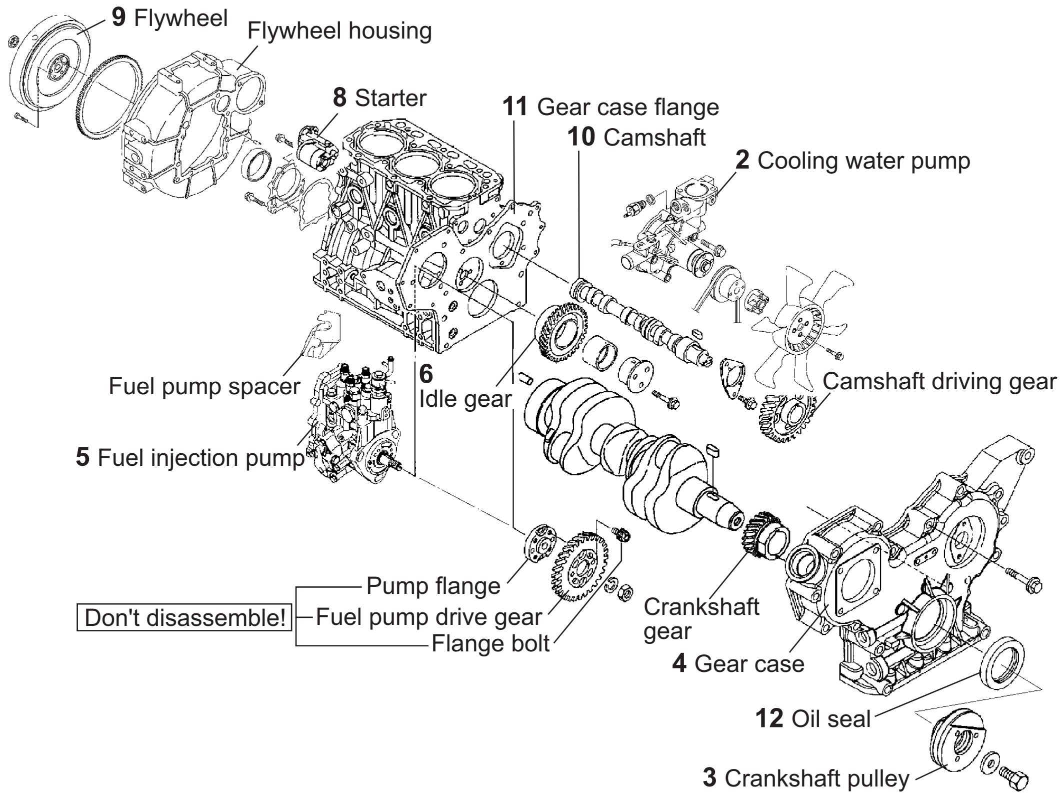
(1) An exploded view, sectional views, a system diagram, etc. are shown at the beginning of each section as required for easy understanding of the mounted states of the components.

(2) For the removal/installation of each part, the procedure is shown with the procedural step No. in the illustration.

(3) Precautions and key points for disassembly and reassembly of parts are described as points. In the explanation for each point, detailed operation method, information, standard and precautions are described.

Description example

- **Illustration**



- **Disassembly procedure**

1 Follow steps 1 to 15 of the cylinder head disassembly procedure.

2 Remove the cooling water pump.

3 Remove the crankshaft pulley. ***(Point 1)***→Operation point to be explained on a later page.

- **Operation points**

Disassemble : Service point for removal

Reassemble : Service point for installation

Disassemble-Reassemble : Service point required in both removal and installation

- **Contents omitted in this manual**

Though the following jobs are omitted in the explanation in this manual, they should be conducted in actual work:

(1) Jacking up and lifting
(2) Cleaning and washing of removed parts as required
(3) Visual inspection

3) Definition of Terms

Notice : Instruction which negligence is very likely to cause an accident. Always observe it.

Standard : Allowable range for inspection and adjustment.

Limit : The maximum or minimum value that must be satisfied during inspection or adjustment.

4) Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
Ass'y	Assembly	T.D.C.	Top dead center
Sub-Ass'y	Sub-assembly	B.D.C	Bottom dead center
a.T.D.C.	After top dead center	OS	Oversize
b.T.D.C.	Before top dead center	US	Undersize
STD	Standard	RPM	Revolutions per minute
IN	Intake	HP (kW)	Output
Ex	Exhaust	T	Bolt/nut tightening torque

4-1-2 Precautions for Service Work

1) Precautions for Safety

Read the safety precautions given at the beginning of this manual carefully and always mind safety in work.

2) Preparation for Service Work

Preparation is necessary for accurate, efficient service work. Check the customer ledger file for the history of the engine.

(1) Preceding service date
(2) Period/operation hours after preceding service
(3) Problems and actions in preceding service
(4) Replacement parts expected to be required for service
(5) Recording form/check sheet required for service

3) Preparation before Disassembly

(1) Prepare general tools, special service tools, measuring instruments, oil, grease, non-reusable parts, and parts expected to be required for replacement.
(2) When disassembling complicated portions, put matchmarks and other marks at places not adversely affecting the function for easy reassembly.

4) Precautions in Disassembly

(1) Each time a parts is removed, check the part installed state, deformation, damage, roughening, surface defect, etc.
(2) Arrange the removed parts orderly with clear distinction between those to be replaced and those to be used again.
(3) Parts to be used again shall be washed and cleaned sufficiently.
(4) Select especially clean locations and use clean tools for disassembly of hydraulic units such as the fuel injection pump.

5) Precautions for Inspection and Measurement

(1) Inspect and measure parts to be used again as required to determine whether they are reusable or not.

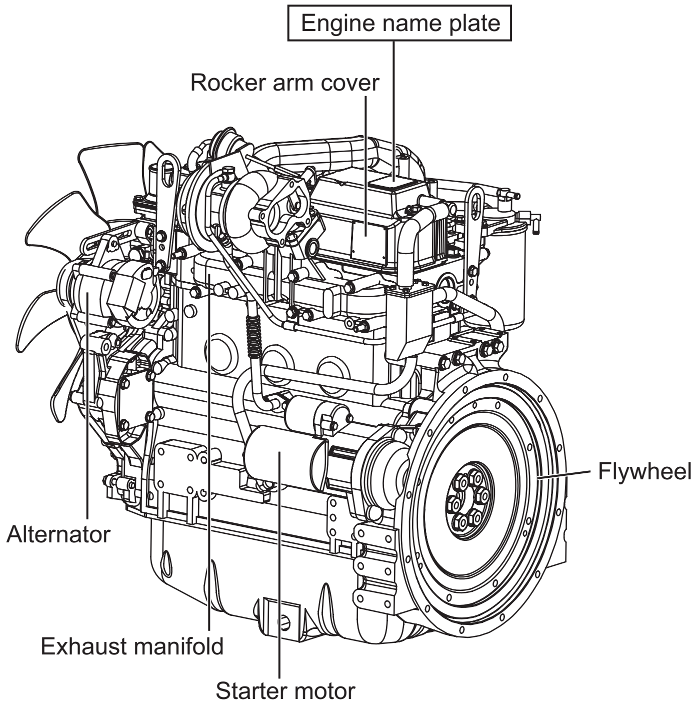
6) Precautions for Reassembly

(1) Reassemble correct parts in correct order according to the specified standards (tightening torques, and adjustment standards). Apply oil to important bolts and nuts before tightening when specified.
(2) Always use genuine parts for replacement.
(3) Always use new oil seals, O-rings, packings and cotter pins.
(4) Apply sealant to packings depending on the place where they are used. Apply oil or grease to sliding contact portions, and apply grease to oil seal lips.

7) Precautions for Adjustment and Check

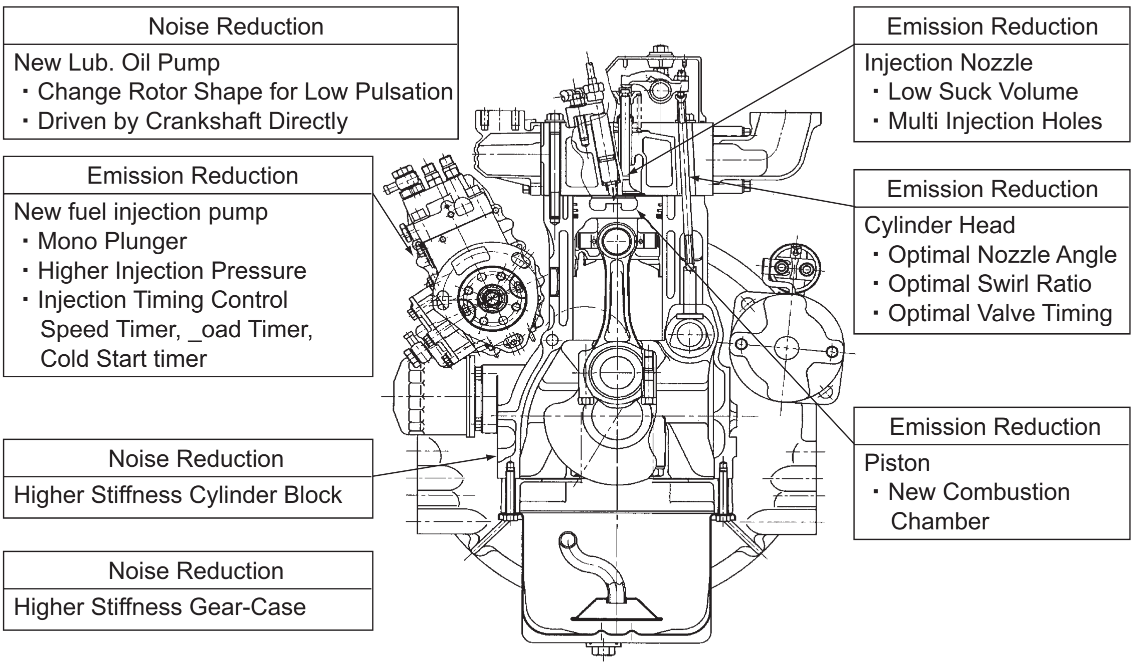
(1) Use measuring instruments for adjustment to the specified service standards.

4-1-3 Engine External Views



Note :
This illustration does not show the 4TNV88 engine.

4-1-4 Structural Description



4-1-5 Exhaust Gas Emission Regulation

The engines in this manual have been certified by the US EPA, California ARB and/or the 97/68/EC Directive.

California

Proposition 65 Warning

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

California

Proposition 65 Warning

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

1) The Emission Standard in USA

(1) EPA Nonroad Diesel Engine Emission Standards

g/kW•hr (g/bhp•hr)

Engine Power	Tier	Model Year	NOx	HC	NMHC + NOx	CO	PM
kW < 8 (hp < 11)	Tier 1	2000	-	-	10.5 (7.8)	8.0 (6.0)	1.0 (0.75)
	Tier 2	2005	-	-	7.5 (5.6)	8.0 (6.0)	0.80 (0.60)
8 <= kW < 19 (11 <= hp < 25)	Tier 1	2000	-	-	9.5 (7.1)	6.6 (4.9)	0.80 (0.60)
	Tier 2	2005	-	-	7.5 (5.6)	6.6 (4.9)	0.80 (0.60)
19<= kW < 37 (25 <= hp < 50)	Tier 1	1999	-	-	9.5 (7.1)	5.5 (4.1)	0.80 (0.60)
	Tier 2	2004	-	-	7.5 (5.6)	5.5 (4.1)	0.60 (0.45)
37 <= kW < 75 (50 <= hp < 100)	Tier 1	1998	9.2 (6.9)	-	-	-	-
	Tier 2	2004	-	-	7.5 (5.6)	5.0 (3.7)	0.40 (0.30)
	Tier 3	2008	-	-	4.7 (3.5)	5.0 (3.7)	
75 <= kW < 130 (100 <= hp < 175)	Tier 1	1997	9.2 (6.9)	-	-	-	-
	Tier 2	2003	-	-	6.6 (4.9)	5.0 (3.7)	0.30 (0.22)
	Tier 3	2007	-	-	4.0 (3.0)	5.0 (3.7)	

Notes :

- *The EPA emission regulation under 130 kW is mentioned below.*
- *As for Model year, the year which a regulation is applicable to is shown.*

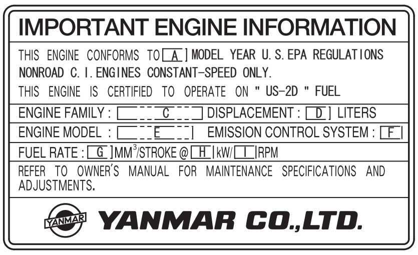
Engine classification	Transient smoke standards % opacity (acceleration/lug/peak modes)
Constant speed engine	Not regulated
Variable speed engine	20/15/50 or less

(2) California ARB Emission Regulation

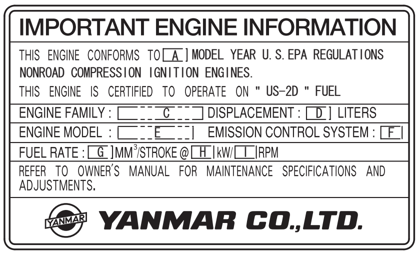
The ARB emission standard is based on that of the EPA.

2) Engine Identification

(1) Emission control labels of US EPA

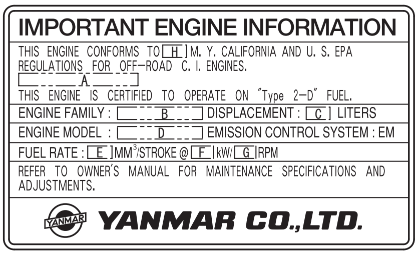


EPA label for constant speed engines

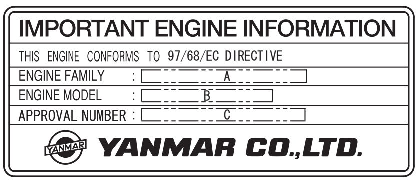


EPA label for variable speed engines

(2) Emission control label for both EPA and ARB



(3) 97/68EC Directive label



3) Guarantee Conditions for the EPA Emission Standard

The following guarantee conditions are set down in the operation manual. In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

(1) Requirement on engine installation condition

(a)Intake air depression

kPa (mmAq)

Initial	Permissible
<= 2.94 (300)	<= 6.23 (635)

(b)Exhaust gas back pressure

kPa (mmAq)

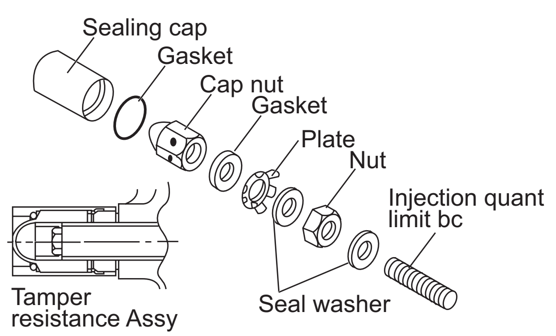
Engine type	Initial	Permissible
Naturally aspirated engines	<= 12.75 (1300)	<= 15.30 (1560)

(2) Fuel oil and lubricating oil

(a)Fuel : The diesel fuel oil US No.2 diesel fuel oil.

(b)Lube oil : API grade, class CD or CF

(3) Do not remove the seals restricting injection quantity and engine speed.



Tamper resistance device for engines certified by ARB/EPA

(4) Perform maintenance without fail.

Note :

Inspections to be carried out by the user and by the maker are divided and set down in the "List of Periodic Inspections" and should be checked carefully.

(5) Maintenance period and Quality guarantee period for exhaust emission related parts

The maintenance of the parts related to the exhaust emission must be carried out in the maintenance period as shown in the below table.

A guarantee period is that either the operation hours or years shown in the table come first in the condition that the maintenance inspection was carried out based on the "List of Periodic Inspections".

	Maintenance period		Quality Guarantee Period
Parts / Power Rating	•Fuel nozzle cleaning	Adjustment, cleaning, repairs for fuel nozzle, fuel pump, turbocharger, electronic control unit etc.	For nozzle, fuel pump, turbocharger
37 <= kW < 130	Every 1500 hours (applied from Tier 2)	Every 3000 hours (applied from Tier 2)	3000 hours / 5 years
19 <= kW < 37 except constant speed engines >= 3000 min^{-1}	Every 1500 hours	Every 3000 hours	3000 hours / 5 years
KW < 19 And constant speed engines beyond 3000 min^{-1} under 37 kW	Every 1500 hours	Every 3000 hours	1500 hours / 2 years

4-2 Troubleshooting

4-2-1 Quick Reference Table for Troubleshooting

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

	Trouble symptom / Cause	Starting failure: Engine does not start	Starting failure: Engine starts but stops soon – Exhaust smoke: None	Starting failure: Engine starts but stops soon – Exhaust smoke: Little	Starting failure: Engine starts but stops soon – Exhaust smoke: Much	Insufficient engine output – Exhaust color: Ordinary	Insufficient engine output – Exhaust color: White	Insufficient engine output – Exhaust color: Black	Poor exhaust color – During work: White	Poor exhaust color – During work: Black	High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting: During idling	Hunting: During work	Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil: Excessive consumption	Lubricating oil: Dilution by fuel oil	Lubricating oil: Mixture with water	Lubricating oil: Low L.O. pressure	Much blow-by gas	Cooling water: Overheat	Cooling water: Low water temperature	Air intake: Pressure drop	Air intake: Pressure rise	Exhaust temperature rise		Corrective action
Engine system	Improper clearance of intake/exhaust valve	○	○			○						○														○		○		Adjust the valve clearance.
	Compression leakage from valve seat					○		○		○		○						○					○			○		○		Lap the valve seat.
	Seizure of intake/exhaust valve	○			○	○		○		○		○			○	○				○			○			○				Correct or replace.
	Blowout from cylinder head gasket					○															○			○						Replace the gasket.
	Seized or broken piston ring	○			○		○		○			○		○		○			○	○			○	○				○		Replace the piston ring.
	Worn piston ring, piston or cylinder	○			○		○		○										○	○			○							Perform honing and use oversize parts.
	Seized crankpin metal or bearing	○	○									○		○	○	○							○							Repair the replace.
	Improper arrangement of piston ring joints		○				○												○				○							Correct the ring joint positions.
	Reverse assembly of piston rings						○		○										○				○							Reassemble correctly.
	Worn crankpin and journal bearing					○						○		○	○	○						○								Measure and replace.
	Loosened connecting rod bolt											○				○						○								Tighten to the specified torque.
	Foreign matter trapped in combustion chamber	○										○							○				○							Disassemble and repair.
	Excessive gear backlash											○																		Adjust gear meshing.
	Worn intake/exhaust valve guide						○												○				○							Measure and replace.
	Defective governor		○											○	○	○	○													Make adjustment.
	Improper open/close timing of intake/exhaust valves	○					○	○	○	○		○																		Adjust the valve clearance.

Cause	Trouble symptom	Starting failure				Insufficient engine output			Poor exhaust color										Lubricating oil					Cooling water		Air intake				Corrective action
			Engine starts but stops soon			Exhaust color			During work					Hunting																
			Exhaust smoke																											
		Engine does not start	None	Little	Much	Ordinary	White	Black	White	Black	High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	During idling	During work	Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure	Much blow-by gas	Overheat	Low water temperature	Pressure drop	Pressure rise	Exhaust temperature rise		
Cooling water system	Excessive cooling effect of radiator								○									○							○					Defective thermostat (kept closed).
	Insufficient cooling effect of radiator							○																○				○		Defective thermostat (kept closed) or slipping fan belt.
	Insufficient cooling water level							○																○				○		Check water leakage from cooling water system.
	Cracked water jacket																				○	○		○						Repair or replace.
	Slackened fan belt							○																○				○		Adjust the belt tension.
	Defective thermostat							○	○															○	○					Check or replace.
Lubricating system	Improper properties of lubricating oil	○	○			○													○			○	○							Use proper lubricating oil.
	Leakage from lubricating oil piping system																		○			○								Repair.
	Insufficient delivery capacity of trochoid pump																					○								Check or repair.
	Clogged lubricating oil filter																					○	○							Clean or replace.
	Defective pressure regulating valve																					○								Clean, adjust or replace.
	Insufficient lubricating oil level		○																			○								Add proper lubricating oil.
Fuel system	Too early timing of fuel injection pump								○	○	○					○														Check and adjust.
	Too late timing of fuel injection pump						○	○	○	○								○										○		Check and adjust.
	Improper properties of fuel oil					○	○	○	○	○			○																	Use proper fuel oil.
	Water entrance in fuel system	○			○		○		○				○	○	○															Perform draining from the fuel filter.
	Clogged fuel filter	○	○			○																								Clean or replace.
	Air entrance in fuel system	○	○			○																								Perform air bleeding.
	Clogged or cracked fuel pipe	○	○			○																								Clean or replace.
	Insufficient fuel supply to fuel injection pump	○	○			○																								Check the fuel tank cock, fuel filter, fuel pipe, and fuel feed pump.
	Uneven injection volume of fuel injection pump						○	○	○	○			○	○	○	○												○		Check and adjust.
	Excessive fuel injection volume									○								○	○				○	○			○	○		Check and adjust.
	Poor spray pattern from fuel injection nozzle						○	○	○	○			○	○	○	○		○												Check and adjust.
	Priming failure	○																												Foreign matter trapped in the valve inside the priming pump. (Disassemble and clean.)
	Clogged strainer at feed pump inlet					○																								Clean the strainer.

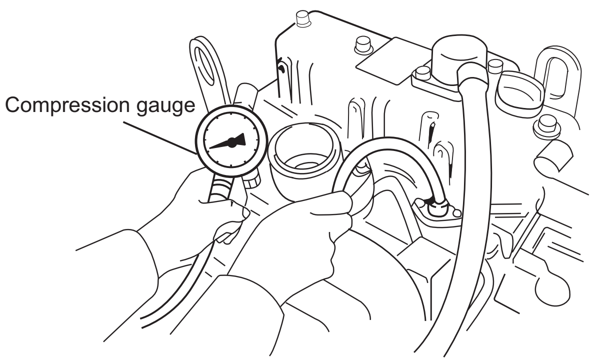
Cause \ Trouble symptom		Starting failure				Insufficient engine output			Poor exhaust color		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil				Much blow-by gas	Cooling water		Air intake		Exhaust temperature rise		Corrective action
		Engine does not start	Engine starts but stops soon / Exhaust smoke: None	Little	Much	Exhaust color: Ordinary	White	Black	During work: White	Black				During idling	During work				Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure		Overheat	Low water temperature	Pressure drop	Pressure rise			
Air/exhaust gas system	Clogged air filter				○			○		○			○													○				Clean.
	Engine used at high temperatures or at high altitude							○		○								○						○		○				Study output drop and load matching.
	Clogged exhaust pipe							○		○			○															○		Clean.
Electrical system	Starting motor defect	○																												Repair or replace.
	Alternator defect	○																												Repair or replace.
	Open-circuit in wiring	○																												Repair.
	Battery voltage drop	○																												Inspect and charge the battery.

4-2-2 Troubleshooting by Measuring Compression Pressure

Compression pressure drop is one of major causes of increasing blow by gas (lubricating oil contamination or increased lubricating oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors :
(1) Degree of clearance between piston and cylinder
(2) Degree of clearance at intake/exhaust valve seat
(3) Gas leak from nozzle gasket or cylinder head gasket
In other words, the pressure drops due to increased parts wear and reduced durability resulting from long use of the engine.
A pressure drop may also be caused by scratched cylinder or piston by dust entrance from the dirty air cleaner element or worn or broken piston ring. Measure the compression pressure to diagnose presence of any abnormality in the engine.

1) Compression Pressure Measurement Method

(1) After warming up the engine, remove the fuel injection pump and valves from the cylinder to be measured.
(2) Crank the engine before installing the compression gage adapter.
[1] Perform cranking with the regulator handle at the stop position (no injection state).
[2] For compression gage and compression gage adapter, refer to Section "4-10 Special Service Tools".
(3) Install the compression gage and compression gage adapter at the cylinder to be measured.
*Never forget to install a gasket at the tip end of the adapter.
(4) With the engine set to the same state as in 2 *1, crank the engine by the starting motor until the compression gage reading is stabilized.



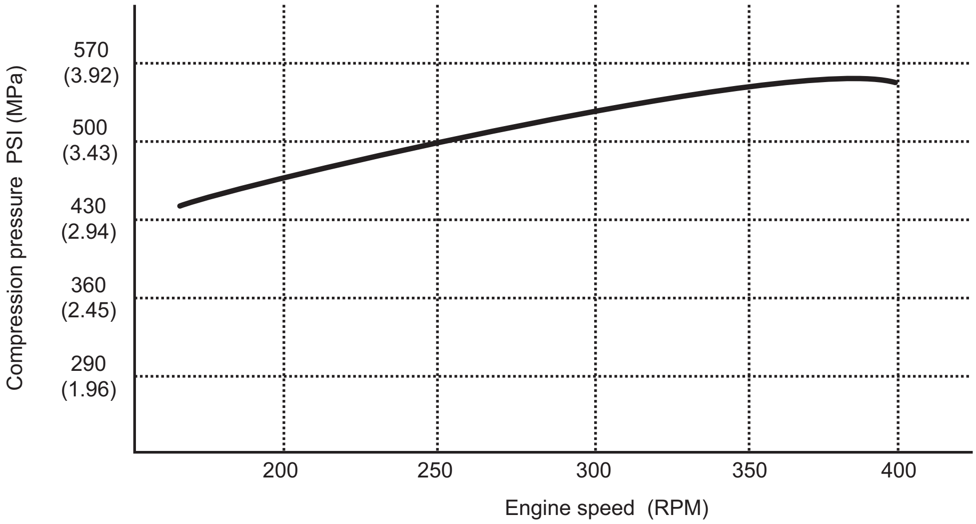
Measuring the compression pressure

2) Standard Compression Pressure

[Engine compression pressure list (reference value)]

Compression pressure (PSI (MPa)) at 250 RPM		Dispersion among cylinders (PSI (MPa))
Standard	Limit	
485 to 515 (3.33 to 3.53)	385 (2.65)	28 to 43 (0.2 to 0.3)

3) Engine Speed and Compression Pressure (Reference)



4) Measured Value and Troubleshooting

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

No.	Item	Cause	Corrective action
1	• Air cleaner	• Clogged element • Broken element • Defect at element seal portion	• Clean the element. • Replace the element.
2	• Valve clearance	• Excessive or no clearance	• Adjust the valve clearance.
3	• Valve timing	• Incorrect valve clearance	• Adjust the valve clearance.
4	• Cylinder head gasket	• Gas leak from gasket	• Replace the gasket. • Retighten the cylinder head bolts to the specified torque.
5	• Intake/exhaust valve • Valve seat	• Gas leak due to worn valve seat or foreign matter trapping • Sticking valve	• Lap the valve seat. • Replace the intake/exhaust valve.
6	• Piston • Piston ring • Cylinder	• Gas leak due to scratching or wear	• Perform honing and use an oversized part.

4-3 Inspection and Adjustment

4-3-1 Oil Inspection

• Standard

The level shall be between the upper and lower limit lines on the dipstick.

Total volume	ViO45-5	ViO55-5
	9.4 Qts. (8.9 L)	

Notice :
The oil should not be overfilled to exceed the upper limit line.
Otherwise, oil may jet out from the breather or the engine may become faulty.

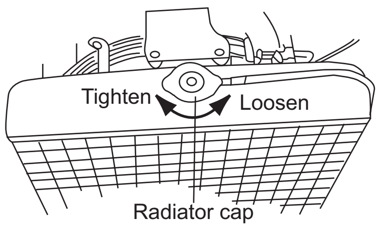
(1) The oil shall not be contaminated heavily and have appropriate viscosity. No cooling water or diesel gas oil shall be mixed.
(2) Insert the dipstick fully and check the oil level.

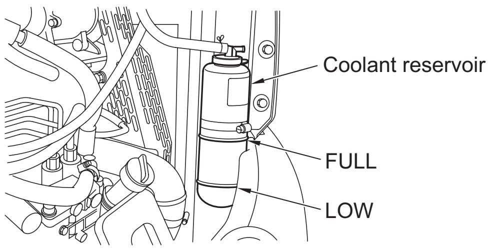
4-3-2 Cooling Water Inspection

• Standard
Engine : The radiator shall be filled up.
Sub-tank : The water level shall be between the upper and lower limit lines.

Capacity	Engine	6.66 Qts. (6.3 L)
	Coolant reservoir	0.42 Qts. (0.4 L)

(1) The cooling water shall be checked when the engine is cold.
(2) If the water level is normal in the sub-tank but low in the radiator, check loosened clamping of the rubber hose between the radiator and coolant reservoir or tear in the hose.

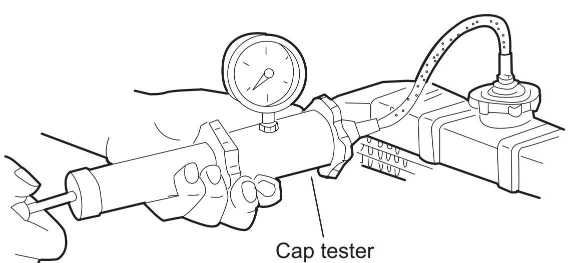




4-3-3 Inspecting Water Leak from Cooling Water System and Radiator

1) Water Leak Check in Cooling Water System

(1) Fill cooling water to the normal level in the radiator, and install the cap tester on the radiator.
(2) Operate the manual pump to set the pressure to 10.7 to 14.9 PSI (73.6 to 103.0 kPa). If the cap tester pressure gage reading drops then, water is leaking from the cooling water system. Check the water leaking point.

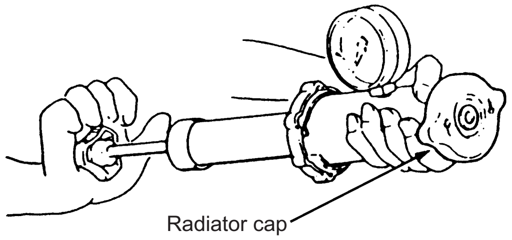


Water leak check in cooling water system

2) Radiator Cap Inspection

Install the radiator cap on the cap tester. Set the tester pressure to 10.7 to 14.9 PSI (73.6 to 103.0 kPa) and see that the cap is opened.

If the cap does not open, replace the cap since it is abnormal.

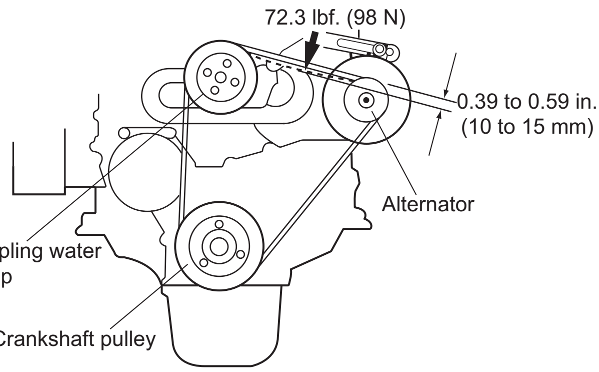


Radiator cap inspection

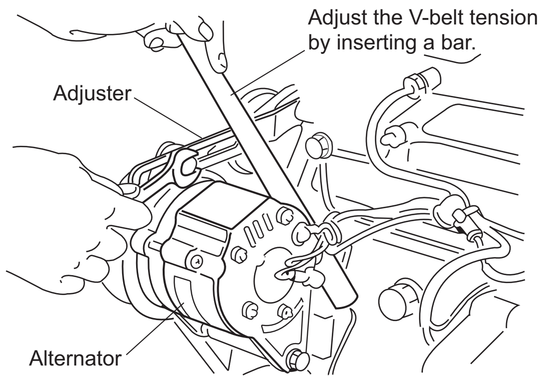
4-3-4 Fan Belt Tension Inspection and Adjustment

Standard : 0.39 to 0.59 in. (10 to 15 mm)/ 72.3 lbf. (98 N)

Push the center of the V belt between the alternator and cooling water with a finger. The V belt tension is normal if the deflection is 0.39 to 0.59 in. (10 to 15 mm). If not, adjust the V belt tension by the alternator adjuster.



V-belt tension



Tension adjustment

4-3-5 Adjusting the Valve Clearance

Standard : 0.006 to 0.01 in. (0.15 to 0.25 mm)

Make measurement and adjustment while the engine is cold.

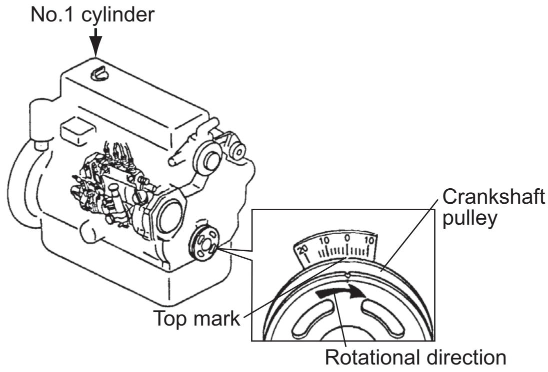
(a)Valve clearance measurement

[1] Remove the rocker arm cover above cylinder head.

[2] Set the No.1 cylinder in the compression TDC

Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, timing scale and the top mark position of the crankshaft pulley.

(Position where both the intake and exhaust valves are closed.)



Top mark

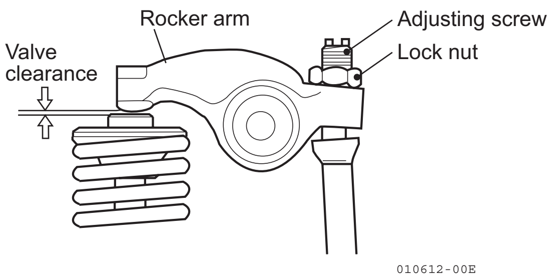
Notes :

- *The crankshaft shall be turned clockwise as seen from the radiator side.*
- *The No.1 cylinder position is on the opposite side of the radiator and the ignition order shall be 1-3-4-2-1 at 180° intervals.*
- *Since the intake and exhaust valve rocker arms are operated the same and there is a clearance between the arm and valve generally at the top dead center, the position can be checked by means of the play when the arm head is held with a hand. Also see that the crankshaft pulley top mark is positioned at zero on the timing scale. If there is no valve clearance, inspection in the disassembled state is necessary since the valve seat may be worn abnormally.*

[3] Valve clearance measurement

Insert a thickness gage between the rocker arm and the valve cap, and record the measured valve clearance.

(Use it as the data for estimating the wear state.)



[4] Adjusting other cylinders

Turn the crankshaft 180° and make adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders in this order.

The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

The adjustment method of reducing the flywheel turning numbers (for reference):
Set No.1 cylinder to the compression T.D.C. and adjust the clearance of the ● mark of the below table. Next, turn the flywheel once, and adjust the clearance of the ○ mark.

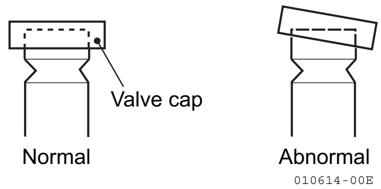
Ignition order of 3 cylinder engines: 1→3→4→2

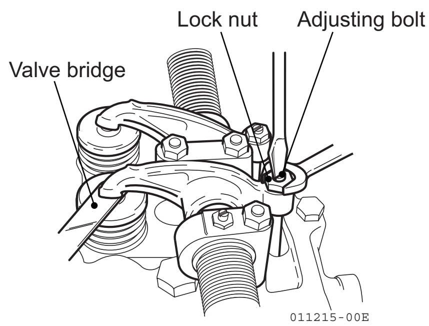
Cylinder No.	1		2		3		4		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No.1 compression T.D.C	●	●	●			●			The first time
No.4 compression T.D.C				○	○		○	○	The second time

(b)Valve clearance inspection and adjustment

[1] Loosen adjusting bolts

Loosen the lock nut and adjusting screw. Check the valve for any inclination of valve cap, dirt or wear.





[2] Measuring valve clearance
Insert a 0.008 or 0.012 in. (0.2 or 0.3 mm) thickness gage between the rocker arm and valve cap and adjust the valve clearance. Tighten the adjusting screw.

Standard valve clearance :
0.006 to 0.01 in. (0.15 to 0.25 mm)

[3] Apply oil to the contact surface between adjusting screw and push rod.

[4] Adjusting other cylinders
Turn the crankshaft 180° then and make adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders in this order.
The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

4-3-6 Inspecting the Fuel Injection Valve Injection Pressure and Spray Pattern

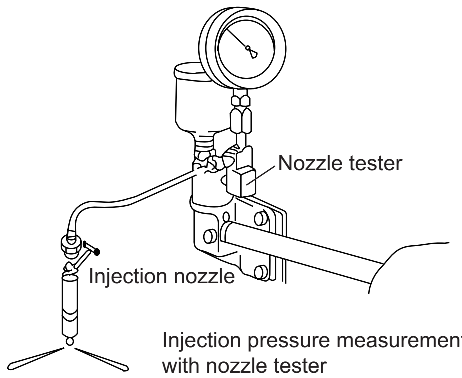
⚠ CAUTION

Wear protective glasses when testing injection from the fuel injection valve. Never approach the injection nozzle portion with a hand. The oil jetting out from the nozzle is at a high pressure to cause loss of sight or injury if coming into careless contact with it.

1) Injection Pressure Measurement
Standard : 2850 to 2950 PSI (19.6 to 20.6 MPa)

*Remove carbon deposit at the nozzle hole thoroughly before

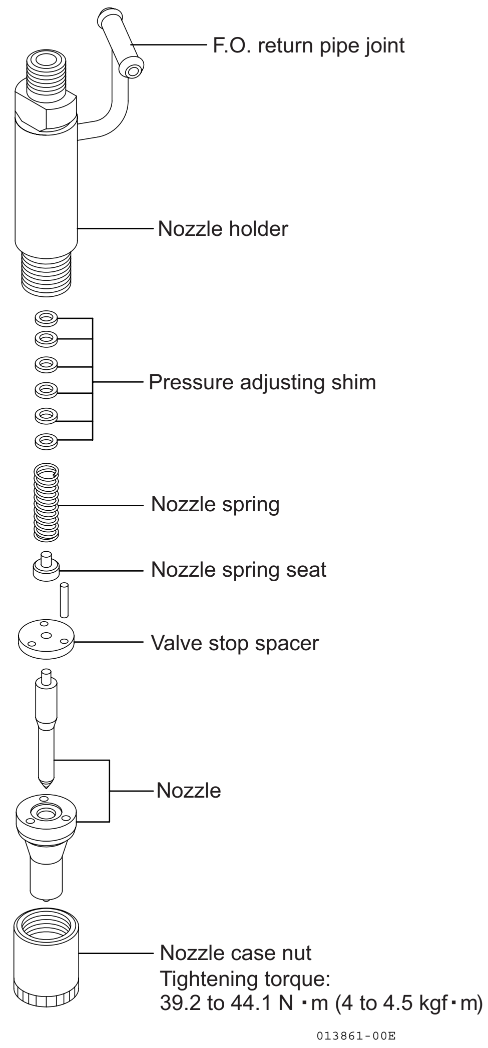
[1] Connect the fuel injection valve to the high pressure pipe of the nozzle tester.
[2] Operate the nozzle tester lever slowly and read the pressure at the moment when the fuel injection from the nozzle starts.
[3] If the measured injection pressure is lower than the standard level, replace the pressure adjusting shim with a thicker one.



Injection pressure measurement with nozzle tester

Type of pressure adjusting shim thickness in. (mm)	Injection pressure adjustment
0.0051 (0.13) 0.0059 (0.15) 0.0071 (0.18) 0.0157 (0.4) 0.0197 (0.5) 0.0315 (0.8)	The injection pressure is increased by approx. 270 PSI (1863 kPa) when the adjusting shim thickness is increased by 0.0039 in. (0.1 mm)

[Reference : Fuel injection valve structure]



2) Spray Pattern Inspection

After adjustment to the specified valve opening pressure, use a nozzle tester and check the spray pattern and seat oil-tightness.

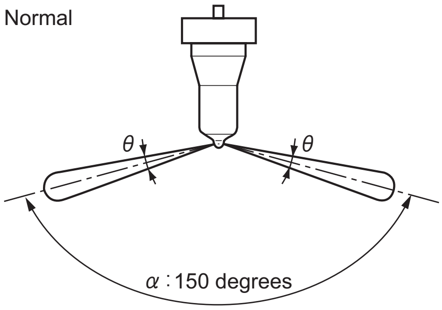
(1) Seat oil-tightness check

- After injecting a few times, increase the pressure gradually. Hold the pressure for about 5 seconds at a little before the valve opening pressure of 284 PSI (1961 kPa), and check to see that oil does not drip from the tip end of the nozzle.
- If extreme oil leak from the overflow joint exists during injection by the nozzle tester, check after retightening. If much oil is leaking, replace the nozzle assembly.

(2) Spray and injection states

- Operate the nozzle tester lever at a rate of once or twice a second and check no abnormal injection.
- If normal injection as shown below cannot be obtained, replace the fuel injection valve.
  - •No extreme difference in angle (θ)
  - •No extreme injection angle difference (α)
  - •Finely atomized spray
  - •Excellent spray departure

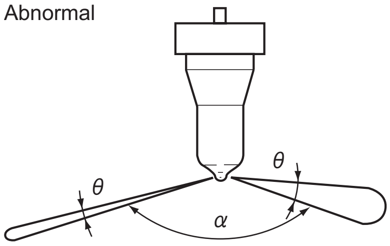
Normal



Uniform spray pattern from each nozzle

010630-00E

Abnormal

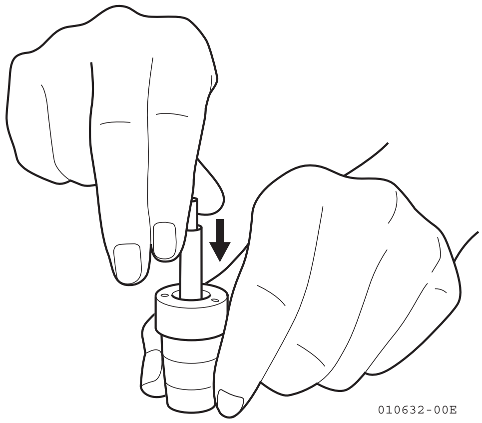


Extreme difference in angle (θ)
Extremely different injection angle (α)
Non-atomized spray
Stagnant spray

010631-00E

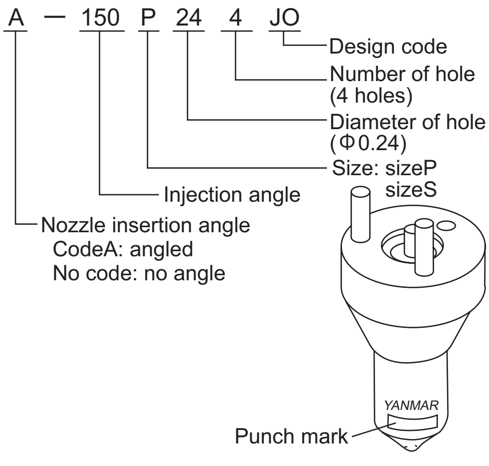
3) Nozzle Valve Sliding Test

Wash the nozzle valve in clean fuel oil. Place the nozzle body vertically and insert the nozzle into the body to about 1/3 of its length. The valve is normal if it smoothly falls by its own weight into the body. In case of a new nozzle, remove the seal peel, and immerse it in clean diesel oil or the like to clean the inner and outer surfaces and to thoroughly remove rust-preventive oil before using the nozzle. Note that a new nozzle is coated with rust-preventive oil and is pasted with the seal peel to shut off outer air.



Nozzle valve sliding check by gravity

4) Nozzle Punch Mark



4-3-7 Fuel Injection Timing Adjustment / Fuel Injection Pump Inspection and Adjustment

The fuel injection timing and the fuel injection pump are adjusted so that engine performance may become the best condition. As for the inspection and adjustment of the fuel pump, it is based on the service manual of the MP pump of the separate volume. The fuel injection timing is adjusted by the following procedure.

As for the engine, which adopts a MP type fuel injection pump, the fuel injection angle θ_i (note) is adjusted for the fuel injection timing adjustment, because the adjusting method of fuel injection timing like an inline fuel pump can't be applied.

Note :

The fuel injection angle θ_i (cam angle) is the difference from the injection valve opening angle while the fuel injection pump being driven by a motor and the angle at the plunger lift 0.098 in. (2.5 mm) of the fuel pump.

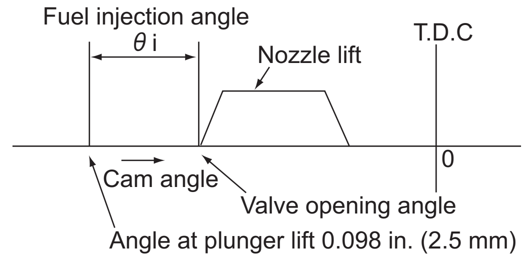
And, as for the actual fuel injection angle θ_i , the measured value is recorded on the pump body by each every fuel pump.

The adjustment of fuel injection angle θ_i

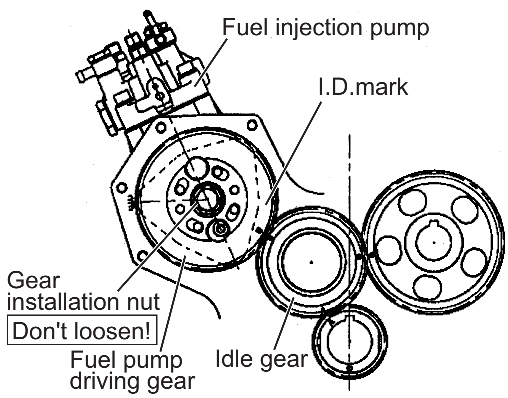
In case that a fuel pump cover, installed with a gear case cover and the fuel pump are removed, and reassembled, the procedure of fuel injection angle adjustment is as follows.

Notice :

Never loosen four flange bolts, which fasten a pump flange and a fuel pump drive gear at the time of the removal of the fuel pump. When it is loosened, the adjustment of the fuel injection timing becomes very difficult.



Fuel injection angle

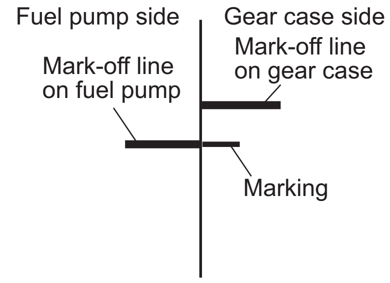


Fuel pump installation angle

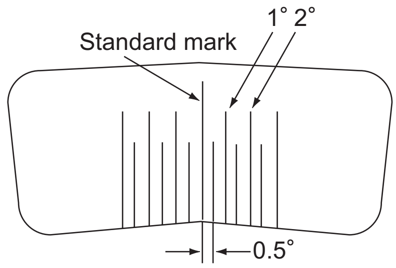
[1] Before removing a fuel pump drive gear, make ID marks on the gearing part of the pump drive gear and the idle gear with paint and so on.

[2] Make the mark-off line to the gear case precisely in accordance with the position of mark-off line of the fuel pump.

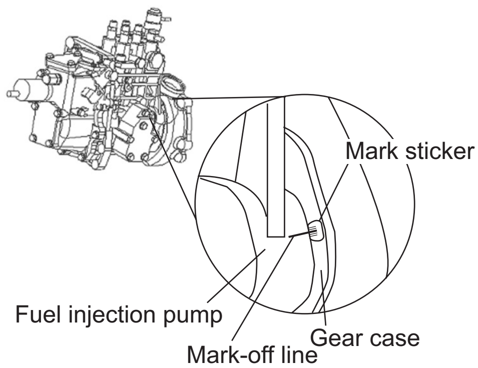
[3] Before removing a fuel pump, put the standard mark of a sticker for fuel injection angle adjustment in accordance with the mark-off line of the fuel pump and paste it on the gear case.



Marking on gear case



Sticker for adjusting injection angle



[4] Remove a fuel pump, and read the fuel injection angle recorded in that fuel pump.

[5] Read the injection angle recorded on a reassembled fuel pump and calculate the difference from the injection angle of the disassembled fuel pump. (When re-installation does the same fuel pump, the angular difference is zero.)
Fuel injection angle difference (cam angle) = (the fuel injection angle of a reassembled fuel pump)
- (the fuel injection angle of a disassembled previous fuel pump)

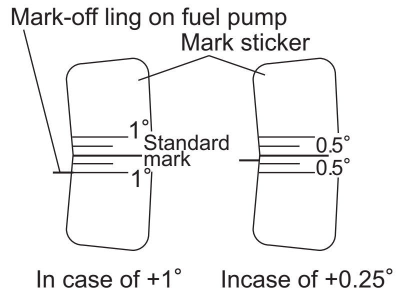
Notice :
Tell the fuel pump number to Yanmar, and inquire the injection angle of the pump when it is hard to find out.

[6] Put the fuel pump on the gear case temporarily and install the drive gear on the cam shaft with checking the ID marks, which were put on the fuel pump drive gear and the idle gear at the time of the disassembling.

Tighten the installation nut of a pump drive gear.

Tightening torque ft•lbf (N•m)	Lubricating oil application (thread portion, and seat surface)
58 to 65 (78 to 88)	Not applied

[7] Adjust the injection angle difference, calculated in the above 5), at 0.25° in the unit in the installation angle of the fuel pump while reading the mark (minimum 0.5° and cam angle) of the adjustment sticker.



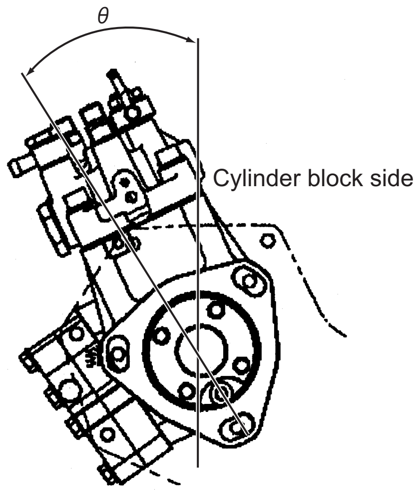
Injection angle adjustment

Notice :
Push down the fuel pump in the outside direction of the cylinder block at +1 degree when a injection angle difference is +1 degree. And, push it down to the cylinder block side when a difference is –1 degree.

[8] Tighten the fuel pump installation nuts.

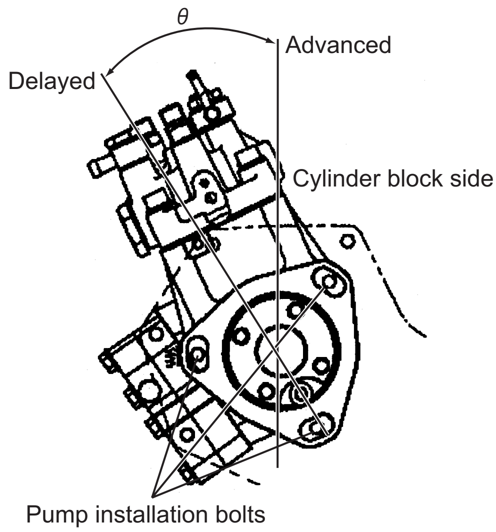
(Supplementary explanation 1)
The installation angle of the fuel pump is as follows.

Model	Installation angle θ (deg.)
4TNV88	25



Fuel pump installation angle

(Supplementary explanation 2)
When fuel injection timing is advanced or delayed, the installation angle of the fuel pump is adjusted.
When fuel injection timing is advanced for example at 2 degrees, loosen the nuts, which fix the fuel pump on the gear case, and turn the fuel pump body in the outside direction of the cylinder block at 1 degree, and tighten the pump installation nuts.
And, when fuel injection timing is delayed, a pump is turned in that reverse direction.



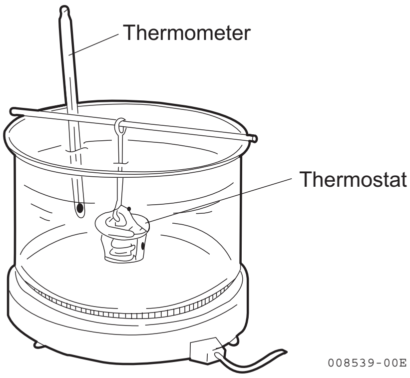
Injection timing adjustment

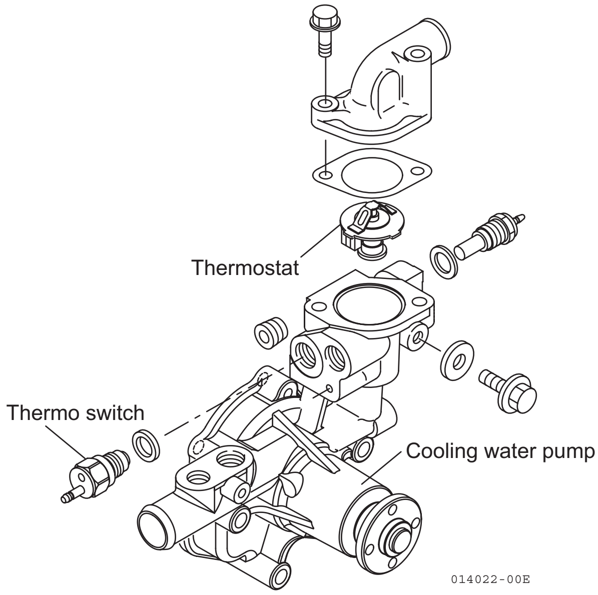
4-3-8 Sensor Inspection

1) Thermostat and Thermal Switch Inspection

(1) Thermostat

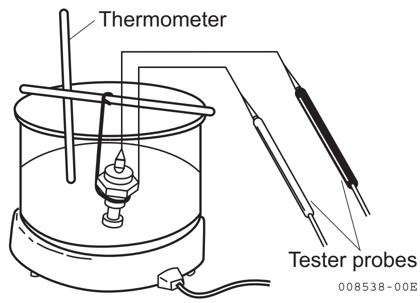
Place the thermostat in a container filled with water. Heat it while measuring the water temperature, and see that the thermostat is actuated at 157.1 to 162.5 °F (69.5 to 72.5 °C).





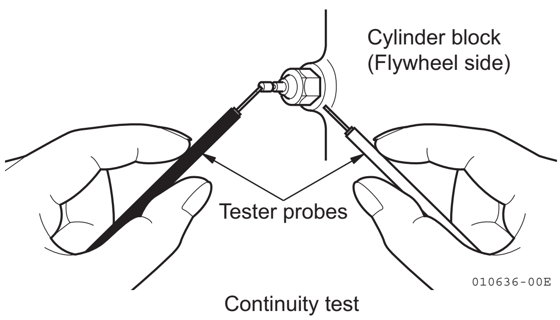
(2) Thermo switch

Place the thermo switch in a container filled with anti-freeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltammeter shows continuity when the fluid temperature is 224.6 to 235.4°F (107 to 113°C)



2) Oil Pressure Switch

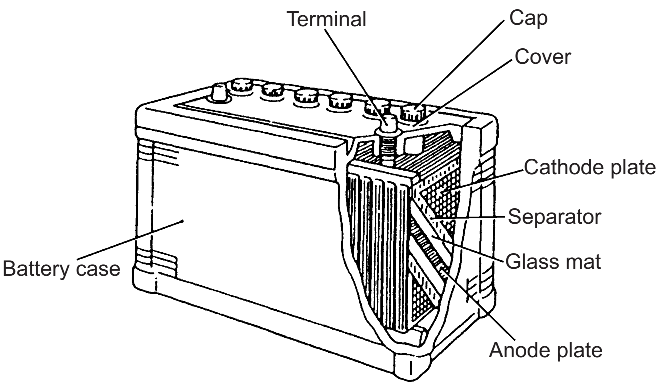
Disconnect the connector from the oil pressure switch. Keep the voltammeter probes in contact with the switch terminal and cylinder block while operating the engine. It is abnormal if circuit is closed.



Continuity test

4-3-9 Battery Inspection

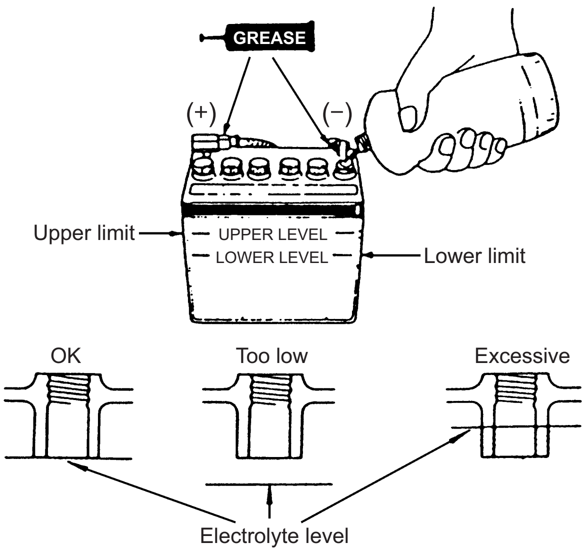
1) Battery Structure



2) Battery Inspection

(1) Electrolyte level

Add distilled water to the upper limit if the level is low.



(2) Battery charge

Use a battery tester or hydrometer and check the battery condition. If the battery is discharged, recharge it.

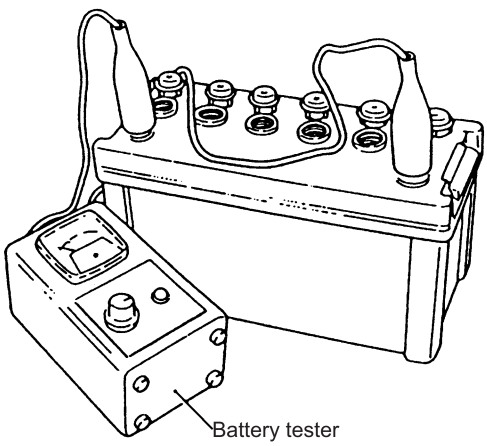
- Measurement with a battery tester

  When checking the battery with the batter tester, connect the red clip of the tester to the battery positive (+) terminal and black clip to the battery negative (–) terminal by pinching them securely, and judge the battery charge level from the indicator position.

  Green zone : Normal

  Yellow zone : Slightly discharged

  Red zone : Defective or much discharged

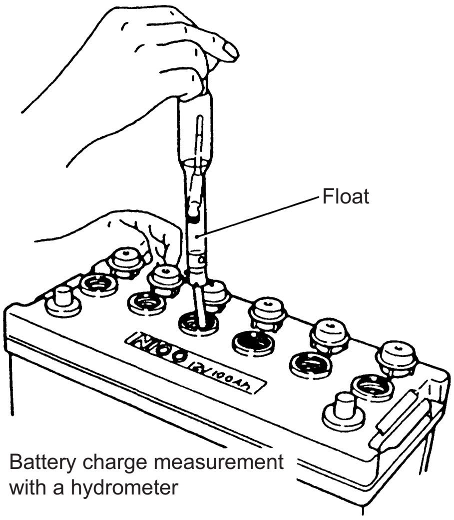


Battery charge measurement with battery tester

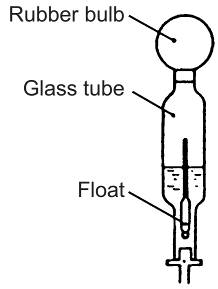
- Measurement with hydrometer
  When using a hydrometer, the measured specific gravity must be corrected according to the temperature at the time of measurement. The specific gravity of battery electrolyte is defined with 68°F (20°C) as the standard. Since the specific gravity increases or decreases by 0.0007 when the temperature varies by 33.8°F (1°C), correct the value according to the equation below.

$$S_{20} = St + 0.007\ (t\text{-}20)$$

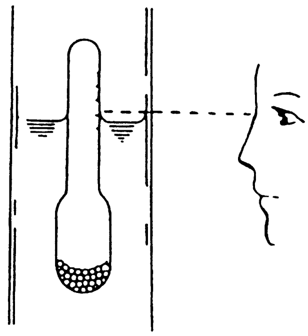
Electrolyte temperature at measurement (° C)
Specific gravity at measurement
Converted specific gravity at 68° F (20° C)



Battery charge measurement with a hydrometer



Hydrometer structure


How to read hydrometer

	To convert	Into	Multiply by
Temperature	°C	°F	°C = 5/9 (°F = 32)

Specific gravity and remaining battery charge

Specific gravity 68°F (20°C)	Discharged quantity of electricity (%)	Remaining charge (%)
1.260	0	100
1.210	25	75
1.160	50	50
1.110	75	25
1.060	100	0

(3) Terminals
Clean if corroded or soiled.
(4) Mounting bracket
Repair or replace it if corroded. Retighten if loosened.
(5) Battery appearance
Replace the battery if cracked or deformed.
Clean with fresh water if contaminated.

4-3-10 Adjusting Operation

Perform adjusting operation as follows after the maintenance job:

(1) Supply the fuel oil, lubricating oil and cooling water.

Note :
Check the levels of the lubricating oil and cooling water again after test running (for about 5 minutes) and add as required.

(2) Start the engine, and carry out idling at a low revolution (700 to 900 RPM) for a few minutes.

(3) Run in the engine for about five minutes at the rated revolution (no-load). Check any water, fuel or oil leak and existence of abnormal vibration or noise. Also check the oil pressure, cooling water temperature and exhaust gas color.

(4) Adjust the no-load minimum and maximum revolutions according to the specifications.

(5) Perform loaded operation as required.

4-3-11 Long Storage

Observe the following instructions when the engine is to be stored for a long period without operation:

(1) Always drain cooling water in a cold season or before a long storage. (This is unnecessary when antifreeze is used.)

Notice :
Negligence of water draining will cause the cooling water remaining inside the engine to be frozen and expanded to damage the engine parts.

Water draining procedure

[1] Remove the radiator cap.
[2] Loosen the water draining cock under the radiator to drain water from the inside.
[3] Loosen the drain cock on the side surface of the cylinder to drain water from the inside.
[4] After draining water, tighten the radiator cap and drain plug and cocks.

(2) Remove the mud, dust and oil deposit and clean the outside.

(3) Perform the nearest periodic inspection before the storage.

(4) Drain or fill the fuel oil fully to prevent condensation in the fuel tank.

(5) Disconnect the battery cable from the battery negative (–) terminal.

(6) Cover the silencer, air cleaner and electric parts with PVC cover to prevent water and dust from depositing or entrance.

(7) Select a well-ventilated location without moisture and dust for storage.

(8) Perform recharging once a month during storage to compensate for self-discharge.

4-3-12 Periodic Maintenance Schedule

The engine periodic inspection timing is hard to determine as it varies with the application, load status, qualities of the fuel and lubricating oils used and handling status. General rules are described here.

○ : Inspection ◇ : Parts replacement

Classification	Item	Daily	Maintenance period				
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 2000 hours
Fuel oil system	Fuel tank level check and fuel supply	○					
	Fuel tank draining		○				
	Water separator draining (Option)		○ Every 100 hours				
	Water separator cleaning (Option)				○		
	Fuel filter element replacement				◇		
Lube oil system	Lube oil level check	○					
	Lube oil replacement		◇ 1st time	◇ 2nd time and there after			
	Lube oil filter replacement						
Cooling water system	Cooling water level check and replenish	○					
	Radiator fin cleaning			○			
	Cooling fan V-belt tension check	○					
	Cooling water replacement					◇	
	Cooling water path flushing and maintenance					○ within one years	
Fuel oil, lube oil and cooling water leakage check		○					
Rubber hose	Fuel pipe and cooling water pipe inspection and maintenance						○
Air intake system	Air cleaner cleaning and element replacement			○	◇		
	Turbocharger blower cleaning					○	
Electrical system	Warning lamp & instruments function check	○					
	Battery electrolyte level check and battery recharging	○					
Cylinder head	Intake/exhaust valve head clearance adjustment					○	
Fuel injection pump and valve	Fuel injection valve pressure inspection					○	
	Fuel injection timing inspection						○

4-4 Engine Body

4-4-1 Introduction

Make preparation as follows before starting engine inspection and service :

(1) Fix the engine on a horizontal base.

⚠ CAUTION

Be sure to fix the engine securely to prevent injury or damage to parts due to falling during the work.

(2) Remove the cooling water hose, fuel oil pipe, wire harness, control wires etc. connecting the driven machine and engine, and drain cooling water, lubricating oil and fuel.

(3) Clean soil, oil, dust, etc. from the engine by washing with solvent, air, steam, etc. Carefully operate so as not to let any foreign matter enter the engine.

⚠ CAUTION

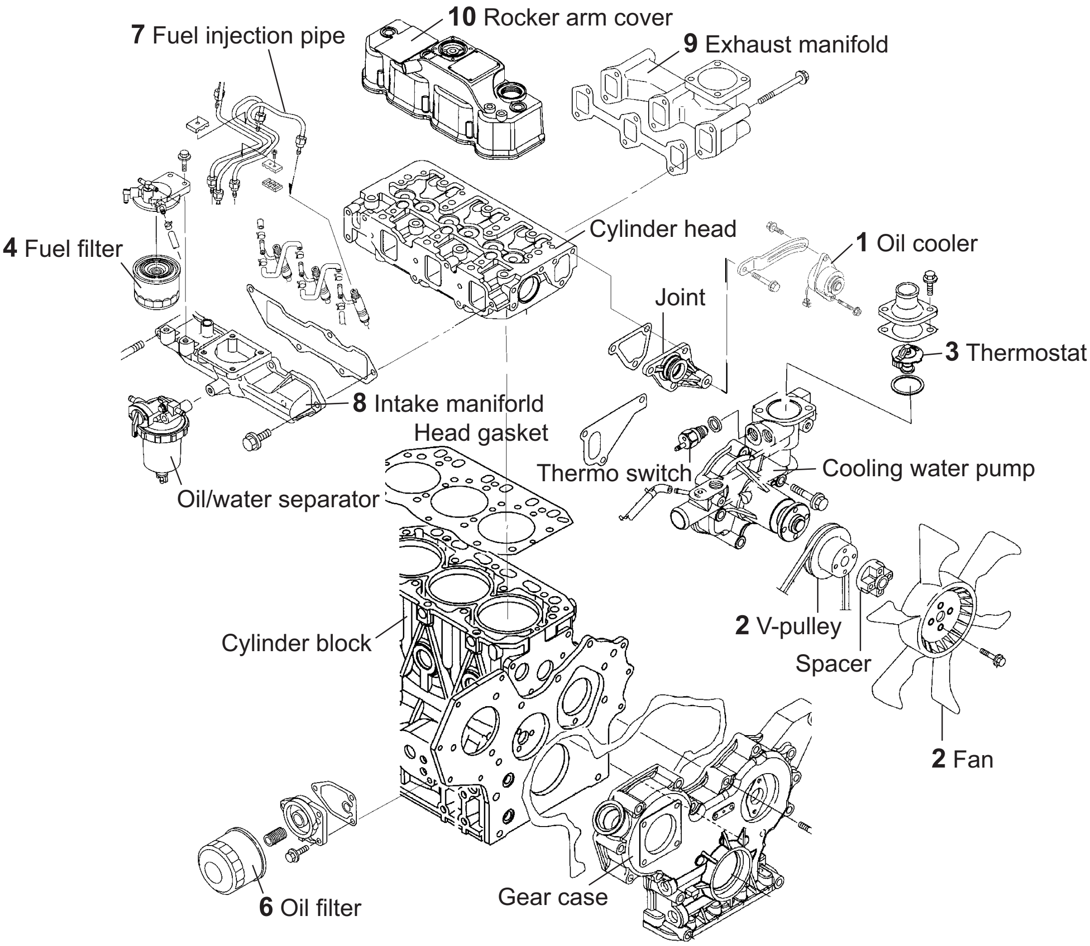
Always wear glasses or other protectors when using compressed air or steam to prevent any foreign matter from getting in the eyes.

Notice :

- *Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit shall be replaced.*
- *Any part predicted to dissatisfy the standard or limit before the next service as estimated from the state of use should be replaced even when the measured value then satisfies the standard or limit.*

4-4-2 Cylinder Head

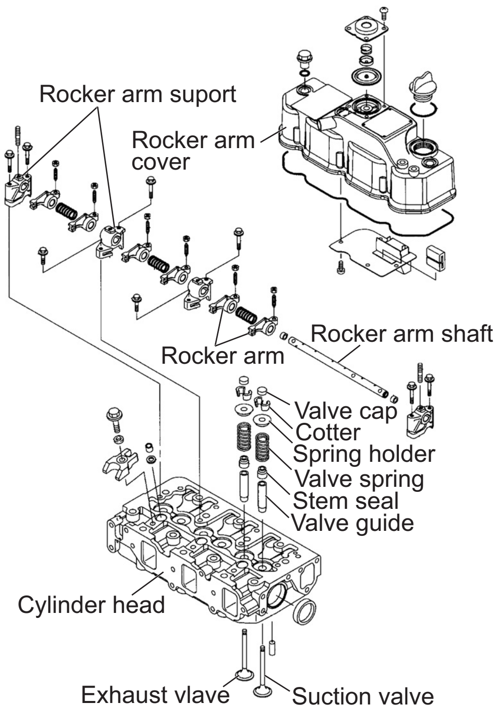
1) Components



2) Disassembly Procedure :

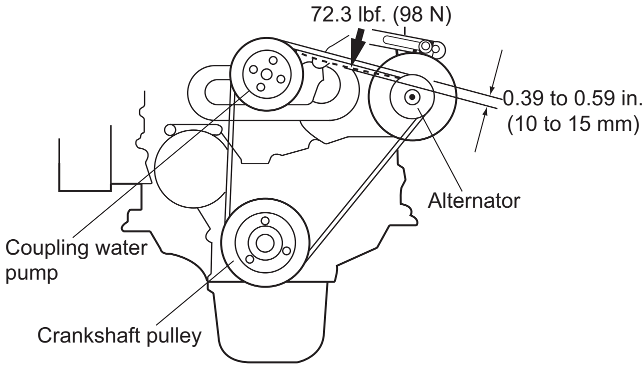
Disassemble in the order of the numbers shown in the illustration.

1 Remove the alternator ass'y. ***(Point 1)***
2 Remove the fan, pulley and V belt.
3 Remove the thermostat case. ***(Point 2)***
4 Remove the fuel filter and fuel oil piping. ***(Point 3)***
5 Remove the oil level gage ass'y.
6 Remove the oil filter. ***(Point 4)***
7 Remove the fuel injection pipes. ***(Point 5)***
8 Remove the intake manifold ass'y.
9 Remove the exhaust manifold ass'y.
10 Remove the rocker arm cover ass'y. ***(Point 6)***
11 Remove the rocker shaft ass'y, push rods and valve caps. ***(Point 7)***
12 Remove the cylinder head ass'y and head gasket. ***(Point 8)***
13 Remove the fuel injection valves and fuel return pipe. ***(Point 9)***
14 Remove the intake/exhaust valves, stem seals and valve springs. ***(Point 10)***
15 Remove the rocker arms from the rocker shaft.



3) Reassembly Procedure :

Reverse order of the disassembly procedure.



V-belt tension

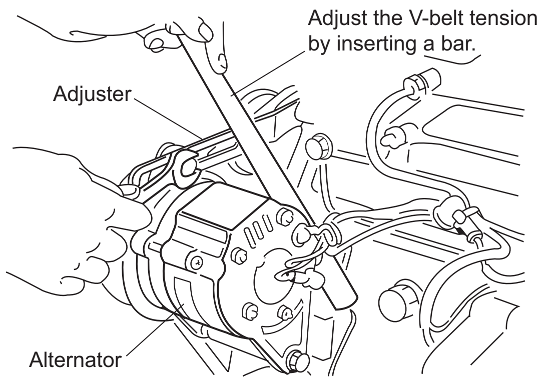
4) Servicing Points

Point 1

Disassemble :

- Loosen the mounting bolt while supporting the alternator.

> **⚠ CAUTION**
>
> **Do not tilt the alternator toward the cylinder block in a haste since it may damage the alternator or pinch a finger.**



Tension adjustment

Reassemble :

- The belt deflection shall be 0.39 to 0.59 in. (10 to 15 mm) (0.28 to 0.35 in. (7 to 9 mm)) for a new belt).

Reassemble :

- Replace the belt with a new one if cracked, worn or damaged.
- Carefully prevent the belt from being smeared with oil or grease.

Point 2

Reassemble :

- Check the thermostat function.

Point 3

Reassemble :

- Replace the fuel filter element with a new one.

Disassemble :

- Cover the fuel pipe opening with tape to prevent intrusion of foreign matters.

Point 4

Reassemble :

- Replace the oil filter with a new one.
- After fully tightening the filter manually, retighten it with a filter wrench by 3/4 turn.

Point 5

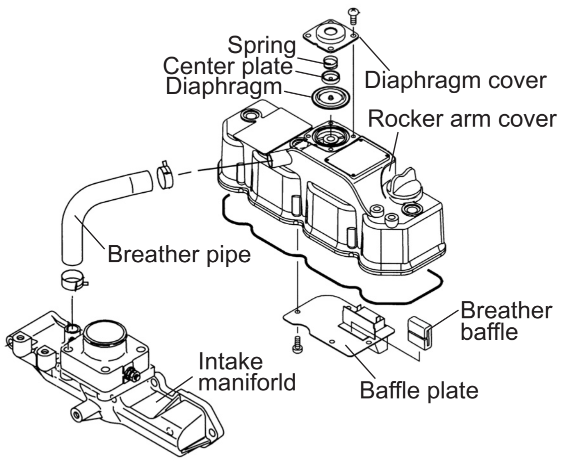
Disassemble :

- Cover the fuel injection pipe and pump inlets and outlets with tape or the like to prevent intrusion of foreign matters.

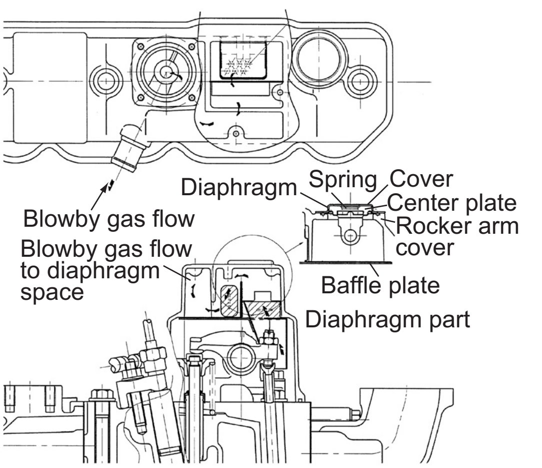
Point 6

Breather system (A redactor to intake air system of blowby gas)

Emitting blowby gas is harmful to natural environment. Therefore blowby gas redactor is adopted to the engine. Some of the combustion gas passes through the clearance between the cylinder and the piston, piston ring, and flows to the crankcase. This is said as blowby gas. While it passes into the cylinder head and the rocker arm cover, the blowby gas mixes with splash oil, and becomes oil mist-blowby gas mixes with splash oil, and becomes oil mist-blowby gas it passing through the baffle plate inside a rocker arm cover. And it passes through a diaphragm assy, and a intake manifold, and is reduced in the combustion chamber. Pressure inside a crankcase is controlled by the function of the diaphragm assy, and suitable amount of blowby gas is reduced in intake air system.



Breather system componert



Blowby gas flow

Disassemble :

- When a rocker arm cover is taken off, check whether oil or the like enter the diaphragm space from a small hole on the side of a diaphragm cover or not without disassembling the diaphragm.

Notice :

- *When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles occur. When the internal pressure of the crankcase decreases too much due to the damage of a spring, much blowby gas containing oil is reduced in intake air system, and it may cause the combustion defect by the early dirt of the intake valve or the urgent rotation of the engine by the oil burning.*
  When pressure progresses in the crank case too much due to the wrong operation of the diaphragm and so on, it is considered that oil leakage from the joint of a oil pan, a oil seal and so on will occur. When a diaphragm is damaged, blowby is discharged from the breathing hole on the side of diaphragm cover, and not reduced in the intake manifold. Therefore, be careful of the diaphragm trouble.
- *At lubricating oil replacement or lube oil supply*
  The amount of lubricating oil isn't to be beyond the standard upper limit (in the engine horizontally, the upper limit mark of the dip stick). Since the blowby gas redactor is adopted, be careful that the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur, when the lubricating oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine.

Reassemble :

- Replace the diaphragm with new one, when it is damaged.

Point 7

Disassemble :

- Keep the removed push rods by attaching tags showing corresponding cylinder Nos.

Reassemble :

- Always apply oil to the contact portions of the push rods and valve clearance adjusting screws.

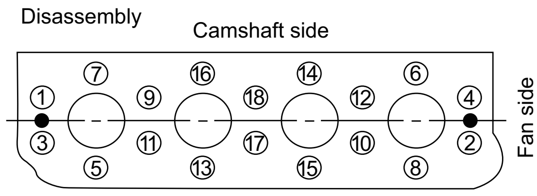
Point 8

Disassemble :

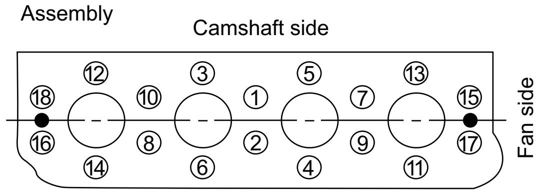
- Loosen the cylinder head bolts in two steps in the illustrated order.
- Place the cylinder head ass'y on a paper board to prevent the combustion face from any damage.

Reassemble :

- Remove the head gasket with a new one.
- Uniformly install the head bolts manually after applying oil on the threaded and seat portions.
- They shall be tightened in two steps in the reverse of the order for disassembly.
  First step : T = 31.0 to 34.0 ft•lbf. (41.1 to 46.9 N•m)
  Second step : T = 63.0 to 67.0 ft•lbf. (85.3 to 91.1 N•m)



Head bolt disassembly order



Head bolt tightning order

Point 9

Disassemble :

- Carefully remove the fuel injection valve so as not to leave the tip end protector from being left inside the cylinder.

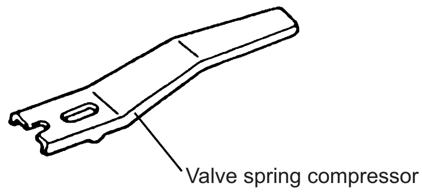
Reassemble :

- Replace the fuel injection valve protector with a new one.

Point 10

Disassemble :

- When removing each intake/exhaust valve from the cylinder head, use a valve spring compressor and compress the valve spring and remove the valve cotter.
- Keep each removed intake/exhaust valve after attaching a tag showing the corresponding cylinder No.



- If cotter burr is seen at the shaft of each intake/exhaust valve stem, remove it with an oilstone and extract the valve from the cylinder head.

Reassemble :

- Replace the stem seal with a new one when an intake/exhaust valve is disassembled.
- Carefully install each valve after oil application so as not to damage the stem seal.
- Different stem seals are provided for the intake and exhaust valves. Do not confuse them since those for exhaust valves are marked with yellow paint.
- After assembling the intake/exhaust valve, stem seal, valve spring, seat, and cotter, tap the head of the valve stem lightly for settling.
- Do not forget to install the valve cap.

5) Parts Inspection and Measurement

(1) Cylinder head

Clean the cylinder head, mainly the combustion surface, valve seats and intake/exhaust ports, remove carbon deposit and bonding agent, and check the surface state.

[1] Appearance check

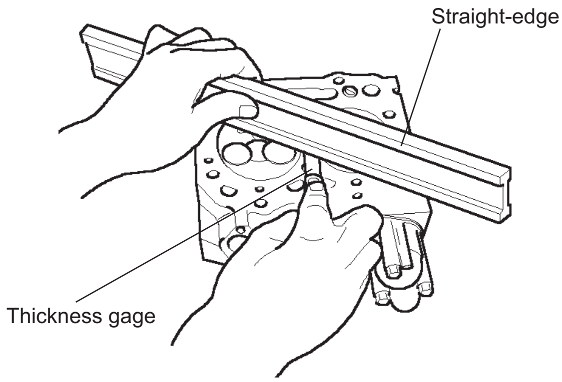
Check mainly discoloration and crack.
If crack is suspected, perform color check.

[2] Combustion surface distortion

Apply a strait-edge in two diagonal directions and on four sides of the cylinder head, and measure distortion with a thickness gage.

in. (mm)

	Standard	Limit
Distortion	0.002 (0.05) or less	0.006 (0.15)



Distortion at combustion surface

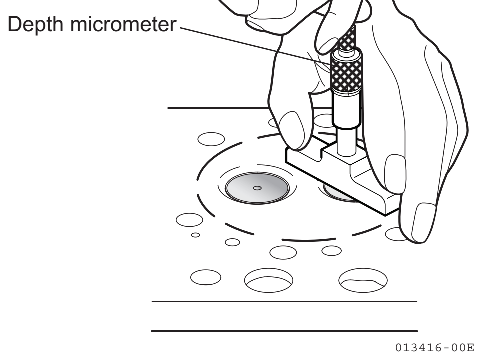
[3] Valve sink

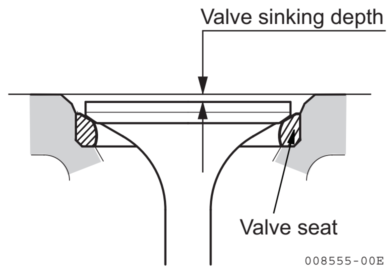
Measure with the valve inserted to the cylinder head.

in. (mm)

		Standard	Limit
Valve sink	Intake	0.012 to 0.020 (0.30 to 0.50)	0.031 (0.8)
	Exhaust	0.012 to 0.020 (0.30 to 0.50)	0.031 (0.8)

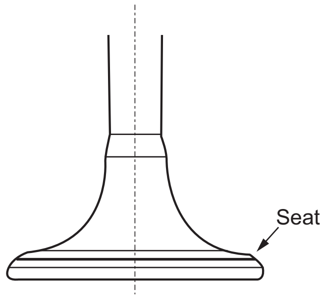
Valve sink





[4] Seat contact
Apply a thin coat of minium on the valve seat. Insert the valve in the cylinder and push it against the seat to check seat contact.
Standard : Continuous contact all around

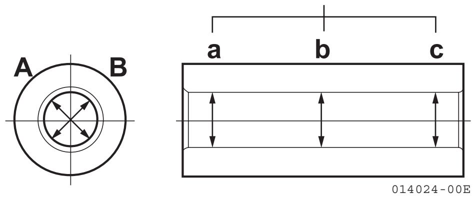
Valve seat contact



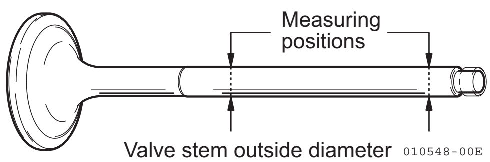
(2) Valve guide
Mainly check damage and wear on the inside wall. Apply supply part code 129907-11810 when replacing the part.
[1] Inside diameter

in. (mm)

		Standard	Limit
Intake valve	Guide I.D.	0.315 to 0.316 (8.010 to 8.025)	0.319 (8.10)
	Stem O.D.	0.313 to 0.314 (7.955 to 7.975)	0.311 (7.90)
	Clearance	0.0014 to 0.0028 (0.035 to 0.070)	0.071 (0.18)
Exhaust valve	Guide I.D.	0.316 to 0.317 (8.015 to 8.030)	0.319 (8.10)
	Stem O.D.	0.313 to 0.314 (7.955 to 7.970)	0.311 (7.90)
	Clearance	0.0018 to 0.0030 (0.045 to 0.075)	0.0071 (0.18)



Valve guide inside diameter

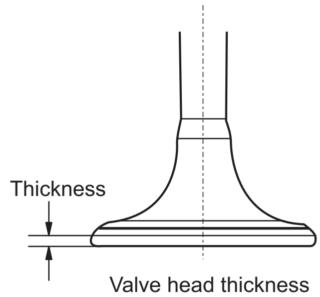


Valve stem outside diameter 010548-00E

(3) Intake/exhaust valve
Mainly clean and check damage and wear at the valve stem and seat.
[1] Seat contact : See (1) [5] above.
[2] Stem outside diameter : See (2) [1] above.
[3] Valve head thickness

in. (mm)

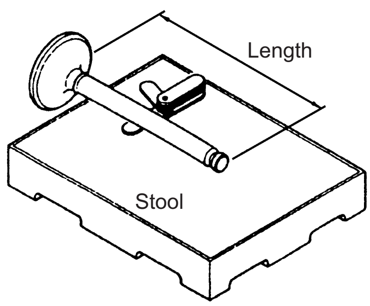
	Standard	Limit
Intake	0.049 to 0.057 (1.24 to 1.44)	0.031 (0.8)
Exhaust	0.053 to 0.061 (1.35 to 1.55)	0.031 (0.8)



Valve head thickness

[4] Valve stem bend

Limit	0.00039 in. (0.01 mm)



Valve bend and length

[5] Overall length

in. (mm)

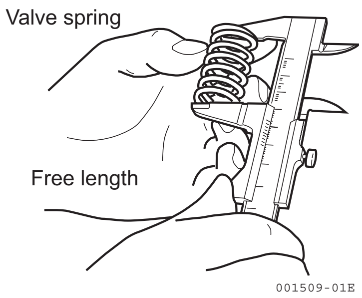
	Standard	Limit
Intake	4.280 to 4.303 (108.7 to 109.3)	4.272 (108.5)
Exhaust		

(4) Valve spring

Mainly inspect damage and corrosion.

in. (mm)

	Standard	Limit
Free length	1.654 (42.0)	1.634 (41.5)
Inclination	–	0.055 (1.4)



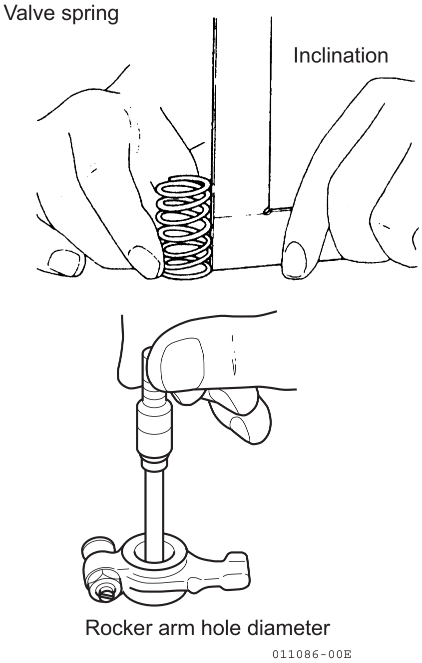
(5) Valve rocker arm

Mainly inspect valve head cap contact surface, inside surface defects and wear.

Slight surface defects shall be corrected with an oilstone.

in. (mm)

	Standard	Limit
Arm hole diameter	0.6299 to 0.6307 (16.00 to 16.02)	0.6327 (16.07)
Shaft O.D.	0.6287 to 0.6291 (15.97 to 15.98)	0.6276 (15.94)
Clearance	0.0006 to 0.0021 (0.016 to 0.054)	0.051 (0.13)



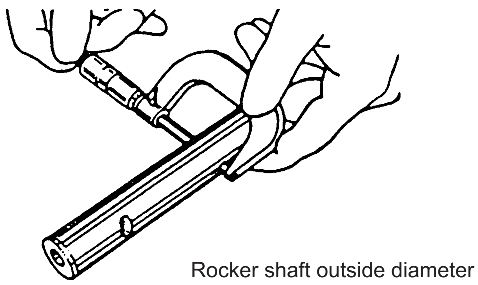
(6) Valve rocker arm shaft

Mainly inspect seizure and wear at the surface in sliding contact with the arm. The rocker shaft diameter shall be as specified in (5) above.

(7) Push rod

Mainly inspect the surface in contact with the tappet and adjusting screw. Slight defects shall be corrected with an oilstone.

Bend limit	0.0012 in. (0.03 mm) or less



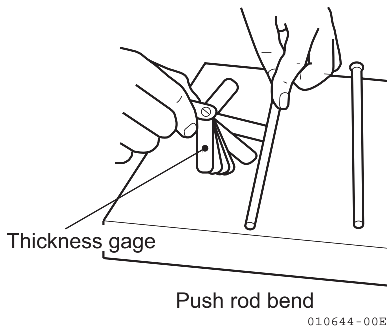
(8) Valve clearance adjusting screw

Mainly inspect the surface in contact with the push rod.

Slight defects shall be corrected with an oilstone.

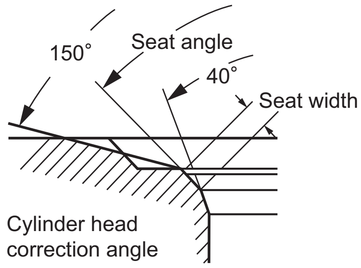
(9) Rocker arm spring

Mainly inspect surface defects and corrosion.



6) Valve Seat Correction

Notice :
Always check the oil clearance between the valve and valve guide before correcting the valve seat. If it exceeds the limit, replace the valve or valve guide first to make the clearance satisfy the standard. After correction, wash the valve and the cylinder head sufficiently with diesel oil to remove all grinding power or compound.

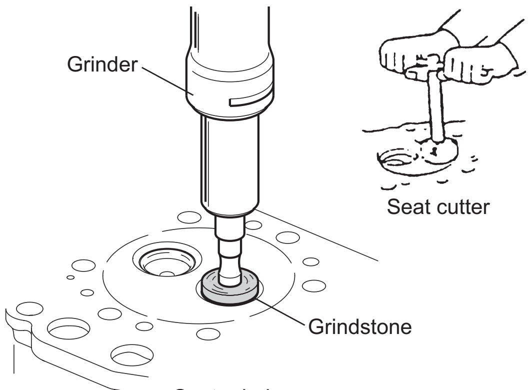


[1] If the seat surface is slightly roughened : perform **[A]** and **[B]** below.

[2] If the seat is heavily roughened but the width is almost normal, correct with a seat grinder or seat cutter first. Then perform lapping **[A]** and **[B]** below.

degrees

Seat cutter angle	Intake	Exhaust
	120	90

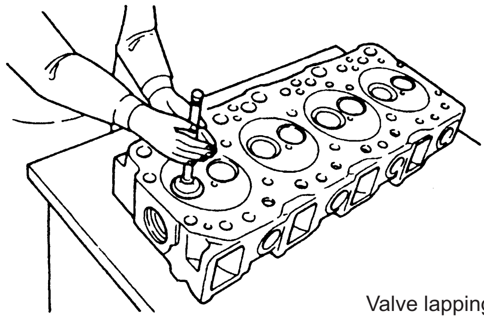


Seat grinder

[3] If the seat is heavily roughened and the width is much enlarged, grind the seat inner surface with a seat grinder whose center angle is 40 degrees, then grind the seat outer surface with a grinder whose center angle is 150 degrees to make the seat width match the standard. Then perform seat correction as described in [2], and then carry out lapping **[A]** and **[B]** below.

degrees

Grinding wheel angle	θ_1	θ_2
	40	150

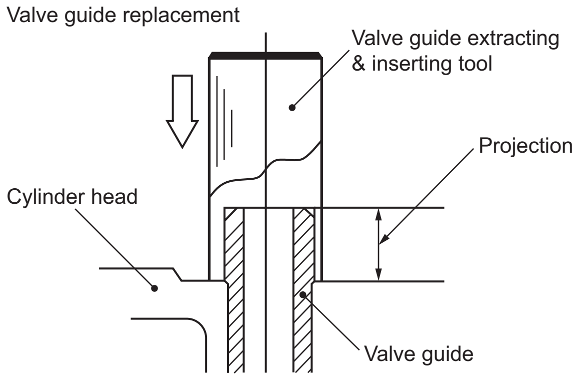

Valve lapping

[A] : Lap the valve and seat with a mixture of valve compound and engine oil.

[B] : Lap with engine oil only.

7) Valve Guide Replacement

[1] Use a valve guide extraction tool and extract the valve guide from the cylinder head.
[2] Put liquid nitrogen or ether (or alcohol) with dry ice added in a container and put the valve guide for replacement in it for cooling. Then insert it in with a valve guide inserting tool.
[3] Check the inside diameter and finish to the standard inside diameter as required with a reamer.
[4] Check the projection from the cylinder head.
Projection : 0.579 to 0.591 in. (14.7 to 15.0 mm)



⚠ CAUTION

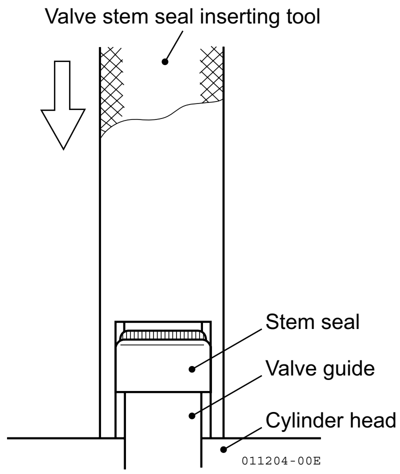
Do not touch the cooled valve guide with bare hands to avoid skin damage.

8) Valve Stem Seal Replacement

Always use a new seal after the intake/exhaust valve is disassembled. Since the one for the exhaust valve is marked with yellow paint, do not confuse the intake and exhaust valves.

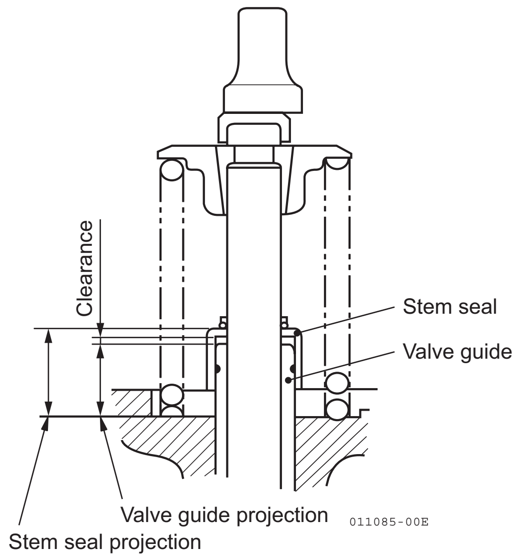
[1] Apply engine oil to the lip.

[2] Push with the inserting tool for installation.



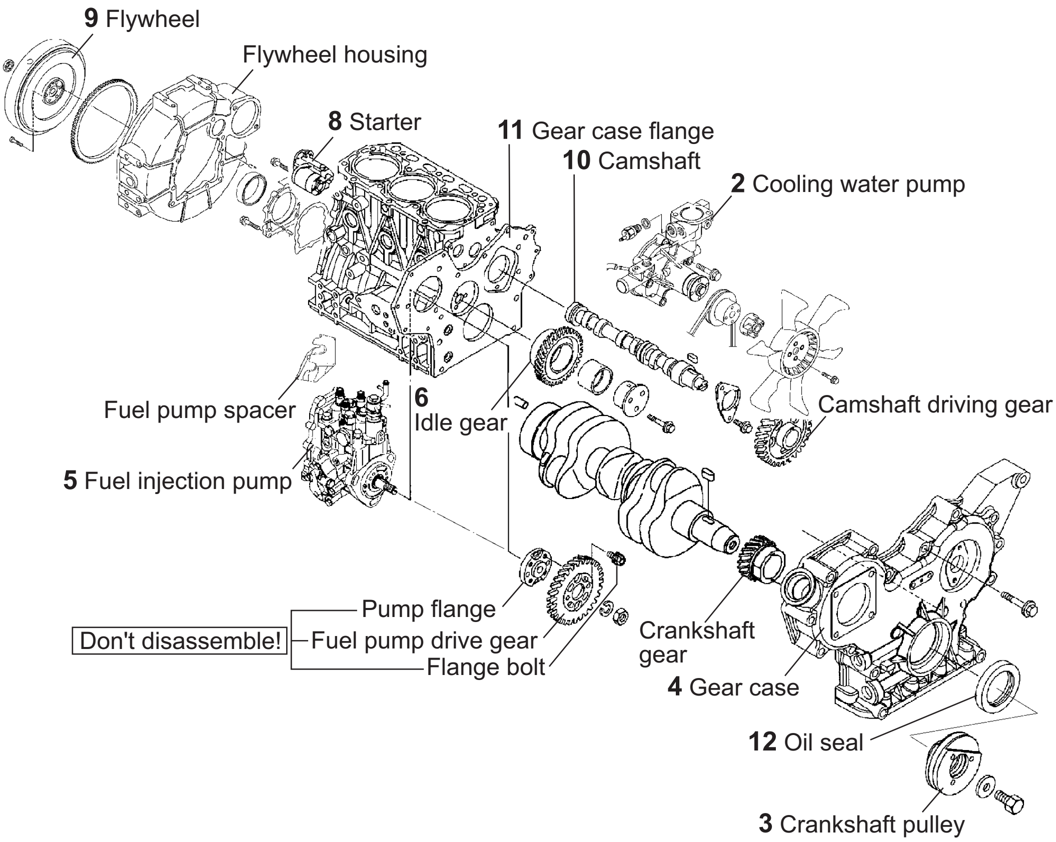
[3] Measure and check the projection of valve stem seal to keep proper clearance between valve guide and stem seal.

Stem seal projection : 0.736 to 0.748 in. (18.7 to 19.0 mm)



4-4-3 Gear Train and Camshaft

1) Components



2) Disassembly Procedure :

Disassemble in the order of the numbers in the illustration.

1 Perform steps 1 to 12 of the cylinder head disassembly procedure.
2 Remove the cooling water pump.
3 Remove the crankshaft pulley. ***(See Point 1)***
4 Remove the gear case cover. ***(See Point 2)***
5 Remove the fuel injection pump. ***(See Point 3)***
6 Remove the idle gear assy. ***(See Point 4)***
7 Remove the P.T.O. drive gear. ***(See Point 5)***
8 Remove the starting motor.
9 Remove the flywheel. ***(See Point 6)***
10 Remove the camshaft assy. ***(See Point 7)***
11 Remove the gear case. ***(See Point 8)***
12 Remove the oil seal from the gear case cover.

3) Reassembly Procedure :

Reverse of the disassembly procedure.

4) Servicing Points

Point 1

Disassemble :

- Remove the crankshaft pulley using a gear puller after removing the mounting bolt. When removing the pulley with the gear puller, use a pad and carefully operate so as not to damage the thread. Set the gear puller securely to prevent the pulley from being damaged.

Reassemble :

- When installing the crankshaft pulley, apply lube oil to the bolt and carefully assemble so as not to damage the oil seal.
  T = 83.2 to 90.4 ft•lbf. (113 to 123 N•m)

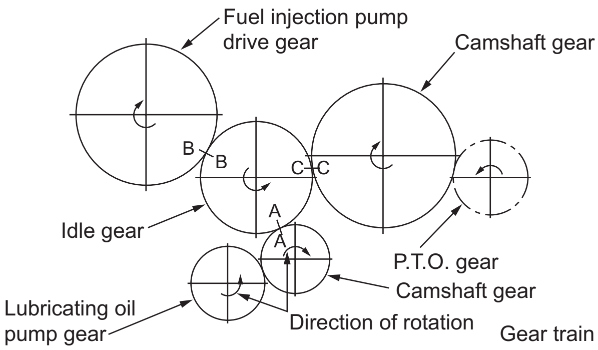
Point 2

Reassemble :

- When installing the gear case cover, do not forget to install the two reinforcing bolts at the center.
- Measure the backlash of each gear.

in. (mm)

	Standard	Limit
Crankshaft gear, Camshaft gear, Fuel injection pump gear, Idle gear, P.T.O. gear	0.0028 to 0.0059 (0.07 to 0.15)	0.0067 (0.17)
Lubricating oil pump gear	0.0043 to 0.0075 (0.11 to 0.19)	0.0083 (0.21)



Gear train

- Apply sealant and install the gear case cover by correctly positioning the two dowel pins.

Point 3

Disassemble :

- Remove the fuel injection pump drive gear mounting nut, remove the gear using the gear puller, and remove the fuel injection pump. Do not forget to remove the stay on the rear side. When extracting the gear using the gear puller, use a pad at the shaft and carefully operate so as not to damage the thread.

Reassemble : • Drive gear nut T = 57.9 to 65.1 ft•lbf. (78 to 88 N•m)

Point 4

Reassemble :

- Assemble crankshaft gear A, fuel injection pump drive gear B and camshaft gear C at the same time by aligning with idle gear A, B and C marks.
- Install the idle gear shaft with the oil hole facing upward.

Point 5

Reassemble :

- Install the P.T.O. drive gear with its inner spline side facing the flywheel.

Point 6

Disassemble :

- Install a bolt as a handle in the hole at the end face of the flywheel and remove carefully so as not to damage the ring gear.
  Reassemble : Flywheel mounting bolt T = 61.5 to 65.1 ft•lbf. (83.3 to 88.2 N•m), apply lube oil

Point 7

Disassemble :

- Measure the camshaft side gap.

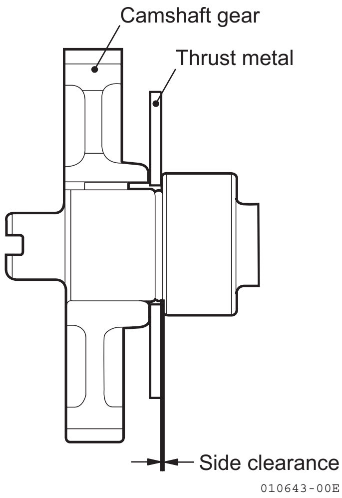
in. (mm)

	Standard	Limit
Side gap	0.002 to 0.0079 (0.05 to 0.20)	0.0118 (0.30)

- If the measured side gap exceeds the limit, replace the thrust metal.

Disassemble :

- Since the camshaft gear is shrink-fit, heat it to 356 to 392°F (180 to 200°C) for extraction.
- For camshaft removal, raise the engine with its mounting flange at the bottom. After removing the thrust metal mounting bolt from the camshaft gear hole, extract the camshaft carefully so as not to damage the bearing bushing.



- Rotate the camshaft a few turns before extracting it to prevent the tappet from being caught by the cam.
- After removing the camshaft, set the engine horizontal and fix it on the base.

⚠ CAUTION

Unforeseen injury may arise due to falling of slipping when raising the engine vertically or returning it to the horizontal position. Proceed carefully so as not to lose balance.

Point 8

Reassemble :

- Do not forget to install the oil pan mounting bolts on the bottom side when installing the gear case.
- Apply sealant (code No.977770-01212) and install the gear case by matching the two dowel pins.

Point 9

Reassemble :

- Replace the oil seal whenever disassembled.
- Apply lithium grease at the time of assembly.

5) Parts Inspection and Measurement

(1) Camshaft

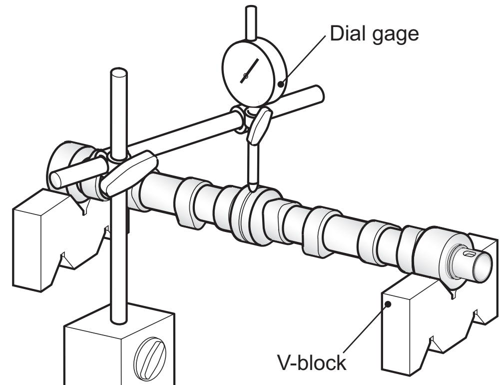
Mainly check the contact between the tappet and cam contact surface, bearing seizure and wear, and gear damage.

[1] Shaft bend measurement

Support the camshaft with V blocks. Rotate the camshaft and measure the runout at the center of the camshaft and at each journal with a dial gage. Half of the runout is the bend.

in. (mm)

	Standard	Limit
Bend	0 to 0.0008 (0 to 0.02)	0.0020 (0.05)

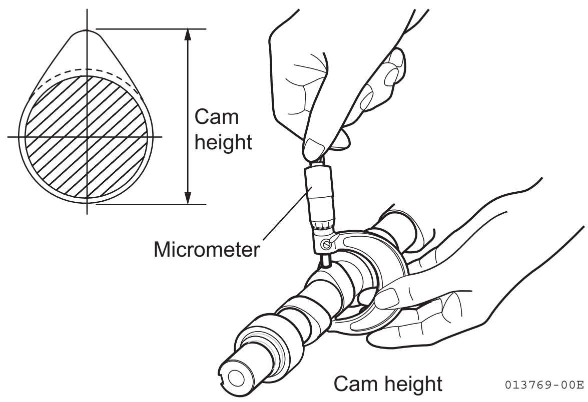


Camshaft bend

[2] Intake/exhaust cam height measurement

in. (mm)

	Standard	Limit
Cam height	1.520 to 1.528 (38.600 to 38.800)	1.510 (38.350)



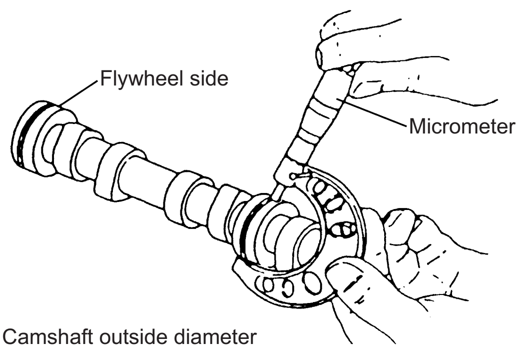
Cam height

[3] Camshaft outside diameter and bearing hole diameter measurement

Measure the camshaft outside diameter with a micrometer. The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the camshaft bushing inside diameter after insertion to the cylinder measured with a cylinder gage.

in. (mm)

		Standard	Limit
Gear side	Camshaft O.D.	1.7687 to 1.7697 (44.925 to 44.950)	1.7673 (44.890)
	Bushing I.D.	1.7713 to 1.7738 (44.990 to 45.055)	1.7768 (45.130)
	Oil clearance	0.0016 to 0.0051 (0.040 to 0.130)	0.0094 (0.240)
Intermediate position	Camshaft O.D.	1.7681 to 1.7691 (44.910 to 44.935)	1.7667 (44.875)
	Bushing I.D.	1.7717 to 1.7726 (45.000 to 45.025)	1.7756 (45.100)
	Oil clearance	0.0026 to 0.0045 (0.065 to 0.115)	0.0089 (0.225)
Wheel side	Camshaft O.D.	1.7687 to 1.7697 (44.925 to 44.950)	1.7673 (44.890)
	Bushing I.D.	1.7717 to 1.7726 (45.000 to 45.025)	1.7756 (45.100)
	Oil clearance	0.0020 to 0.0039 (0.050 to 0.100)	0.0083 (0.210)

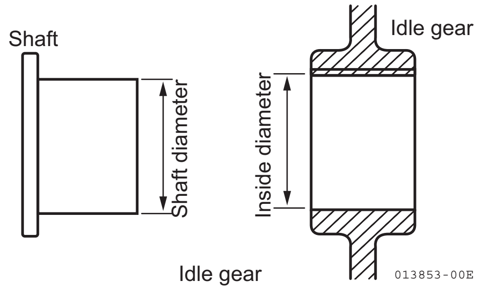


Camshaft outside diameter

(2) Idle gear

Mainly check the bushing seizure and wear, and gear damage.

[1] Shaft outside diameter and bushing inside diameter measurement



in. (mm)

	Standard	Limit
Shaft outside diameter	1.8091 to 1.9675 (45.950 to 49.975)	1.8071 (45.009)
Bushing inside diameter	1.8110 to 1.8120 (46.000 to 46.025)	1.8140 (46.075)
Clearance	0.0010 to 0.0030 (0.025 to 0.075)	0.0069 (0.175)

(3) P.T.O. drive gear

Mainly check sticking of bearings on both sides, gear damage and looseness, and gear shaft damage and wear.

6) Oil Seal Replacement (Gear Case Side)

[1] Replace the oil seal with a new one when the gear case is disassembled.
Extract the used oil seal.

[2] Insert a new oil seal. Fit the position of the oil seal insertion to the end face of the gear case.
(Refer to the below figure.)

[3] Apply lithium grease to the oil seal tips. For the oil seal with double lips dust seal, further, lightly apply engine oil on the oil seal lip so as not to damage them, when installing the pulley.

Notice :

Pay attention not to drop any oil on the taper surface of the crankshaft. If dropped, clean by wiping off using detergent.

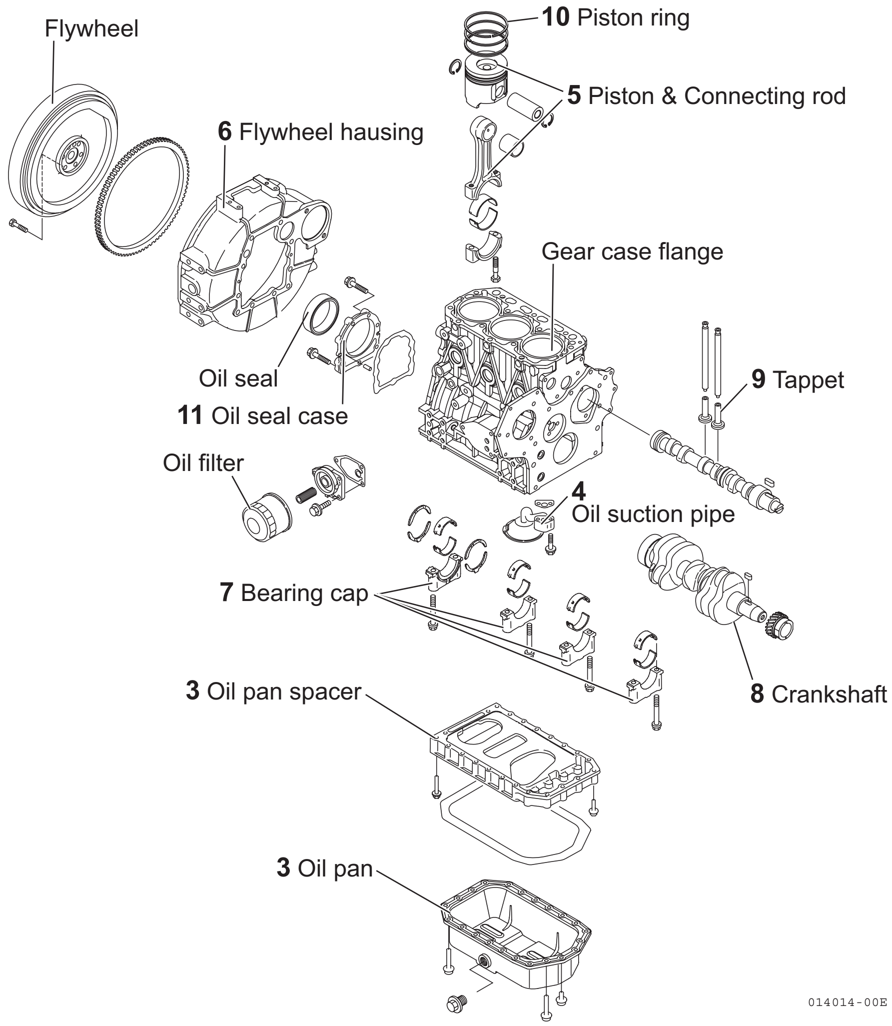
[4] Carefully install the crankshaft pulley so as not to damage the oil seal lips.

7) Camshaft Bushing Replacement

Replace the bushing using the special service tool.

4-4-4 Cylinder Block

1) Components



2) Disassembly Procedure :

Disassemble in the order of the numbers in the illustration.

1 Perform steps 1 to 12 in the cylinder head disassembly procedure.

2 Perform steps 1 to 12 in the gear train disassembly procedure.

3 Remove the oil pan. ***(See Point 1)***

4 Remove the lubricating oil suction pipe.

5 Remove the piston w/rod. ***(See Point 2)***

6 Remove the mounting flange. ***(See Point 3)***

7 Remove the bearing metal caps. ***(See Point 4)***

8 Remove the crankshaft. ***(See Point 5)***

9 Remove the tappets.

10 Remove the pistons and rings. ***(See Point 6)***

11 Remove the oil seal from the mounting flange.

3) Reassembly Procedure :

Reverse of the disassembly procedure.

4) Servicing Points

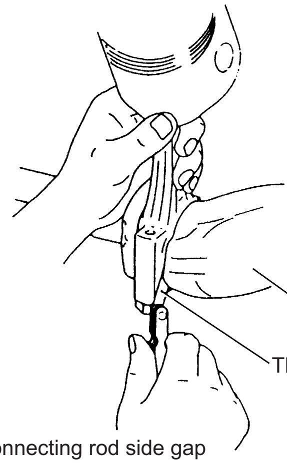
Point 1 Oil pan

Disassemble :

- Sealant is applied to the oil pan mounting surface on the block. Carefully operate so as not to damage or distort the bonding surface.

Reassemble :

- Apply sealant (code No.977770-01212) before reassembly.



Point 2 Piston w/rod

Disassemble :

- Measure the connecting rod side gap.
  Standard : 0.0079 to 0.0157 in. (0.20 to 0.40 mm)
- Carefully remove the carbon deposit on top of the cylinder so as not to damage the inner side of the cylinder.
- Set the piston at the BDC position and remove the connecting rod cap. Then set the piston at the TDC position, and push the connecting rod big end with the wooden shaft of a hammer. Proceed carefully so as not to cause the cylinder block catch the rod big end. Set the rod caps and crankpin metals in their correct combinations.

Reassemble :

- Apply oil especially carefully to the sliding contact surfaces of the pistons, rods and rings.
- Use the piston insertion tool to insert each piston w/rod in the cylinder block and install the bearing metal cap.
  Rod bolt tightening torque : T = 33.0 to 36.0 ft•lbf. (44.1 to 49.0 N•m), apply lube oil

Point 3 Mounting flange

Disassemble :

- Place the engine on a stable base with the cylinder block upper surface facing down, and remove the mounting flange carefully so as not to damage the combustion surface.

Reassemble :

- Apply sealant (code No.977770-01212) and install the mounting flange by matching the two dowel pins. After assembly, raise the engine with its mounting flange on the bottom side.

⚠ CAUTION

Unforeseen injury may arise due to falling of slipping when raising or reversing the engine. Carefully operate so as not to lose balance.

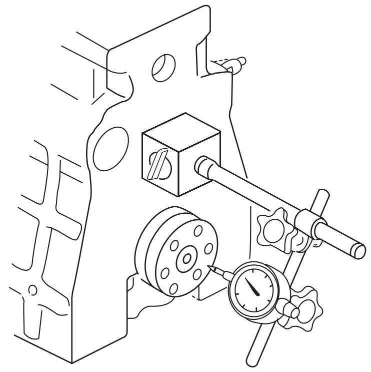
Point 4 Journal bearing cap

Disassemble :

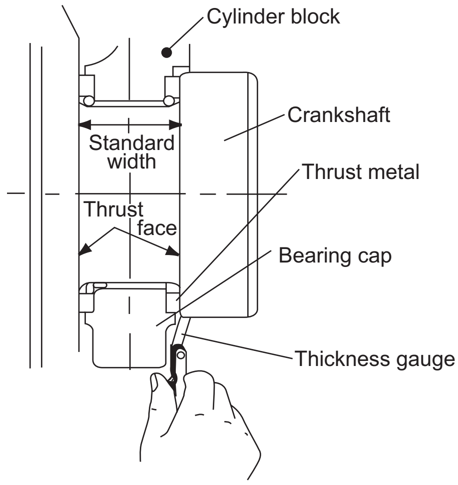
- Before removing the journal bearing, measure the crankshaft side gap. Measure it in either method because there are the next two methods.

[1] Install a dial gage on the cylinder block, and move a crankshaft in front and back, and measure the side gap as shown in the right figure.

[2] Put a thickness gauge in the clearance between thrust metal and crankshaft directly, and measure it.



Side gap measurement 1



Side gap measurement 2

Side gap standard

in. (mm)

Model	Standard	Limit
All models	0.0051 to 0.0091 (0.13 to 0.23)	0.0110 (0.28)

Reassemble :

- If the side gap exceeds the standard, replace the thrust metal with an oversize one.
  Machine the standard width of the crankshaft thrust part into the dimension of the below table at the same time.
  Refer to a parts catalog when ordering the part.

  The surface finishing precision (refer to 4.4.5(2) in Chapter4): 1.6

0.0098 in. (0.25 mm) Oversized thrust metal (0.25 DS)

in. (mm)

Thrust metal assy code	Standard thickness
129150-02940	0.0809 to 0.0829 (2.055 to 2.105)

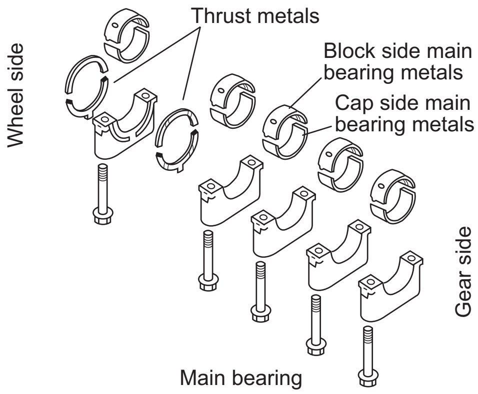
The standard width of the crankshaft thrust part

in. (mm)

Model	Standard thickness
3TNV88	1.1122 to 1.1130 (28.250 to 28.271)

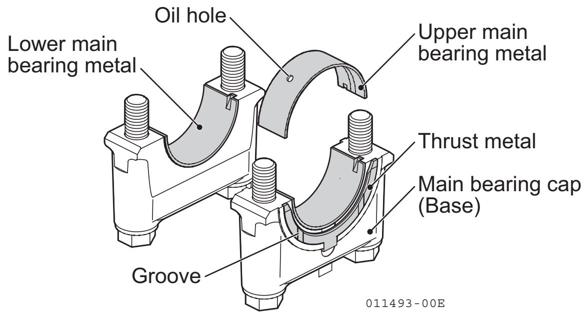
Disassemble :

- Remove the bearing caps, cap side bearings, and thrust metals. Place each thrust metal with identification of the position and direction.
  The position number of reassembling is punched on a metal cap (except for both ends) and a cylinder block.



Reassemble :

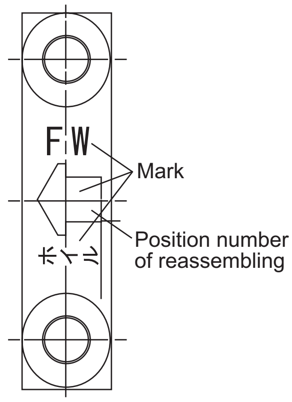
- Carefully install each thrust metal so that the grooved one is positioned away from the cap.
- Do not confuse the upper and lower main bearing metals. The upper main bearing metal (block side) has an oil hole, and the lower one does not. The “arrow” marks on the cap shall face the flywheel. Tighten main bearing cap bolts.



Main bearing cap bolt tightening torque (apply lube oil)

ft•lbs (N•m)

Standard
69.0 to 76.0 (93.2 to 98.1)



Journal bearing cap

Point 5 Crankshaft

Disassemble :

- Remove the crankshaft. Remove each main bearing metal upper (block side) and pair it with the metal cap side lower metal.

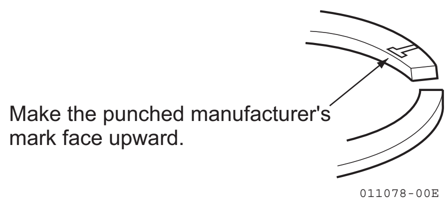
⚠ CAUTION

Carefully prevent damage to the bearing or finger injury when removing the crankshaft because it is heavy.

Point 6 Piston pin and rings

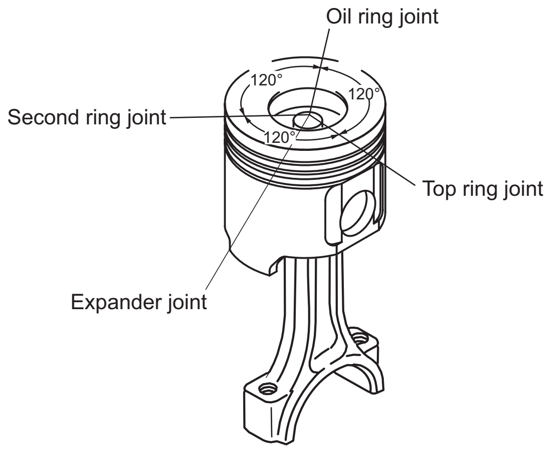
Disassemble :

- Use the piston ring replacer, remove the piston rings.
- Remove the circlip and remove the piston pin by pushing it out.



Reassemble :

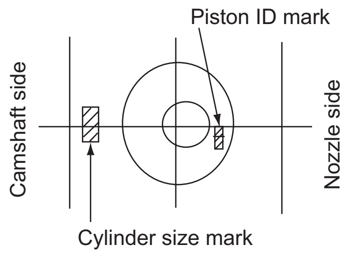
- Install each piston ring on the piston, with the punched manufacturer's mark facing upward.



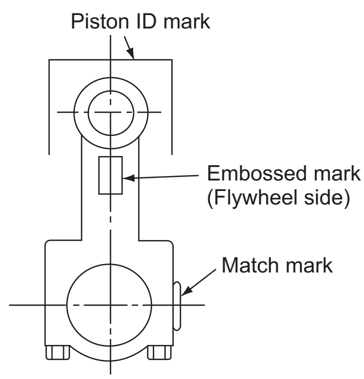
Ring joins

Reassemble :

- The piston ring joints shall be staggered at by 120 degrees intervals. Do not position the top ring joint vertical to the piston pin. The coil expander joint shall be opposite to the oil ring joint.



Flywheel side



(Assembly direction of connecting rod and piston)

Reassemble :

- When installing the piston pin to the rod and piston, the punched match mark on the big end of the connecting rod shall be opposite to the size mark on the piston top.

Reassemble :

- Install the piston in the cylinder block with the punched mark on the big end of the rod on the nozzle side.(The embossed mark at the connecting rod I-beam section shall be on the flywheel side.)

Point 7 Oil seal

Reassemble :

- Replace the oil seal with a new one whenever disassembled. Apply lithium grease at the time of assembly.

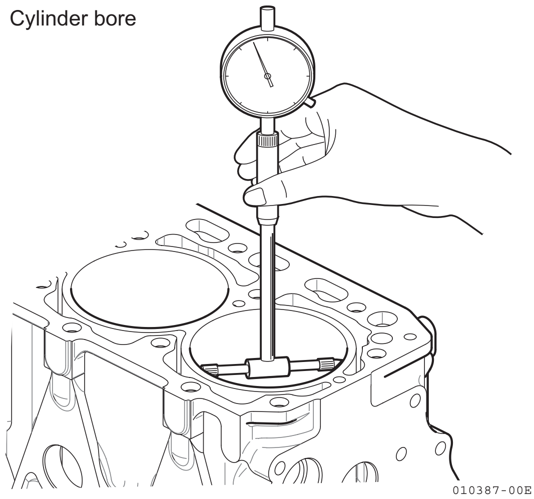
5) Parts Inspection and Measurement

(1) Cylinder block

Especially clean head surface, cylinder bores and oil holes, and check after removing any carbon deposit and bonding agent.

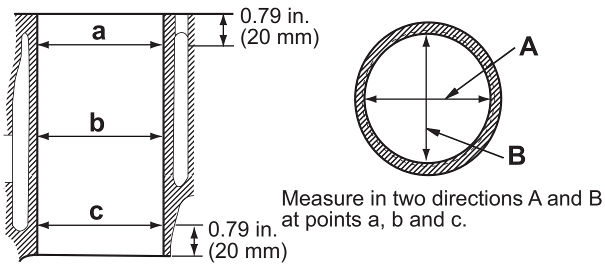
[1] Appearance inspection
Check if there is any discoloration or crack. If crack is suspected, perform color check. Sufficiently clean the oil holes and check they are not clogged.

[2] Cylinder bore and distortion
Measure at 0.39 in.(10 mm) below the crest of the liner, at 0.79 in.(20 mm) from the bottom end and at the center.
Roundness : Maximum value of the difference between the measured values in the same cross section.
Cylindricity : Maximum value of the difference between the measured values in the same direction.



in. (mm)

	Standard	Limit
Bore	3.4646 to 3.4657 (88.000 to 88.030)	3.4724 (88.200)
Roundness	0.0004 (0.01) or less	0.0012 (0.03)
Cylindricity	0.0004 (0.01) or less	0.0012 (0.03)



Cylinder bore measurement positions

[3] If the limit is exceeded or any surface defect is found, repair by boring and honing. Use an oversized piston (and new piston rings) as required.

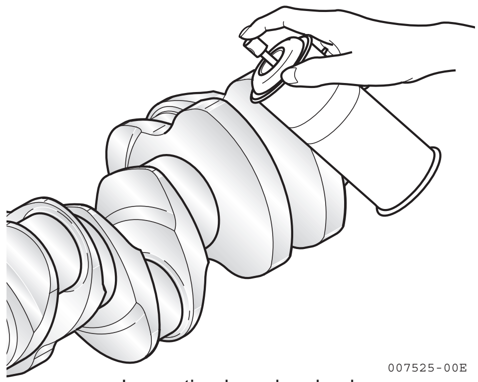
0.25 OS	Piston ass'y code (incl./Piston ring ass'y)	Piston ring ass'y code	Boring dimension in. (mm)
	129005-22900	129005-22950	Ø3.4744 to Ø3.4756 (Ø88.250 to Ø88.280)

(2) Crankshaft

Mainly check seizure and wear of the crankpins and journals. Since the crankshaft gear is shrink-fitted, heat to 356 to 392°F (180 to 200°C) when extraction is necessary.

[1] Shaft portion color check

After washing the crankshaft, inspect it by means of color check or a magnaflux inspector. Replace it if cracked or heavily damaged. Slight defects shall be corrected by grinding.

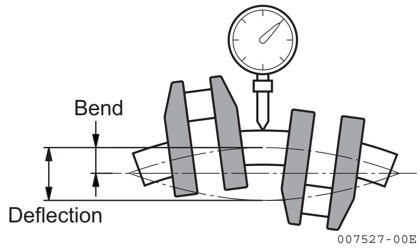


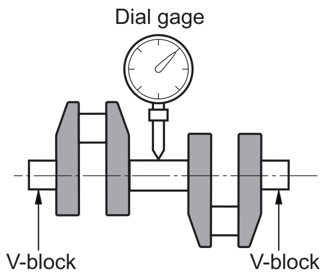
Inspection by color check

[2] Crankshaft bend

Support the crankshaft journals at both ends with V-blocks. Use a dial gage and measure the runout at the center journal while rotating the shaft to inspect the bend.

Limit	0.00079 in. (0.02 mm) or less

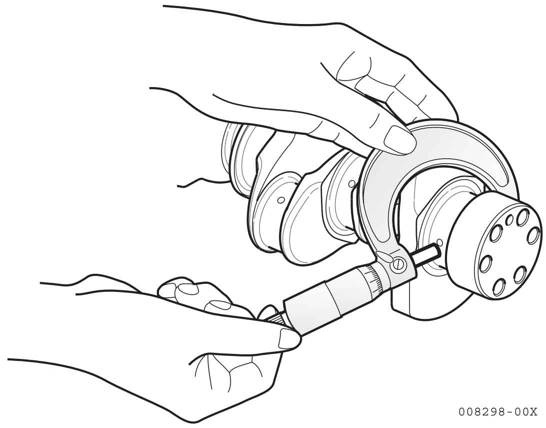


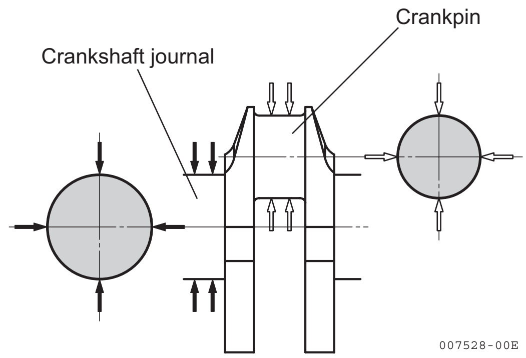


Crankshaft bend measurement

014025-00E

[3] Crankpin and journal measurement
Measure the outside diameter, roundness and taper at each crankpin and journal.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Replace if the defect is excessive.





Measuring position of the crankpin and crank journal

• Crankpin

in. (mm)

	Standard	Limit
Pin outside diameter	1.8879 to 1.8883 (47.952 to 47.962)	2.2796 (47.902)
Metal thickness	0.0587 to 0.0591 (1.492 to 1.500)	–
Oil clearance	0.0015 to 0.0029 (0.038 to 0.074)	0.0059 (0.150)

If the oil clearance exceeds the limit, use an undersized bearing.

0.25 US bearing

in. (mm)

Part code	129150-23610
Standard thickness	0.0637 to 0.0640 (1.617 to 1.625)
Pin machining dimension	Ø1.8780 to Ø1.8784 (Ø47.702 to Ø47.712)

• Crank journal

in. (mm)

	Standard	Limit
Journal O.D.	2.1241 to 2.1245 (53.952 to 53.962)	2.1221 (53.902)
Metal thickness	0.0786 to 0.0783 (1.995 to 1.990)	–
Oil clearance	0.0015 to 0.0027 (0.038 to 0.068)	0.0059 (0.150)

If the clearance limit is exceeded, use an undersized bearing.

• 0.25 US Crank journal bearing

in. (mm)

Part code	129150-02870
Standard thickness	0.0831 to 0.0837 (2.112 to 2.125)
Journal bearing machining dimension	Ø2.1142 to Ø2.1146 (Ø53.702 to Ø53.712)

Notice :

- *If the oil clearance is excessive though the thicknesses of the journal and crankpin metals are normal or if partial uneven wear is observed, re-grind the crankshaft and use an oversized metals.*
- *If rust or surface roughening exists on the rear side of the metals, coat it with blue or minimum. Then assemble the crankpin metal to the connecting rod, and tighten the rod bolt to the specified torque to check the metal for contact. If the contact surface occupies 75% or more, the metal is normal. If the contact surface is insufficient, the metal interference is insufficient. Replace the metal with a new one.*

(3) Thrust metal inspection

Inspect any damage or wear.

[1] Thickness

in. (mm)

	Standard	Limit
Thickness	0.0760 to 0.0780 (1.930 to 1.980)	0.0728 (1.850)

[2] Side gap

in. (mm)

	Standard	Limit
Side gap	0.0055 to 0.0087 (0.14 to 0.22)	0.0110 (0.28)

If the side gap is exceeded, use an oversized thrust metal.

0.25 OS	129150-02940
Standard thickness	0.0809 to 0.0829 in. (2.055 to 2.105 mm)

(4) Piston

Especially clean the combustion surface, circumference, ring grooves and piston pin bosses, and check after removing any carbon deposit. Any burr at a ring groove or snap ring groove shall be removed. If crack is suspected, inspect by color check.

[1] Piston outside diameter measurement

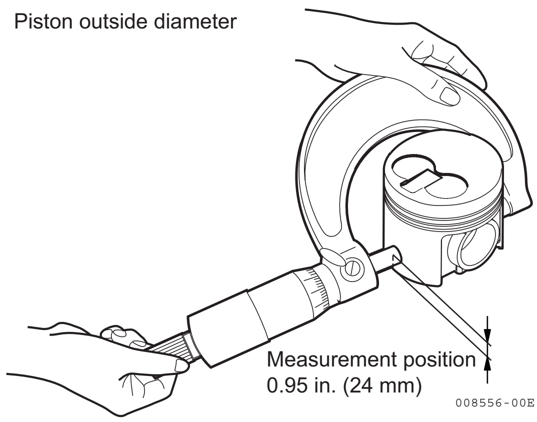
Measure the long diameter at 0.95 in. (24 mm) from the bottom end of the piston of the oval hole in the vertical direction to the piston pin hole.

in. (mm)

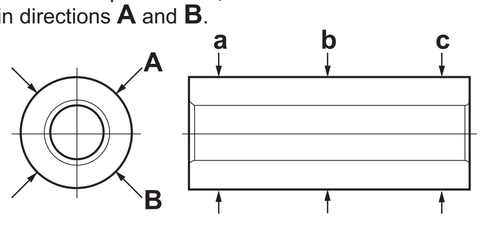
		Standard	Limit
Long diameter		3.4622 to 3.4634 (87.940 to 87.970)	3.4604 (87.895)
Clearance between piston and cylinder	Min.	0.0018 (0.045)	0.0016 (0.040)
	Max.	0.0030 (0.075)	0.0028 (0.070)

If the clearance between piston and cylinder exceeds the limit, use an oversized piston.

Piston outside diameter



Measure at positions **a**, **b** and **c** in directions **A** and **B**.



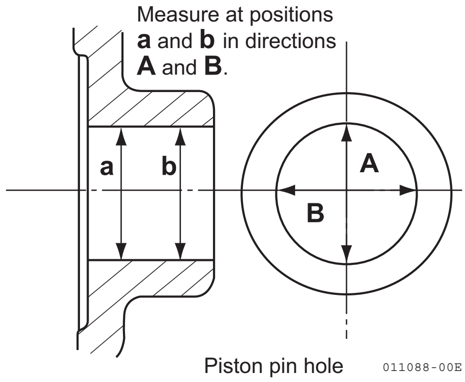
Piston pin outside diameter

0.25 OS	Piston ass'y code (incl./Piston ring ass'y)	Piston ring ass'y code	Boring dimension in. (mm)
	129005-22900	129005-22950	Ø3.4744 to Ø3.4756 (Ø88.250 to Ø88.280)

[2] Piston pin hole measurement

in. (mm)

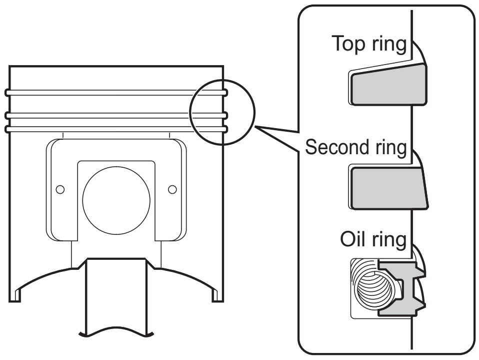
	Standard	Limit
Pin hole diameter	1.0236 to 1.0240 (26.000 to 26.009)	1.0252 (26.039)
Pin outside diameter	1.0234 to 1.0236 (25.995 to 26.000)	1.0222 (25.965)
Oil clearance	0.000 to 0.0006 (0.000 to 0.014)	0.0029 (0.074)



Piston pin hole

[3] Piston ring, ring groove and end clearance measurement

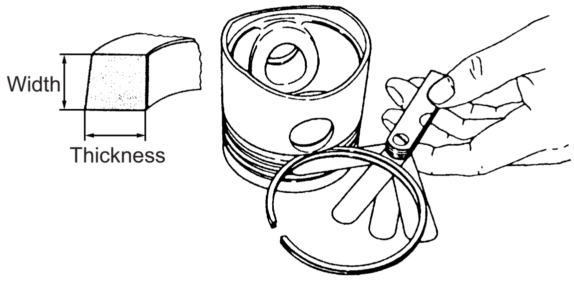
- Except for the top ring, to measure the piston ring groove width, first measure the width of the piston ring. Then insert the piston ring into the ring groove. Insert a thickness gage in between the piston ring and groove to measure the gap between them. Obtain the ring groove width by adding ring width to the measured side clearance.
- To measure the end clearance, push the piston ring into the sleeve using the piston head, insert a thickness gage in end clearance to measure. The ring shall be pushed in to approx.1.18 in. (30 mm) above the bottom end of the cylinder. For the top ring, measure only the piston ring joint end clearance in normal state.



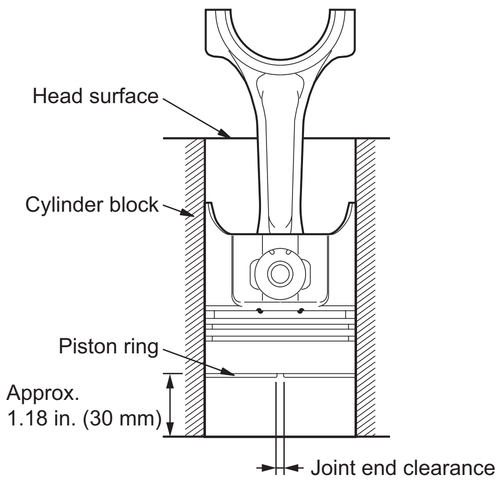
Ring components

in. (mm)

		Standard	Limit
Top ring	Ring groove width	0.0811 to 0.0817 (2.060 to 2.075)	–
	Ring width	0.0776 to 0.0783 (1.970 to 1.990)	0.0768 (1.950)
	Side clearance	0.0028 to 0.0041 (0.070 to 0.105)	–
	End clearance	0.0079 to 0.0157 (0.200 to 0.400)	0.0193 (0.490)
Second ring	Ring groove width	0.0797 to 0.0803 (2.025 to 2.040)	0.0843 (2.140)
	Ring width	0.0776 to 0.0783 (1.970 to 1.990)	0.0768 (1.950)
	Side clearance	0.0014 to 0.0028 (0.035 to 0.070)	0.0075 (0.190)
	End clearance	0.0079 to 0.0157 (0.200 to 0.400)	0.0193 (0.490)
Oil ring	Ring groove width	0.1581 to 0.1587 (4.015 to 4.030)	0.1626 (4.130)
	Ring width	0.1563 to 0.1571 (3.970 to 3.990)	0.1555 (3.950)
	Side clearance	0.0010 to 0.0024 (0.025 to 0.060)	0.0071 (0.180)
	End clearance	0.0079 to 0.0157 (0.200 to 0.400)	0.0193 (0.490)



Measuring side clearance



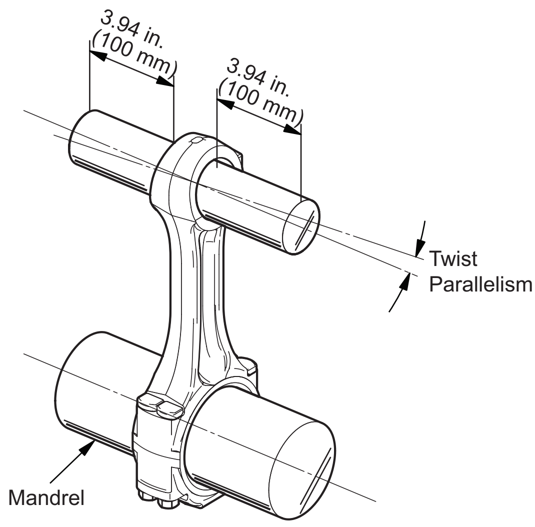
Ring joint end clearance measurement

001524-01E

(5) Connecting rod

[1] Appearance inspection

Inspect the portion near the boundary of the chamfered portion and I-beam section of the big and small ends of the connecting rod as well as the portion near the oil hole of the bushing at the small end for cracks, deformation, and discoloration.



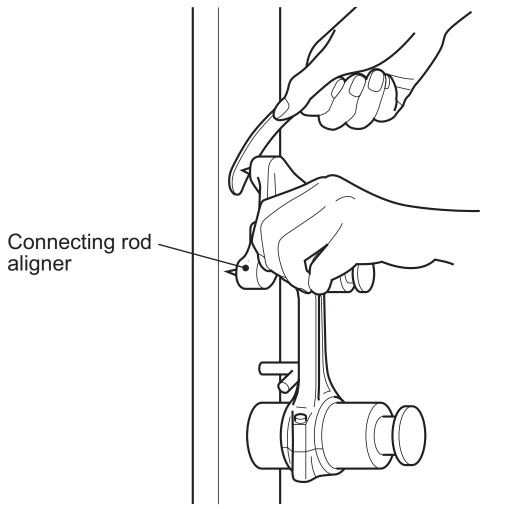
Twist and parallelism measurement 008726-00E

[2] Twist and parallelism measurement

Use a connecting rod aligner and measure the twist and bend.

in. (mm)

	Standard dimension	Limit dimension
Twist and parallelism	0.0012 (0.03) or less per 3.94 (100)	0.0031 (0.08)



Twist measurement using a connecting rod aligner 011233-00E

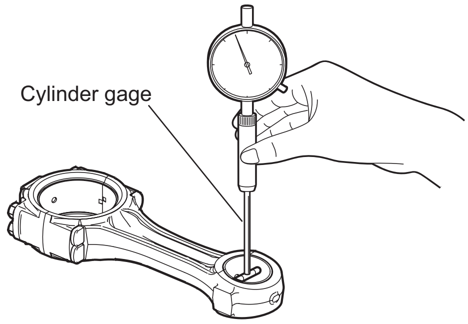
[3] Rod small end measurement

Measure the pin outside diameter according to (4) [1] described above.

in. (mm)

	Standard	Limit
Piston pin I.D. bushing	1.0246 to 1.0251 (26.025 to 26.038)	1.0263 (26.068)
Piston pin O.D.	1.0231 to 1.0236 (25.995 to 26.000)	1.0220 (25.967)
Oil clearance	0.0010 to 0.0017 (0.025 to 0.043)	0.0040 (0.101)

If the bushing is to be replaced because the oil clearance exceeds the limit, use spare part code No.129100-23910.

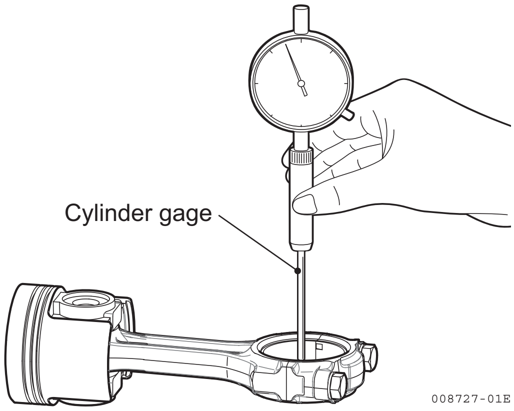


Connecting rod small end 008728-00E

[4] Rod big end measurement

Measure the crankpin and bushing according to (2) [3] described above.

Calculate the oil clearance of a crank pin metal and a crank pin from the measured values of the crank pin metal inner diameter and the crank pin outside diameter.
Replace a crank pin metal if the oil clearance becomes about the limit dimension of the below table.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Also use an undersized metal.



Rod bushing I.D. measurement

Notice :
When measuring the inside diameter of the rod big end, install the crankpin metals in the rod big end not to mistake the top and bottom of the metals and tighten the rod bolts by the standard torque.

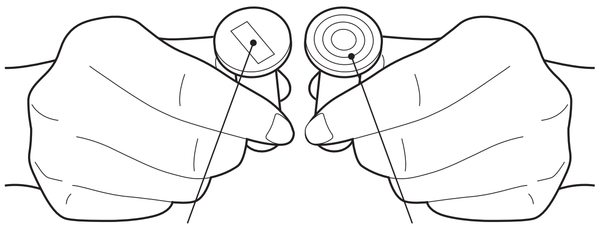
Tightening torque of rod bolt

Tightening torque ft•lbf (N•m)	Lubricating oil application (threaded portion, and bearing seat surface)
33 to 36 (44.1 to 49.0)	Lube. oil applied

Standard of rod big end in. (mm)

Item	Standard	Limit
Rod I.D. bushing	1.8879 to 1.8883 (47.952 to 47.962)	1.8859 (47.902)
Crankpin O.D.	1.8898 to 1.8908 (48.000 to 48.026)	-
Metal thickness	0.0587 to 0.0591 (1.492 to 1.500)	-
Clearance	0.0015 to 0.0029 (0.038 to 0.074)	0.0059 (0.150)

(6) Tappet
Mainly check the tappet contact surface with the cam and push rod. Slight surface defects shall be corrected with an oilstone.

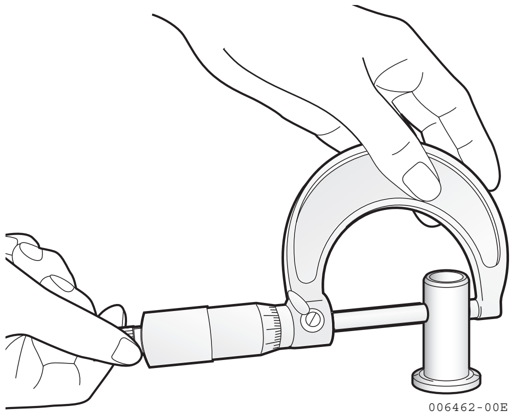


Tappet

[1] Tappet stem outside diameter measurement

in. (mm)

	Standard	Limit
Stem O.D.	0.4715 to 0.4720 (11.975 to 11.990)	0.4707 (11.955)
Tappet hole I.D.	0.4724 to 0.4734 (12.000 to 12.025)	0.4742 (12.045)
Oil clearance	0.0004 to 0.0020 (0.010 to 0.050)	0.0035 (0.090)

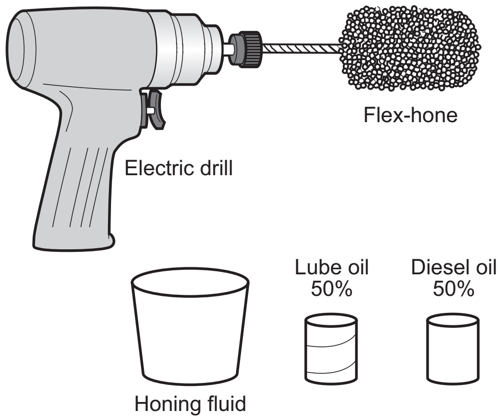


Tappet stem outside diameter measurement

6) Cylinder Bore Correction

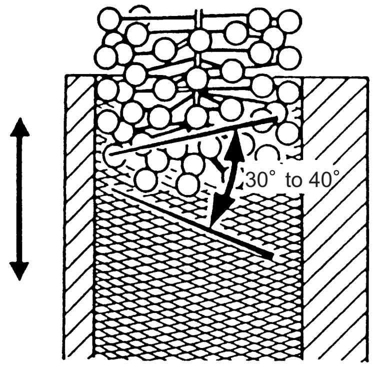
[1] Slight uneven worn, flawed, etc. shall be corrected by honing only. If the cylinder is unevenly worn partially, flawed or otherwise damaged and cannot be repaired simply by honing, rebore the cylinder first and then hone. See 5) (1) [3] for the boring dimension.

[2] Items to be prepared for honing
- Flex-Hone
- Electric drill
- Honing fluid (50 : 50 mixture of lube oil and diesel oil)



Items to be prepared for honing

[3] Apply the honing fluid to the Flex-Hone and turn the electric drill at 300 to 1200 RPM. Then insert the Flex-Hone into the cylinder bore while turning it, and move it up and down for about 30 sec. to obtain a honing mark with a cross hatch angle of 30 to 40 degrees.



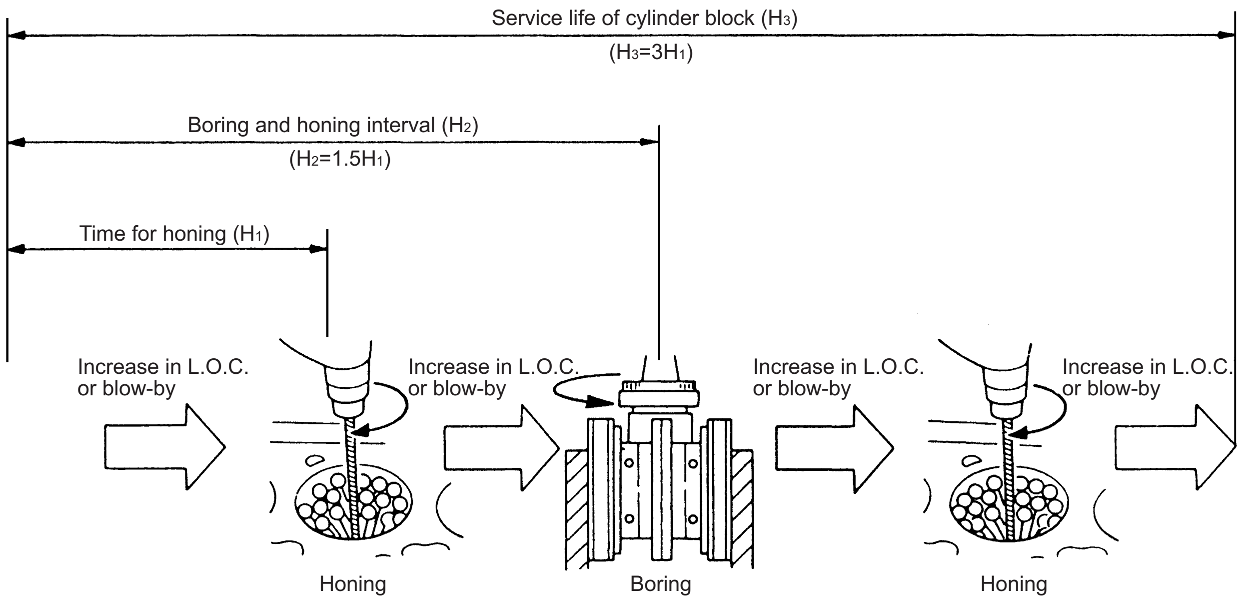
Honing cross hatch

in. (mm)

Cylinder bore after re-boring and honing	3.4744 to 3.4756 (88.250 to 88.280)
Sureface roughness	Rmax 0.04 to 0.14 S (1.0 to 3.5 S)
Roundness (Cylindericity)	0.0004 (0.01) or less

Notice :
- *Avoid faster revolution than 1200 RPM since it may cause breakdown.*
- *Do not insert or extract the Flex-hone in stopped state because the cylinder will be damaged.*

- Cylinder overhaul (reference)



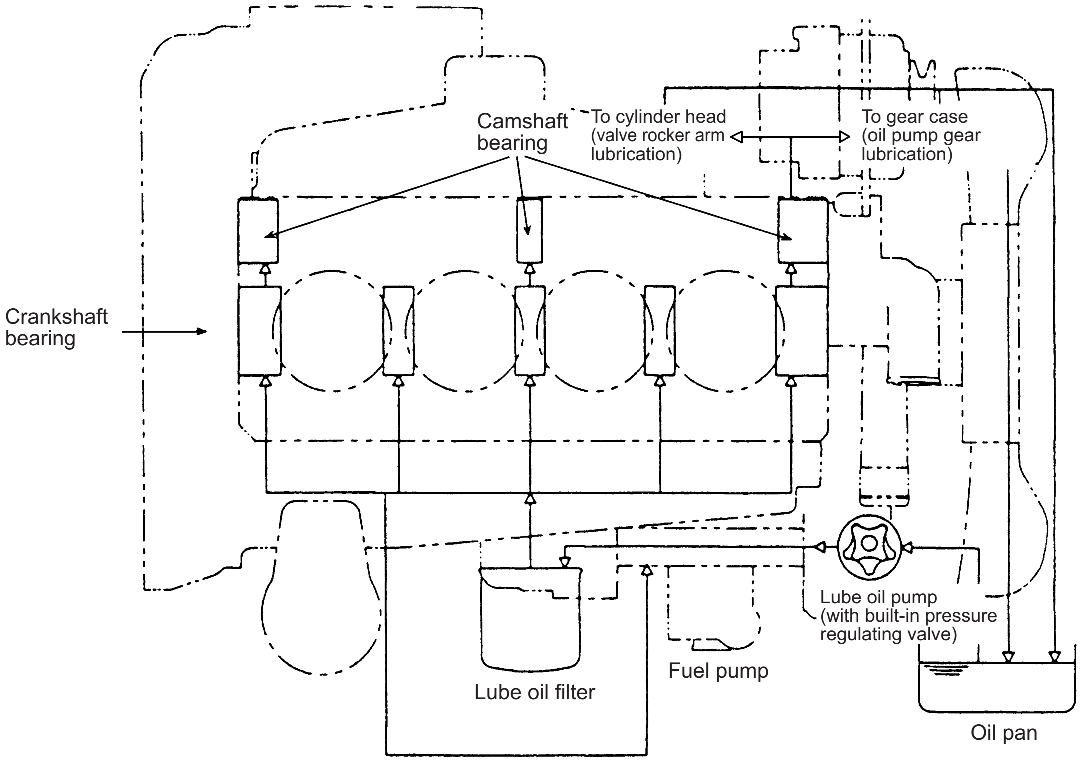
Study if an oversized piston or piston ring is usable

(7) Piston pin bushing replacement
Replace bushing by using the special service tool.

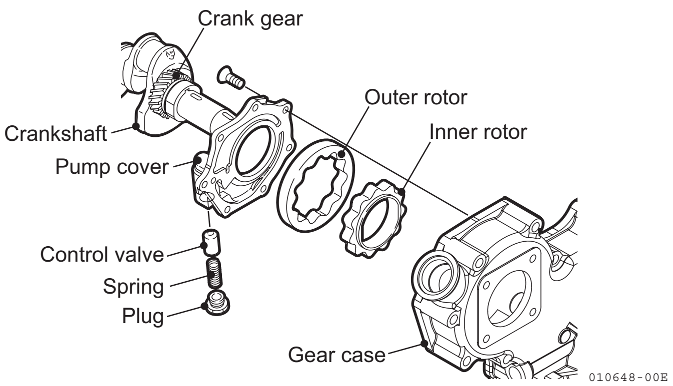
(8) Oil seal replacement
[1] Replace oil seal, when mounting flange is removed. Extract the used oil seal.
[2] Insert a new oil seal with the oil seal insertion tool.
[3] Apply lithium grease.

4-5 Lubrication System

4-5-1 Lubrication System Diagram



4-5-2 Trochoid Pump Components



4-5-3 Disassembly (Reverse the Procedure Below for Assembly)

[1] Loosen the belt, and remove the radiator pulley, fan and V-belt. See 4-4-2 2) 2 in Chapter 4-4.

[2] Remove the crankshaft pulley. See 4-4-3 2) 3 in Chapter 4-4.

[3] Remove the gear case cover. See 4-4-3 2) 4 in Chapter 4-4.

[4] Remove the lubricating oil pump ass'y from the gear case. ***(Point 1)***

[5] Remove the pressure regulating valve from the lubricating oil pump body. ***(Point 2)***

4-5-4 Servicing Points

Point 1

Disassemble :

- Check if the pump rotates smoothly and see that there is no play between the shaft and gear, and inner rotor.

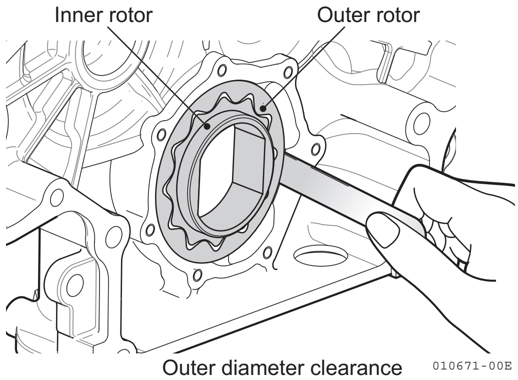
Reassemble :

- Install the outer rotor in the gear case so that the punch mark on the end face is seen.
- When replacing the lubricating oil pump, replace the whole ass'y.

Point 2

Disassemble-reassemble :

- Only wash the pressure regulating valve. Disassembly is unnecessary unless any abnormality in operation is detected.



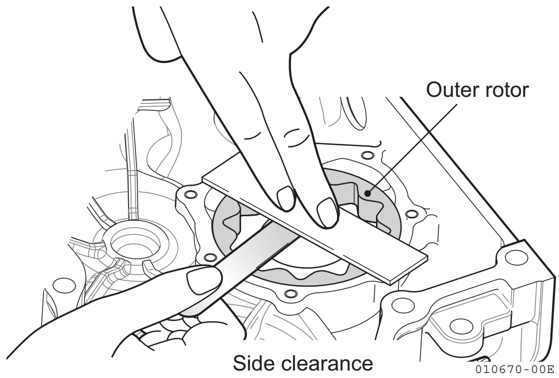
4-5-5 Parts Inspection and Measurement

1) Outer Rotor

- Oil clearance between the outer rotor and inside diameter of the gear case hole.
- Side clearance between outer rotor and gear case hole.

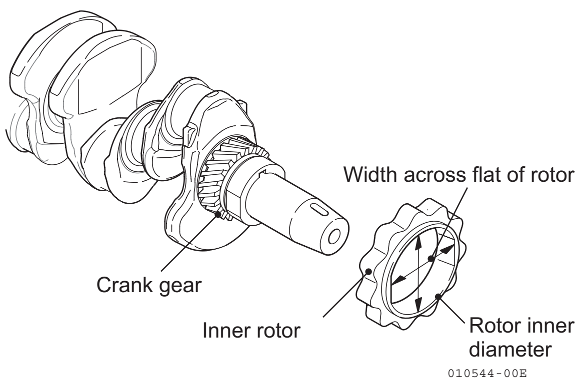
in. (mm)

	Standard	Limit
Oil clearance	0.0047 to 0.0083 (0.12 to 0.21)	0.0118 (0.30)
Side clearance	0.0008 to 0.0028 (0.02 to 0.07)	0.0047 (0.12)



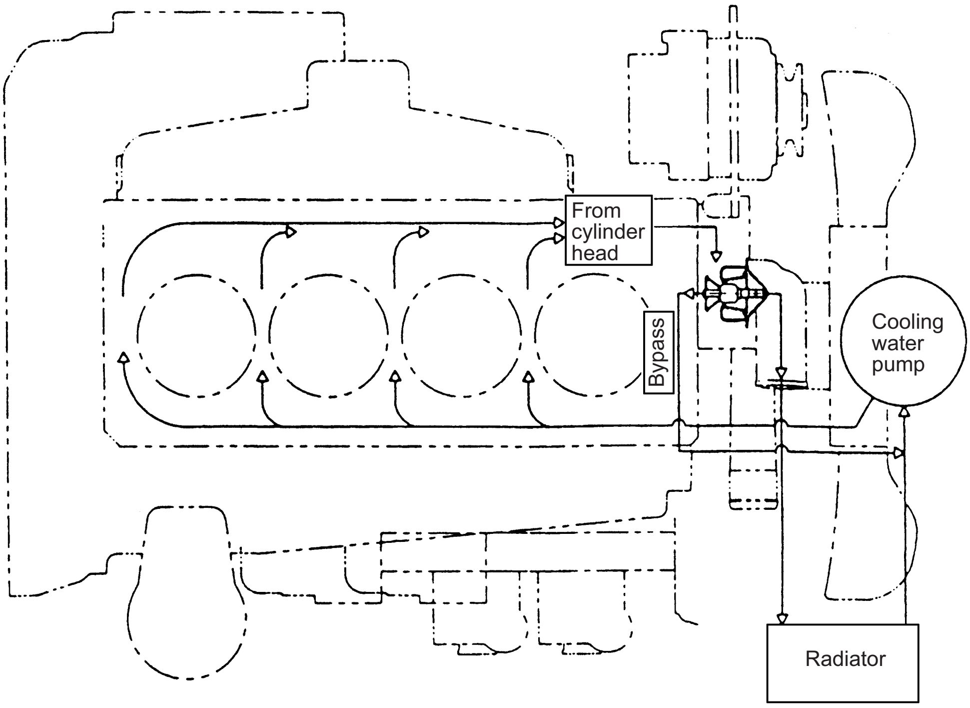
2) Inner Rotor and Gear Boss Clearance

Item	Part	Standard dimension in. (mm)	Standard clearance in. (mm)	Standard clearance limit in. (mm)
Inside clearance of inner rotor	Gear boss diameter	2.089 to 2.093 (53.05 to 53.15)	0.012 to 0.020 (0.3 to 0.5)	0.024 (0.6)
	Rotor inner diameter	2.104 to 2.108 (53.45 to 53.55)		
Width across flat clearance of inner rotor	Width across flat of gear boss	1.947 to 1.959 (49.45 to 49.75)	0.008 to 0.024 (0.2 to 0.6)	0.028 (0.7)
	Width across flat of rotor	1.967 to 1.971 (49.95 to 50.05)		

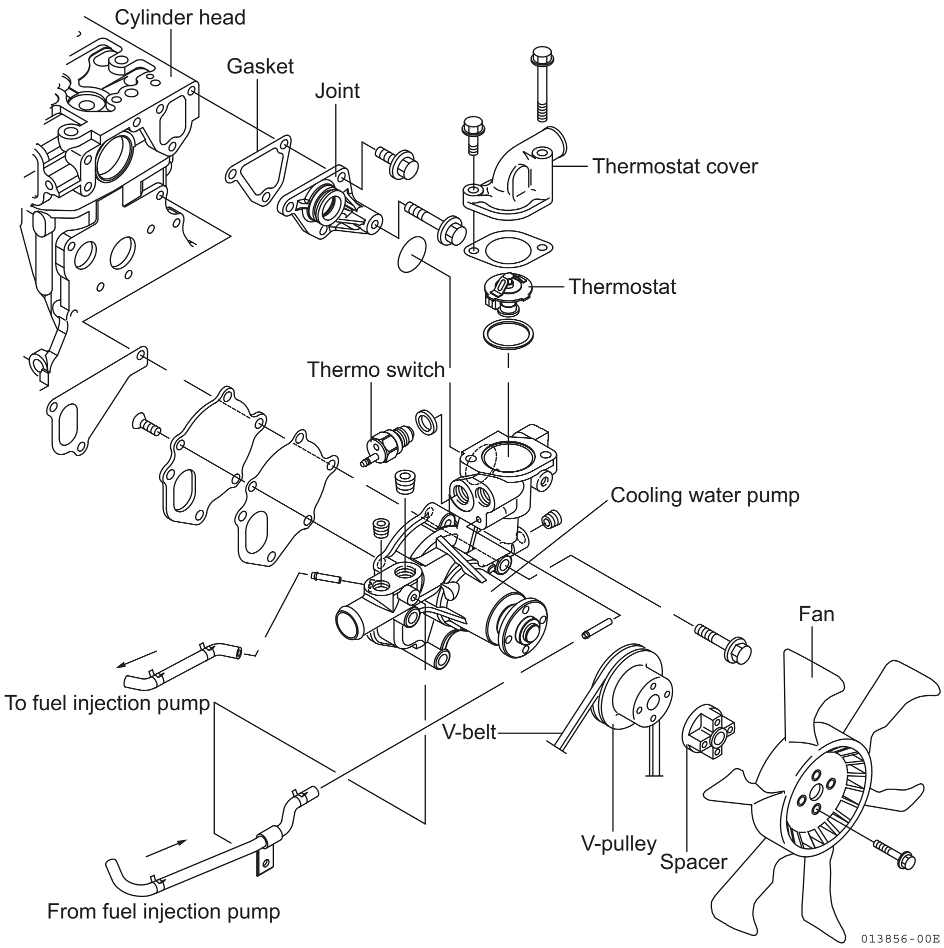


4-6 Cooling System

4-6-1 Cooling Water System



4-6-2 Cooling Water Pump Components



4-6-3 Disassembly (Reverse the Procedure Below for Assembly)

[1] Remove the alternator. See 4-4-2 2) 1 in Chapter 4-4.
[2] Remove the fan, V-belt and pulley. See 4-4-2 2) 2 in Chapter 4-4.
[3] Remove the thermostat cover. See 4-4-2 2) 3 in Chapter 4-4.
[4] Remove the cooling water pump. ***(Point 1)***
[5] Remove the thermostat. ***(Point 2)***

4-6-4 Servicing Points

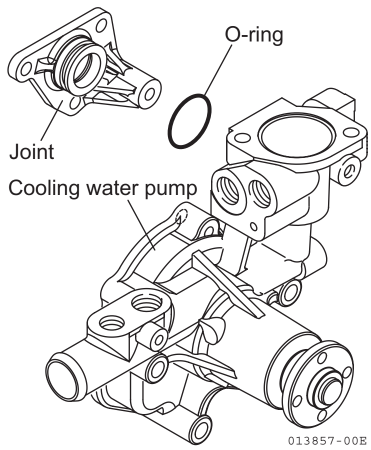
Point 1

Disassemble-Reassemble :

- Check to see that the cooling water pump bearing is free from abnormal noise, sticking or play and water leakage from the bearing. If replacement is necessary, replace the whole cooling water pump ass'y.

Notice :

Replace the O-ring of the cooling water pump with new one when disassembling. And, be sure to use the special O-ring for each engine model, because the material is different, although the dimension is the same as a commercial part. (Refer to the right figure.)



Point 2

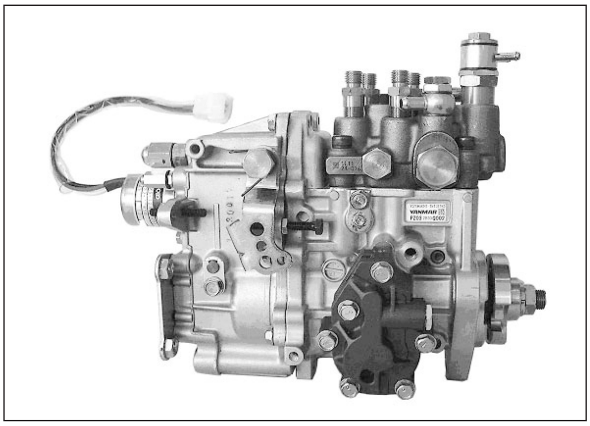
Disassemble :

- Check the thermostat function. See 4-3-8 (1) [1] in Chapter 4-3 for the inspection method.

4-7 Fuel Injection Pump / Governor

Only the outline of the MP fuel pump is explained in this chapter. Refer to the MP pump service manual of the separate volume for the disassembly and assembly.

4-7-1 Introduction



It is described about the features of the fuel injection pump, YDP-MP, manufactured by Yanmar, disassembly, assembly and adjustment procedure.

Fuel injection pump is the most important equipment, which is enable to make the sensitive adjustment according to the variable load of the engine.

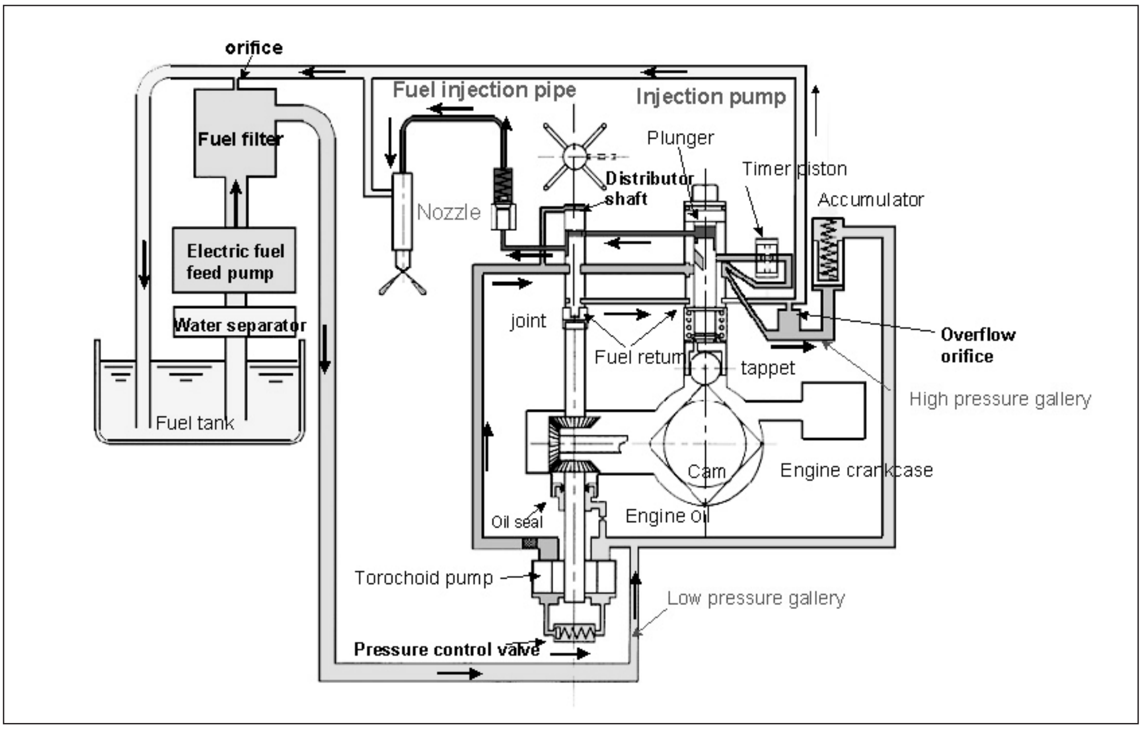
Therefore all of the parts are required not only very precise machining but also finest, assembling with top level.
The careful arrangement of keeping off the dust and the rust when disassemble, adjustment and reassemble of the fuel injection pump is made in the market.

Yanmar YDP-MP Pump is a distributor type pump which is unified of Mono-plunger, a distributing shaft, a hydraulic head which equipped the delivery valve for each cylinder, pump housing which has a cam shaft internally and governor.
The fuel, which is pressurized by the up and down movement of the plunger driven by the cam-rotation, is supplied through the distributor shaft, which is rotating accordingly.

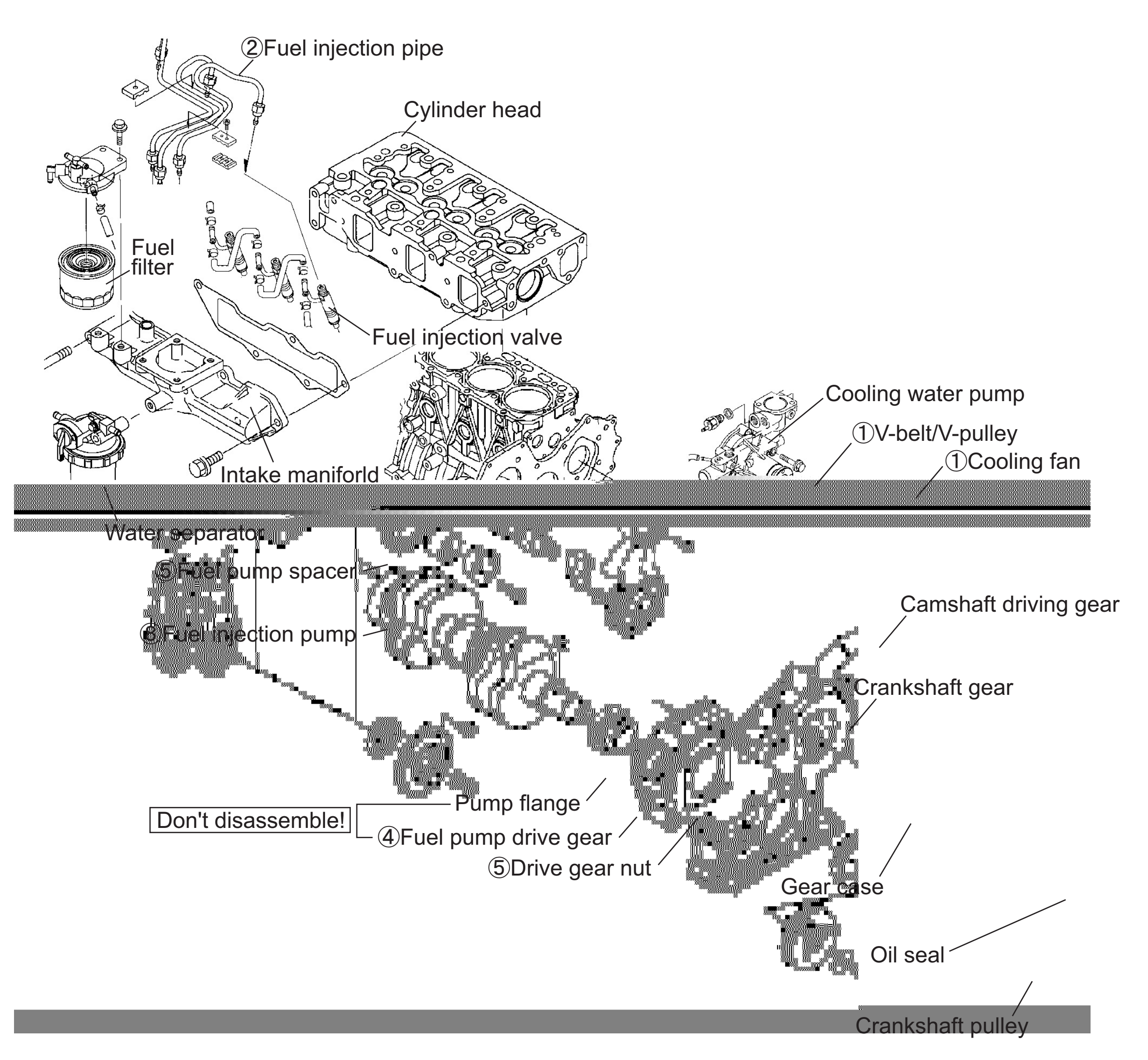
There are a model YDP-MP2 and a model YDP-MP4, and plunger diameter and fuel cam speed are different.

4-7-2 Fuel Injection Pump

1) Fuel System Diagram



2) External View and Components



3) Disassembly Procedure :

Disassembly from the engine body

(1) Remove the cooling fan, pulley and V-belt.

(2) Remove the fuel injection pipe, fuel oil piping, fuel return pipe and rear stay. See point 1 of 5).

(3) Remove the fuel injection pump cover (the cover of the drive gear).

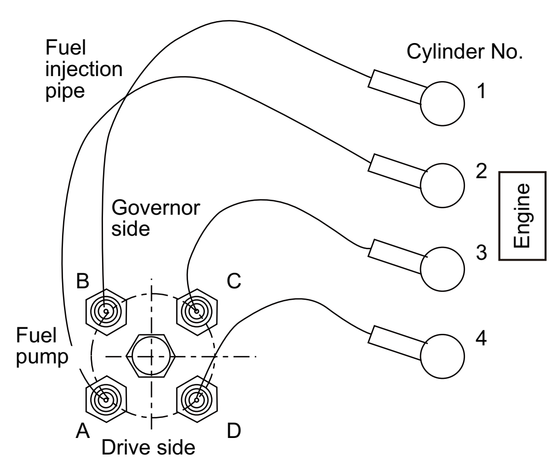
(4) Make ID marks on the gearing part of the pump drive gear and the idle gear with paint and so on. See Point 2 of 5).

(5) Loosen a fuel pump drive gear nut, and remove a pump drive gear from the fuel pump by using a gear puller. See Point 3 of 4-4-3 4).

(6) Remove a drive gear nut carefully not to drop it to the inside of the gear case.

(7) Record the installation angle of the fuel pump precisely by using a mark-off line and a sticker. See 4-3-7.

(8) Remove the fuel injection pump. See Point 3 of 5).



Fuel pump

4) Assembly Procedure

Reverse the disassembly procedure and adjust the fuel injection timing finally. See (4) of 4-3-7.

5) Servicing Points

Point 1

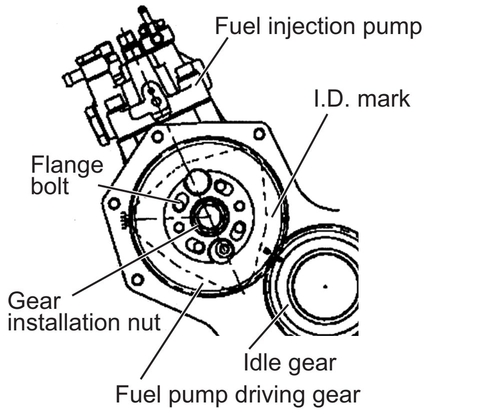
Disassemble :

- Block an entrance with the tape so that trash may not enter the fuel injection pipe and the fuel injection pump.

Point 2

Disassemble :

- After putting the I.D. marks on the gearing part of the pump drive gear and the idle gear with paint and so on, remove the gear installation nut.



Fuel pump driving gear

Notice :

Don't remove four flange bolts.

Reassemble :

- Reassemble the pump driving gear while checking the I.D. marks on the driving gear and idle gear.

Tightening torque of the gear installation nut

ft•lbf (N•m)	Lubricating oil application (thread portion, and seat surface)
58 to 65 (78 to 88)	Not applied

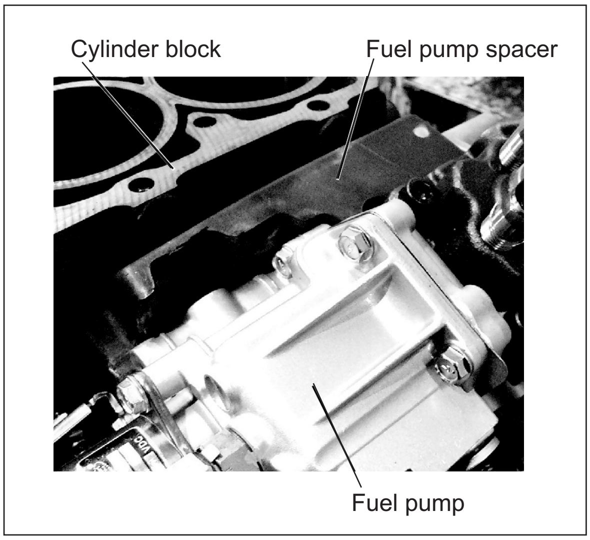
Point 3

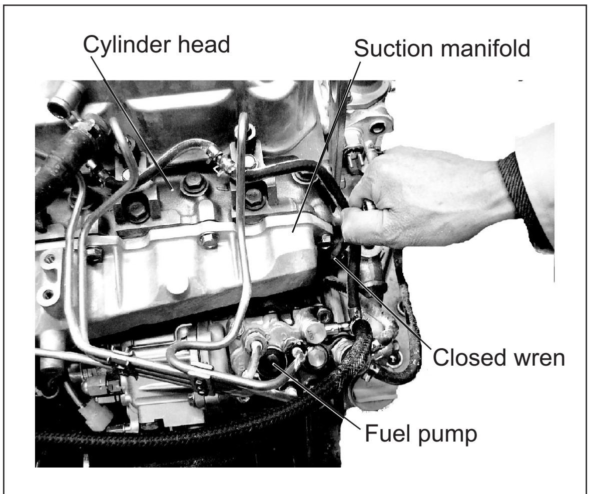
Disassemble :

There is an acoustic material part to name as fuel pump spacer between the fuel pump and the cylinder block. Loosen fuel pump installation bolts with a closed wrench when disassembling a fuel pump.

Notice :

An intake manifold may obstruct the disassembly of the fuel pump by the engine model. Remove the fuel pump after removing the intake manifold first.





Disassembling a fuel pump

Reassemble :

When installing a fuel pump on the gear case, put a fuel pump spacer between the cylinder block and the pump.

See the Service Manual of "Fuel Injection Equipment (Model YPD-MP2 / YPD-MP4 series)" for further information of the fuel injection pump.

4-8 Electrical Equipment

4-8-1 Starter Motor

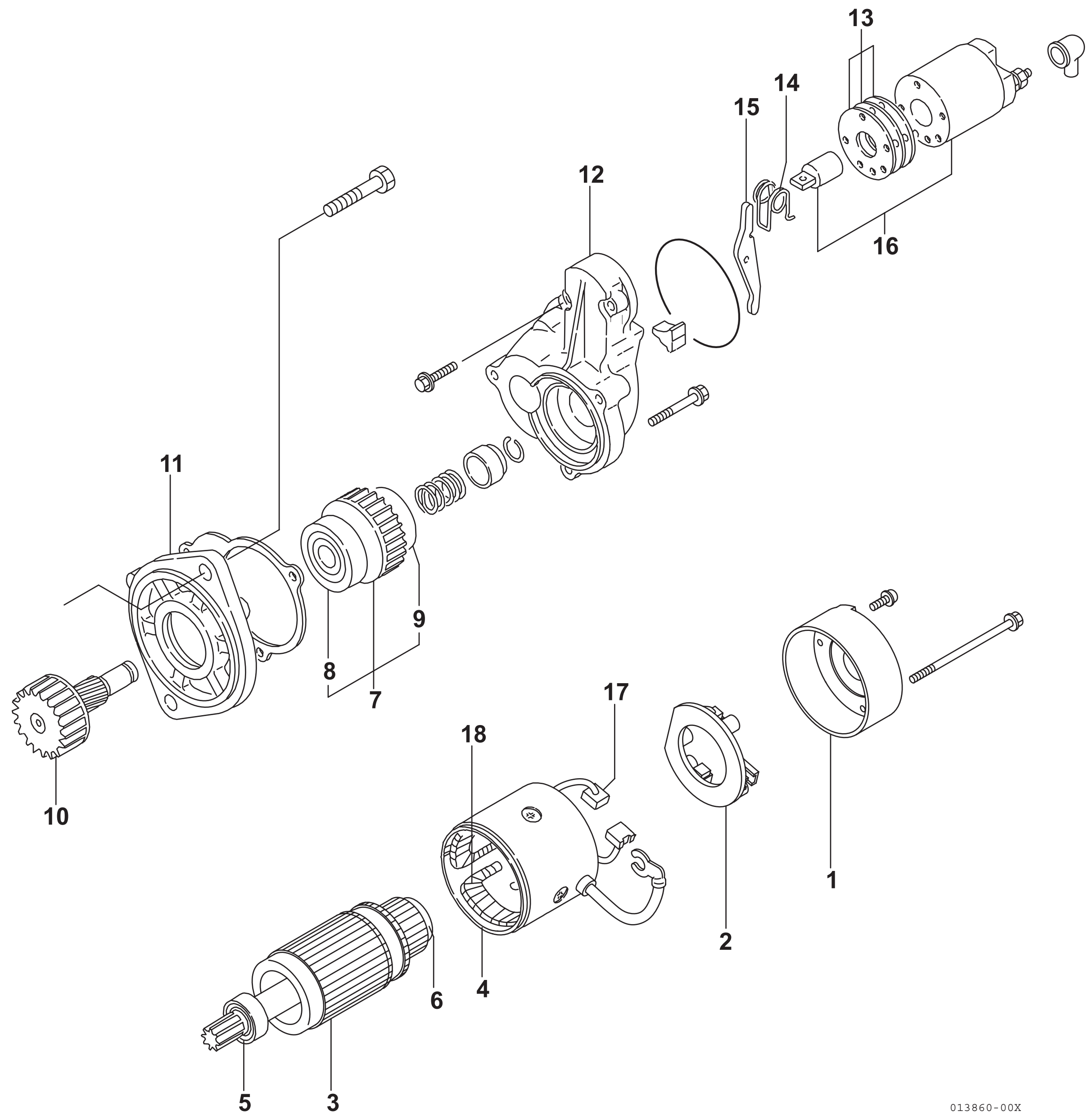
To start the engine, the starter motor rotates the ring gear installed on the engine flywheel with the pinion gear engaged with the ring gear so that the force generated by the rotation exceeds the resistance including the engine compression pressure and all frictional force. The starter motor consists of the following major parts : a motor which generates torque ; a pinion which transmits the torque to the engine ring gear ; a clutch ; and a magnetic switch which pushes out the pinion and turns on and off the principal current.

1) Specifications and Service Data

Yanmar code				129136-77011
Applicable model				4TNV88-PBV
Starter motor model				S13-332
Nominal output / Weight			kW / lbs. (kg)	2.3 / 11.7 (5.3)
Rotation direction (Viewed from pinion side)				Clockwise
Engagement method				Magnetic shift
No load	Terminal voltage / Current		V / A	11 / ≦140
	Speed		rpm	≧4100
Load characteristics	Terminal voltage / Current		V / A	2.5 / 1050
	Torque / Speed		ft•lbf (N•m) / rpm	≧18.5 (25.0)
Clutch type				Overrunning clutch
Pinion coming out voltage			V	≦8.7
Pinion DP or module / Number of pinion teeth				DP10 / 15
Brush	Standard spring force		lbs. (N)	22.9 to 28.8 (31 to 39)
	Standard height / Wear limit		in. (mm)	0.59 (15.0) / 0.35 (9.0)
Magnetic switch resistance at 68 °F (20 °C)	Series coil / Shunt coil		Ω	0.37 / 0.62
Commutator	Outside diameter	Standard / Wear limit	in. (mm)	Ø1.43 (36.5) / Ø1.40 (35.5)
	Difference between max. and min. dia.	Correction limit / Precision		0.0079 (0.2) / 0.0012 (0.03)
	Mica undercut	Correction limit / Precision		0.00787 (0.2) / 0.02 to 0.03 (0.5 to 0.8)
Standard diameters	Armature side bearing	Shaft diameter / Bearing inside diameter	in. (mm)	Armature 6903Z / Bearing (F/R) 608Z
	Pinion clutch bearing	Shaft diameter / Bearing inside diameter		Gear case 608ZZ / Bearing (F/R) 608ZZ
	Pinion sliding section	Shaft diameter / Bearing inside diameter		6004ZZ
	Pinion side bearing	Shaft diameter / Bearing inside diameter		6004ZZ
Gap between pinion and pinion stopper			in. (mm)	0.01 to 0.06 (0.3 to 1.5)

2) Construction of Starter Motor

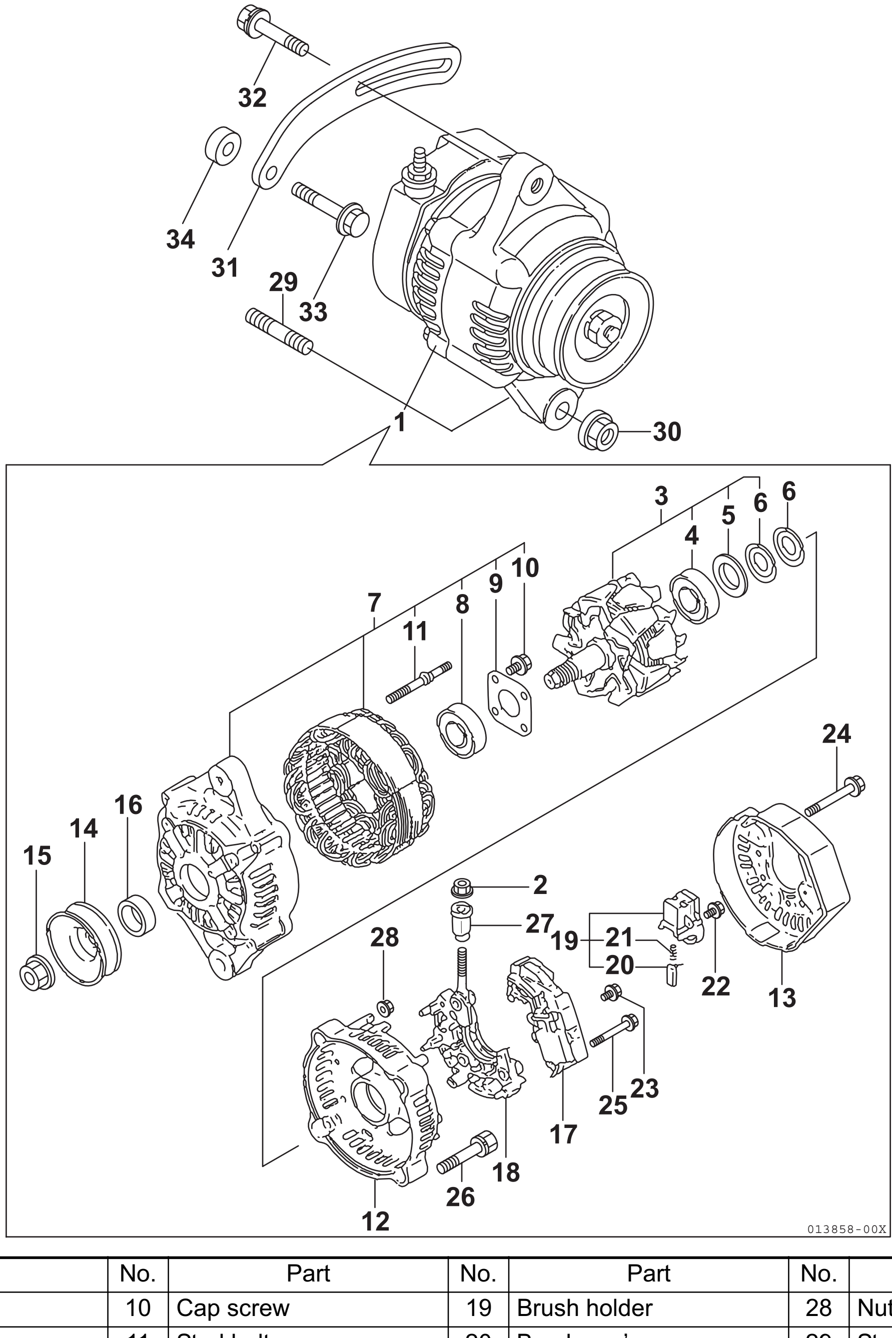
No.	Part	No.	Part
1	Rear cover	10	Pinion gear
2	Brush holder	11	Gear case
3	Armature	12	Center housing
4	Yoke	13	Dust cover
5	Ball bearing	14	Torsion spring
6	Ball bearing	15	Shift lever
7	Pinion clutch	16	Magnetic switch
8	Ball bearing	17	Brush
9	Ball bearing	18	Coil



4-8-2 Alternator

The alternator is a revolving-field type three-phase AC generator. The AC electricity generated by the alternator is converted to DC through the full-wave rectification by the diode and is stored in the battery.
The alternator contains a regulator using an IC and can detect the battery voltage to adjust the generated voltage in the alternator.

1) Components



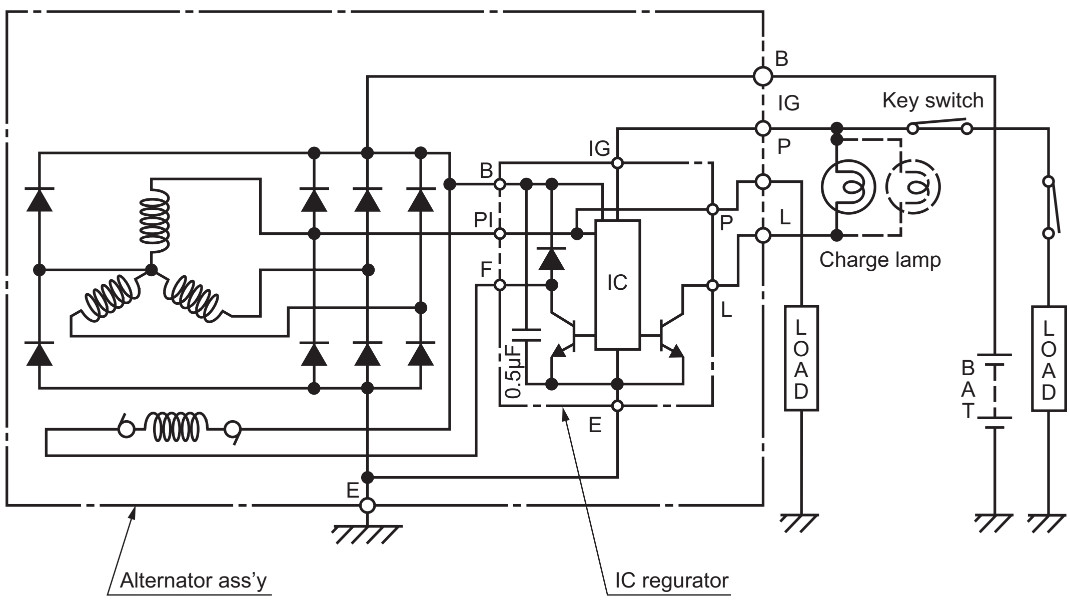
No.	Part	No.	Part	No.	Part	No.	Part
1	Alternator	10	Cap screw	19	Brush holder	28	Nut
2	Nut	11	Stud bolt	20	Brush ass'y	29	Stud bolt
3	Rotor ass'y	12	Rear frame ass'y	21	Spring	30	Flange nut
4	Ball bearing	13	Rear end cover	22	Cap screw	31	Bolt tension adjuster
5	Bearing cover	14	Pulley	23	Cap screw	32	Adjuster bolt
6	Washer	15	Nut	24	Bolt	33	Plated bolt 8×45
7	Drive frame ass'y	16	Collar	25	Cap screw	34	Spacer
8	Ball bearing	17	Regulator ass'y	26	Bolt		
9	Retainer plate	18	Holder	27	Insulation bushing		

2) Specifications

Alternator model	-	ACFA68
Yanmar P/#	-	129423-77200
Battery voltage	V	12
Nominal output (at 13.5 V in hot condition)	A	40
Rated speed	min^{-1}	5000
Operating speed	min^{-1}	1350 to 18000
Ground polarity	-	Negative
Rotation direction (viewed from pulley side)	-	Clockwise
Regulation method		IC Regulator
Weight	lb (kg)	6.2 (2.8)
Pulley diameter	in. (mm)	2.72 (69.2)
V-belt type	-	A type

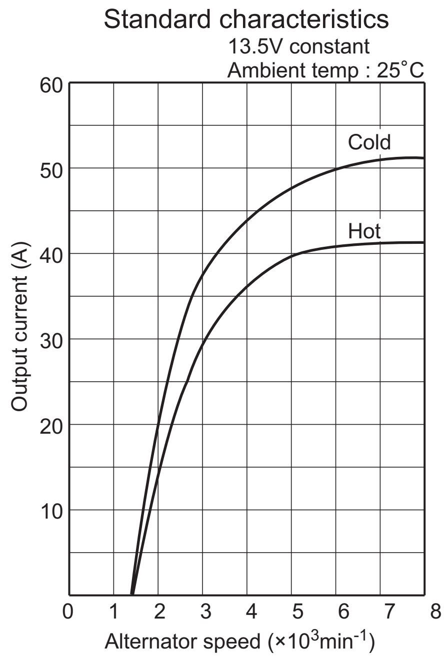
3) Connections

Wiring diagram



4) Standard Output Characteristics

The standard performance is shown to the right.



Note:

- *Be careful not to connect wrong terminals and short circuit.*
- *Do not directly connect the terminals of IG to L. Always install the charge lamps between them.*
- *No load between the terminals L and E.*
- *Do not disconnect the terminal B and that of the battery while the alternator is running.*
- *Cut-off the battery switch while the alternator is not running.*
- *Tighten each terminal to 1.25 to 1.70 ft•lb (1.7 to 2.3 N•m)*

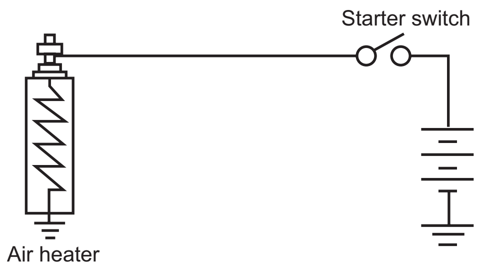
4-8-3 Air Heater

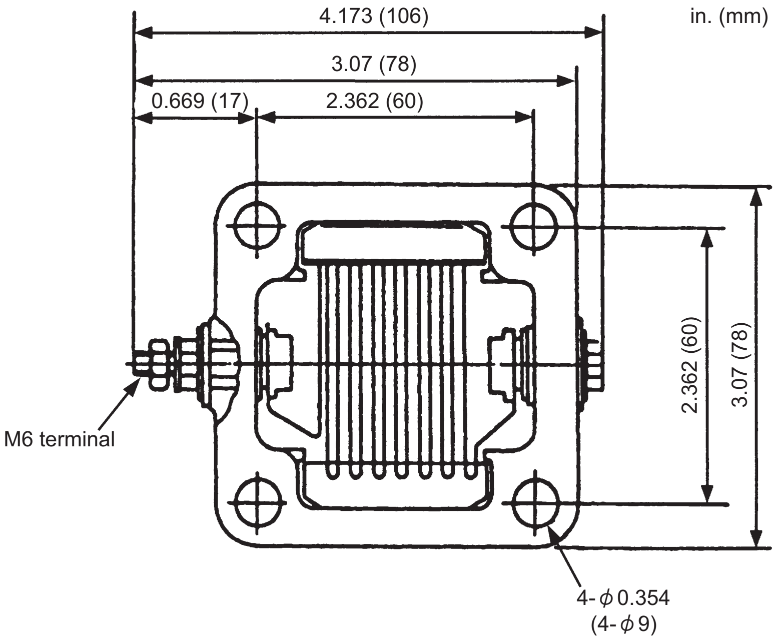
The air heater installed on the intake manifold is a starting aid in cold weather, which serves to warm the air and send it to the combustion chamber to start the engine easily at low ambient temperature.
The air heater is operated to warm the sucked air by setting the starter switch key to "AIR HEATER" position and supplying electricity for about 10 to 15 seconds.
If electricity is supplied to the air heater for more than 15 seconds, this will cause breaking of the heater lead or battery trouble.

Specifications

Rated output	400 W
Rated current	33.3 A
Rated voltage	DC12 V
Rated operating time	30 sec. max.
Ground polarity	Negative

(Air heater circuit)





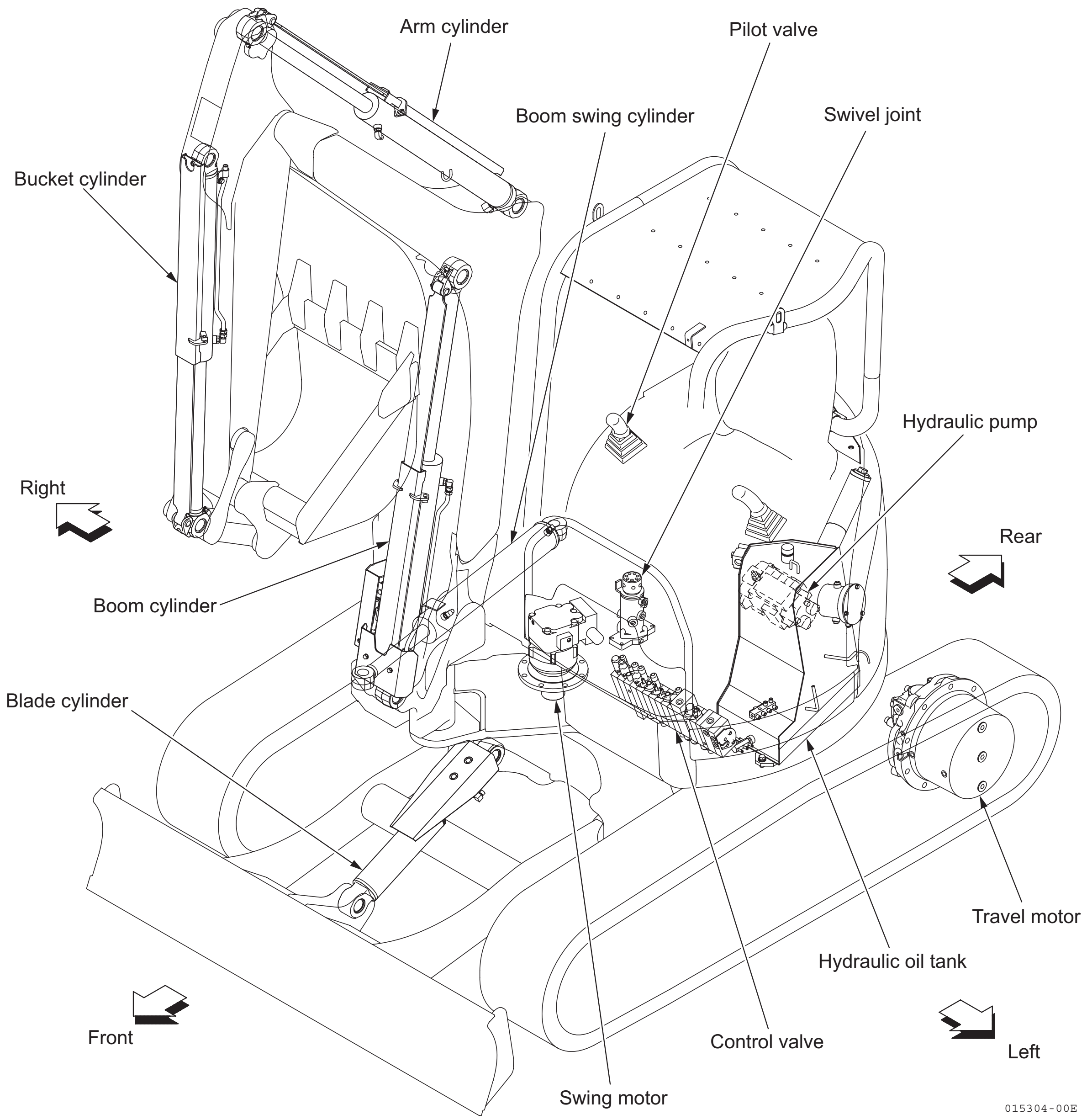
CHAPTER 5

HYDRAULIC SYSTEM

5. Hydraulic System

5-1 Outline

The hydraulic system consists of an engine, variable displacement piston pumps, a gear pump, a control valve, a boom cylinder, an arm cylinder, a bucket cylinder, a boom swing cylinder, a blade cylinder, a swing motor, a swivel joint, two travel motors, 2 way valve and a hydraulic oil tank. The oil discharged from the variable displacement piston pumps and that from the gear pump flow to the actuators through the control valve.
The hydraulic pilot control system comprises a pilot pump, a cut-off valve mounted on the hydraulic pump and two pilot valves. The oil discharged from the pilot pump flows into the pilot ports of the control valve through the cut-off valve, the pilot valves and 2 way valve to control the valve spool movement in proportion to the pressure at the port.



5. HYDRAULIC SYSTEM

1) Hydraulic Pump

The variable displacement piston pumps, the gear pump and the pilot pump are linked to the flywheel of the engine through the coupling. The number of revolutions of each hydraulic pump is identical to the engine speed.

cu. in. (cu. cm) / rev

No.	Pump		ViO45-5	ViO55-5
1	Piston pump	P1	1.02 (16.8)	
2	Piston pump	P2	1.02 (16.8)	
3	Gear pump	P3	1.02 (16.8)	
4	Pilot pump	P4	0.30 (4.9)	

2) Oil Flow

(1) Piston pumps P1 and P2, and gear pump P3

The pumps take in oil through the suction filter from the hydraulic oil tank and discharge it. The discharged oil flows to the ports P1, P2 and P3 of the control valve and returns from the ports T1 and T2 to the hydraulic oil tank through the return filter. This circulation is repeated.

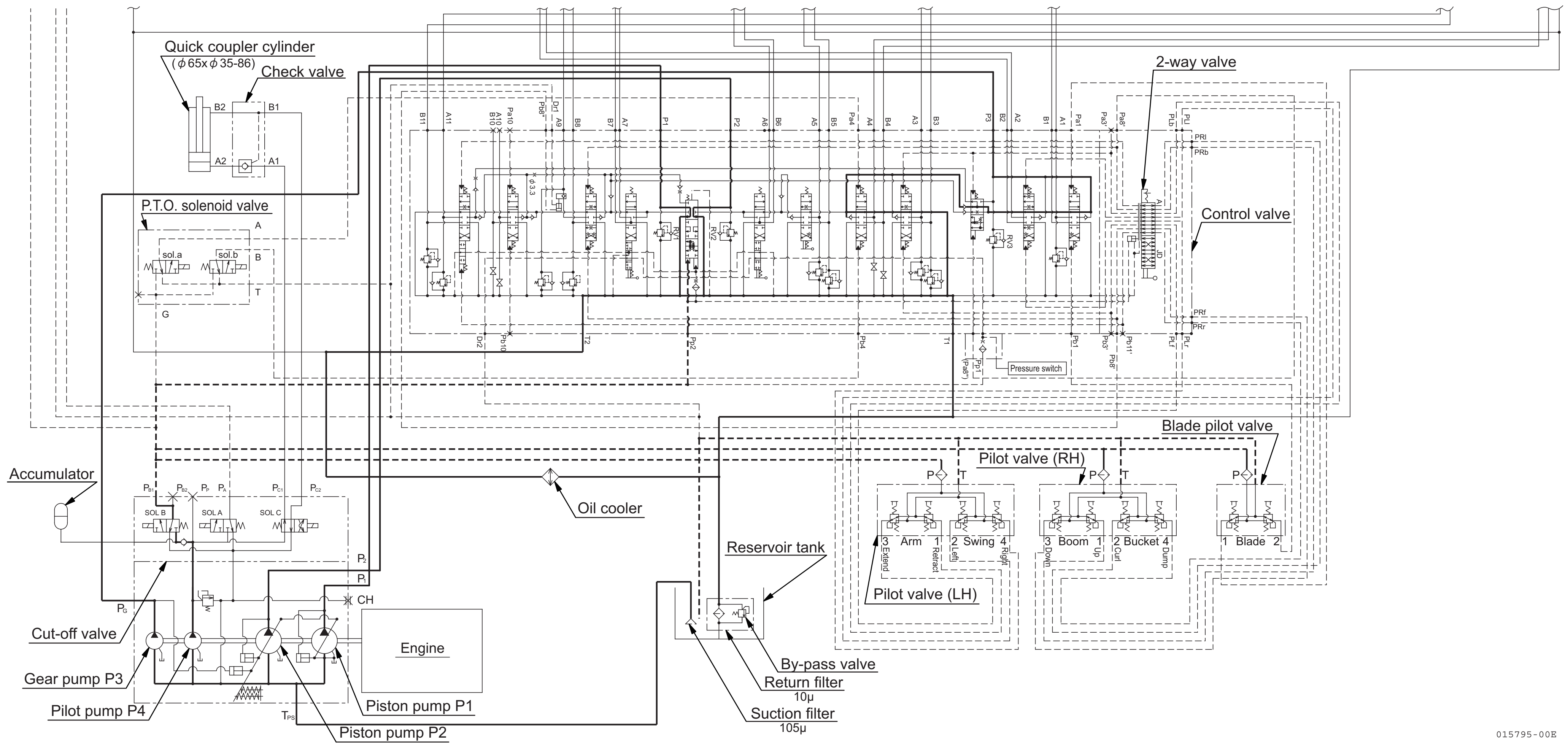
The bypass valve in the return filter opens at a differential pressure of 21.3 PSI (0.147 MPa).

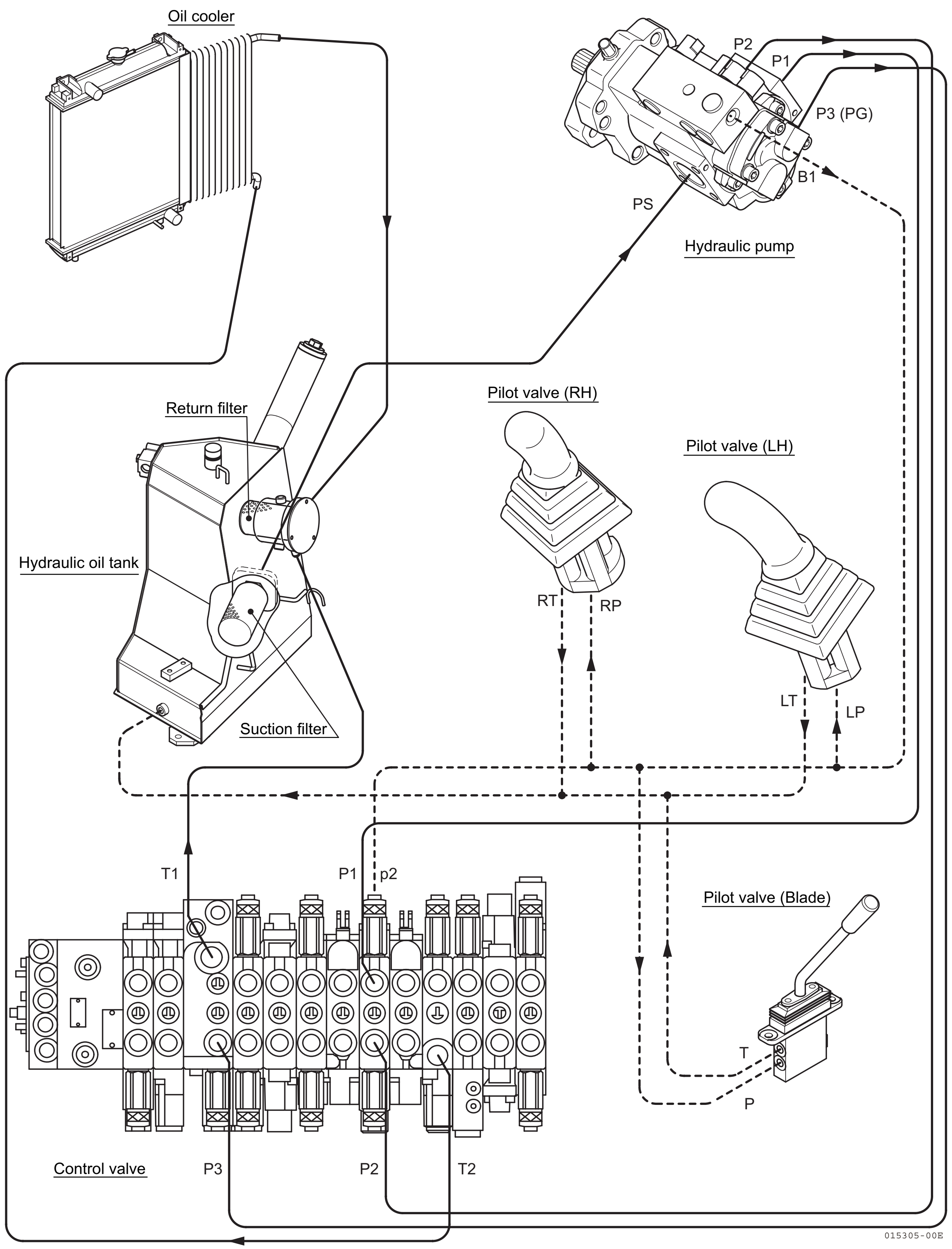
(2) Pilot pump P4

The oil from the pilot pump P4 flows back to the hydraulic oil tank through the port B1 of the cut-off valve integrated into the pump, the pilot valves, the blade control pilot valve and the return filter.

3) System Relief Valve

The system relief valves RV1, RV2 and RV3 of the control valve control the discharge pressure of the pumps.





Oil cooler
P2
P1
P3 (PG)
B1
PS
Hydraulic pump
Pilot valve (RH)
Pilot valve (LH)
Return filter
Hydraulic oil tank
RT
RP
LT
LP
Suction filter
T1
P1
p2
Pilot valve (Blade)
T
P
Control valve
P3
P2
T2
015305-00E

5-1-1 Control Valve Operation

1) Oil Flow from Hydraulic Pump

(1) Piston pump P1

The oil from the piston pump P1 is fed to the right travel motor and the boom and bucket cylinders through the port P1 of the inlet section, the travel (R), boom and bucket sections.

(2) Piston pump P2

The oil from the piston pump P2 is fed to the left travel motor, the boom swing and arm cylinders and the P.T.O. through the port P2 of the inlet section, the travel (L), boom swing, arm and P.T.O. sections.

(3) Gear pump P3

The oil from the gear pump P3 flows through the port P3 of the parallel-flow divider to the swing and blade sections, and also to the arm and P.T.O. sections to be combined with the oil from the piston pump P2.

2) Simultaneous Operation of Boom and Bucket

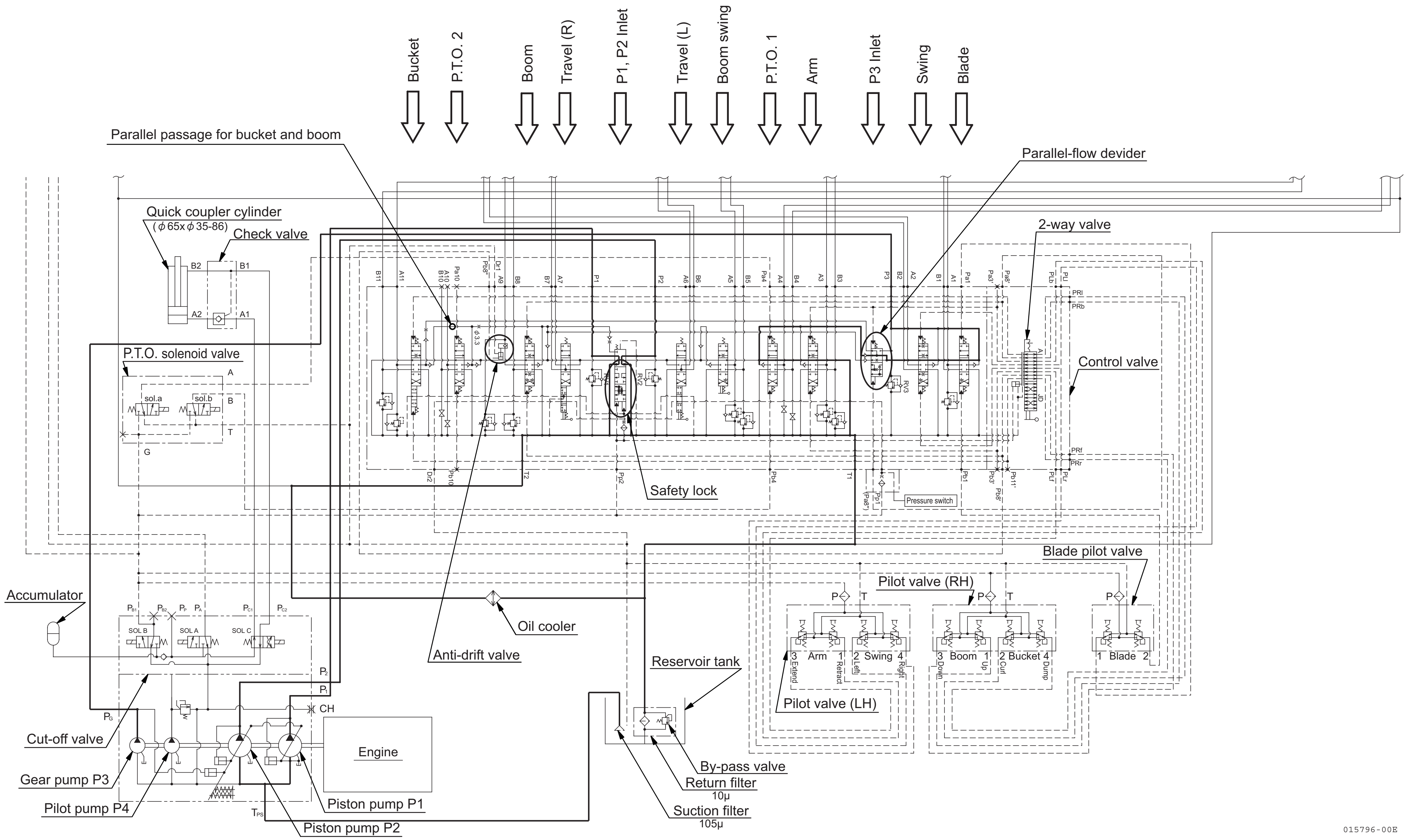
A parallel passage is provided for the boom and bucket sections. The parallel passage has a throttle in the bucket section, so that the oil can flow to the boom section more smoothly than to the bucket section when the boom is given a heavier load. Therefore, the boom and the bucket can be operated simultaneously.

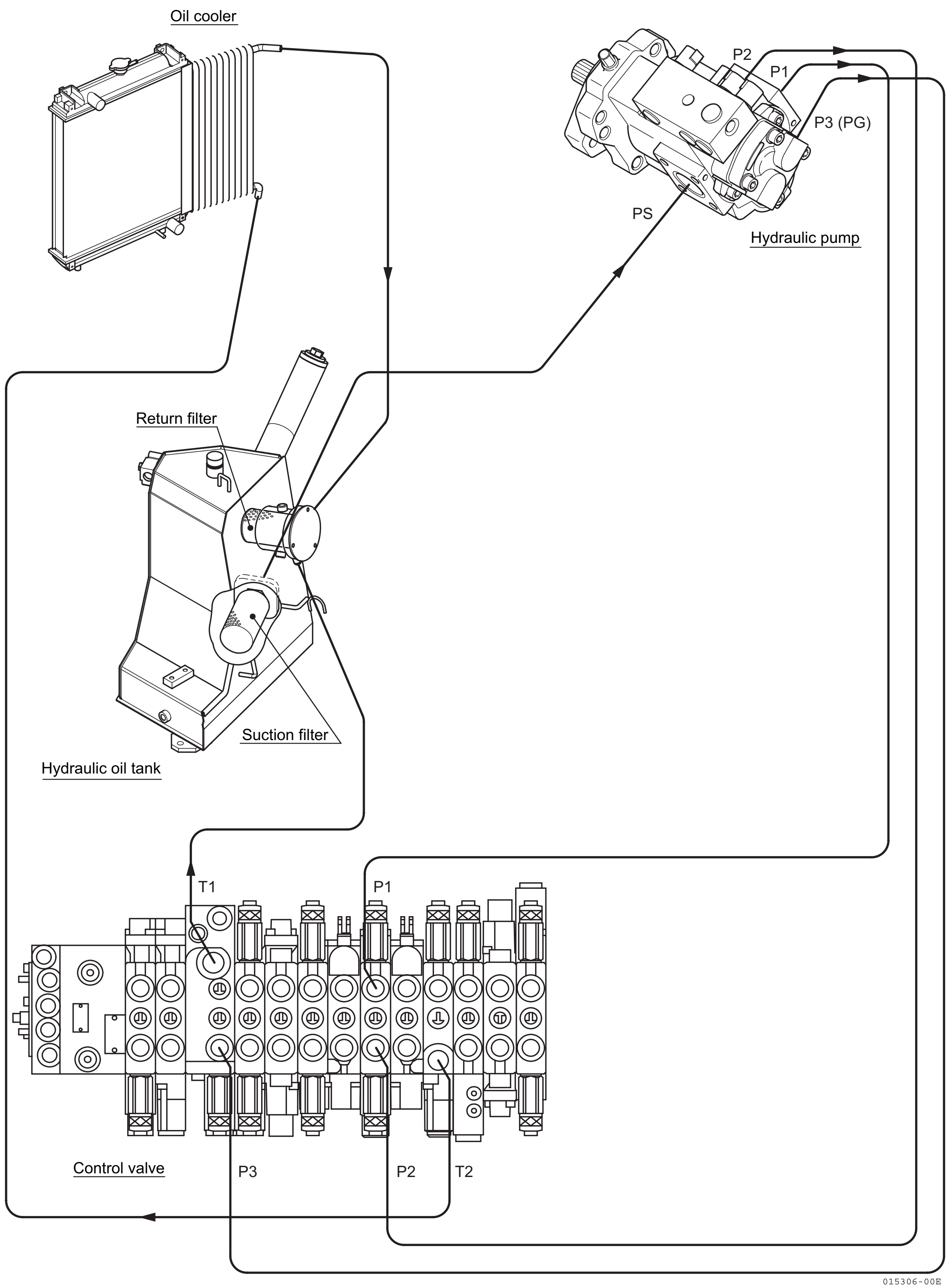
3) Anti-Drift Valve (Reduction of Boom Drifting)

The anti-drift valve is installed in the boom section to reduce the boom drifting.

4) Track Drive Lock

When the lock lever is set to the "LOCK" position, the spool of the inlet section is in the neutral position, so that the oil from the piston pumps P1 and P2 flows back to the hydraulic oil tank through the return passage. Therefore, the implement does not operate and the machine does not travel even when the control or travel lever is operated.





Oil cooler
P2
P1
P3 (PG)
PS
Hydraulic pump
Return filter
Suspection filter
Hydraulic oil tank
T1
P1
Control valve
P3
P2
T2
015306-00E

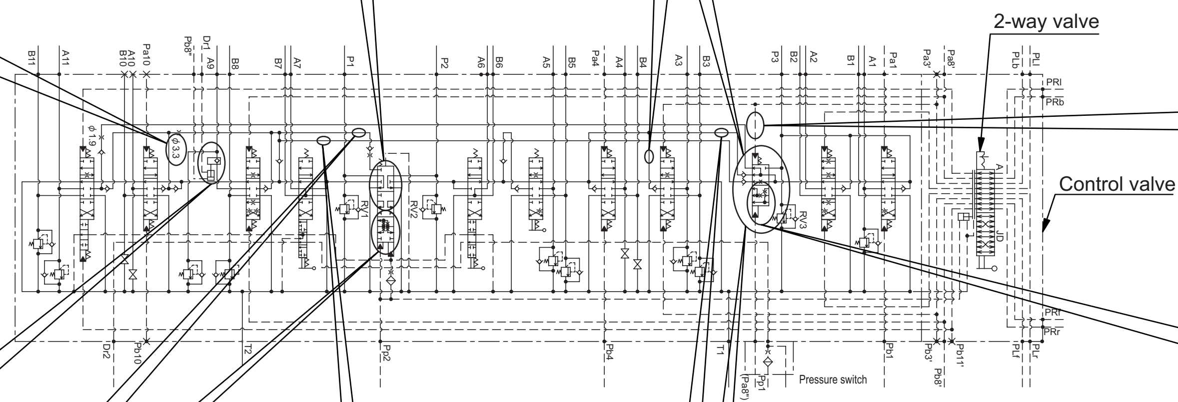
5-1-2 Additional Operation of Control Valve

Safety Lock
(1) With lock lever in "LOCK" position
The spool of the inlet section is in the neutral position, and the oil from the pump port P1 and that from the pump port P2 flow back to the hydraulic oil tank through the return passage. Therefore, no oil is supplied to any sections, and cylinders and motors do not operate even when a spool of every section is moved.
(2) With lock lever in "UNLOCK" position
The oil from the pilot pump P4 flows to the port a2 of the inlet section through the cut-off valve, and the spool of the inlet section is moved.
The oil from the pump P1 and that from the pump P2 can flow to sections to move their spools, and flow to cylinders and motors to operate them.

Simultaneous Operation of Boom and Bucket
The bucket section has a parallel passage so that the boom and bucket can be operated simultaneously and a check valve {ϕ0.13 in. (3.3 mm)} so that the oil can flow to the boom section prior to the bucket section even when the boom is highly loaded.

Combined Oil Flow for Arm Retract Operation
When the arm is retracted, the oil from the port 1 of the pilot valve (LH) flows to the port PLb of the arm section and the parallel-flow divider to move their spools. The oil from the gear pump P3 flows through the parallel-flow divider and the parallel passage to the arm section and combines with the oil from the piston pump P2.

Anti-Drift Valve (Reduction of Boom Drifting)
The anti-drift valve is installed in the port A9 of the boom section to reduce the boom drifting. The valve blocks the oil in the bottom end circuit of the boom cylinder to prevent the boom from drifting due to internal leakage when the control valve is in the neutral position. When the boom control lever is pushed forward to lower the boom, the oil from the port 3 of the pilot valve (RH) flows to the ports Pb8' and Pb8" to open the check valve, so that the return oil can flow back to the hydraulic oil tank.



Simultaneous Operation of "Boom Up" and "Arm Retract"
When the arm control lever is pulled back to retract the arm while the boom is raising, the oil from the port 1 of the pilot valve (LH) flows to the port PLb. The pilot oil moves the spool of the parallel-flow divider to the neutral position to let the oil from the gear pump P3 flow into the arm section prior to the boom section.

Combined Oil Flow for Boom Up Operation
When the boom is operated, the oil from the port 1 of the pilot valve (RH) flows to the port a8 of the boom section and the port a8' of the parallel-flow divider to move their spools. The oil from the gear pump P3 flows through the parallel-flow divider and parallel passage to the boom section and combines with the oil from the piston pump P2.

Non-Deviation Travel 1
When the arm and the boom are simultaneously or individually operated while the machine is traveling, the oil from the pilot valve flows to the port b4' and/or b8' to move the respective spools. The oil from the gear pump P3 is divided at the parallel-flow divider and flows to the arm and/or boom sections through the parallel passage. Consequently, even when the oil from the piston pumps P1 and P2 flows only to the left and right travel sections, respectively, in the most upstream for the pumps P1 and P2, the arm and the boom can be operated. In other words, the machine can travel with no deviation even when the control levers are moved while the machine is traveling.

Non-deviation Travel 2
When the bucket is operated while traveling, the spools of travel and bucket sections are moved to block the pilot oil passage, and then the inlet section spool is moved. The oil discharged from the pump P1 and that from the pump P2 are led to the travel sections and the bucket section, so that the bucket operation while traveling does not cause any deviation.

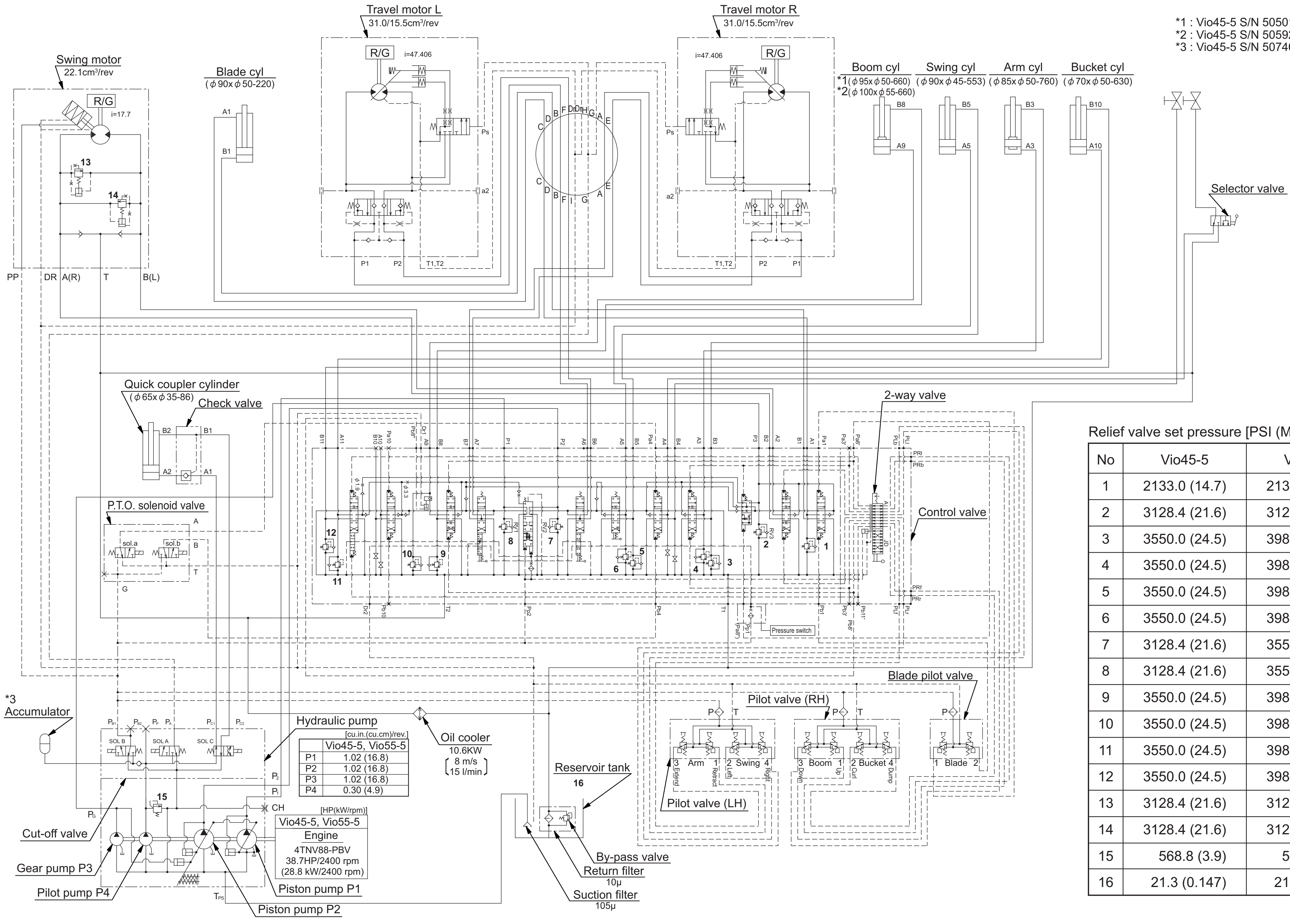
Note : The 2-way valve in the schematic shows the SAE lever pattern position.

015797-00E

5-2 Hydraulic Circuit Schematic

Applicable model : ViO45-5, 55-5

*1 : Vio45-5 S/N 50501 to 50591, Vio55-5 S/N 50501 to 50800
*2 : Vio45-5 S/N 50592 and after, Vio55-5 S/N 50801 and after
*3 : Vio45-5 S/N 50740 and after, Vio55-5 S/N 51054 and after



Relief valve set pressure [PSI (MPa)]

No	Vio45-5	Vio55-5
1	2133.0 (14.7)	2133.0 (14.7)
2	3128.4 (21.6)	3128.4 (21.6)
3	3550.0 (24.5)	3981.6 (27.5)
4	3550.0 (24.5)	3981.6 (27.5)
5	3550.0 (24.5)	3981.6 (27.5)
6	3550.0 (24.5)	3981.6 (27.5)
7	3128.4 (21.6)	3550.0 (24.5)
8	3128.4 (21.6)	3550.0 (24.5)
9	3550.0 (24.5)	3981.6 (27.5)
10	3550.0 (24.5)	3981.6 (27.5)
11	3550.0 (24.5)	3981.6 (27.5)
12	3550.0 (24.5)	3981.6 (27.5)
13	3128.4 (21.6)	3128.4 (21.6)
14	3128.4 (21.6)	3128.4 (21.6)
15	568.8 (3.9)	568.8 (3.9)
16	21.3 (0.147)	21.3 (0.147)

015832-00E

5-3 Circuit Operation

5-3-1 Boom

1) Boom “Up”

(1) Pilot oil flow

When the boom control lever is pulled back to raise the boom, the oil from the pilot pump P4 flows through the cut-off valve and the port 1 of the pilot valve (RH) to the port Rb of the control valve and the port a8" of the parallel-flow divider through the port a8' and the boom section to move their spools.

(2) Oil flow from hydraulic pump

The oil discharged from the piston pump P1 flows to the boom section through the port P1 of the inlet section, while the oil discharged from the gear pump P3 flows to the boom section through the port P3 of the parallel-flow divider and the parallel passage, and combines with the oil from the piston pump P1. Then the combined oil opens the check valve of the anti-drift valve in the boom section and flows through the port A9 to A9 of the boom cylinder to extend its cylinder rod, raising the boom. The return oil from B8 of the boom cylinder flows back to the hydraulic oil tank through the port B8 of the boom section, the ports T1 and T2 of the control valve and the oil cooler.

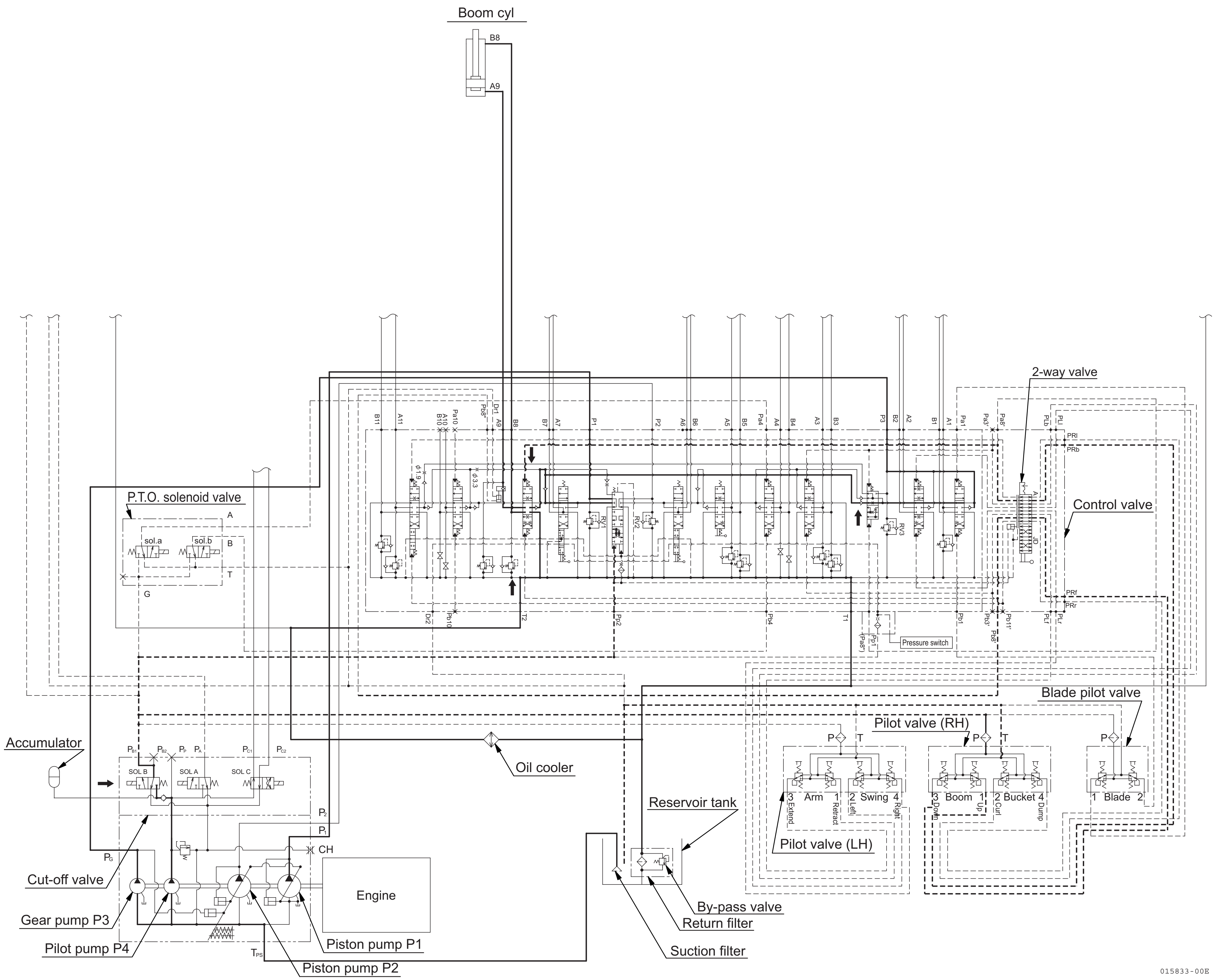
2) Boom "Down"

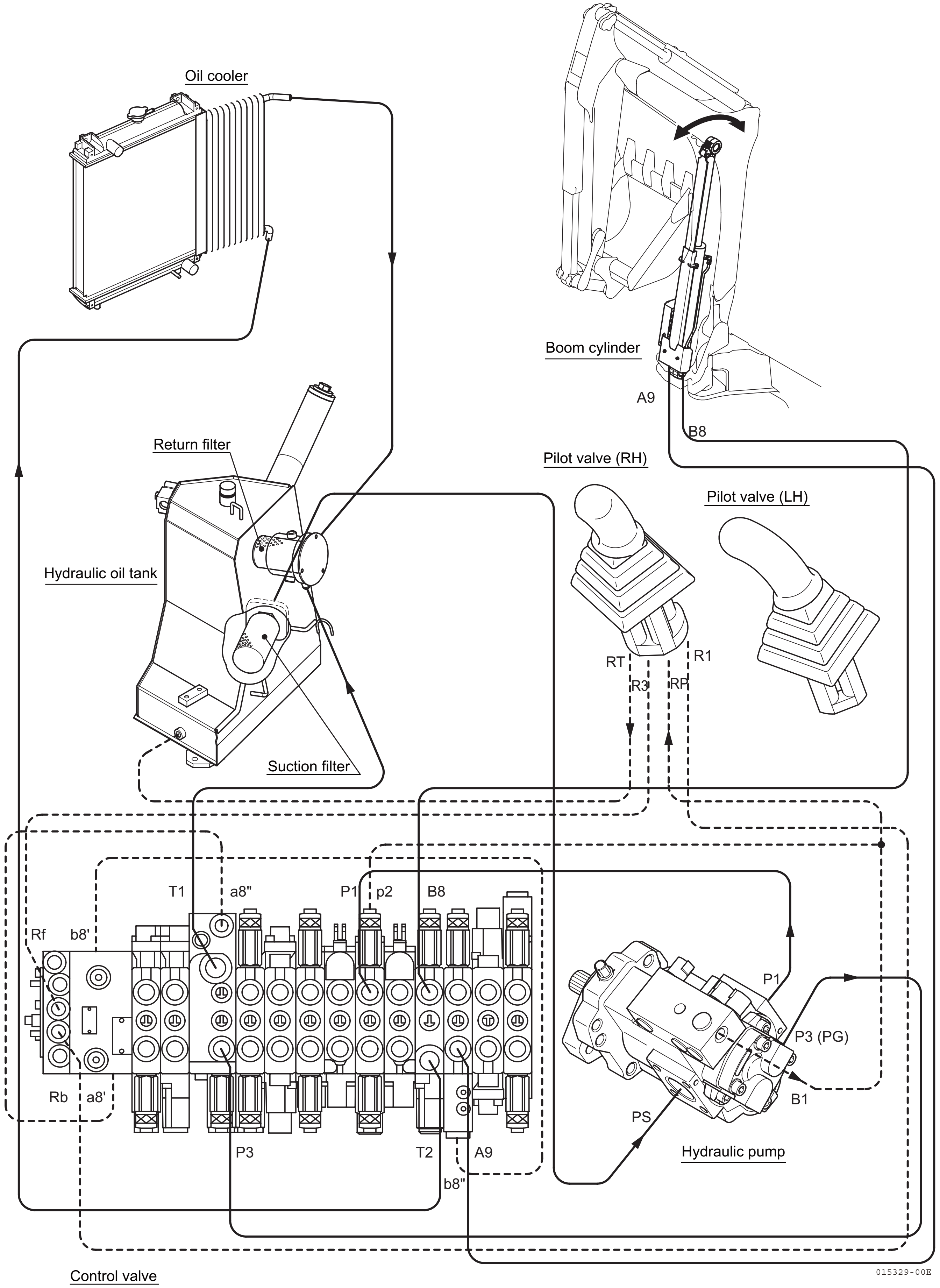
(1) Pilot oil flow

When the boom control lever is pushed forward to lower the boom, the oil from the pilot pump P4 flows to the port b8’’ of the anti-drift valve through the cut-off valve and the port 3 of the pilot valve (RH) and flows to the port Rf of the control valve to move its spool. The pilot oil also presses the piston of the anti-drift valve to open the check valve.

(2) Oil flow from hydraulic pump

The oil discharged from the piston pump P1 flows through the port P1 of the inlet section to the boom section. In this operation, the oil flows in the opposite direction to the oil flow in the Boom Up operation with regard to the boom cylinder.




Oil cooler
Boom cylinder
A9
B8
Return filter
Pilot valve (RH)
Pilot valve (LH)
Hydraulic oil tank
RT
R1
R3
RP
Suction filter
T1
a8"
P1
p2
B8
Rf
b8'
P1
P3 (PG)
B1
Rb
a8'
PS
P3
T2
A9
Hydraulic pump
b8"
015329-00E
Control valve

5-3-2 Arm

1) Arm “Retract”

(1) Pilot oil flow

When the arm control lever is pulled back to retract the arm, the oil from the pilot pump P4 flows through the cut-off valve and the port 1 of the pilot valve (LH) to the port Lb of the control valve, then flows to the parallel-flow divider and the arm sections to move their spools.

(2) Oil flow from hydraulic pump

The oil from the piston pump P2 flows through the port P2 of the inlet section to the arm section. The oil from the gear pump P3 flows through the port P3 of the parallel-flow divider and the parallel passage to the arm section and combines with the oil from the piston pump P2. The combined oil flows through the port A3 of the control valve to A3 of the arm cylinder to extend its cylinder rod. The return oil from B3 of the arm cylinder flows back to the hydraulic oil tank through the port B3 of the arm section, the ports T1 and T2 of the control valve and the oil cooler.

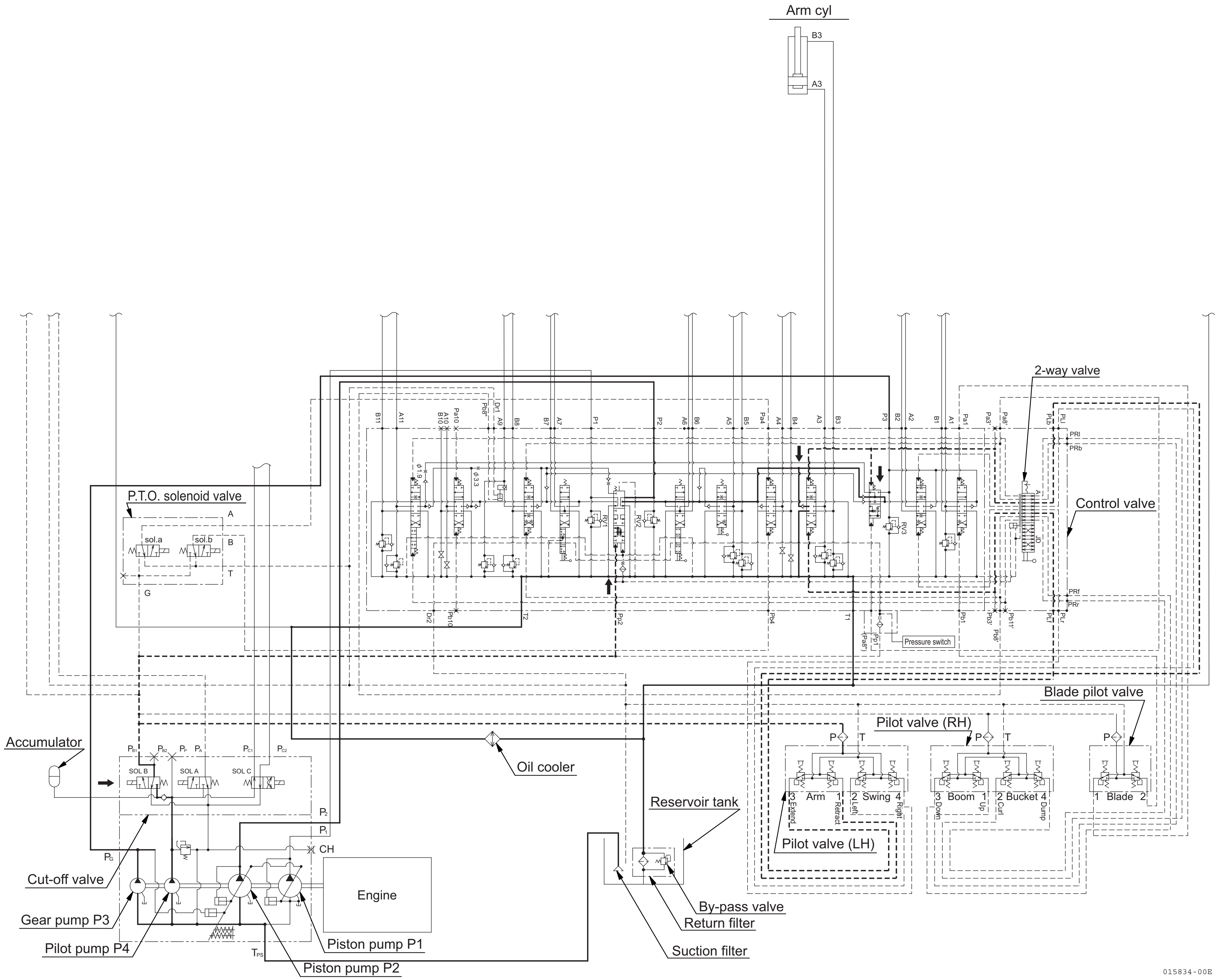
2) Arm "Extend"

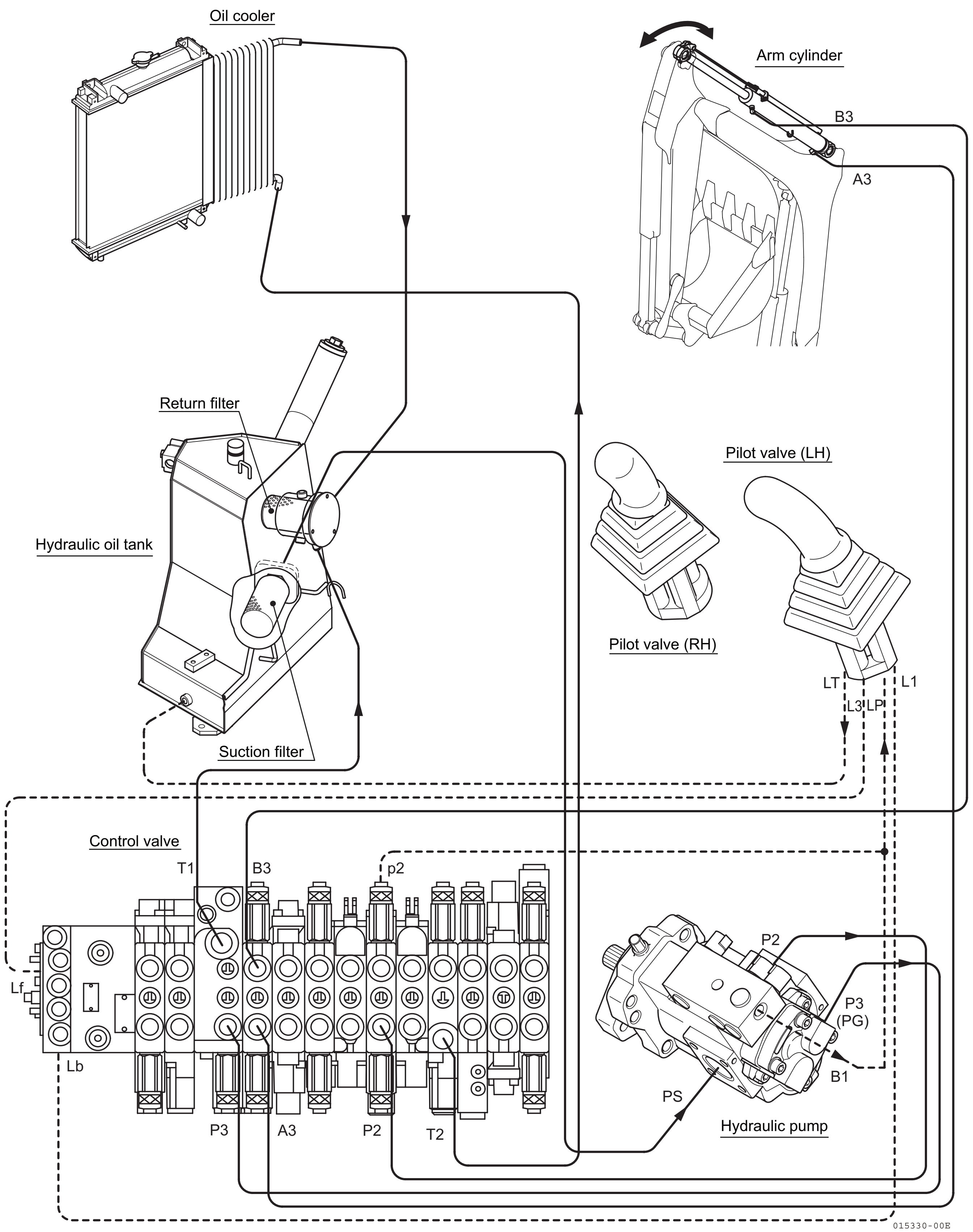
(1) Pilot oil flow

When the arm control lever is pushed forward to extend the arm, the oil from the pilot pump P4 flows through the cut-off valve and the port 3 of the pilot valve (LH) to the arm section through the port Lf of the control valve to move its spool.

(2) Oil flow from hydraulic pump

The oil from the piston pump P2 flows through the port P2 of the inlet section to the arm section. The oil from the gear pump P3 flows through the port P3 of the parallel-flow divider and the parallel passage to the arm section and combines with the oil from the port P2. The combined oil flows in the opposite direction to the oil flow in the arm retract operation with regard to the arm cylinder.





Oil cooler
Arm cylinder
B3
A3
Return filter
Pilot valve (LH)
Hydraulic oil tank
Pilot valve (RH)
LT
L1
L3
LP
Suction filter
Control valve
T1
B3
p2
P2
Lf
P3
(PG)
Lb
B1
PS
Hydraulic pump
P3
A3
P2
T2
015330-00E

5-3-3 Bucket

1) Bucket “Curl”

(1) Pilot oil flow

When the bucket control lever is moved to the left to curl the bucket, the oil from the pilot pump P4 flows through the cut-off valve, the port 2 of the pilot valve (RH) and the port RI of the control valve to the bucket section to move its spool.

(2) Oil flow from hydraulic pump

The oil from the piston pump P1 flows through the port P1 of the inlet section to the bucket section, the port A10 of the control valve and to the A10 of the bucket cylinder to extend its cylinder rod.

The return oil from B10 of the bucket cylinder flows back to the hydraulic oil tank through the port B10 of the bucket section, the ports T1 and T2 of the control valve and the oil cooler.

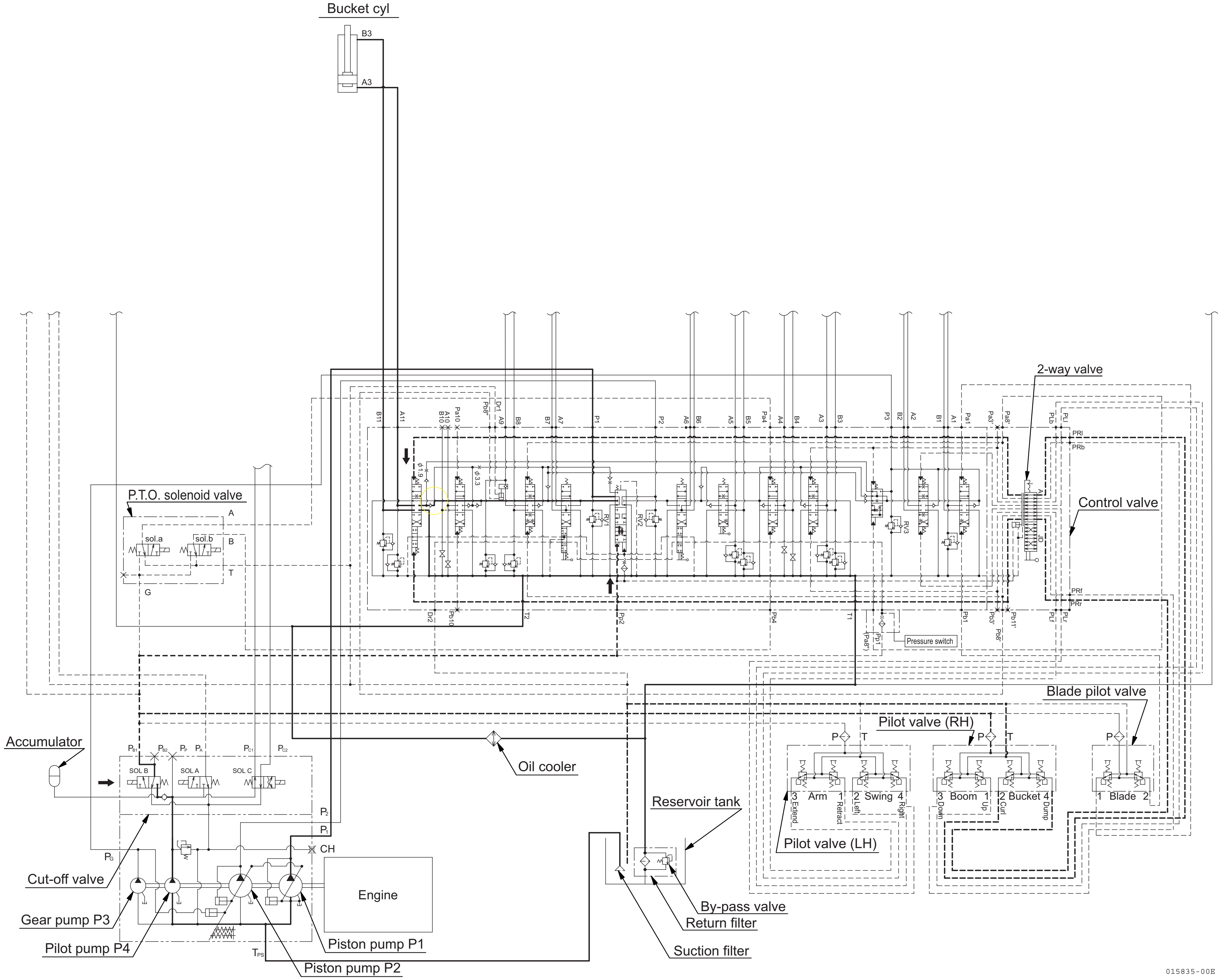
2) Bucket "Dump"

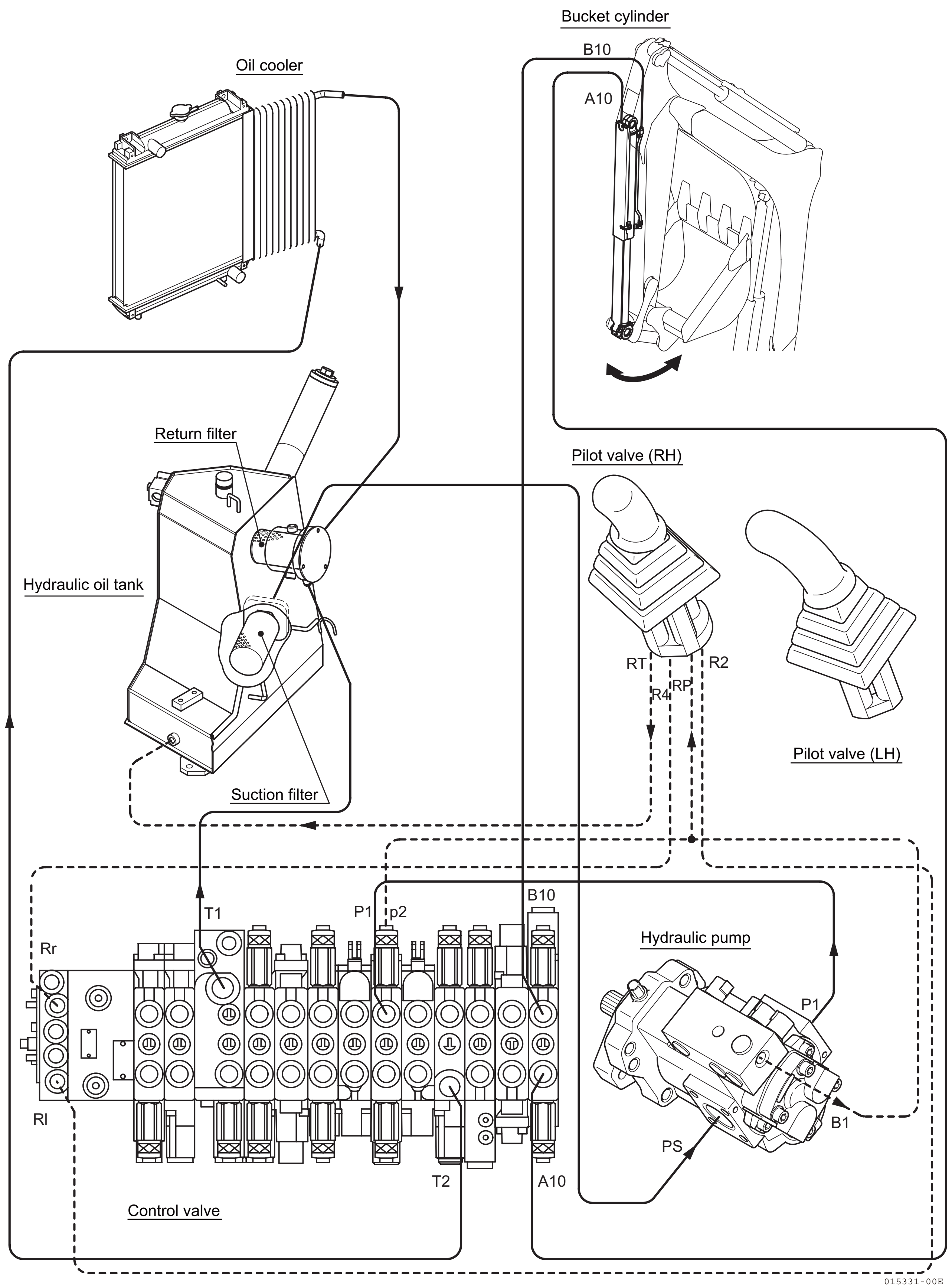
(1) Pilot oil flow

When the bucket control lever is moved to the right to dump the bucket, the oil from the pilot pump P4 flows through the cut-off valve, the port 4 of the pilot valve (RH) and the port Rr of the control valve to the bucket section to move its spool.

(2) Oil flow from hydraulic pump

The oil flows in the opposite direction to the oil flow in the Bucket Curl operation with regard to the bucket cylinder.




Bucket cylinder
B10
A10
Oil cooler
Return filter
Hydraulic oil tank
Pilot valve (RH)
RT
R2
R4
RP
Pilot valve (LH)
Suction filter
T1
P1
p2
B10
Rr
Hydraulic pump
P1
Rl
B1
PS
T2
A10
Control valve
015331-00E

5-3-4 Swing

1) Right Swing
(1) Pilot oil flow
When the swing control lever is moved to the right, the oil from the pilot pump P4 flows through the cut-off valve, the port 4 of the pilot valve (LH) and the port Lr of the control valve to the swing section to move its spool.

(2) Oil flow from hydraulic pump
The oil from the gear pump P3 flows through the port P3 of the parallel-flow divider and the port B2 of the swing section to the port A1 of the brake valve, so that the swing motor is rotated.
The return oil from the port B1 of the brake valve flows back to the hydraulic oil tank through the port A2 of the swing section, the ports T1 and T2 of the control valve and the oil cooler.

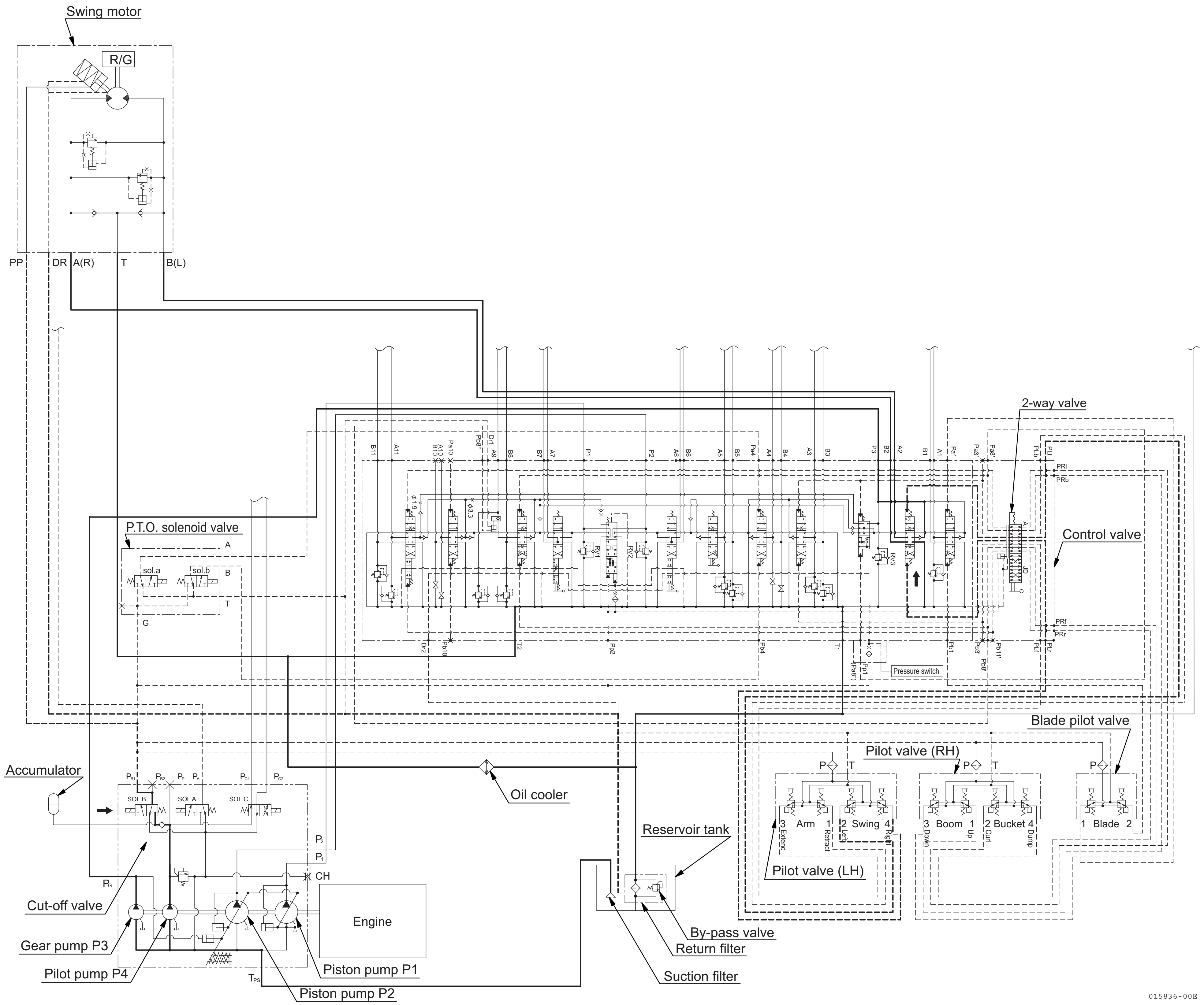
2) Left Swing
(1) Pilot oil flow
When the swing control lever is moved to the left, the oil from the pilot pump P4 flows through the cut-off valve, the port 2 of the pilot valve (LH) and the port Ll of the control valve to the swing section to move its spool.

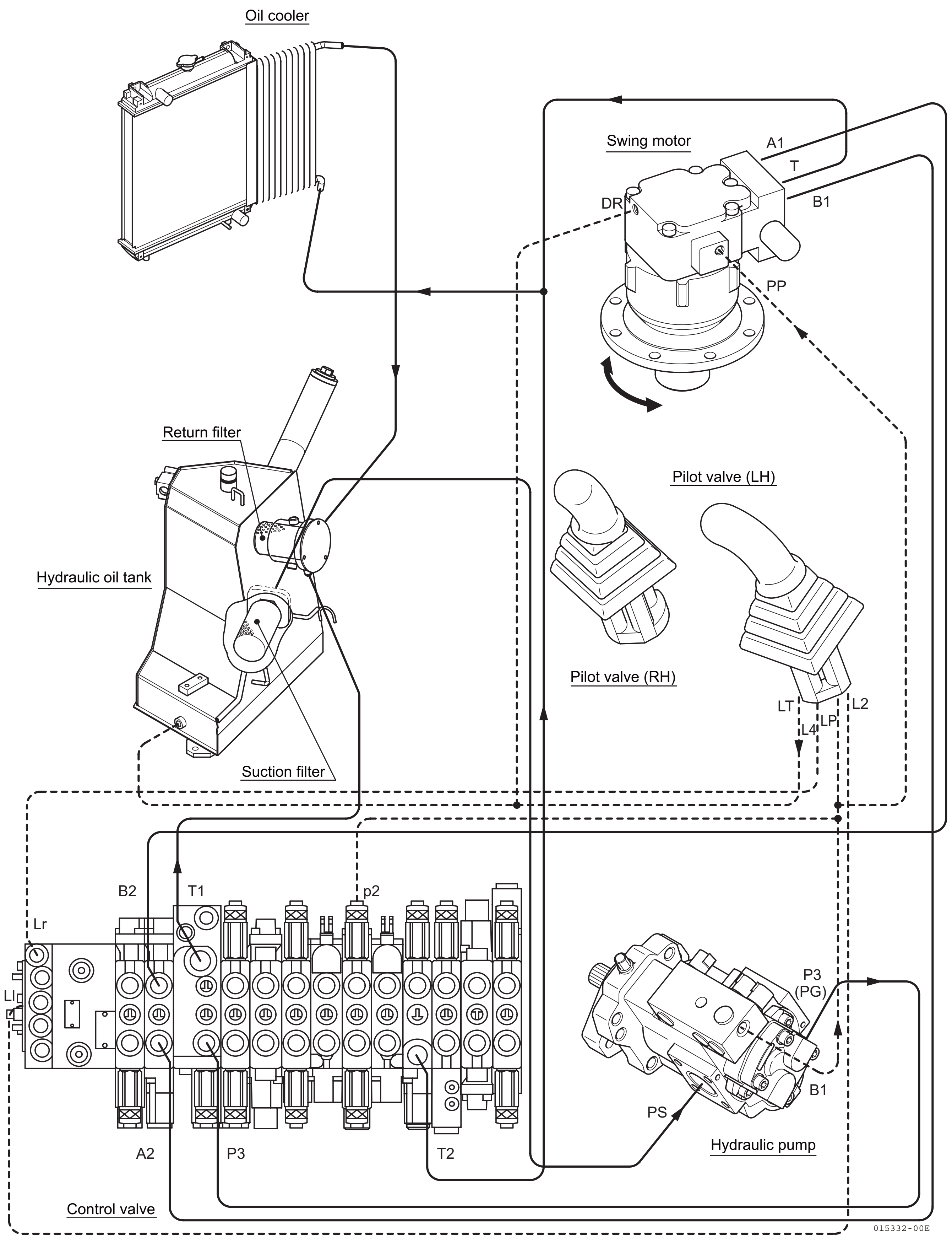
(2) Oil flow from hydraulic pump
The oil flows in the opposite direction to the oil flow in the Right Swing operation with regard to the swing motor.

3) Release and Operation of Swing Motor Mechanical Brake
(1) Release
When the lock lever is pushed forward, the oil from the pilot pump P4 flows to the port PP of the swing motor and presses the piston (with a spring) of the swing motor mechanical brake to release the brake.

(2) Operation
When the lock lever is pulled backward, the oil from the pilot pump P4 does not flow to the swing motor so that the spring force causes the brake to be applied.

4) Swing Motor Hydraulic Brake Operation
When the swing control lever is released (i.e., returned to the neutral position), the oil flow to the swing motor is blocked and the pressures at the ports A1 and B1 of the brake valve become equal and consequently the brake is applied. However, the swing motor continues to rotate in a short time due to its inertia. This causes the motor to act like a pump and increases the circuit pressure on the port B2 side. The increased pressure opens the relief valve SR1 to let the oil on the lower pressure side escape to the port A2, so that the circuit pressure is absorbed and cavitation is prevented on the port A2 side.
The port T of the swing motor has the drain function and a circuit which directly takes in the return oil flowing from the port T2 to the hydraulic oil tank to prevent negative pressure in the swing motor.
The relief valve of the hydraulic brake is a shockless type which has a piston to absorb the shock caused by the brake operation.





Oil cooler
Swing motor
A1
T
B1
DR
PP
Return filter
Pilot valve (LH)
Hydraulic oil tank
Pilot valve (RH)
LT
L4
LP
L2
Suction filter
B2
T1
p2
Lr
Ll
P3
(PG)
B1
PS
A2
P3
T2
Hydraulic pump
Control valve
015332-00E

5-3-5 Boom Swing

The boom swing pedal is linked to the spool of the control valve through an L-ball and a rod.

1) Right Boom Swing

Oil Flow from Hydraulic Pump

When the boom swing pedal is moved on the right, the spool is pressed forward. The oil from the piston pump P2 flows through the port P2 of the inlet section and the port B5 of the boom swing section to B5 of the boom swing cylinder to retract its cylinder rod.

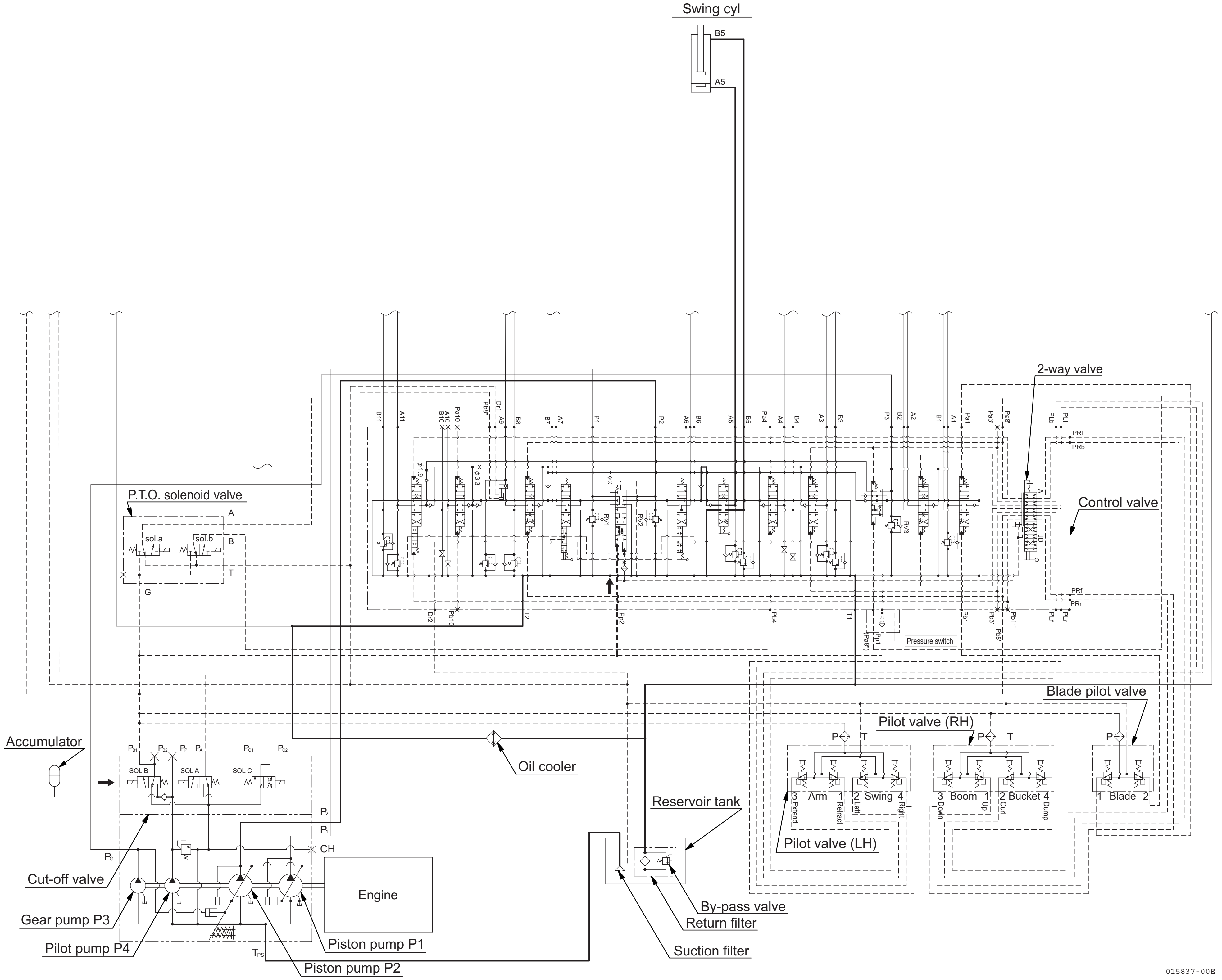
The return oil from A5 of the boom swing cylinder flows back to the hydraulic oil tank through the port A5 of the boom swing section, the ports T1 and T2 of the control valve and the oil cooler.

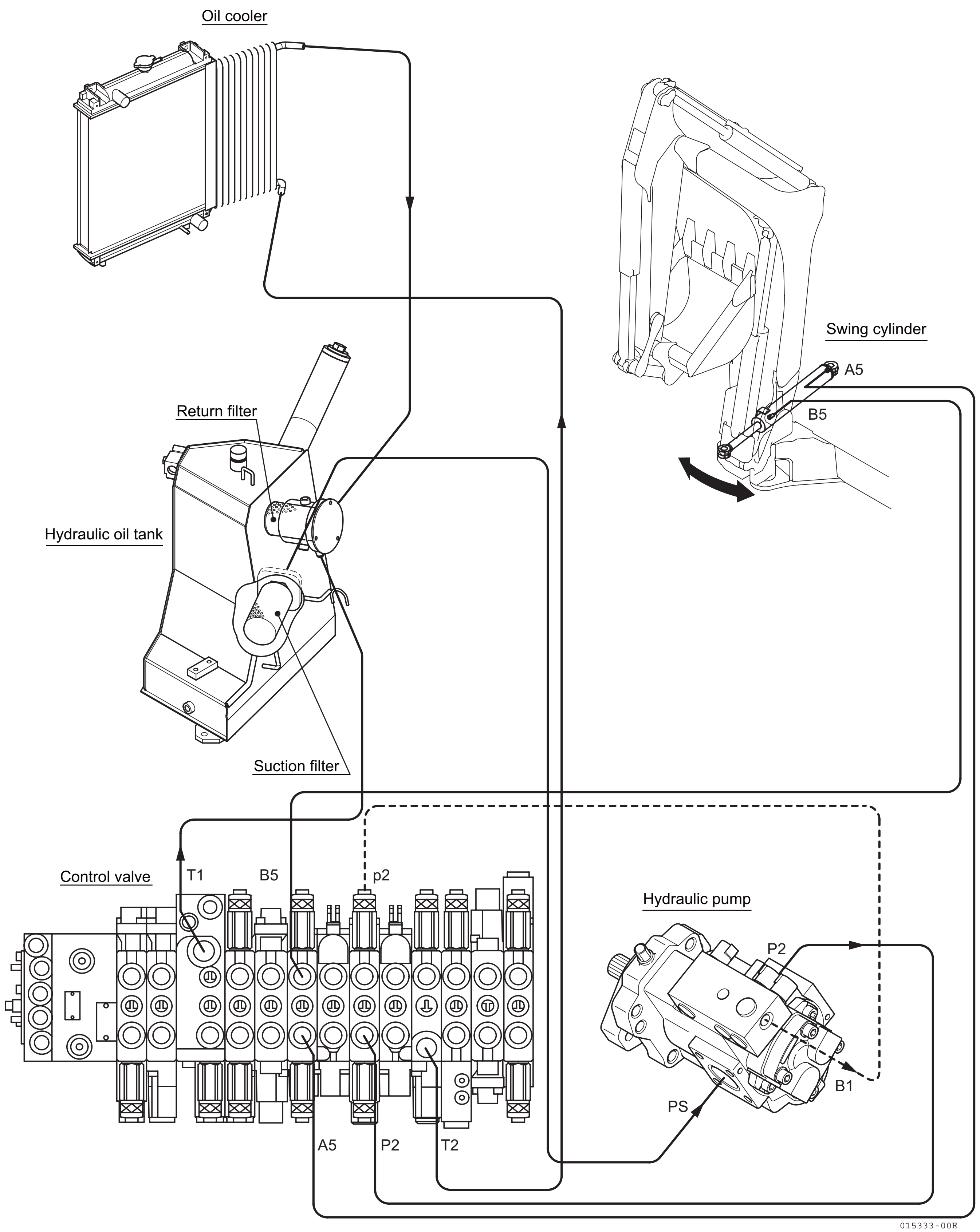
2) Left Boom Swing

Oil Flow from Hydraulic Pump

When the boom swing pedal is moved on the left, the spool is pulled back.

The oil flows in the opposite direction to the oil flow in the right boom swing operation with regard to the boom swing cylinder.




Oil cooler
Swing cylinder
A5
B5
Return filter
Hydraulic oil tank
Suction filter
Control valve
T1
B5
p2
Hydraulic pump
P2
B1
PS
A5
P2
T2
015333-00E

5-3-6 Blade

1) Blade "Down"

(1) Pilot oil flow

When the blade lever is pushed forward, the oil from the pilot pump P4 flows through the cut-off valve and the port 2 of the blade control pilot valve to the port b1 of the blade section to move its spool.

(2) Oil Flow from Hydraulic Pump

When the blade lever is pushed forward to lower the blade, the oil from the gear pump P3 flows through the port P3 of the P3 inlet section the blade section, the port B1 of the control valve and the port D of the swivel joint to B1 of the blade cylinder to extend its cylinder rod, lowering the blade.

The return oil from A1 of the blade cylinder flows back to the hydraulic oil tank through the port C of the swivel joint, the port A1 of the blade section, the ports T1 and T2 of the control valve and the oil cooler.

2) Blade "UP"

(1) Pilot oil flow

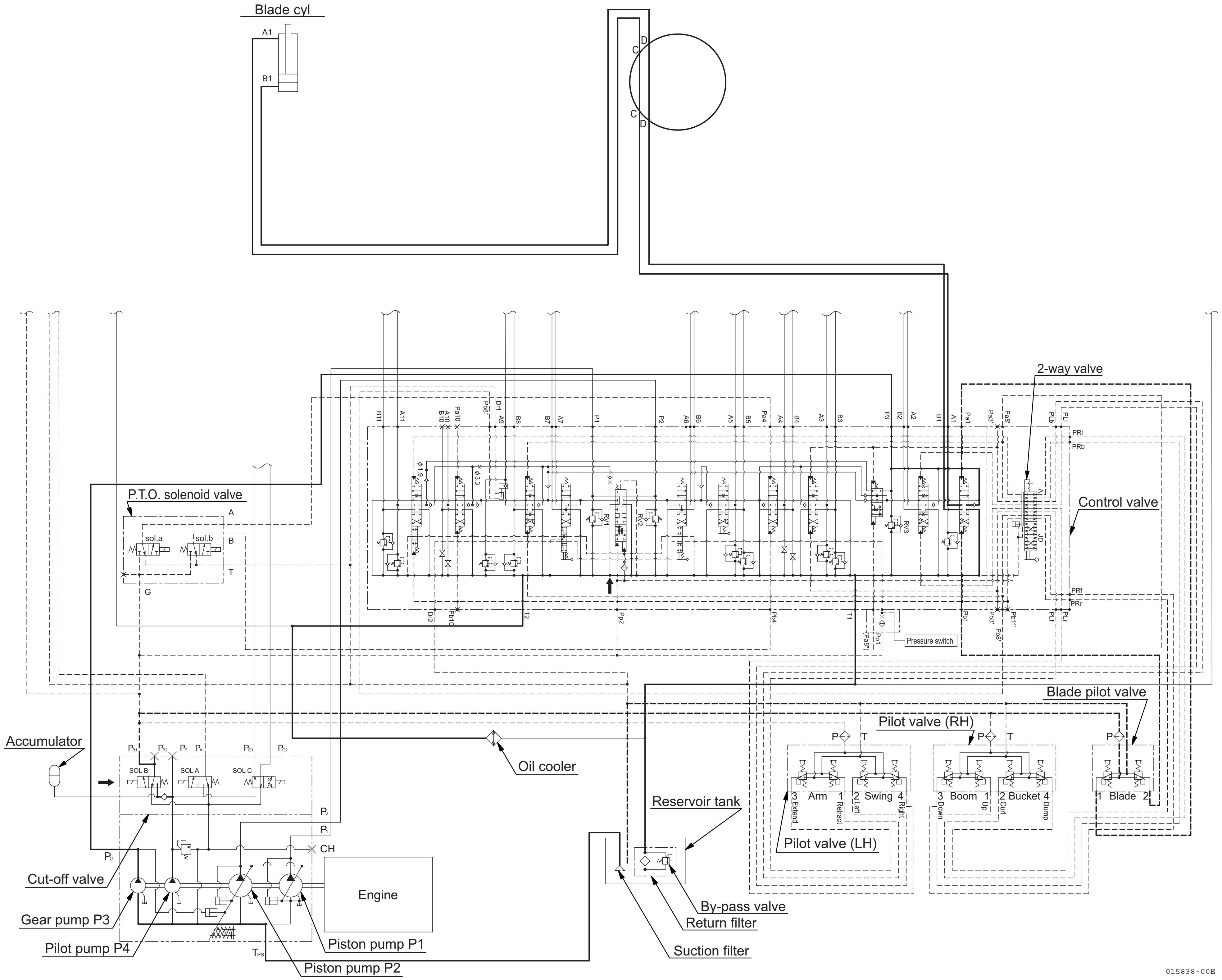
When the blade lever is pulled backward, the oil from the pilot pump P4 flows through the cut-off valve and the port 1 of the blade control pilot valve to the port a1 of the blade section to move its spool.

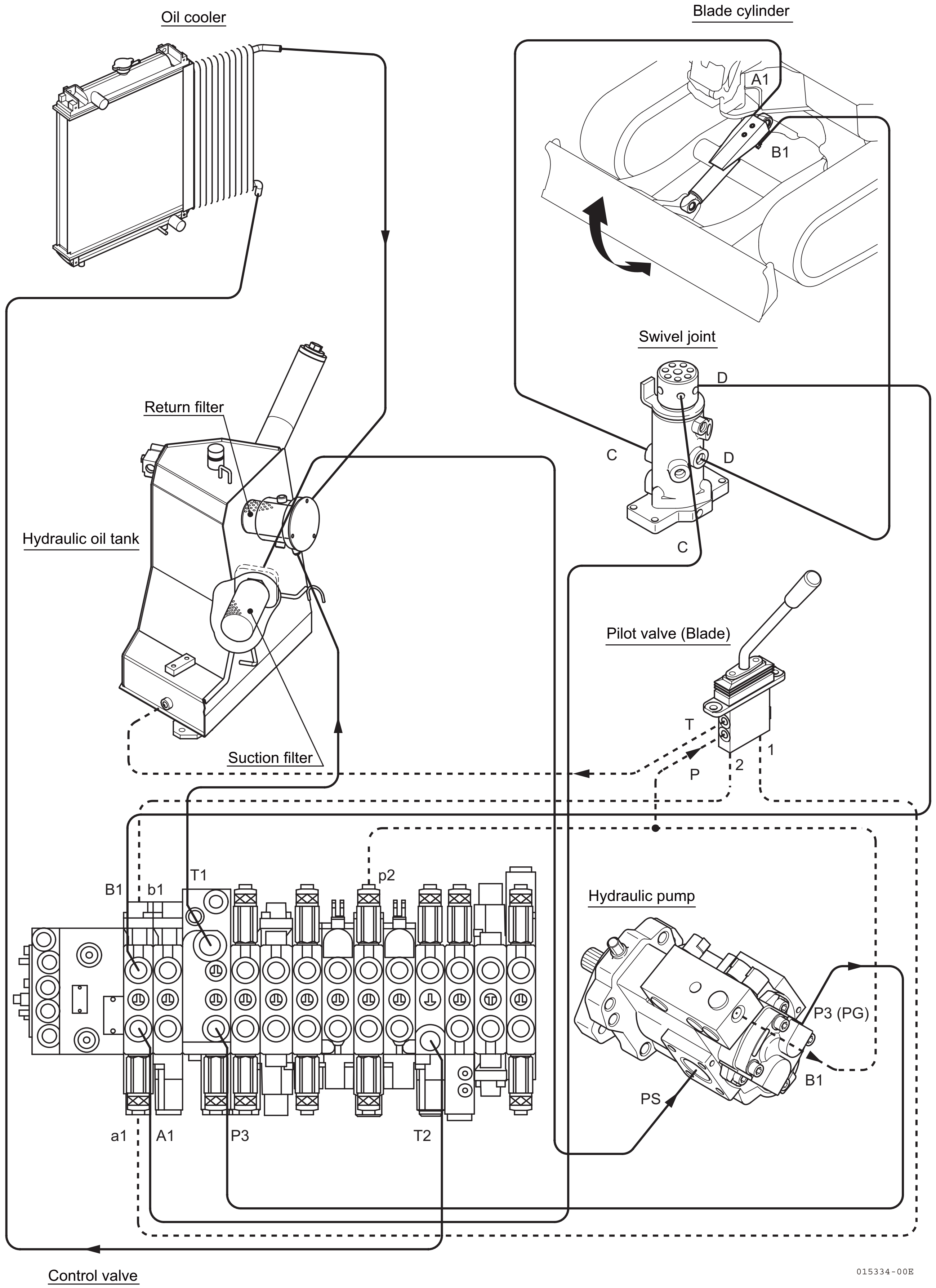
(2) Oil Flow from Hydraulic Pump

The oil flows in the opposite direction to the oil flow in the blade down operation with regard to the blade cylinder.

3) Circuit Relief Valve Installed in Blade "Up" Circuit

When the blade is raised while the machine is traveling, the oil quantity control function of the hydraulic pump operates to reduce its discharge volume, and the travel speed is slowed down. To minimize such speed reduction, a circuit relief valve with the set pressure lower than that of the system relief valve is installed in the blade cylinder circuit for raising the blade.




Oil cooler
Blade cylinder
A1
B1
Swivel joint
D
C
D
C
Return filter
Hydraulic oil tank
Pilot valve (Blade)
T
2
1
P
Suspension filter
B1
b1
T1
p2
Hydraulic pump
P3 (PG)
B1
PS
a1
A1
P3
T2
Control valve
015334-00E

5-3-7 Travel

Each travel lever is linked to the spool of the control valve through an L-ball and a rod.

1) Forward Travel (Right)
Oil Flow from Hydraulic Pump
When the right travel lever is pushed forward, the spool of the right travel section is pulled up.
The oil from the piston pump P1 flows through the port P1 of the inlet section, the port A7 of the right travel section and the port E of the swivel joint to the port P2 of the right travel motor to rotate it.
The return oil from the port P1 of the right travel motor flows back to the hydraulic oil tank through the port A of the swivel joint, the port B7 of the right travel section, the ports T1 and T2 of the control valve and the oil cooler.

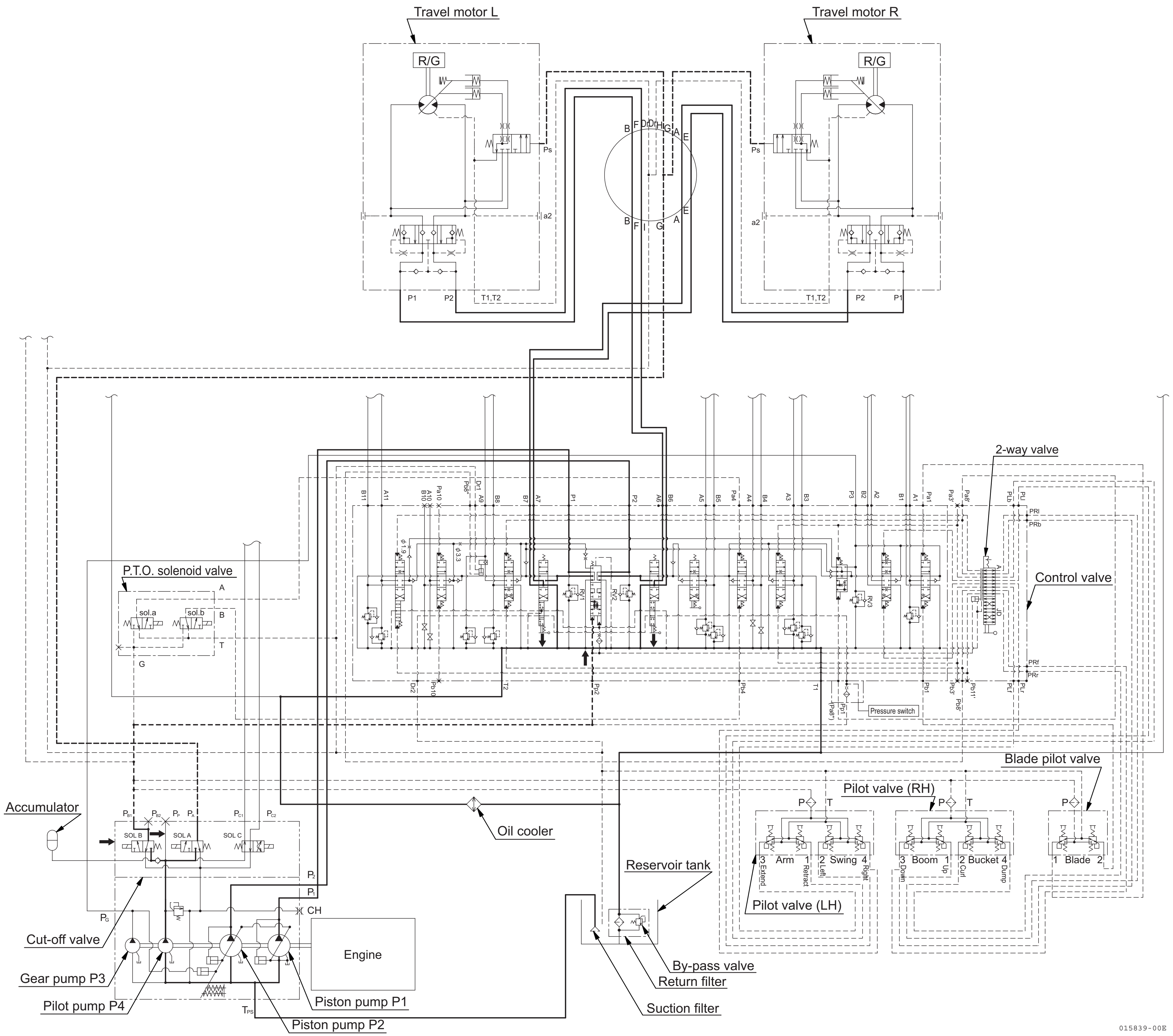
2) Forward Travel (Left)
Oil Flow from Hydraulic Pump
The oil from the piston pump P2 flows through the port P2 of the inlet section, the port A6 of the left travel section and the port B of the swivel joint to the port P1 of the left travel motor to rotate it.
The return oil from the port P2 of the left travel motor flows back to the hydraulic oil tank through the port F of the swivel joint, the port B6 of the left travel section, the ports T1 and T2 of the control valve and the oil cooler.

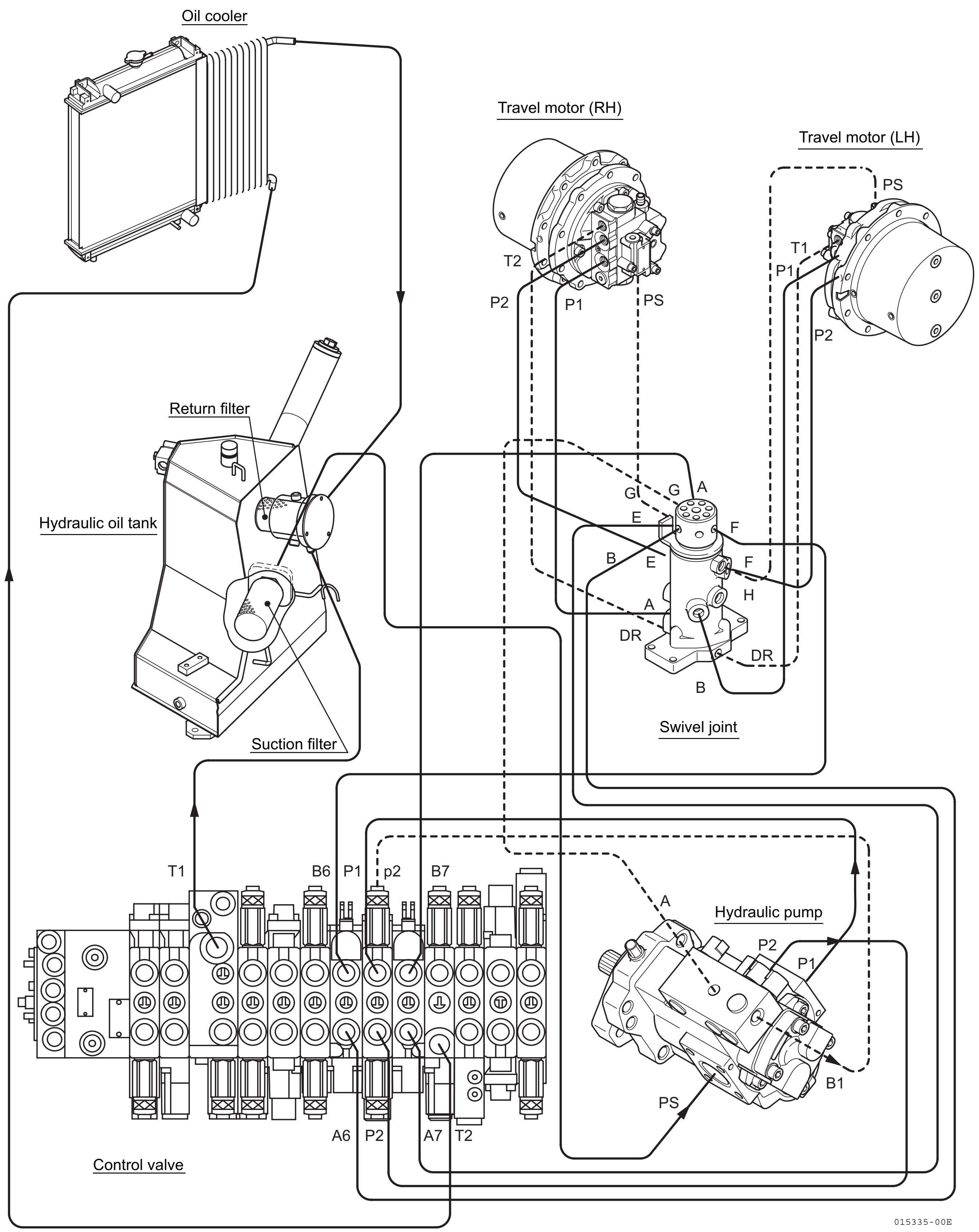
3) Reverse Travel (Right and Left)
Oil Flow from Hydraulic Pump
When the right or left travel lever is pulled back, the spool of the travel section is pressed down.
The oil flows in the opposite direction to the oil flow in the Forward Travel operation with regard to the right or left travel motor.

4) High-Speed Function
When the high-speed pedal is moved, the signal is transmitted from the safety switch to the solenoid valve A to increase the travel speed.

(1) Pilot oil flow
When the high-speed pedal is moved, the signal is transmitted from the safety switch to the cut-off valve and the solenoid valve A is opened. The oil from the pilot pump P4 flows through the port A of the solenoid valve A to the port G of the swivel joint and is divided into two flows to the ports G and H there to flow to the port Ps of each travel motor.

(2) Increase in output speed of travel motor
The pilot oil from the pilot pump P4 moves the swash plate control piston to reduce the inclination angle of the swash plate, which shortens the piston stroke of the travel motor and decreases the travel motor capacity to increase its output speed. This increases the travel speed.
Meanwhile, the travel driving force weakens as the output torque of the travel motor becomes smaller due to the shortened piston stroke.




Oil cooler
Travel motor (RH)
Travel motor (LH)
PS
T1
P1
T2
P2
P1
PS
P2
Return filter
Hydraulic oil tank
G
G
A
E
F
B
E
F
H
A
DR
DR
B
Swivel joint
Suction filter
T1
B6
P1
p2
B7
A
Hydraulic pump
P2
P1
B1
PS
A6
P2
A7
T2
Control valve
015335-00E

5-3-8 Non-Deviation Travel (with Boom, Arm or Boom Swing Operation)

Oil Flow from Hydraulic Pump

1) Travel Section

The oil from the piston pump P1 and that from the piston pump P2 flow through the ports P1 and P2 of the inlet section to the right and left travel sections, respectively. The right and left travel sections are each connected in series in their respective section groups and located the most upstream in the circuits of the piston pumps P1 and P2, respectively. Therefore, all of the oil from each piston pump flows to the travel motor when the travel lever is operated.

2) Boom Section

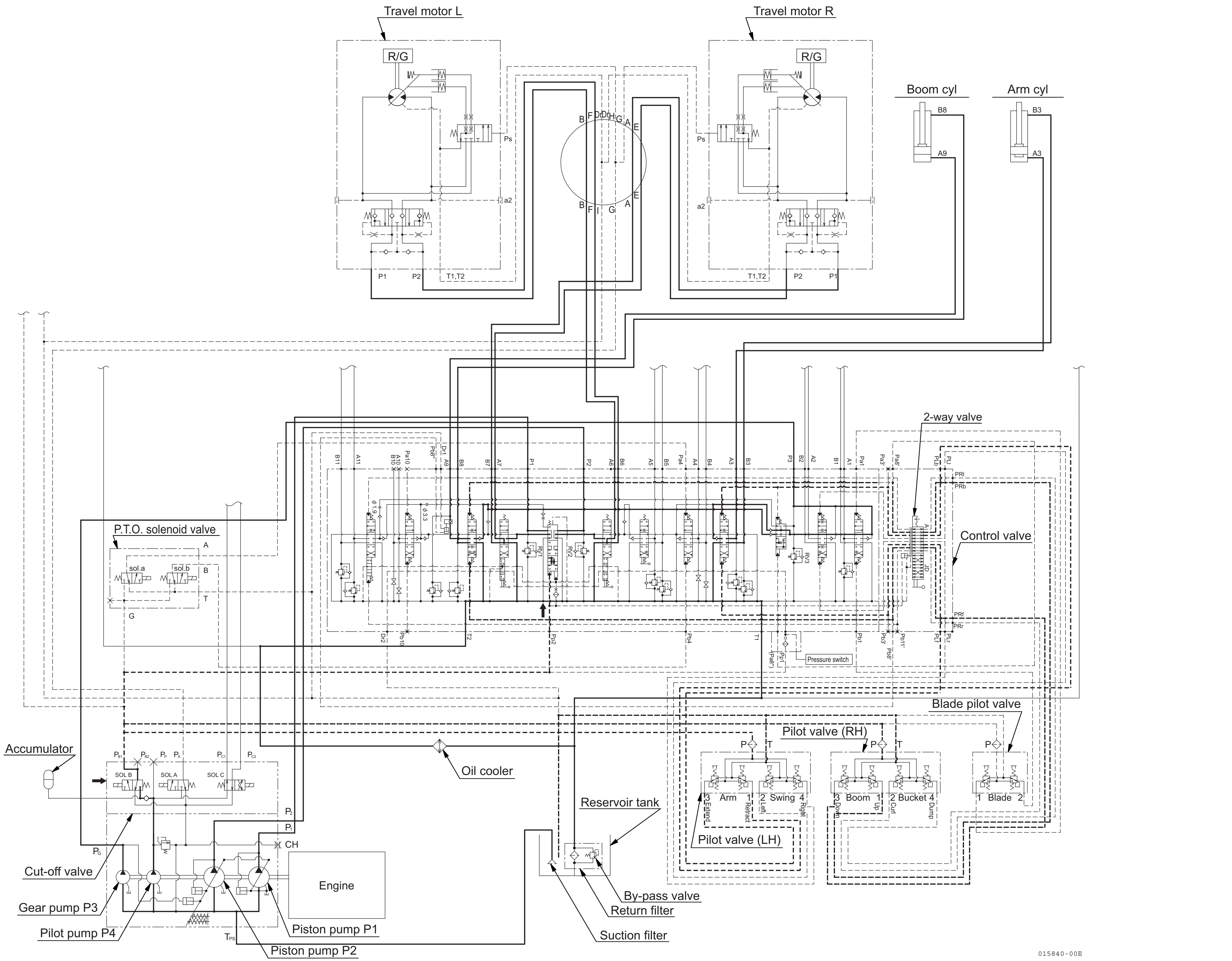
The oil from the gear pump P3 flows through the parallel-flow divider and the parallel passage to the boom section. Therefore, the machine can travel with no deviation even when the boom control lever is moved while the machine is traveling.

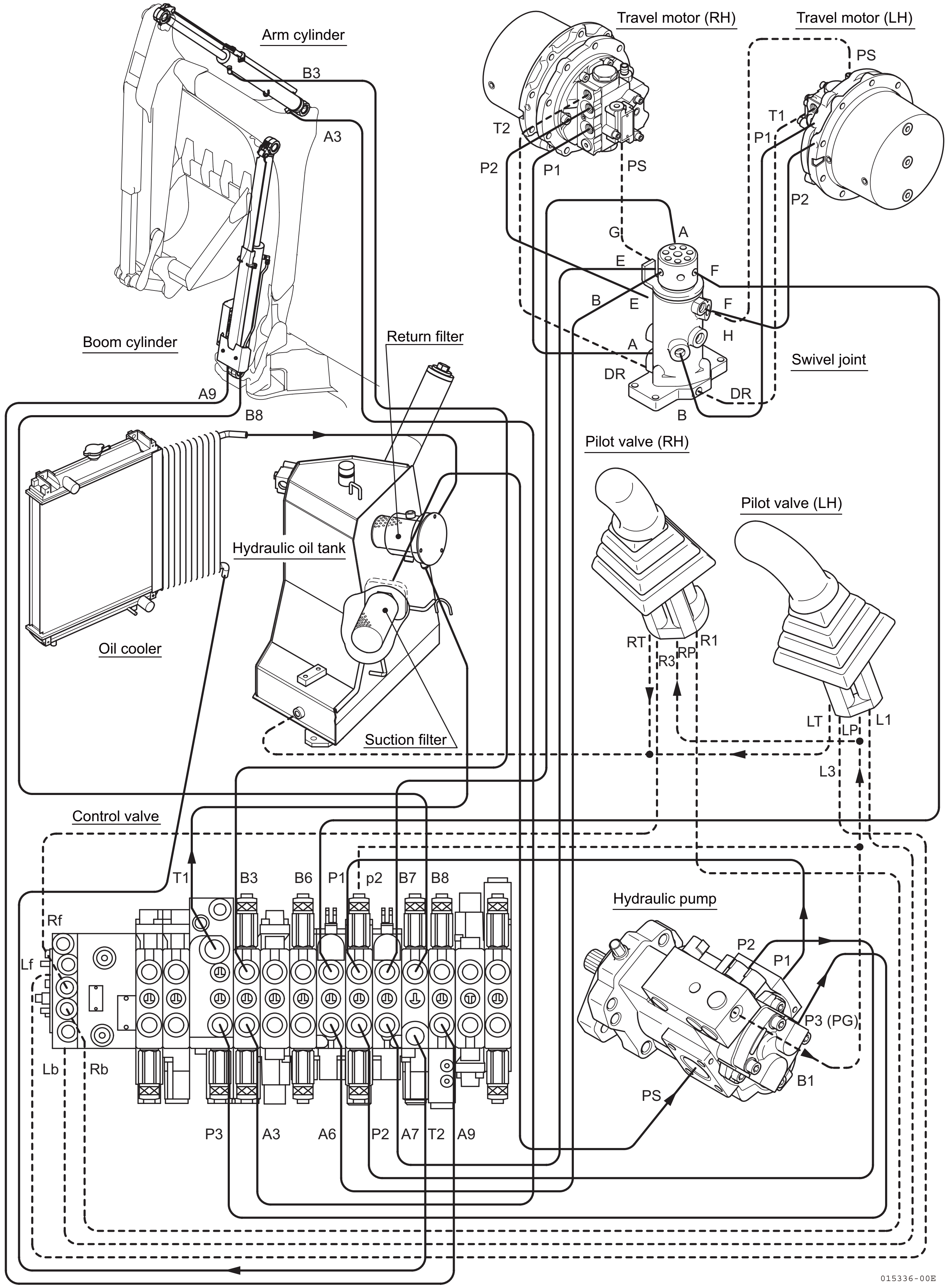
3) Arm Section

The oil from the gear pump P3 flows through the parallel-flow divider, blade and swing sections and the parallel passage to the arm section. Therefore, the machine can travel with no deviation even when the arm control lever is moved while the machine is traveling.

4) Boom Swing Section

All the oil in the circuit of the piston pump P2 is supplied to the travel section in the most upstream for the pump P2, and the boom swing section in the downstream is supplied with no oil. None of the oil from the gear pump P3 is supplied to the boom swing section, either, so that the boom does not swing while the machine is traveling.



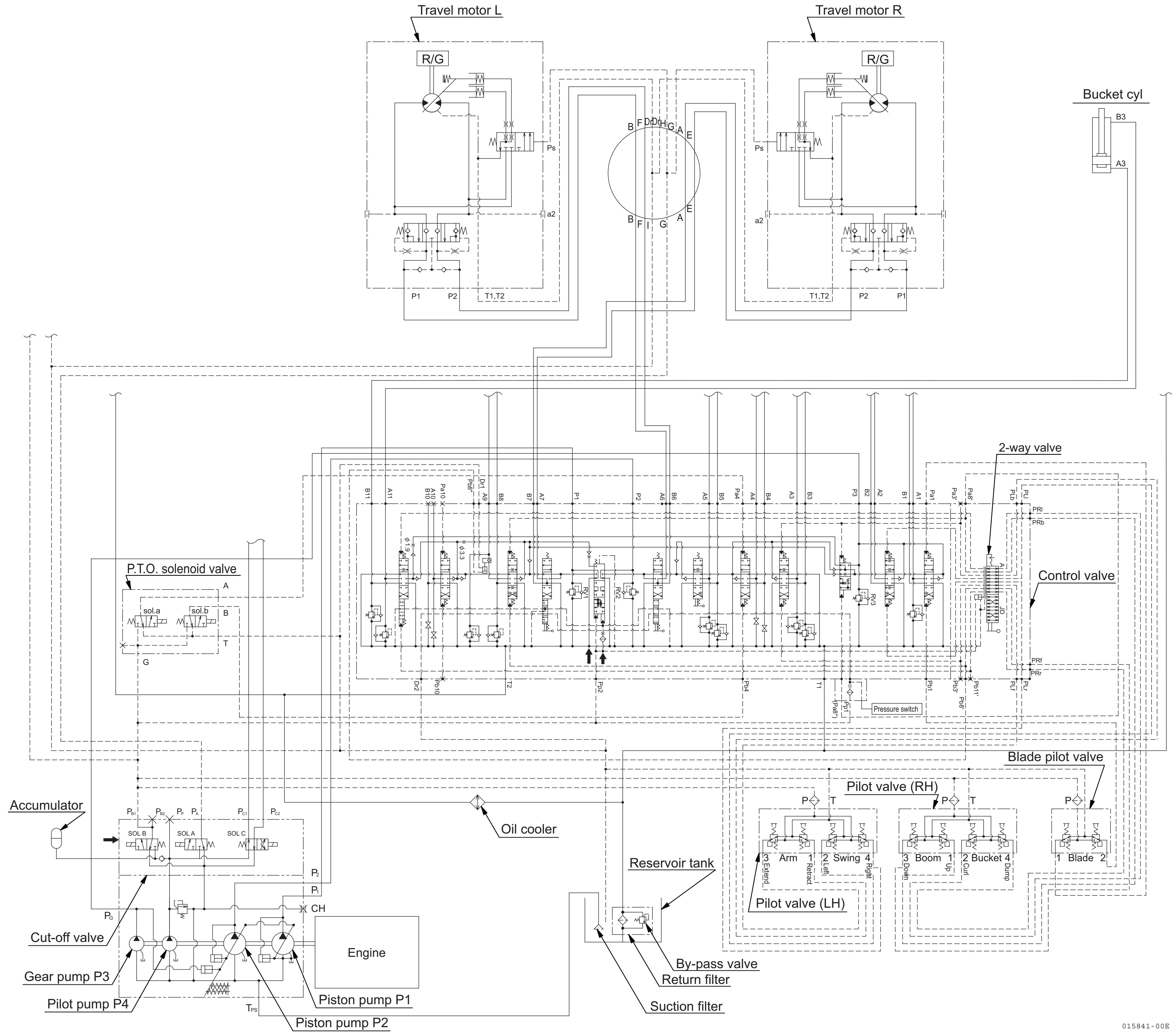

Arm cylinder
B3
A3
Boom cylinder
A9
B8
Travel motor (RH)
Travel motor (LH)
PS
T1
P1
P2
T2
P2
P1
PS
G
A
E
F
B
E
F
H
A
DR
DR
B
Swivel joint
Return filter
Hydraulic oil tank
Oil cooler
Suction filter
Pilot valve (RH)
Pilot valve (LH)
RT
R3
RP
R1
LT
LP
L1
L3
Control valve
T1
B3
B6
P1
p2
B7
B8
Rf
Lf
Lb
Rb
P3
A3
A6
P2
A7
T2
A9
Hydraulic pump
P2
P1
P3 (PG)
B1
PS
015336-00E

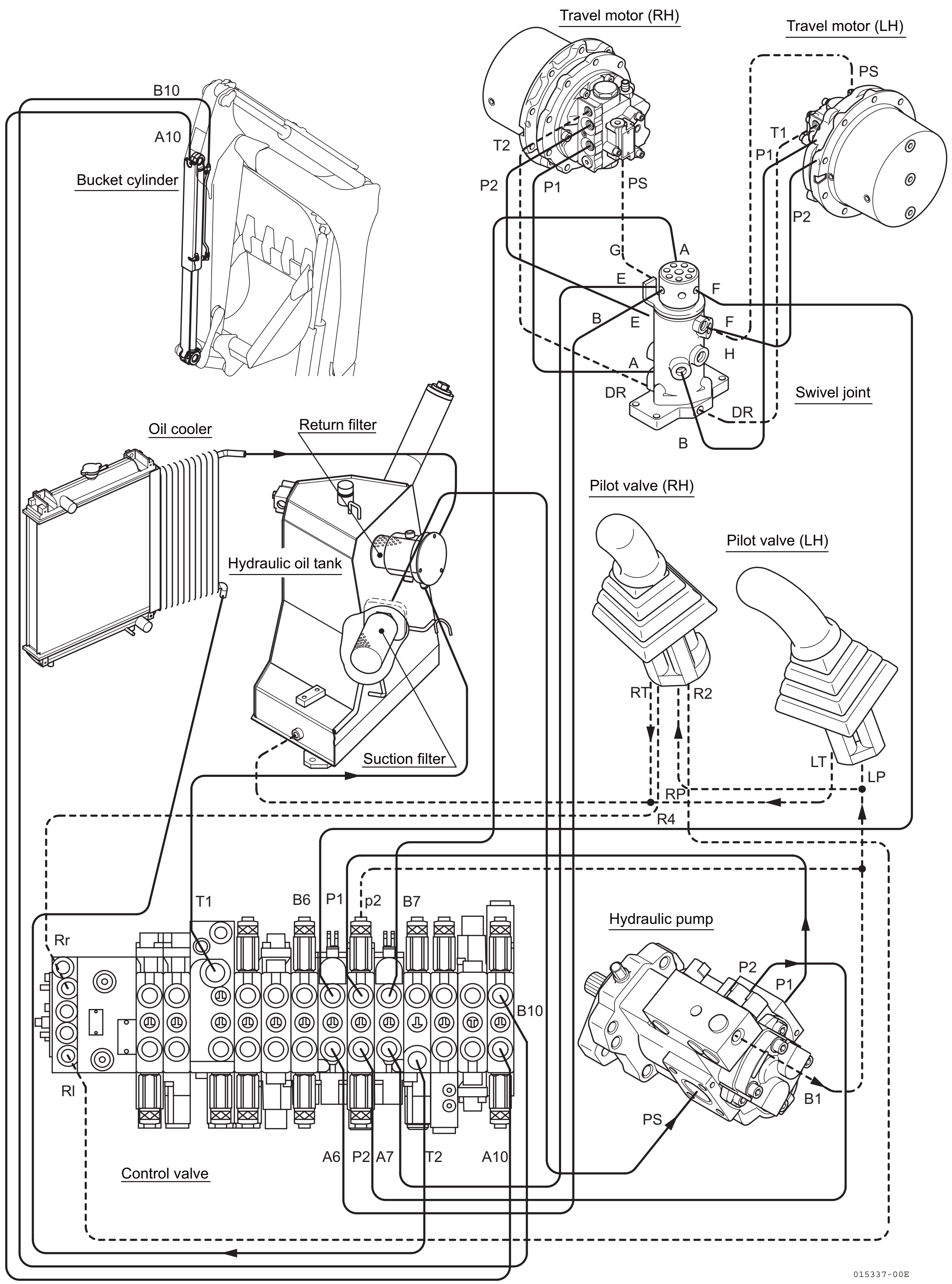
5-3-9 Non-Deviation Travel (with Bucket Operation)

When the bucket is operated while traveling, the spools of travel and bucket sections are moved, so that the pilot oil passages are blocked at the sections. Consequently, the pilot oil pressure at the port p2 of the inlet section raises to move the spool of the inlet section.

Oil Flow from Hydraulic Pump

The pilot oil moves the spool of the parallel-flow divider to the neutral position to let the oil from the gear pump P3 flow into the arm section prior to the boom section.





Travel motor (RH)
Travel motor (LH)
B10
A10
Bucket cylinder
T2
P2
P1
PS
T1
P1
P2
PS
G
A
E
F
B
E
F
H
A
DR
DR
B
Swivel joint
Oil cooler
Return filter
Hydraulic oil tank
Suction filter
Pilot valve (RH)
Pilot valve (LH)
RT
R2
LT
LP
RP
R4
T1
B6
P1
p2
B7
Rr
B10
Rl
A6
P2
A7
T2
A10
Control valve
Hydraulic pump
P2
P1
B1
PS
015337-00E

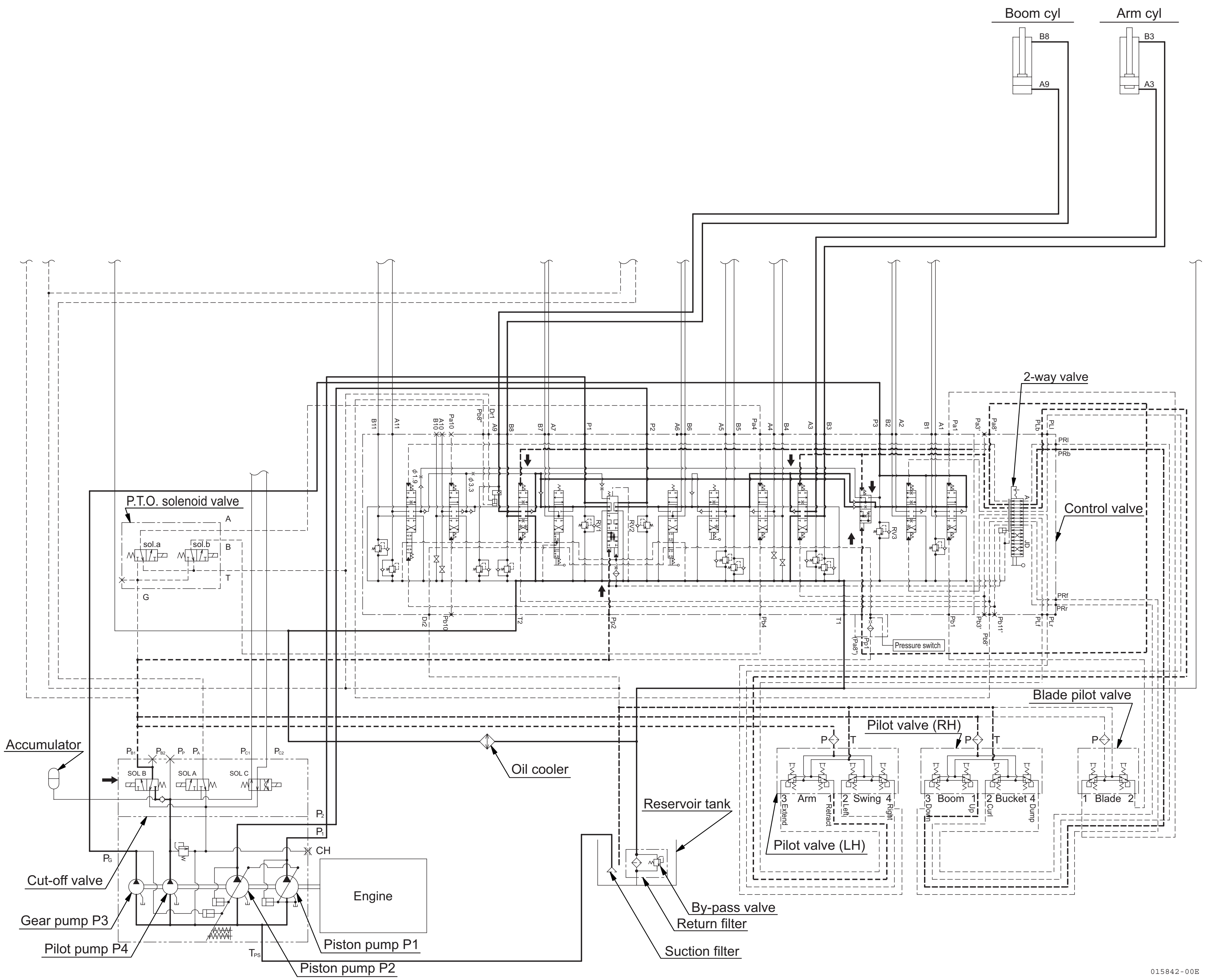
5-3-10 Simultaneous Operation of Boom Up and Arm Retract

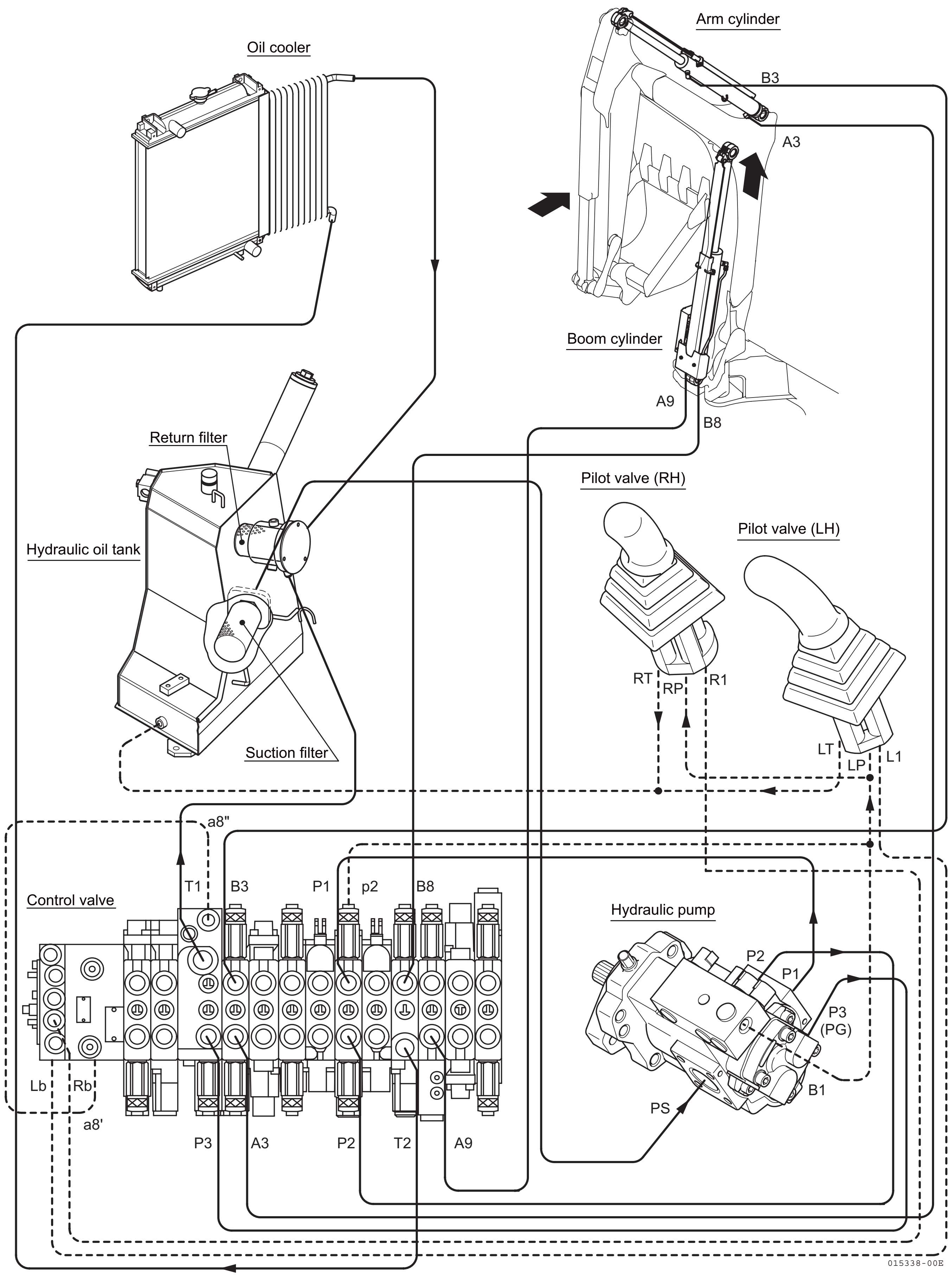
Oil Flow from Hydraulic Pump

If the arm control lever is pulled back to retract the arm while the boom control lever is pulled back to raise the boom, the parallel-flow divider receives the same pilot oil pressure from the ports a8'' and Lb to keep the spool in the neutral position.

At that time, the oil from the gear pump P3 is combined with the oil to the arm cylinder prior to the boom cylinder to increase the speed of the Arm Retract operation.

Refer to Section "5-3-1 Boom" and Section "5-3-2 Arm" for the oil flow with regard to the boom and arm cylinders.



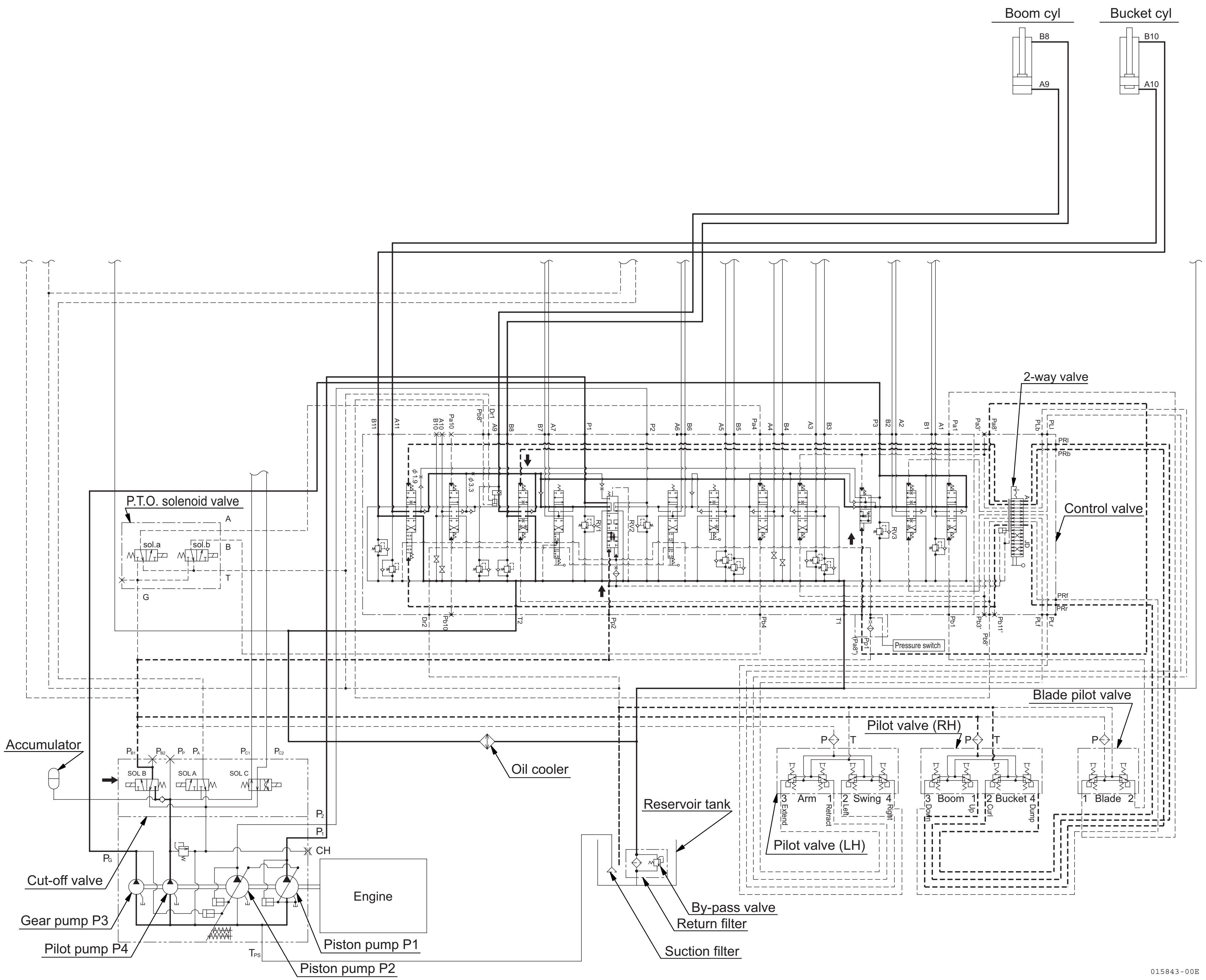

Arm cylinder
Oil cooler
B3
A3
Boom cylinder
A9
B8
Return filter
Pilot valve (RH)
Pilot valve (LH)
Hydraulic oil tank
RT
RP
R1
LT
LP
L1
Suction filter
a8"
T1
B3
P1
p2
B8
Control valve
Hydraulic pump
P2
P1
P3
(PG)
B1
PS
Lb
Rb
a8'
P3
A3
P2
T2
A9
015338-00E

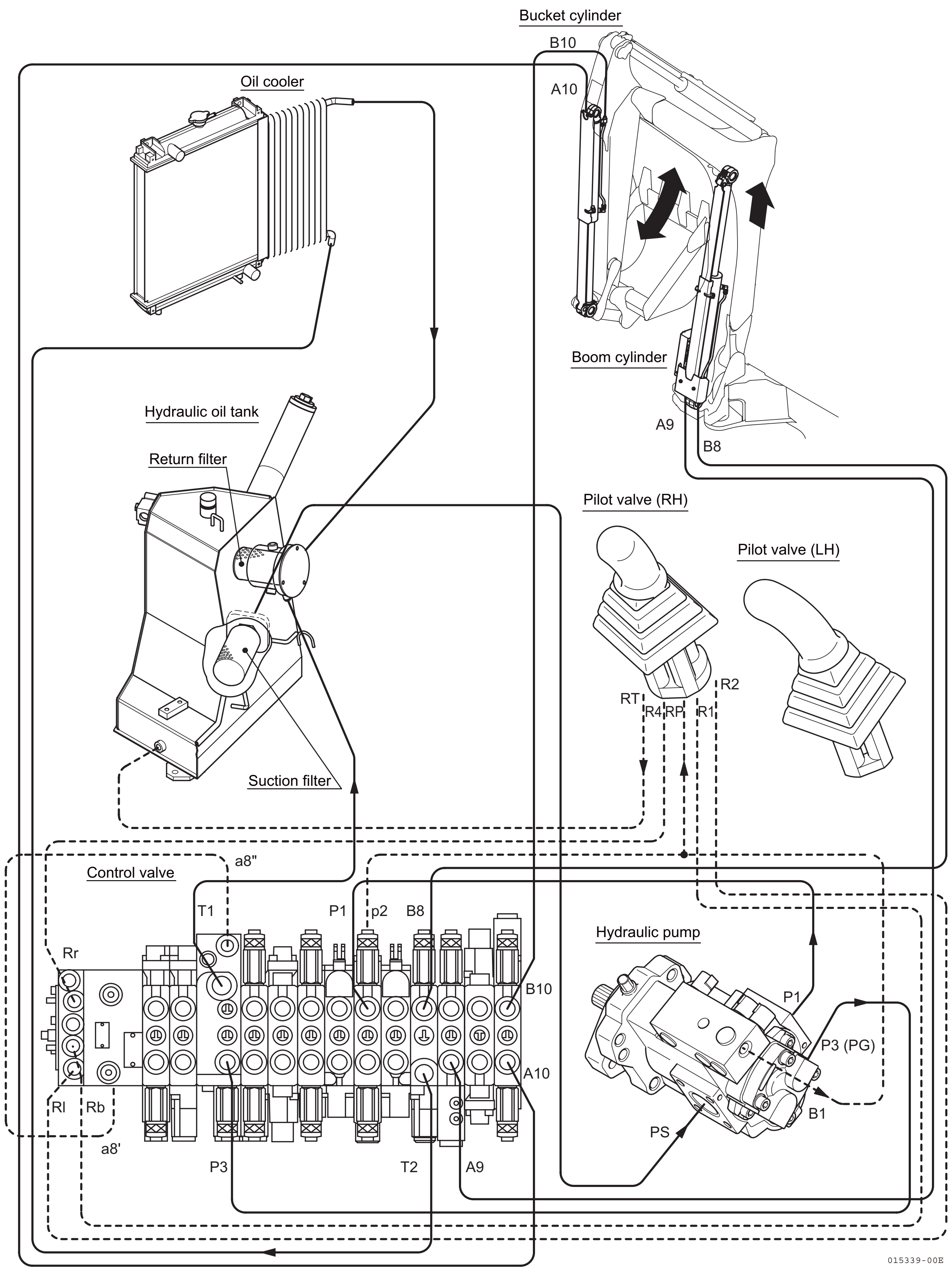
5-3-11 Simultaneous Operation of Boom Up and Bucket

Oil Flow from Hydraulic Pump

A throttle ([Ø0.13 in. [3.3 mm]) is installed in the parallel passage in the bucket section so that the oil can flow more smoothly to the boom section when the bucket control lever is moved while the boom with a heavy load is being raised. Therefore, the boom and the bucket can operate simultaneously.

Refer to Section "5-3-1 Boom" and Section "5-3-3 Bucket" for the oil flow with regard to the boom and bucket cylinders.




Bucket cylinder
B10
A10
Oil cooler
Boom cylinder
A9
B8
Hydraulic oil tank
Return filter
Pilot valve (RH)
Pilot valve (LH)
RT
R4
RP
R1
R2
Suction filter
a8"
Control valve
T1
P1
p2
B8
Rr
B10
Hydraulic pump
P1
P3 (PG)
A10
Rl
Rb
a8'
B1
PS
P3
T2
A9
015339-00E

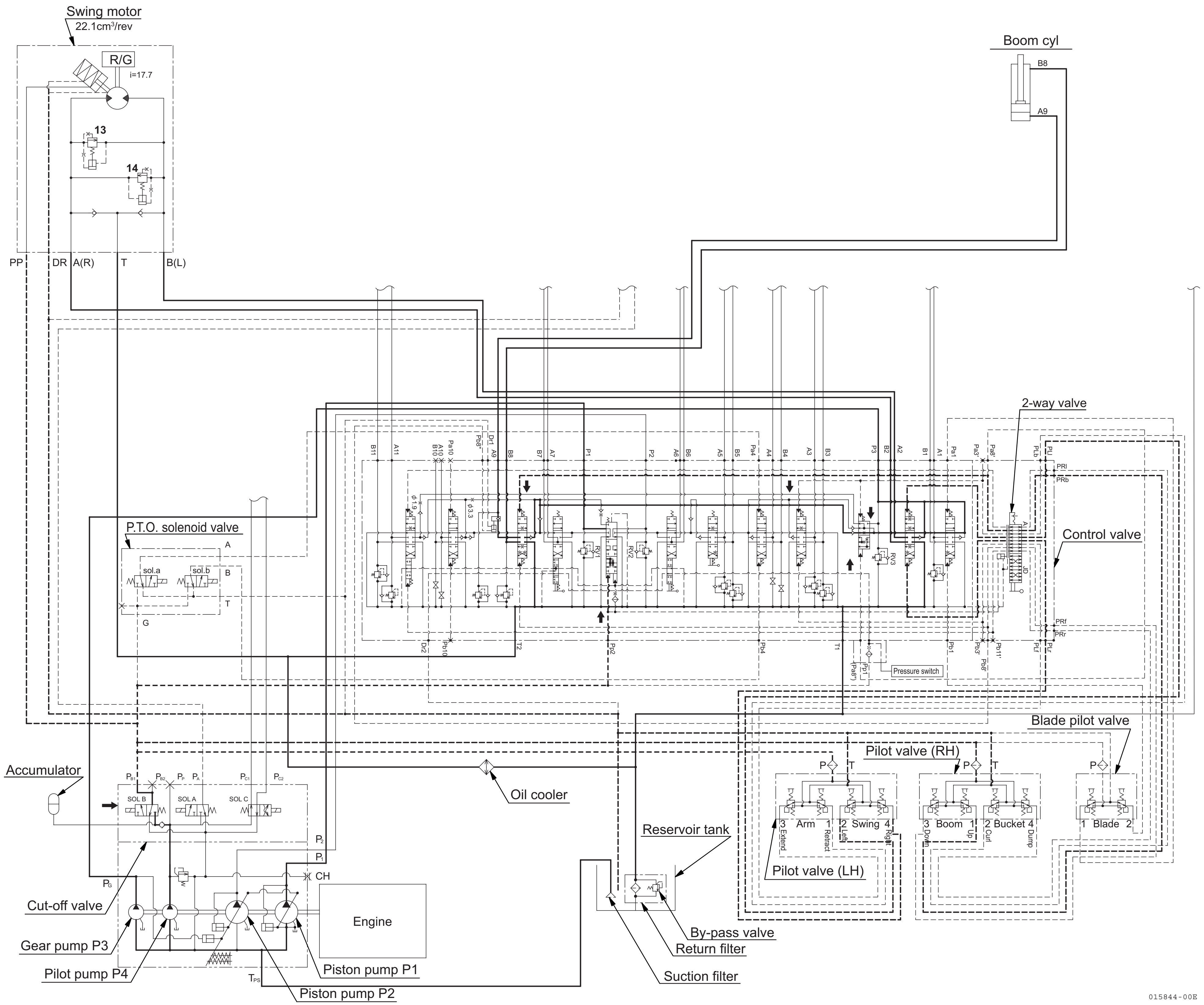
5-3-12 Simultaneous Operation of Boom Up and Swing

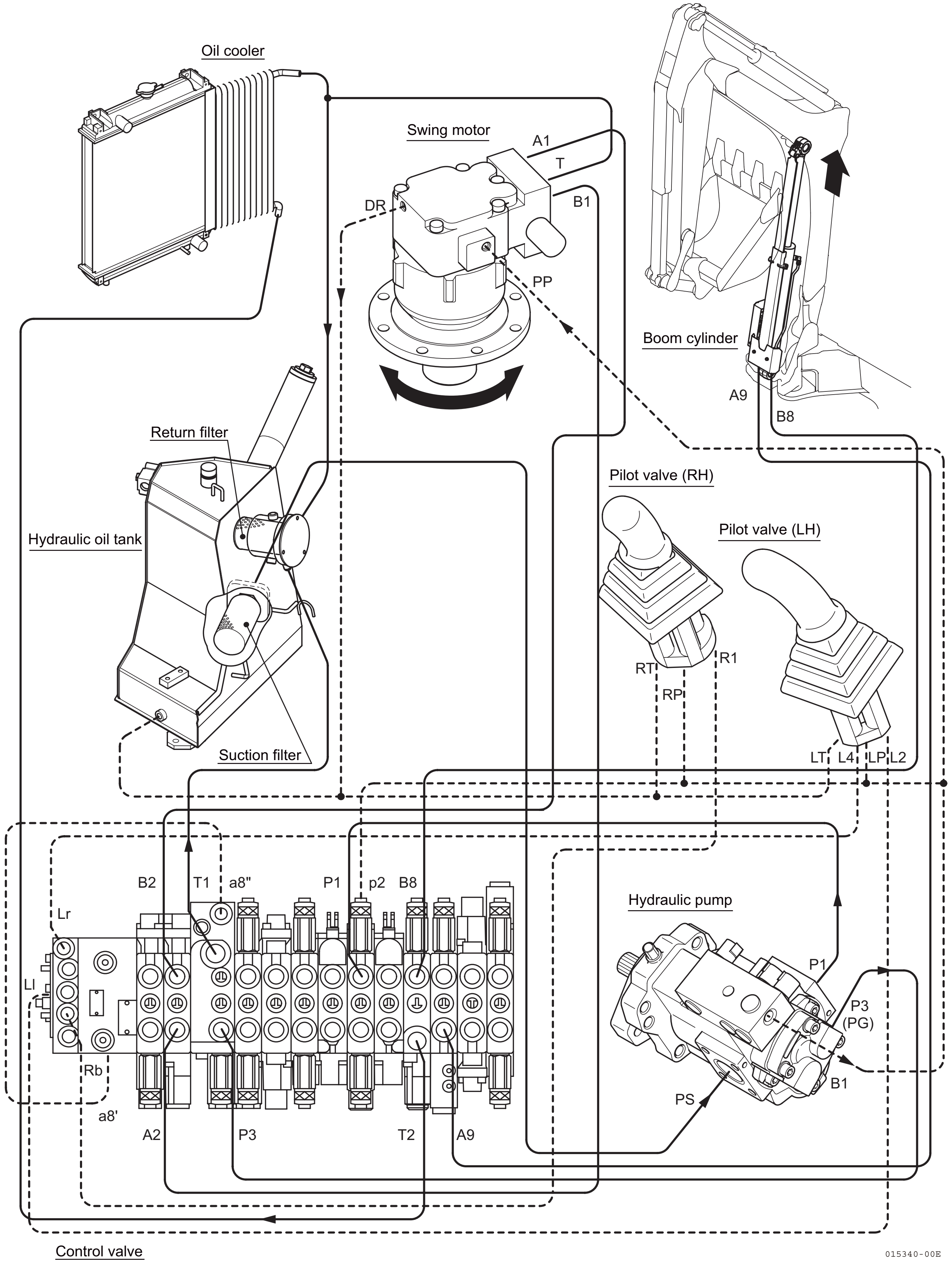
Oil Flow from Hydraulic Pump

The oil from the gear pump P3 flows to the port P3 of the parallel-flow divider and is divided into two oil flows. One of them flows to the swing section through the parallel passage, and the other flows to the boom section through the parallel passage to combine with the oil from the piston pump P1.

Throttles and a check valve are installed in the swing section so as to match the swing speed to the boom-up speed.

Refer to Section "5-3-1 Boom" and Section "5-3-4 Swing" for the oil flow with regard to the boom cylinder and the swing motor.



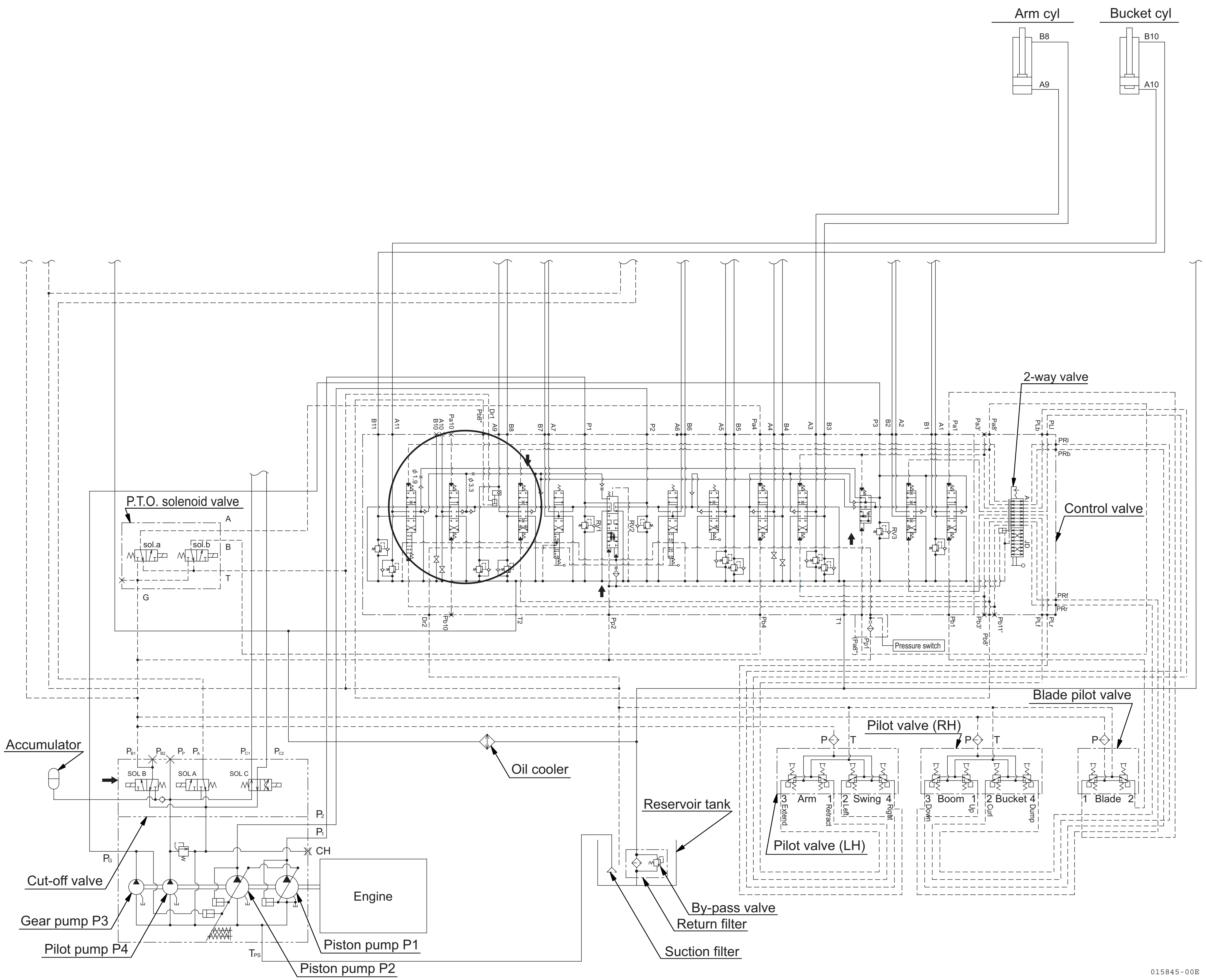

Oil cooler
Swing motor
A1
T
B1
DR
PP
Boom cylinder
A9
B8
Return filter
Hydraulic oil tank
Pilot valve (RH)
Pilot valve (LH)
RT
R1
RP
LT
L4
LP
L2
Suction filter
B2
T1
a8"
P1
p2
B8
Lr
Ll
Rb
a8'
A2
P3
T2
A9
Hydraulic pump
P1
P3
(PG)
B1
PS
Control valve
015340-00E

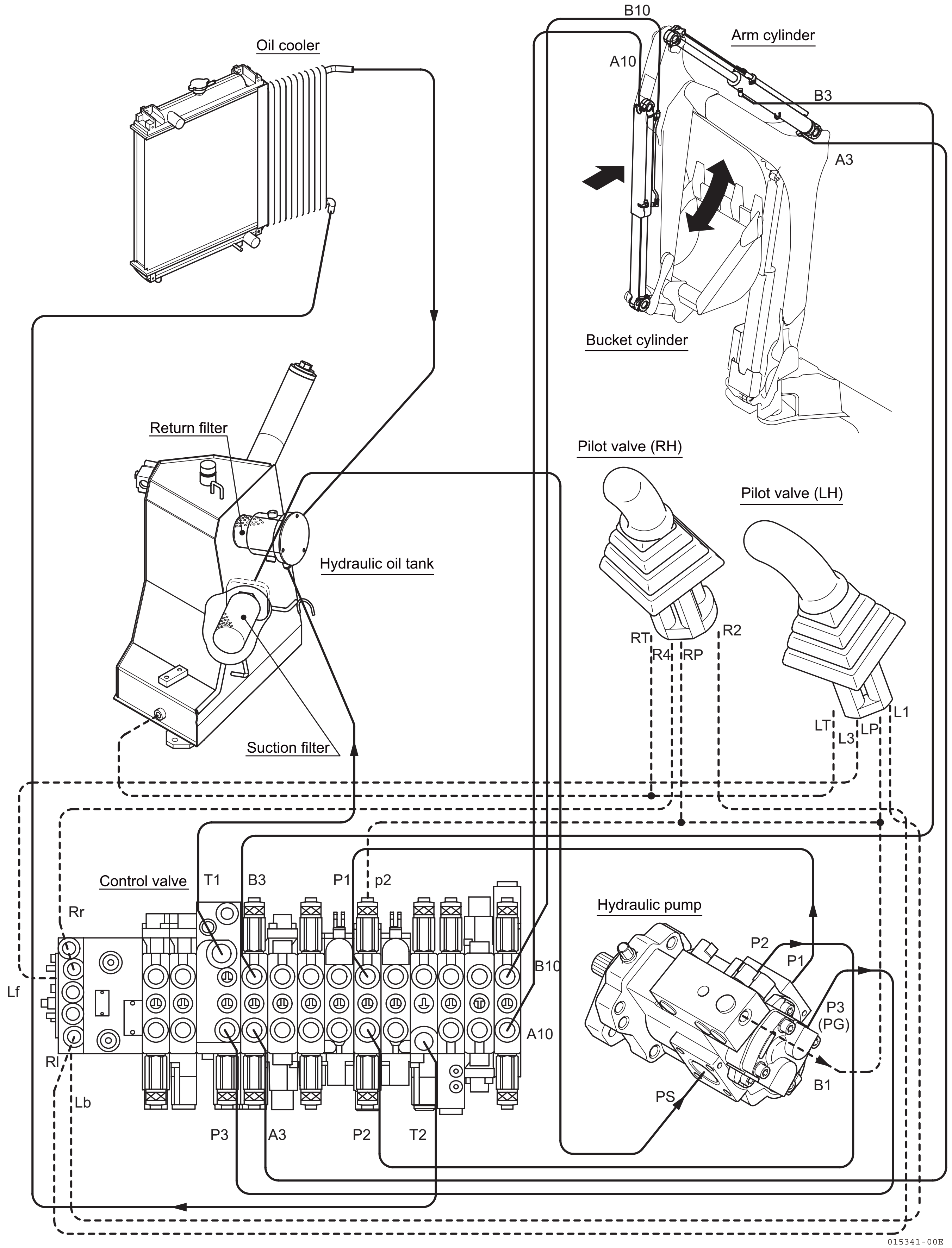
5-3-13 Simultaneous Operation of Arm and Bucket

Oil Flow from Hydraulic Pump

When the arm is given a heavy load, the horsepower control shift of the gear pump P3 works to decrease the discharge volume of the piston pump P1, so the bucket speed slows down. To make up for the bucket speed reduction, the oil from the gear pump P3 flows through the parallel-flow divider and the parallel passage to the bucket section and combines with the oil from the piston pump P1.

Refer to Section "5-3-2 Arm" and Section "5-3-3 Bucket" for the oil flow with regard to the arm and bucket cylinders.




Oil cooler
B10
Arm cylinder
A10
B3
A3
Bucket cylinder
Return filter
Hydraulic oil tank
Suction filter
Pilot valve (RH)
Pilot valve (LH)
RT
R4
RP
R2
LT
L3
LP
L1
Control valve
T1
B3
P1
p2
Rr
Lf
Rl
Lb
B10
A10
P3
A3
P2
T2
Hydraulic pump
P2
P1
P3
(PG)
B1
PS
015341-00E

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

The P.T.O. operation is controlled by the switch on the RH lever or the P.T.O. foot switch.

1) Oil Flow from Hydraulic Pump

Turn the knob on the P.T.O. return selector valve to select single or double acting of the P.T.O.

2) Single Acting P.T.O.

When the left position of the lever switch or the foot switch is pressed, the solenoid of the P.T.O. solenoid valve SOL b is exited to move its spool. The oil from the pilot pump P4 flows through the port B1 of the cut-off valve, and the port B of the P.T.O. solenoid valve to the port b4 of the P.T.O. section to move its spool.

Oil Flow from Hydraulic Pump

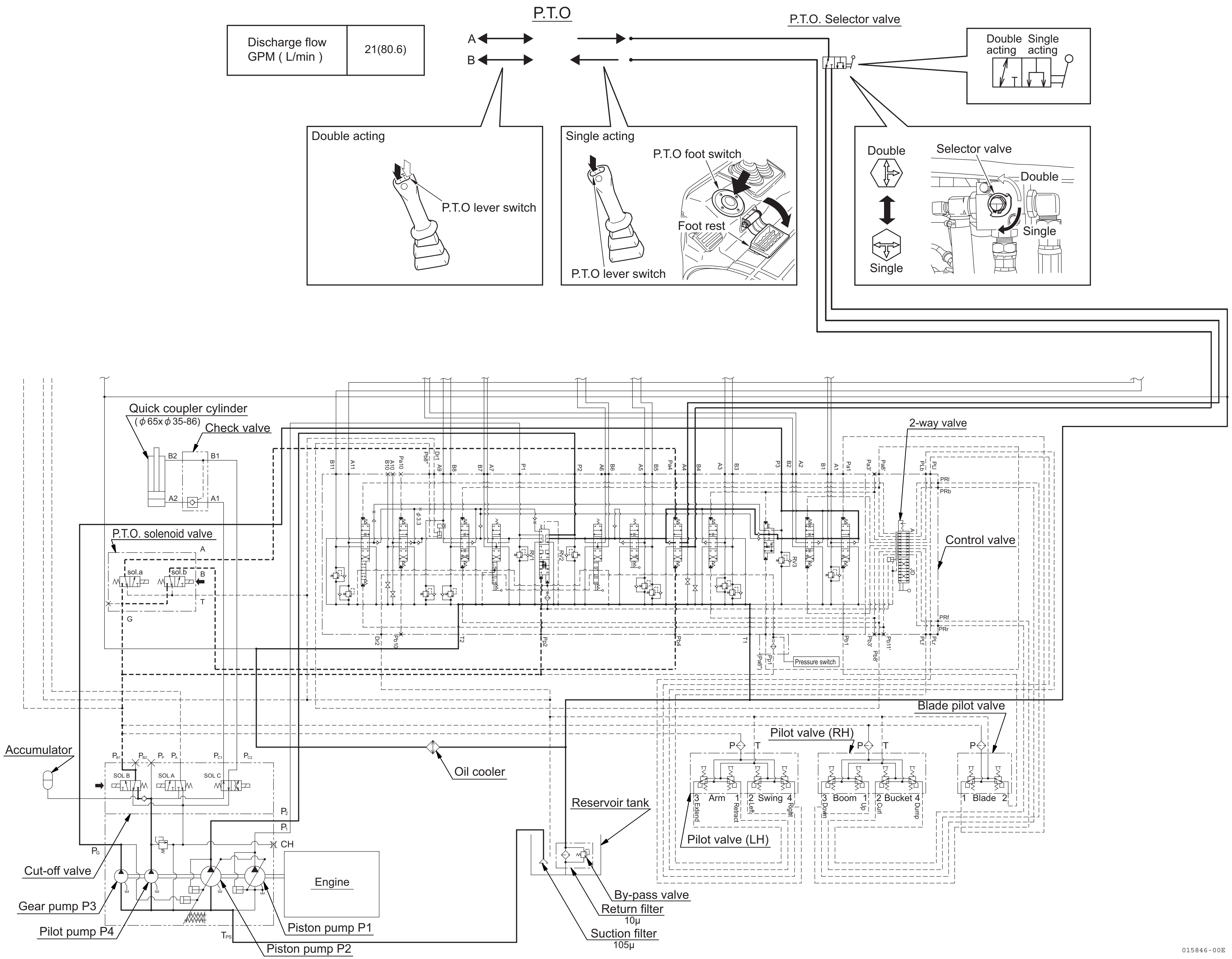
The oil from the piston pump P2 flows to the P.T.O. section through the port P2 of the inlet section. The oil from the gear pump P3 flows through the parallel-flow divider section and the parallel oil passage to the P.T.O. section and is combined with the oil from the piston pump P2. The combined oil flows to the port B4 of the P.T.O. section.
Some return oil directly flows back to the reservoir and the remaining returns through the port A4 of the P.T.O. section and the port T1 or T2 and the oil cooler to the reservoir.

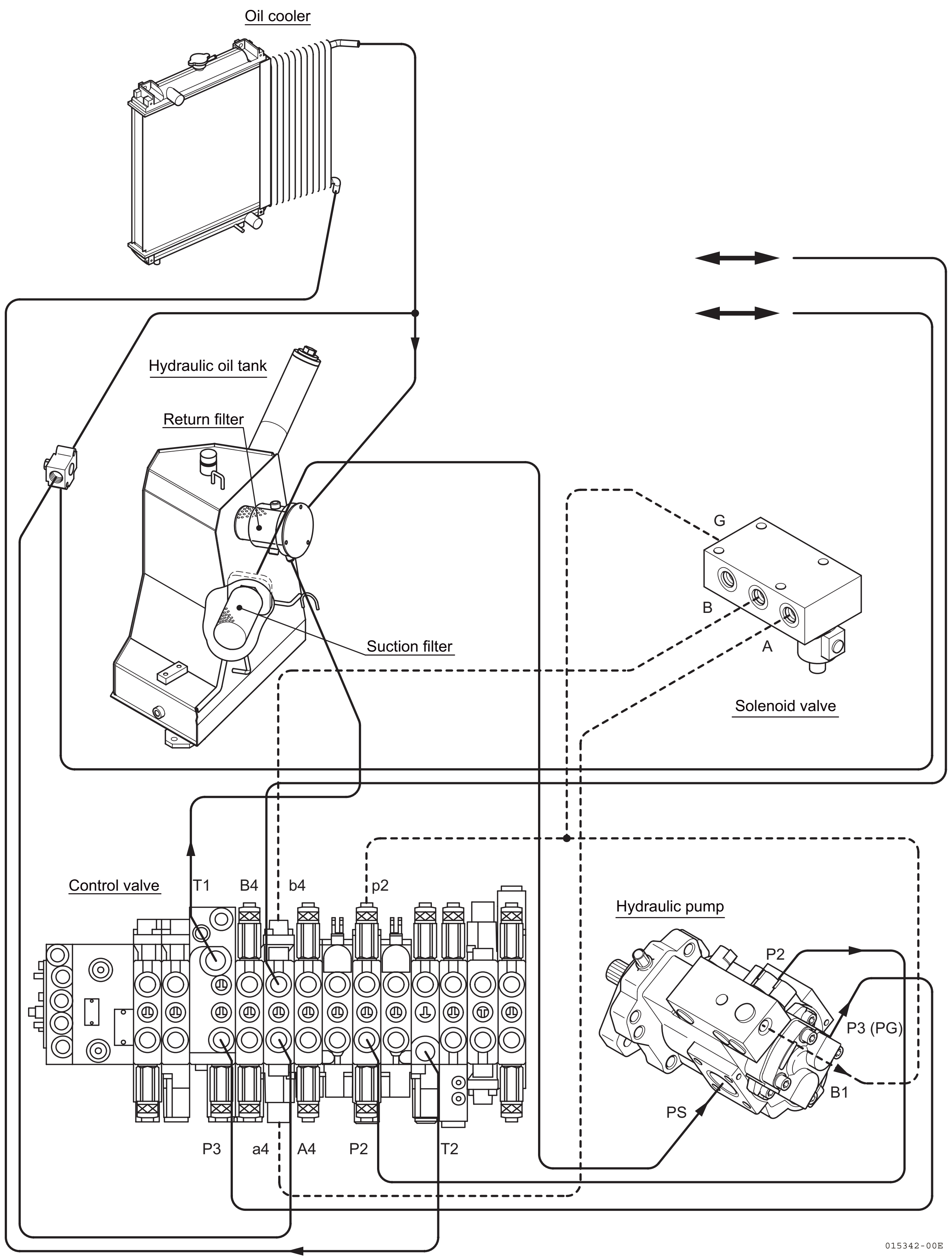
3) Double Acting P.T.O.

When the left position of the lever switch is pressed, oil flow is the same as that when the single acting P.T.O. is selected.
When the right position of the lever switch is pressed, the solenoid of the P.T.O. solenoid valve SOL a is exited to move its spool. The oil from the pilot pump P4 flows through the port A of the P.T.O. solenoid valve to the port a4 of the P.T.O. section to move its spool.

Oil Flow from Hydraulic Pump

When the right position of the lever switch is pressed, oil flows in the opposite direction to that when the left position is pressed.





Oil cooler
Hydraulic oil tank
Return filter
Suction filter
G
B
A
Solenoid valve
Control valve
T1
B4
b4
p2
Hydraulic pump
P2
P3 (PG)
B1
PS
P3
a4
A4
P2
T2
015342-00E

5-3-15 Quick Coupler

The quick coupler is operated by turning the control switch to the mounting or dismounting position.

Oil Flow from Hydraulic Pump

1) Control Switch in Mounting Position

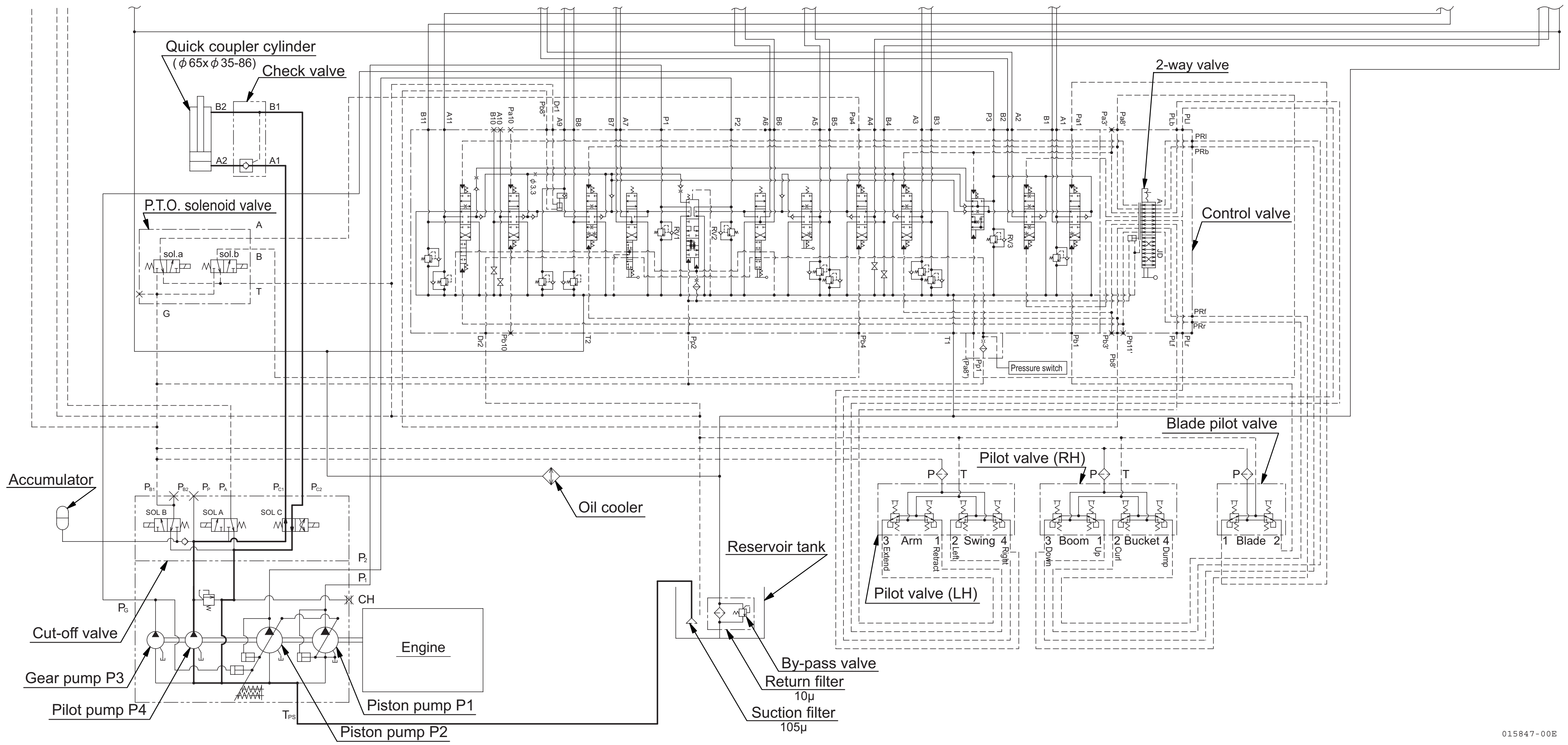
The oil from the pilot pump P4 flows through the port C1 of the cut-off valve and the operate check valve to the bottom side of the quick coupler cylinder to extend its cylinder rod.

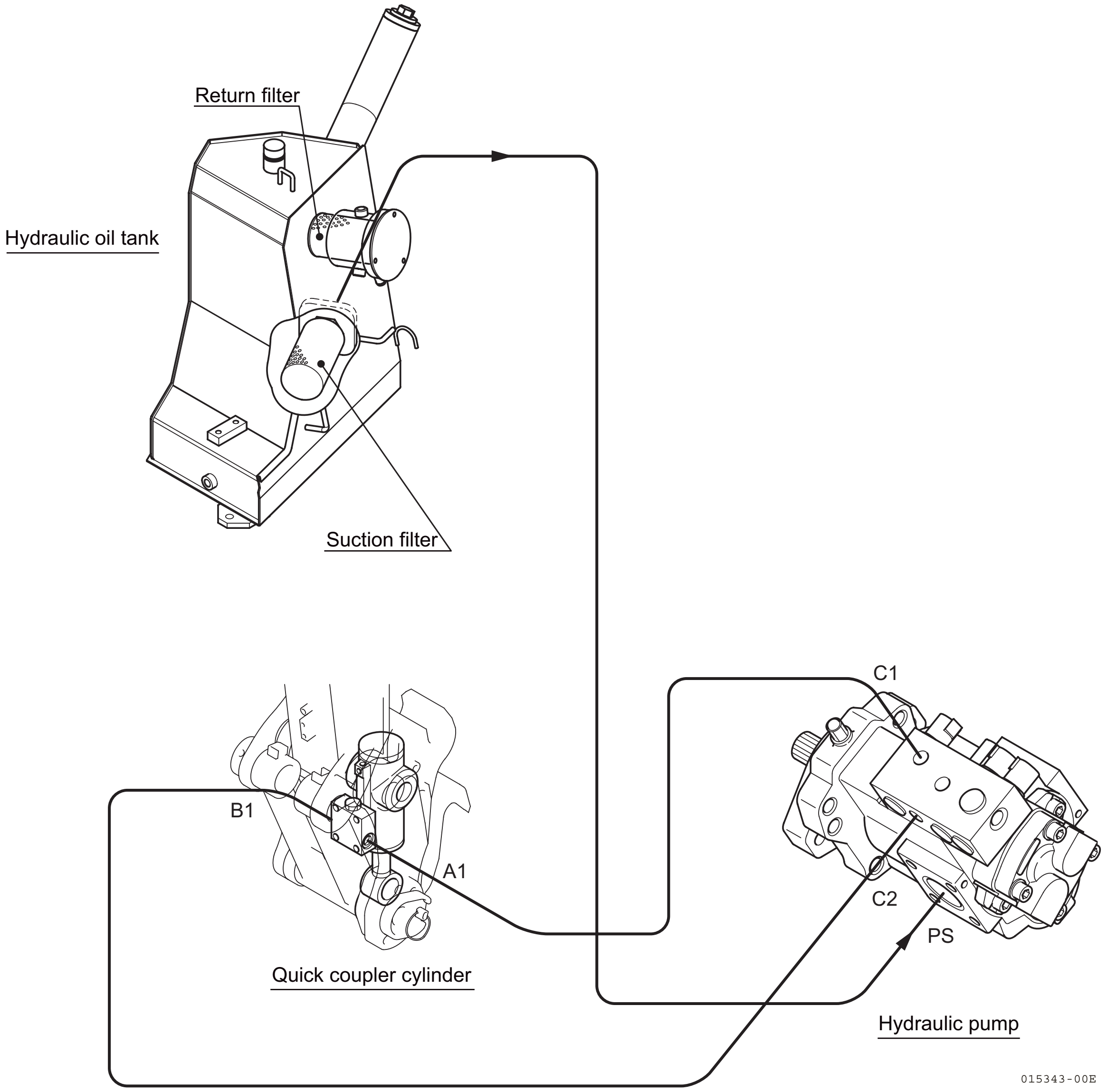
The return oil flows through the operate check valve and the port C2 of the cut-off valve to the suction circuit of the pilot pump P4.

2) Control Switch in Dismounting Position

The oil from the pilot pump P4 flows through the port C2 of the cut-off valve and opens the check valve in the operate check valve to flow to the rod side of the quick coupler cylinder, so that the cylinder rod is retracted.

The return oil flows through the operate check valve and the port C1 of the cut-off valve to the suction circuit of the pilot pump P4.




Return filter
Hydraulic oil tank
Suction filter
C1
B1
A1
C2
PS
Quick coupler cylinder
Hydraulic pump
015343-00E

5-4 Pressure Adjustment

5-4-1 Relief Valves

1) Conditions

(1) Engine : rated speed
(2) Hydraulic oil temperature : 122 to 140 °F (50 to 60 °C)
(3) Pressure gauge capacity : 5000 to 6000 PSI (35 to 40 MPa)

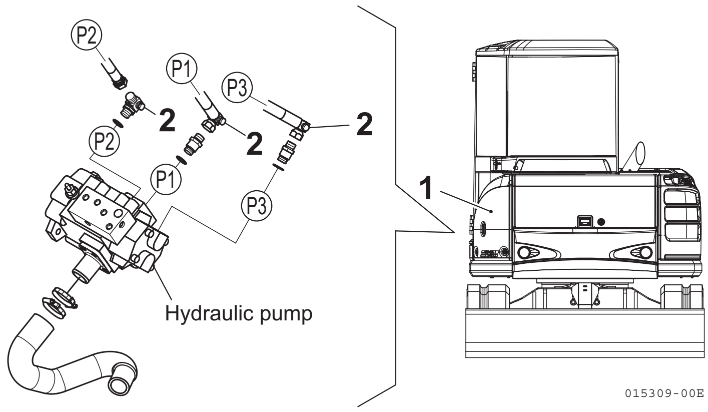
2) Relief Valve Specifications

[Unit : PSI (MPa) at GPM (L/min)]

Valve		Pump	Set pressure	
			ViO45-5	ViO55-5
System relief valve	R1	Piston pump P1	3128.4 (21.6) at 8.0 (30)	3555.0 (24.5) at 8.0 (30)
	R2	Piston pump P2	3128.4 (21.6) at 8.0 (30)	3555.0 (24.5) at 8.0 (30)
	R3	Gear pump P3	3128.4 (21.6) at 8.0 (30)	3555.0 (24.5) at 8.0 (30)
Circuit relief valve	Boom (rod end)	Piston pump P1	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Boom (bottom end)	Piston pump P1	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Arm (rod end)	Piston pump P2	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Arm (bottom end)	Piston pump P2	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Bucket (rod end)	Piston pump P1	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Bucket (bottom end)	Piston pump P1	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Boom swing (rod end)	Piston pump P2	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Boom swing (bottom end)	Piston pump P2	3555.0 (24.5) at 5.3 (20)	3981.6 (27.5) at 5.3 (20)
	Blade (rod end)	Gear pump P3	2133.0 (14.7) at 10.5 (40)	2133.0 (14.7) at 10.5 (40)

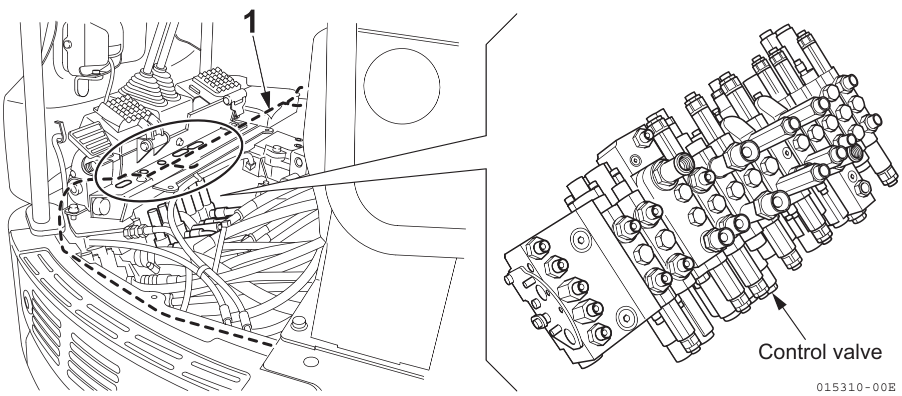
3) Measuring Points

(1) Open the bonnet L **1**.
(2) Remove the plugs (BSPT 1/8) **2** and install the oil pressure gauge.



4) Adjustment Procedure

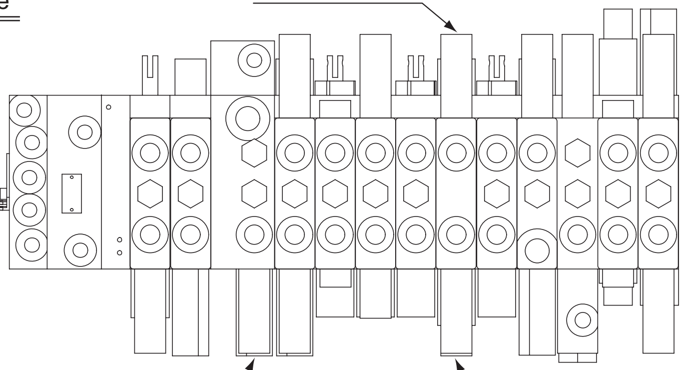
(1) Remove step **1**.
(2) Use hex bar wrench through the holes in the circled area to adjust pressure for the relief valves near the floor.



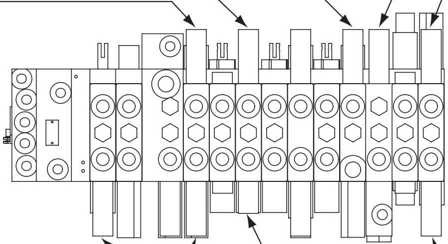
(3) To check the pressure of the system relief valve R1 (for the piston pump P1) in the control valve, retract the bucket cylinder to its stroke end, hold the lever and read the gauge. Adjust the pressure if necessary.

(4) To check the pressure of the system relief valve R2 (for the piston pump P2), retract the arm cylinder to its stroke end, hold the lever and read the gauge. Adjust the pressure if necessary.

(5) To check the pressure of the system relief valve R3 (for the gear pump P3), extend the blade cylinder to its stroke end, hold the lever and read the gauge. Adjust the pressure if necessary.



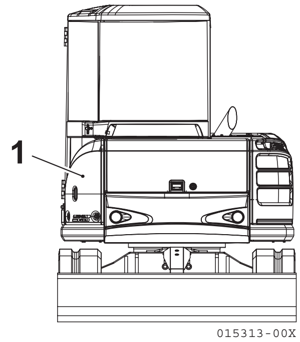
(6) To adjust the pressure of each circuit relief valve, extend or retract the cylinder to its stroke end, hold the lever and read the gauge. Whether the pressure of the circuit relief valve is lower than that of the system relief valve can be read on the gauge.
Increase the pressure of the system relief valve and that of the circuit relief valve by turns, and lock the adjust screw when the specified pressure of the circuit relief valve is obtained. Then lower the pressure of the system relief valve to the specified pressure and lock the adjust screw.



5) Pressure Change by One Turn of Adjust Screw

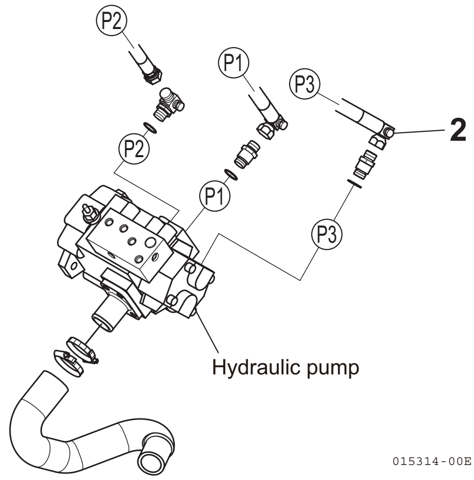
	Pressure change PSI (MPa)	Number of adjust screw turns	Tightening torque for lock nut ft.·lbf (N·m)
System relief valve	1740 (12.0)	1/1	14.47(19.6)
Circuit relief valve			

5-4-2 Swing Brake Valve



1) Conditions

(1) Engine : rated speed
(2) Hydraulic oil temperature : 122 to 140 °F (50 to 60 °C)
(3) Pressure gauge capacity : 5000 to 6000 PSI (35 to 40 MPa)
(4) Set pressure : 3130 (21.6 MPa)



2) Measuring Procedure

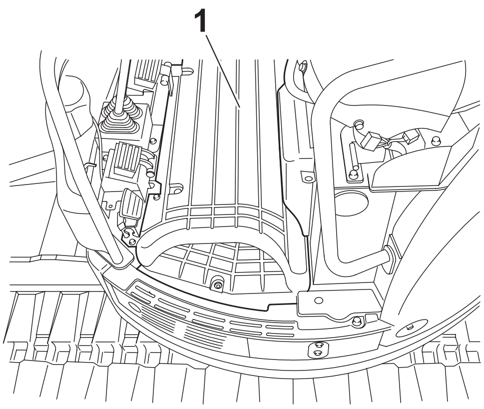
(1) Open the bonnet L **1**.
(2) Remove the plug (BSPT 1/8) **2** to install the pressure gauge.
(3) Fix the upper structure and move the swing lever to the right and the left, hold the lever with relief pressure applied and read the gauge.

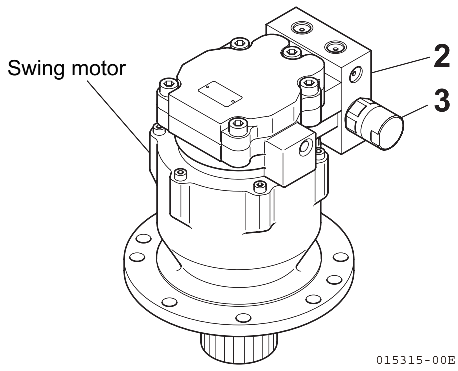
3) Adjustment Procedure (Relief Valve Replacement Procedure)

Since the relief valve is a fixed-pressure type, replace the relief valve assembly with a new one if the relief pressure needs to be adjusted.

(1) Remove the step **1**.
(2) Remove the relief valve assembly **4** from the brake valve **3**.

Tightening torque for relief valve
95.0 to 123.0 ft·lbf (127.5 to166.7 N·m)





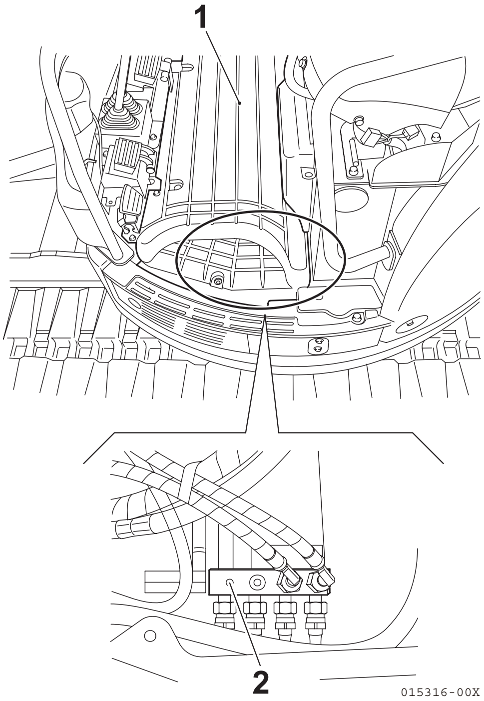
5-4-3 Cut-Off Valve

1) Conditions

(1) Engine : rated speed
(2) Hydraulic oil temperature : 122 to 140 °F (50 to 60 °C)
(3) Pressure gauge capacity : 1500 PSI (10 MPa)
(4) Set pressure : 569 PSI (3.9MPa)

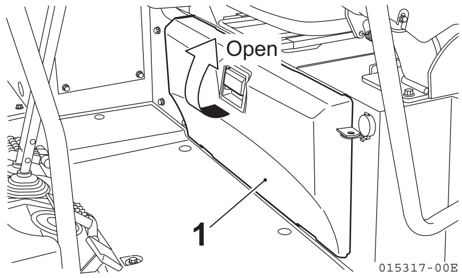
2) Measurement Procedure

(1) Open the engine hood A **1**.
(2) Remove the plug (BSPT 1/8) **2** for the hose connector and install the pressure gauge.
(3) Move the lock lever to the "UNLOCK" position, and read the gauge.



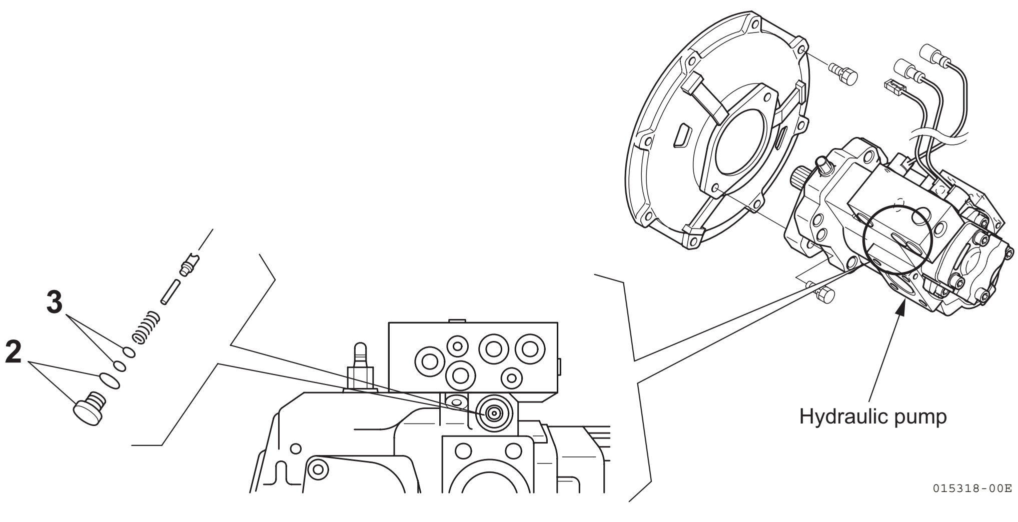
3) Pressure Adjustment Procedure

(1) Remove the grill assembly **1**.
(2) Remove the plug (with O-ring) **2**.
(3) Increase or decrease the number of shims **3** to adjust the pressure to the specified value.



Pressure change with a shim

Pressure change	Tightening torque for lock nut
28.4 to 35.6 PSI (0.2 to0.25 MPa)	21.7 ft·lbf (29.4 N·m)



CHAPTER 6

HYDRAULIC EQUIPMENT

6. Hydraulic Equipment

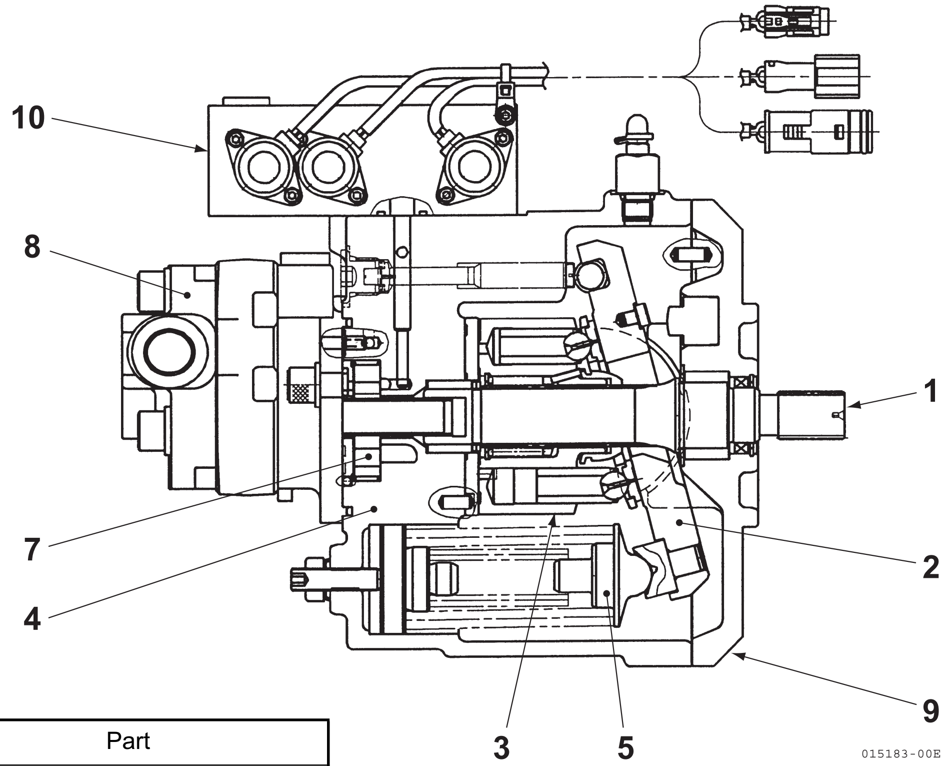
6-1 Hydraulic Pump

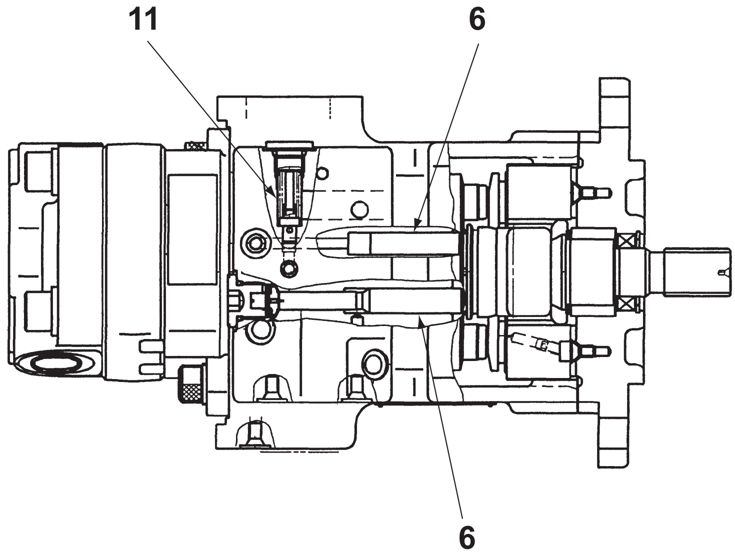
Applicable Model : ViO45-5/55-5

1. Outline

1) Piston Pump

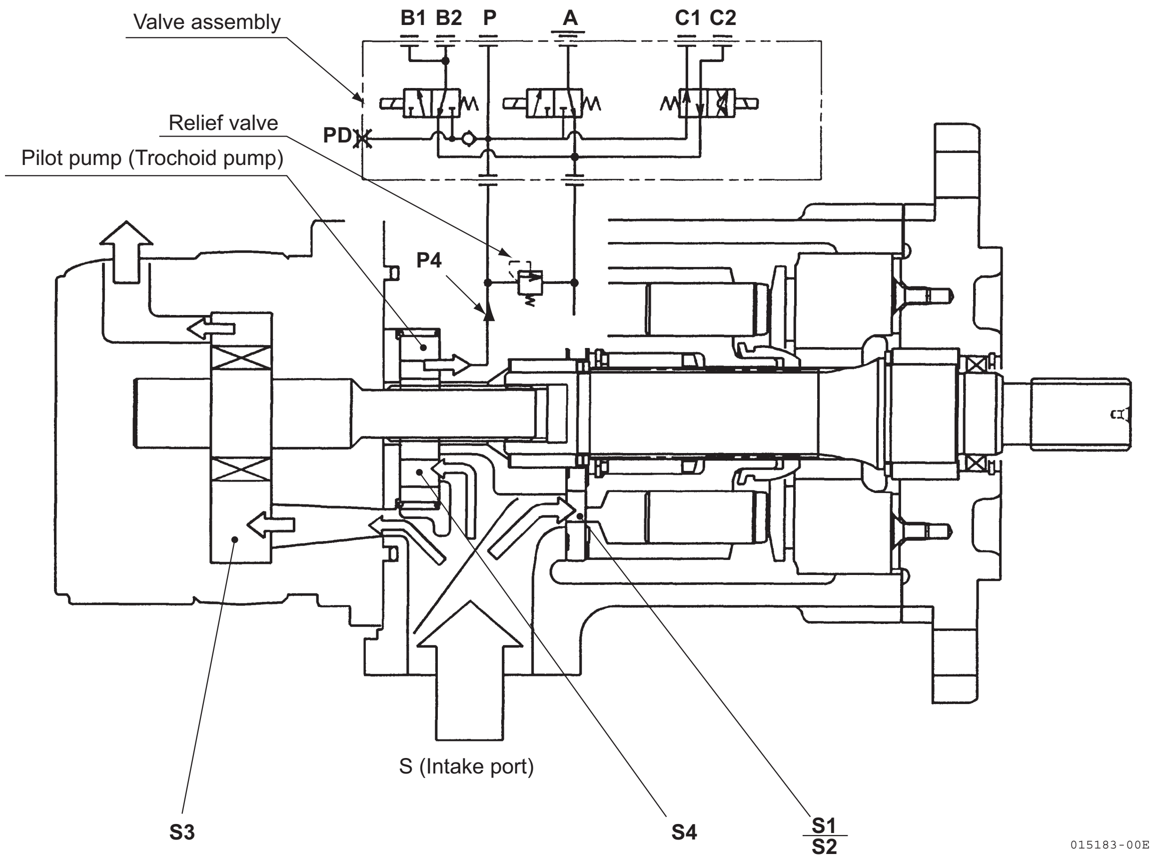
The piston pump consists of a drive shaft, a swash plate, a rotary group, a housing, a control spring, a control piston, a pilot pump, a gear pump, a flange, a valve assembly, a relief valve, and other components. It is a variable displacement piston pump that discharges two equivalent volumes by means of a rotary group.
One rotary group is divided into one intake port and two discharge ports.
The gear pump P3 and the pilot pump P4 are connected to the piston pump via the drive shaft and these pumps and the piston pump share one intake port.
The control system is a simultaneous incline angle full horsepower control.





No.	Part
1	Drive shaft
2	Swash plate
3	Rotary group
4	Housing
5	Control spring
6	Control piston
7	Pilot pump
8	Gear pump
9	Flange
10	Valve assembly
11	Relief valve

2) Oil Flows from Intake Port and Pilot Pump Discharge Port



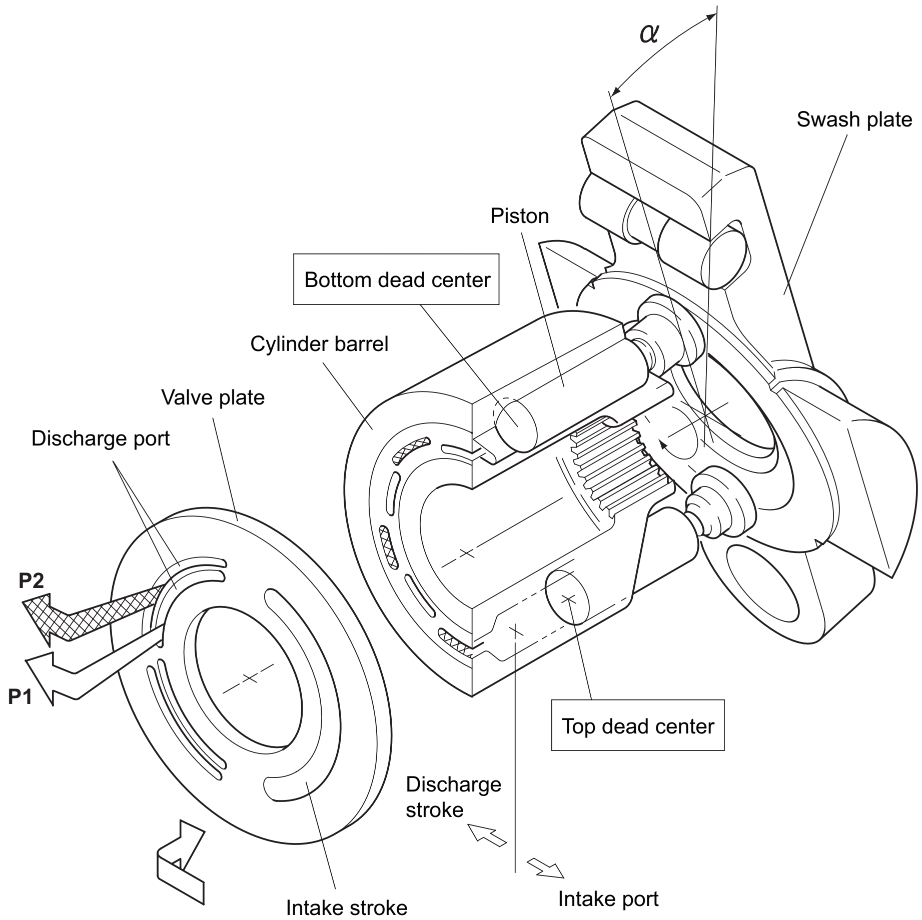
The oil flows from the intake port S of this pump and the discharge port P4 of the pilot pump are as follows :

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

2. Theory of Operation

1) Pump Functions

- The cylinder barrel, which is splined to the drive shaft, revolves with the shaft.
- The pistons installed into the cylinder barrel, following the swash plate, make a reciprocating motion, which causes the volume of the cylinder to change, thereby enabling the intake and discharge pump operations.
- As the pistons move from the bottom dead center to the top dead center, thereby increasing the volume, oil flowing from the intake port runs through the valve plate into the cylinder barrel. (Intake stroke)
- As the pistons move from the top dead center to the bottom dead center, thereby decreasing the volume, the oil in the cylinder barrel is discharged to the discharge port. (Discharge stroke)
- By changing the inclination of the swash plate, the piston stroke is changed and thus the displacement of the piston can be changed.
- Oil taken in from the inner port of the cylinder barrel is discharged from the inner discharge port of the valve plate.
- Oil taken in from the outer port of the cylinder barrel is discharged from the outer discharge port of the valve plate.
- The oil discharged from the inner port (the outer port) of the valve plate is discharged from the port P1 (P2).



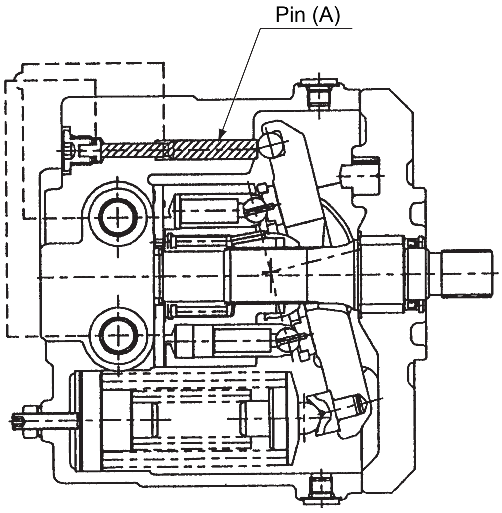
2) Horsepower Control

Control the discharge volume of the piston pumps so that the amount of load in the piston pumps P1 and P2, the trochoid pump and the gear pump does not exceed the set torque.

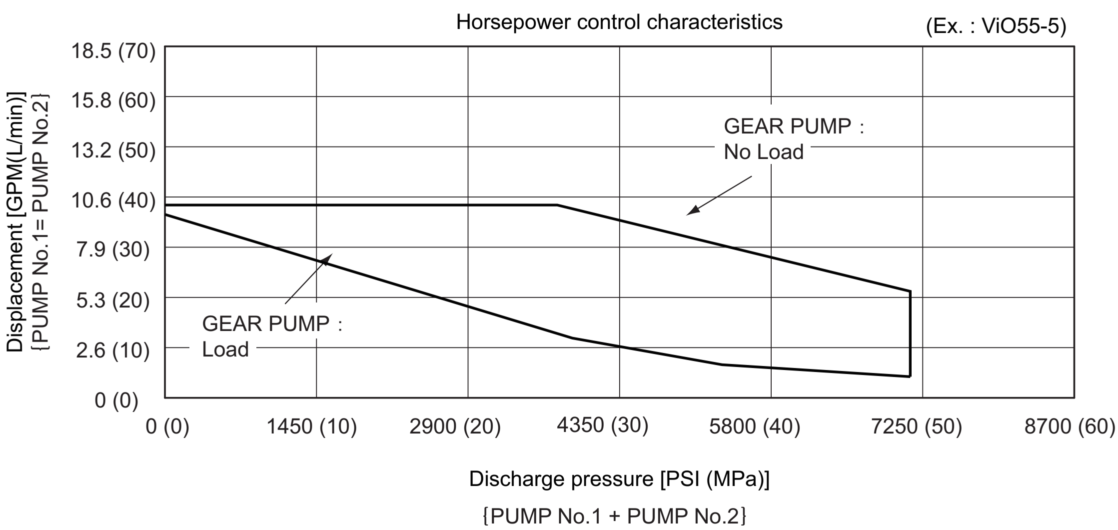
The oil pressure from the piston pumps P1 and P2 flows to the control pin (A) through the oil passage inside the port block. The discharge pressure of the gear pump flows to the control pin (B) through the inner passage of the piston pump body.

The oil pressure discharged from the piston pumps P1 and P2 and the gear pump rises and presses the respective control pins, causing the inclination angle of the swash plate to decrease and the discharge volume of the pumps to reduce.

The one side of the swash plate is held with springs. The spring force is adjusted according to the discharge pressure of each pump. The amount of horsepower (torque) of the pumps is controlled by the springs not to exceed the set torque.



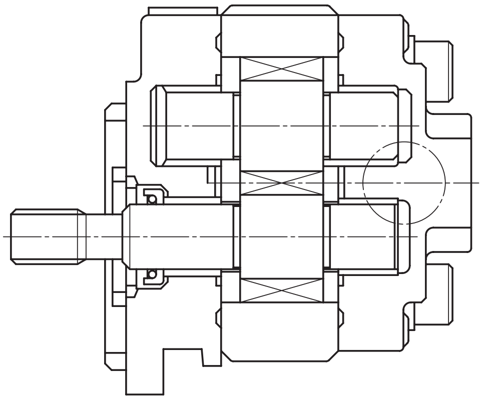
Horsepower control explanation drawing

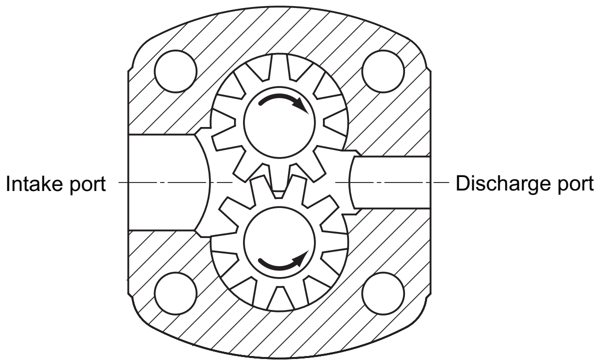


Horsepower control characteristics explanation diagram

3) Gear Pump

The gear pump is used as the pump for the swing motor and blade.





Structural drawing of gear pump

Two gears in the housing rotate engaging with each other to work as a pump by transferring the oil between the gear tooth and the inner surface of the housing.

The special loading system, which adjusts the clearance between the side surface of the gear tooth and the inner surface of the housing to the appropriate value reflecting the discharge pressure, is adopted to the gear pump so that the high efficiency is maintained for a long time.

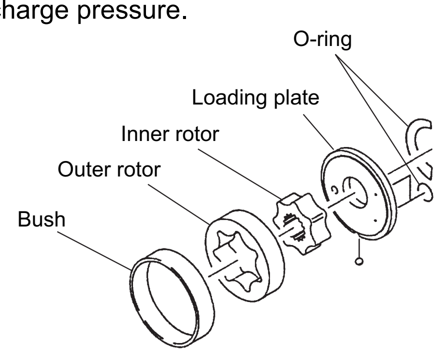
4) Pilot Pump

The main part of the pilot pump comprises a trochoid rotor, which consists of inner and outer rotors, and a loading plate, which keeps appropriate side clearance of trochoid rotor.

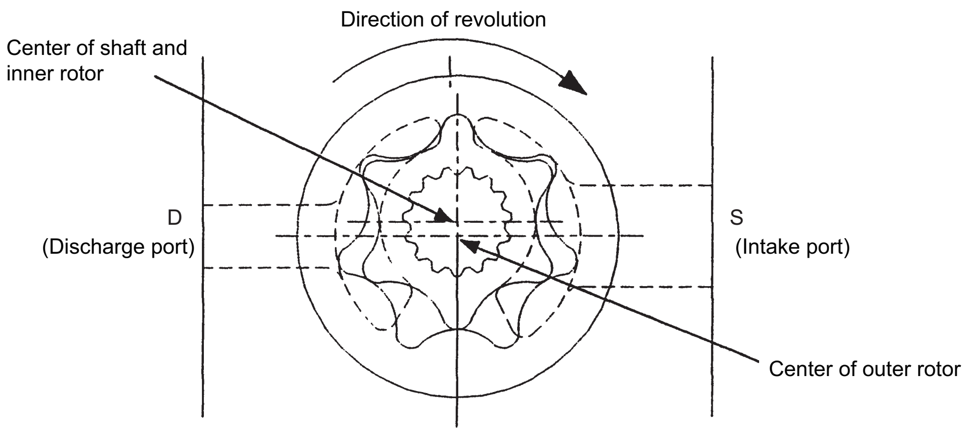
The rotation center of the outer rotor is off the center of the shaft. The inner rotor is involved by the spline engaging with the shaft. When the shaft rotates to revolve the inner rotor, the inner rotor drives the outer rotor.

At this time, the oil is continuously sucked into the intake port on the right side S and discharged from the discharge port on the left side D in the figure below as the oil capacity inside the pilot pump changes due to the off-center revolution.

The loading plate leads the oil pressure from the discharge side of the trochoid pump to the rear side to keep the appropriate side clearance by the discharge pressure.



Exploded view of pilot pump



Explanation view of pilot pump operation

5) Function of Valve Assembly

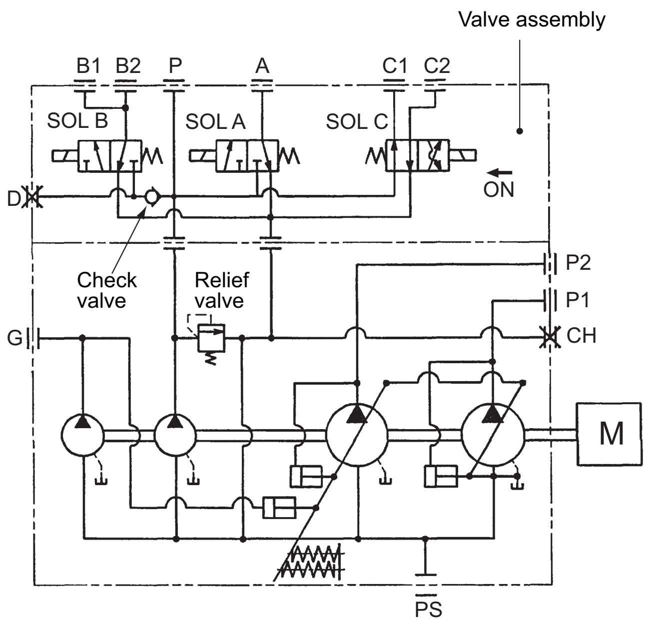
This pump has a valve assembly, which switches the directions of the pressure oil flow from the pilot pump. Some solenoid and check valves are installed in the valve block assembly.

[1] The solenoid valve A supplies pressure oil to the port A when the solenoid is turned on. When the solenoid is turned off, the solenoid valve A blocks the pilot oil pressure and allows the oil in the port A to escape to the intake port through the housing of the piston pump.

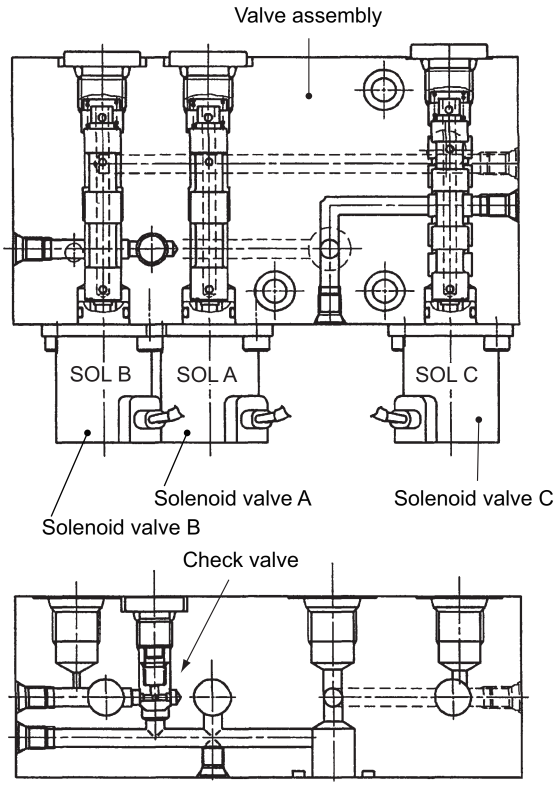
[2] The pressure oil is supplied to the solenoid valve B through the check valve. The oil flowing from the check valve toward the solenoid valve B is divided into two directions. One flows to the solenoid valve B and the other flows to the port D through the orifice.

[3] The solenoid valve B supplies the pilot pressure oil to the ports B1 and B2 when the solenoid is turned on. When the solenoid is turned off and no pilot oil is supplied from the pilot pump for some reason, the check valve works to keep the pressure decrease of the ports B1 and B2 at a minimum.
When the solenoid is turned off, the solenoid valve B blocks the pilot pressure oil and allows the oil in the ports B1 and B2 to escape to the intake port through the housing of the piston pump.

[4] When the solenoid is turned on, the solenoid valve C supplies the pilot pressure oil to the port C2 and allows the oil in the port C1 to escape to the intake port through the housing of the piston pump. When the solenoid is turned off, the solenoid valve C supplies the pilot pressure oil to the port C1 and allows the oil in the port C2 to escape to the intake port through the housing of the piston pump.



Hydraulic circuit schematic of three series solenoid valve



Structural drawing of three series solenoid valve

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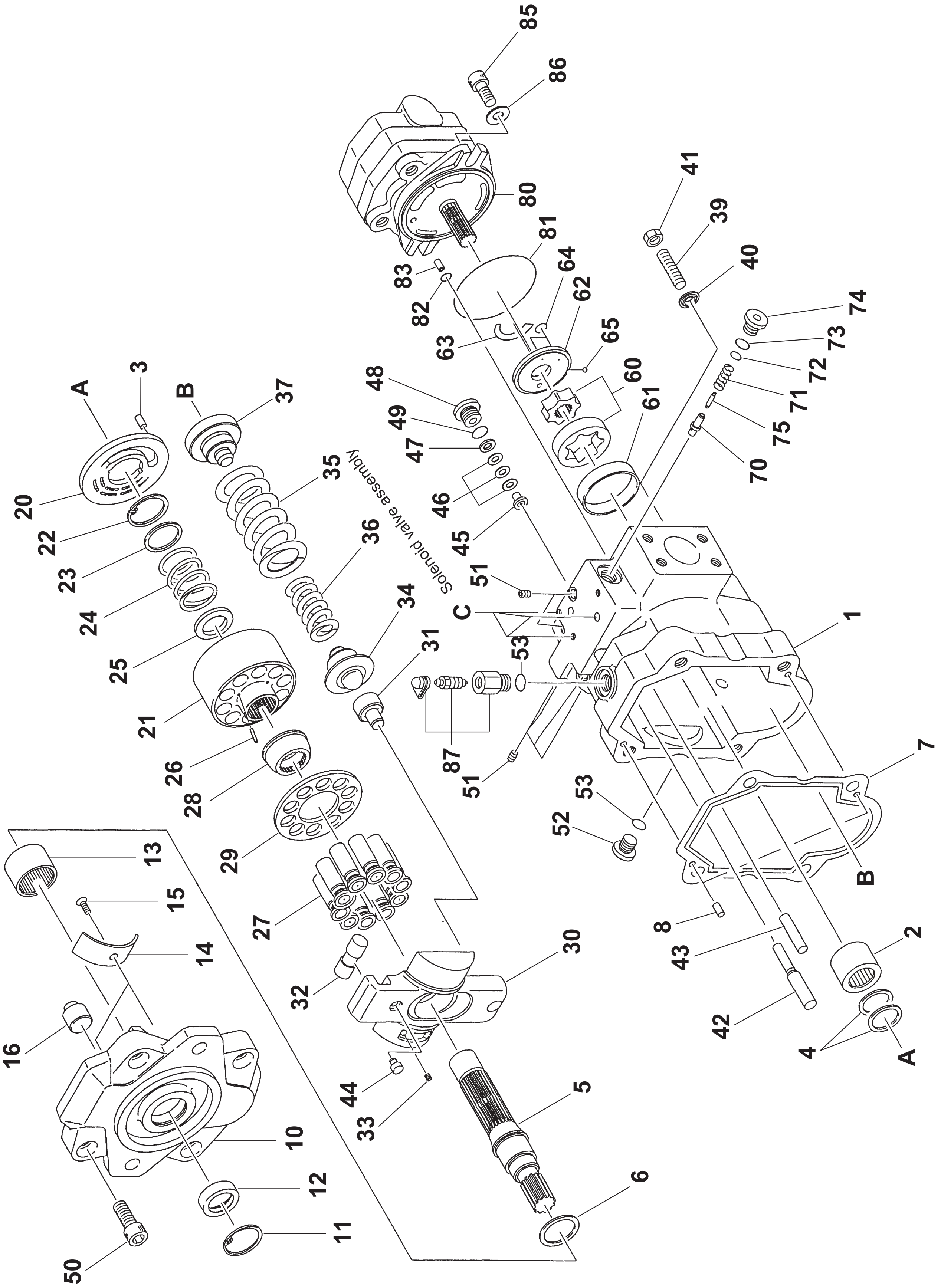
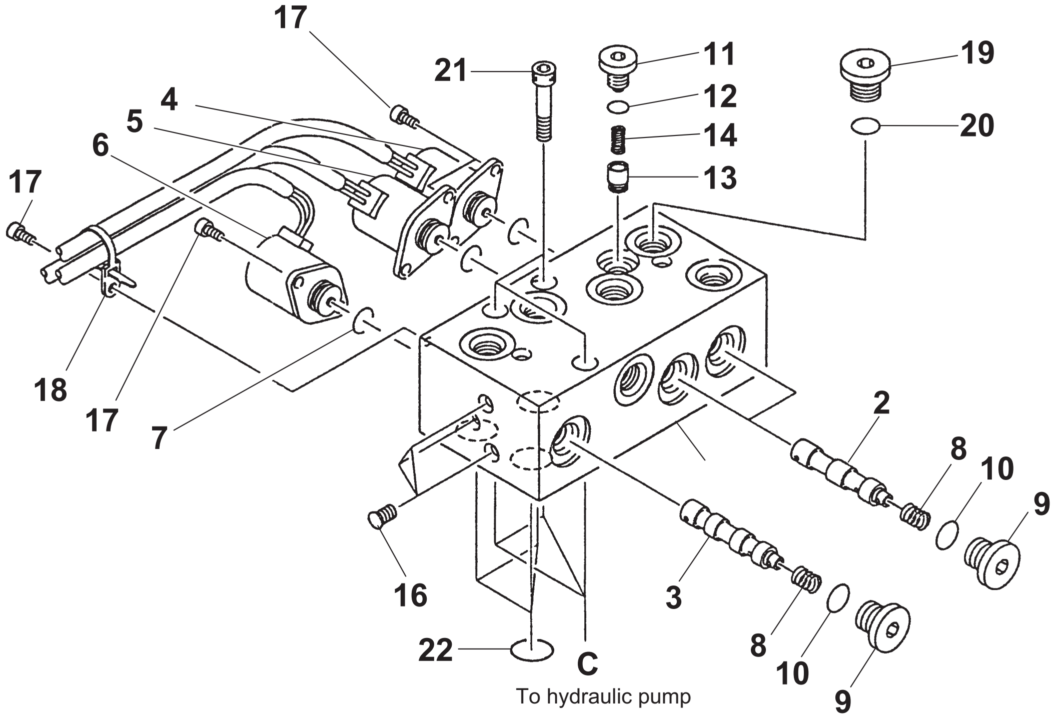
3. Exploded View and Parts Comprised

1) Hydraulic Pump



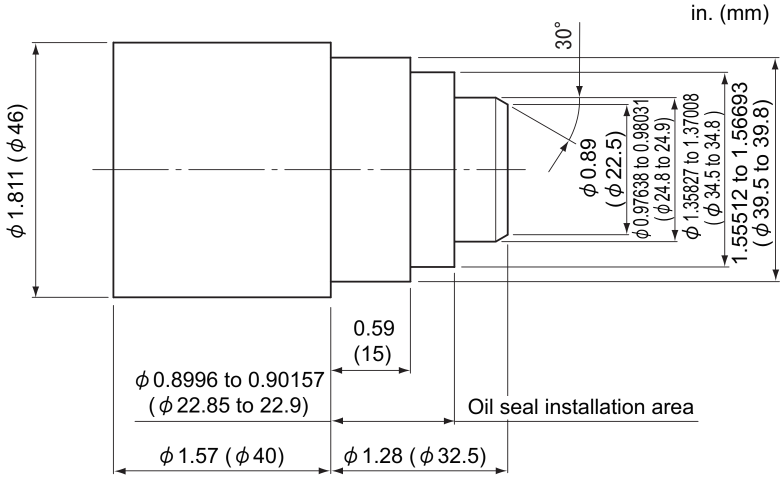
No.	Part	Q'ty	No.	Part	Q'ty	No.	Part	Q'ty
1	Housing	1	28	Retainer holder	1	52	—	—
2	Needle bearing	1	29	Retainer plate	1	53	O-ring	1
3	Pin	1	30	Swash plate	1	60	Trochoid rotor assembly	1
4	Thrust washer	2	31	Holder	1	61	Bush	1
5	Shaft	1	32	Pin	1	62	Loading plate	1
6	Thrust washer	1	33	Orifice	1	63	O-ring	1
7	Gasket	1	34	Spring seat	1	64	O-ring	2
8	Pin	2	35	Spring	1	65	Steel ball	1
10	Flange	1	36	Spring	1	70	Poppet	1
11	Internal snap ring	1	37	Spring seat	1	71	Spring	1
12	Oil seal	1	39	Set screw	1	72	Shim	2
13	Needle bearing	1	40	Seal washer	1	73	O-ring	1
14	Bush	2	41	Nut	1	74	Plug	1
15	Screw	2	42	Pin	1	75	Pin	1
16	Stopper	1	43	Pin	1	80	Gear pump	1
20	Valve plate	1	44	Stopper	1	81	O-ring	1
21	Cylinder barrel	1	45	Stopper	1	82	O-ring	1
22	Internal snap ring	1	46	Disc spring	3	83	Pin	1
23	Collar	1	47	Washer	1	85	Socket head bolt	2
24	Spring	1	48	Plug	1	86	Washer	2
25	Collar	1	49	O-ring	1	87	Air bleeder assembly	1
26	Pin	3	50	Socket head bolt	5			
27	Piston assembly	10	51	Plug	6			

2) Valve Assembly



No.	Part	Q'ty	No.	Part	Q'ty
1	Body	1	12	O-ring	1
2	Spool	2	13	Poppet	1
3	Spool	1	14	Spring	1
4	Solenoid	1	16	Plug	1
5	Solenoid	1	17	Socket head bolt	7
6	Solenoid	1	18	Clamp	1
7	O-ring	1	19	Plug	1
8	Spring	3	20	O-ring	1
9	Plug	3	21	Socket head bolt	3
10	O-ring	3	22	O-ring	3
11	Plug	1			

4. Special Tools

<table>
<tr><th></th><th></th></tr>
<tr><td>(12) Oil seal installation jig</td><td>
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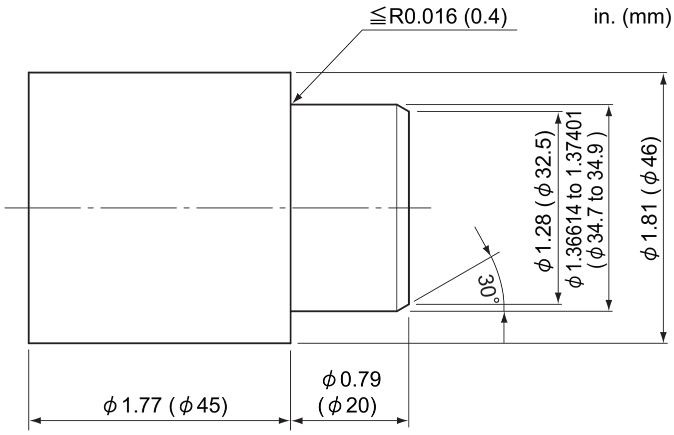
<tr><td>(13) Bearing installation jig</td><td>
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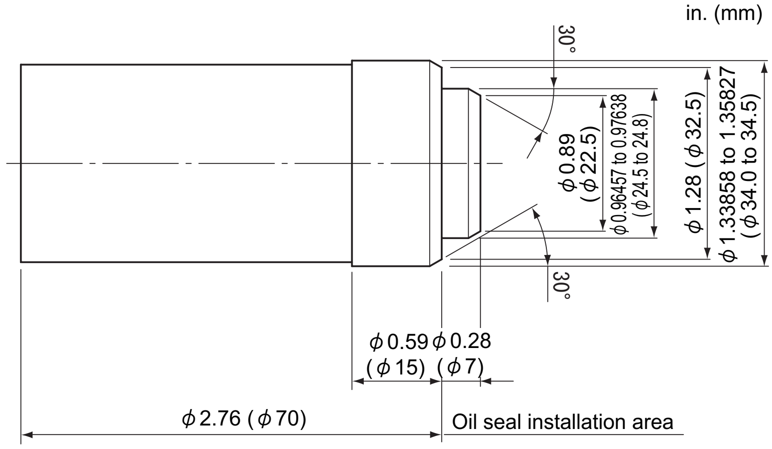
<tr><td>(12) Oil seal

(13) Bearing disassembly jig</td><td>
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5. Disassembly and Reassembly

1) Precautions for Disassembly and Reassembly

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

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

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

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

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

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

(7) Handling of O-rings

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

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

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

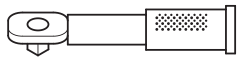
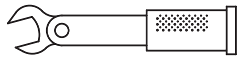
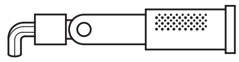
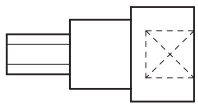
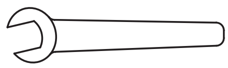
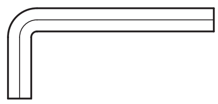
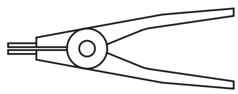
[4] Avoid rolling the O-rings when fitting them.
A distorted O-ring may not return to its original shape, and therefore may cause oil leak.

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

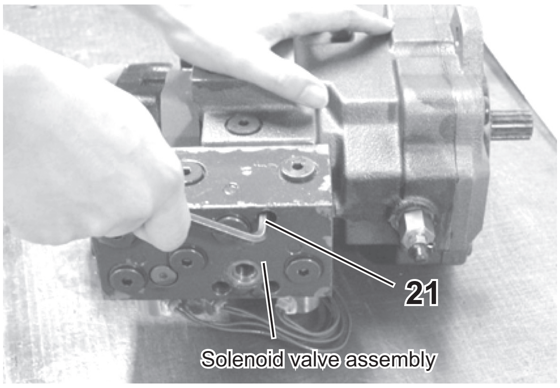
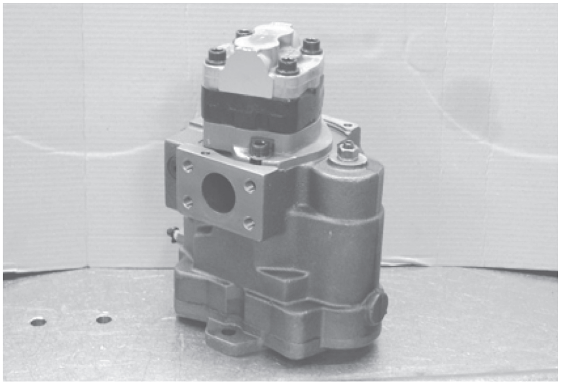
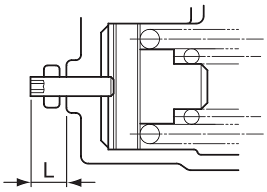
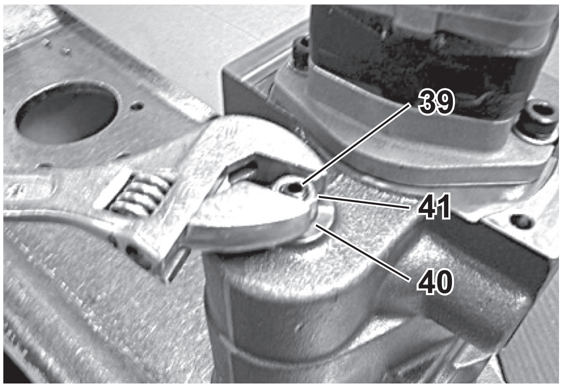
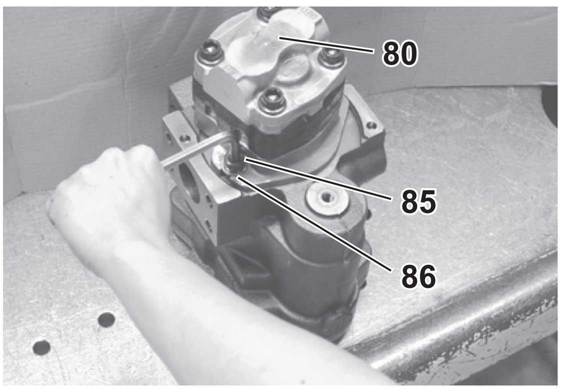
(9) Use a torque wrench to tighten the bolts following the torque specification.

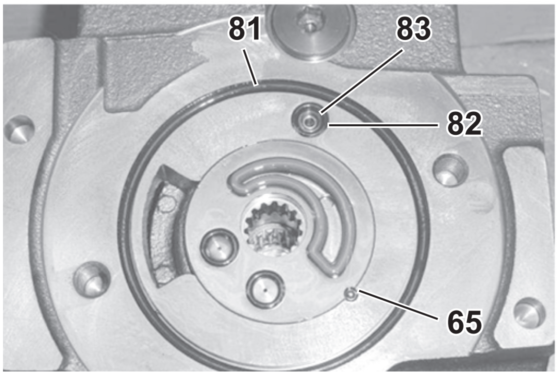
(10) When installing or removing snap rings, take care not to let snap rings jump out. It may damage the other parts.

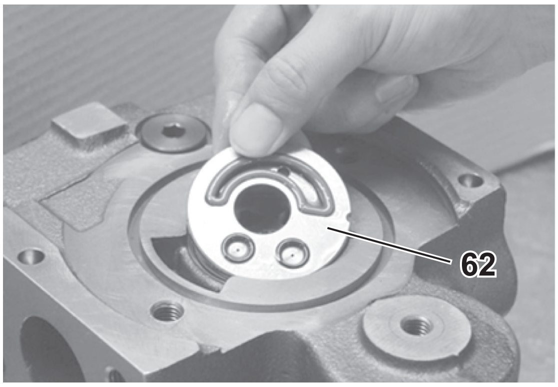
2) Tools for Disassemlbfbly and Reassembly

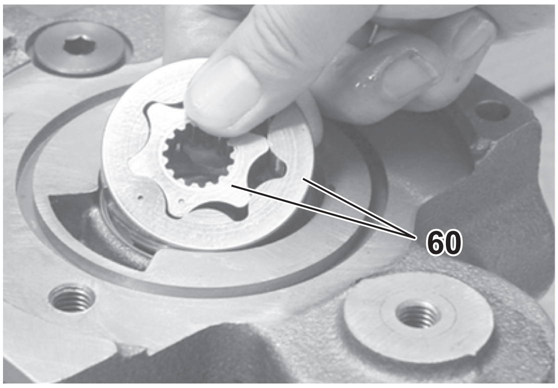
Tools		Applicable part	Form
Torque wrench	Tightening torque : 4.35 ft·lbf (5.9 N·m)	(15) Screw	
	Tightening torque : 37.6 ft·lbf (51.0 N·m)	(48) Plug	
	Tightening torque : 78.8 ft·lbf (106.9 N·m)	(50) Socket head bolt	
	Tightening torque : 21.7 ft·lbf (29.4 N·m)	(52), (74) Plug	
	Tightening torque : 9.33 ft·lbf (12.65 N·m)	(21) Socket head bolt (for valve assembly)	
	Tightening torque : 11.6 ft·lbf (15.7 N·m) Width across flats : 0.67 in. (17 mm)	(41) Nut	
	Tightening torque : 32.5 ft·lbf (44.1 N·m) Width across flats : 0.31 in. (8 mm)	(85) Socket head bolt	
Hexagon socket for torque wrench	Width across flats : 0.12 in. (3 mm)	(15) Screw	
	Width across flats : 0.31 in. (8 mm)	(48) Plug	
	Width across flats : 0.39 in. (10 mm)	(50) Socket head bolt	
	Width across flats : 0.24 in. (6 mm)	(52), (74) Plug	
	Width across flats : 0.20 in. (5 mm)	(21) Socket head bolt (for valve assembly)	
Wrench	Width across flats : 0.67 in. (17 mm)	(41) Nut	
Hexagon bar wrench	Width across flats : 0.12 in. (3 mm)	(15) Screw	
	Width across flats : 0.20 in. (5 mm)	(39) Set screw	
	Width across flats : 0.31 in. (8 mm)	(48) Plug	
	Width across flats : 0.39 in. (10 mm)	(50) Socket head bolt	
	Width across flats : 0.24 in. (6 mm)	(52), (74) Plug	
	Width across flats : 0.20 in. (5 mm)	(21) Socket head bolt (for valve assembly)	
Snap ring pliers	For internal snap ring	For internal snap ring	
Vice		(1) Housing (for holding housing)	
Hand press		(12) Oil seal (13) Bearing	

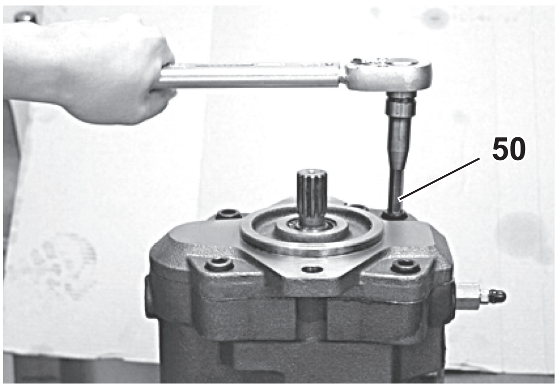
3) Disassembly

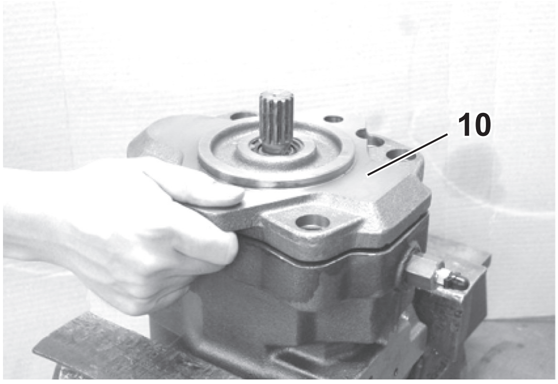
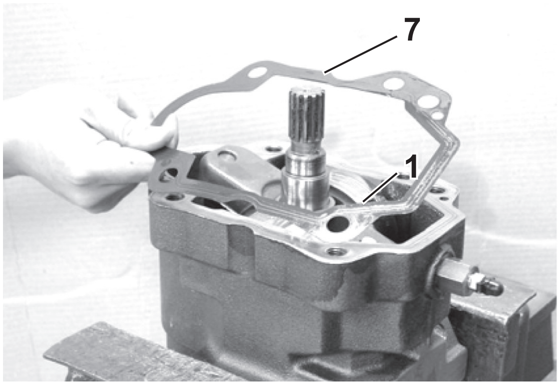
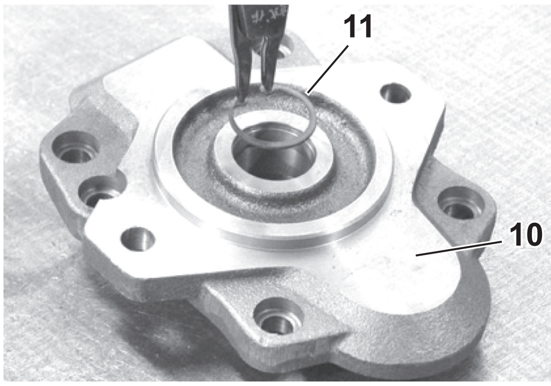
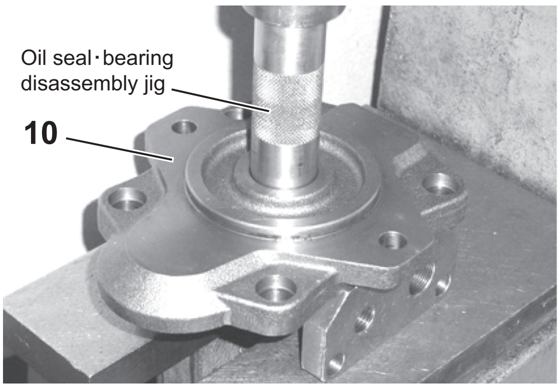
Procedure	
(1) Remove the socket head bolt to remove the solenoid valve assembly.	
(2) Fix the pump with the input shaft down.	
(3) Remove the set screw **39**, the nut **41**, and the seal washer **40**. ***Note :*** *Do not disassemble when there are no trouble around these parts, such as oil leak. When disassembly is done, it makes horsepower control change. Therefor, measure the dimension of L before removal, and adjust it to the same dimension when reinstallation.* 	
(4) Remove the socket head bolts **85** and the washers **86**, and then remove the gear pump **80**.	

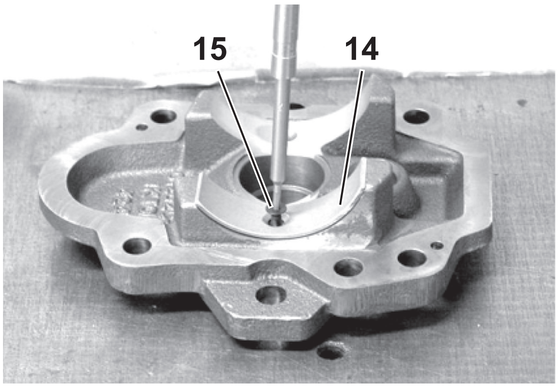
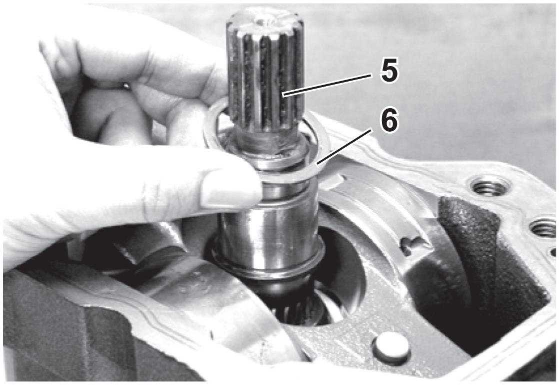
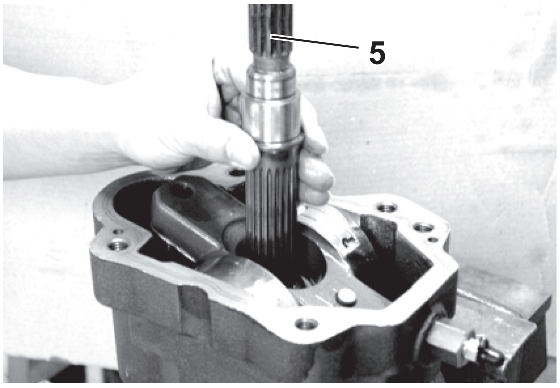
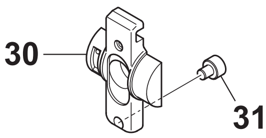
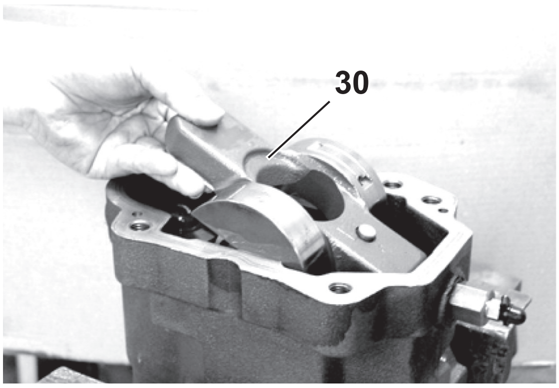
Procedure	
(5) Remove the O-rings **81** and **82**, the pin **83** and the steel ball **65**.	

(6) Remove the loading plate **62**.	

(7) Remove the trochoid rotor assembly **60**.	

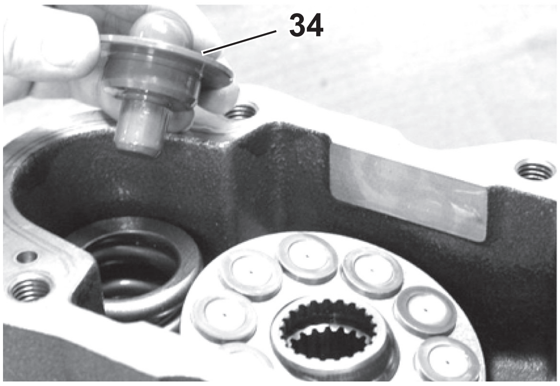
(8) Fix the pump with the input shaft up, and the remove socket head bolts **50**.	

Procedure	
(9) Remove the flange **10**.	
(10) Remove the gasket **7** and the pins **8** from the flange **10** or the housing **1**.	
(11) Remove the internal snap ring **11** from the flange **10**.	
(12) Press the oil seal **12** and the needle bearing **13** with a hand press to remove them from the flange **10**.	

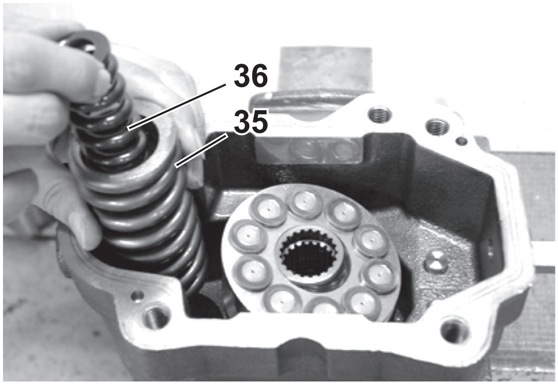
Procedure	
(13) Remove the screws **15** to remove the bushes **14**.	
(14) Remove the thrust washer **6** from the shaft **5**.	
(15) Remove the shaft **5**.	
(16) Remove the swash plate **30** and the holder **31**. ***Note :*** *When removing the swash plate, take care not to drop the holder. It may damage the internal parts, such as pistons.* 	

Procedure

(17) Remove the spring seat **34**.



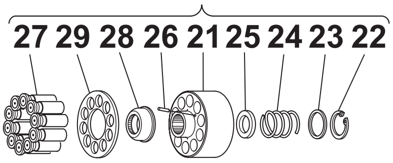
(18) Remove the springs **35** and **36** from the housing.



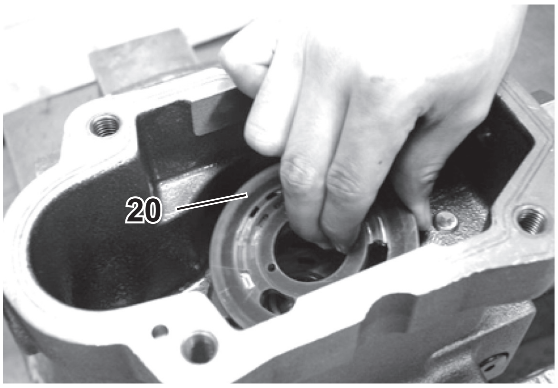
(19) Remove the cylinder barrel assembly **21** to **29**.

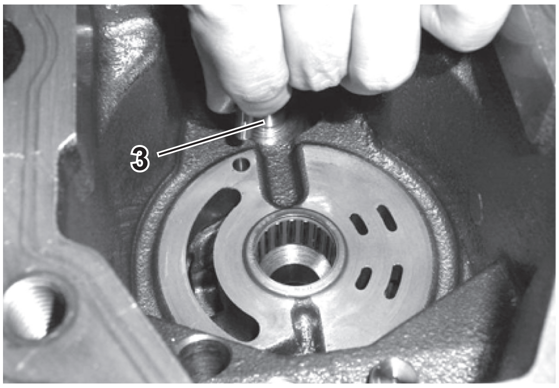
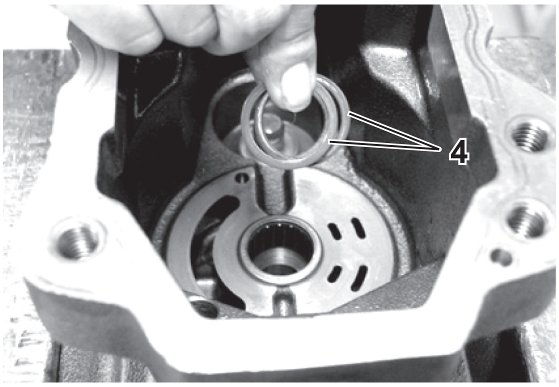
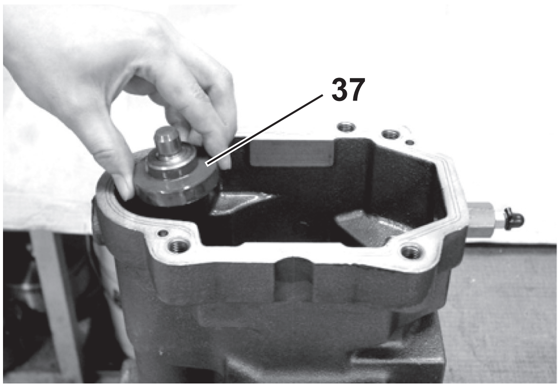
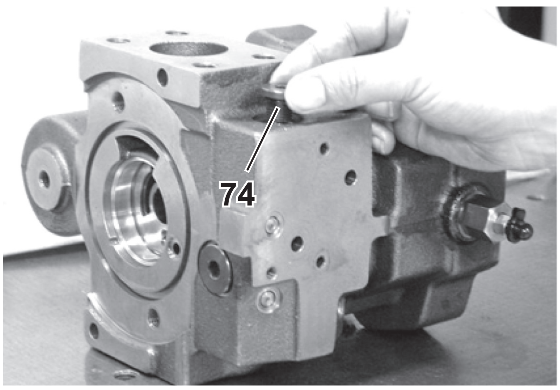
Note :
*Take care not to drop the valve plate **20**, which may cling under the cylinder barrel.*

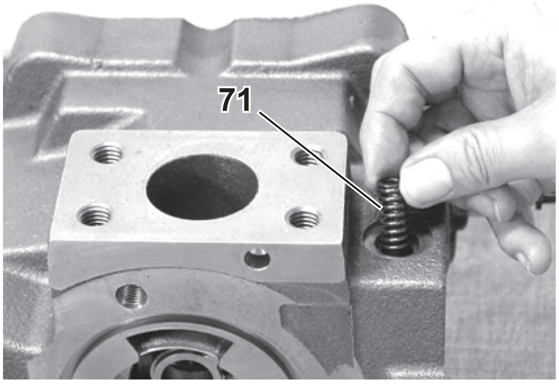
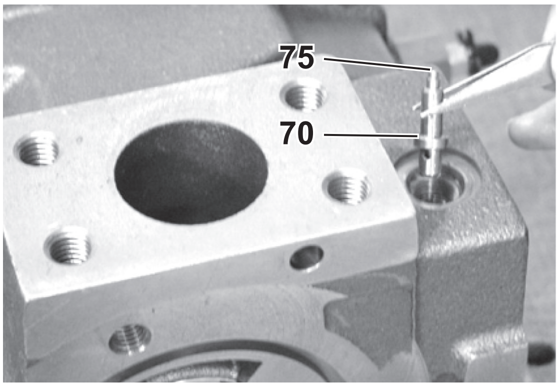
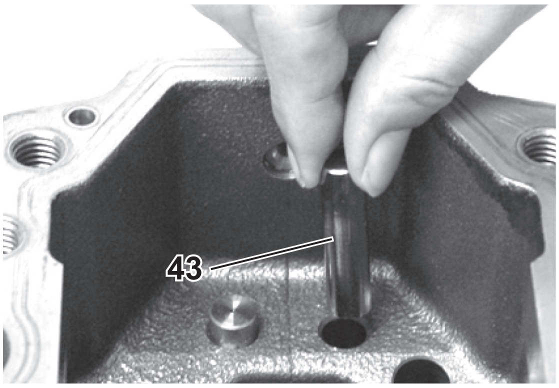
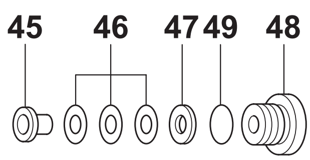
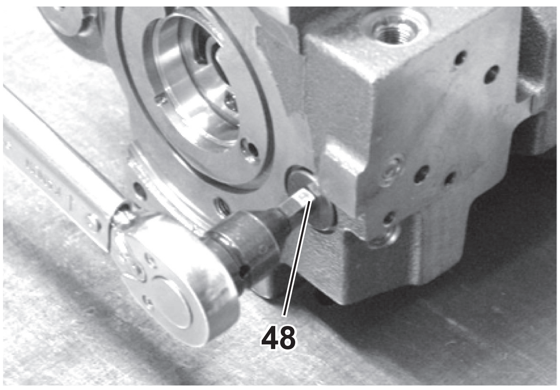
Cylinder barrel assembly

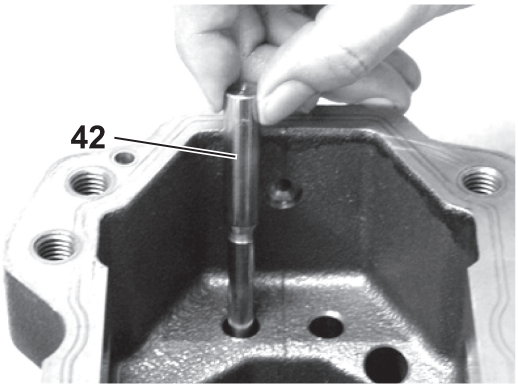


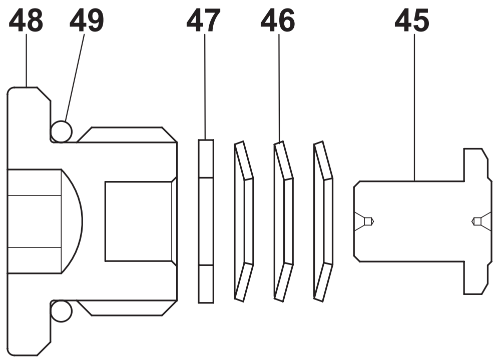
(20) Remove the valve plate **20**.



Procedure	
(21) Remove the pin **3**.	
(22) Remove the thrust washers **4**.	
(23) Remove the spring seat **37**.	
(24) Remove the plug **74**. ***Note :*** *Take care not to lose the shims **72**, which may cling to the backside of the plug. If the shim is lost, the relief set pressure of the pilot pump decreases.*	

Procedure	
(25) Remove the spring **71**.	
(26) Remove the poppet **70** and the pin **75**.	
(27) Remove the pin **43**.	
(28) Remove the plug **48**. ***Note :*** *The stopper **45**, the disc springs **46** and the washer **47** cling to the housing side of the plug. Take care not to drop and loose them.*  	

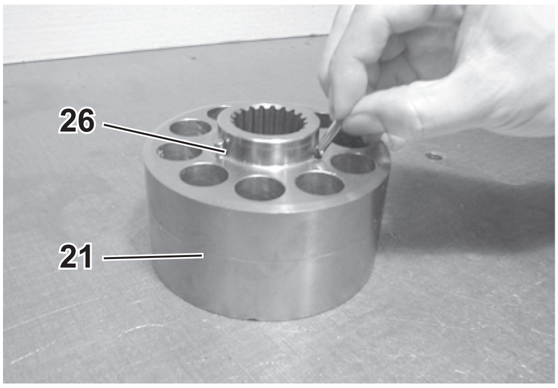
Procedure	
(29) Remove the pin **42**.	

(30) Remove the stopper **45**, the disc springs **46**, and the washer **47** from the plug **48**.	

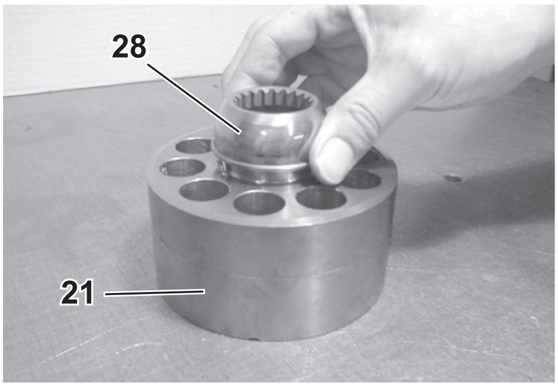
4) Reassembly

Procedure

(1) Apply grease to the pins **26** and install them into the cylinder barrel **21**.

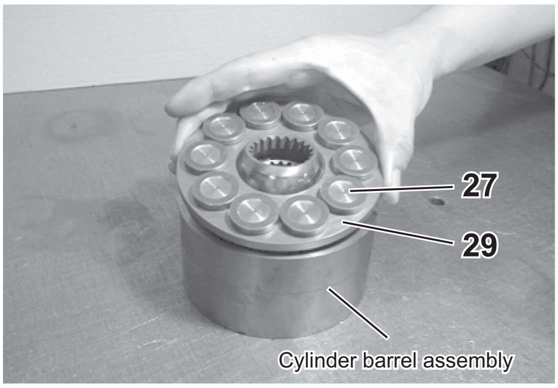


(2) Insert the retainer holder **28** into the cylinder barrel **21**.



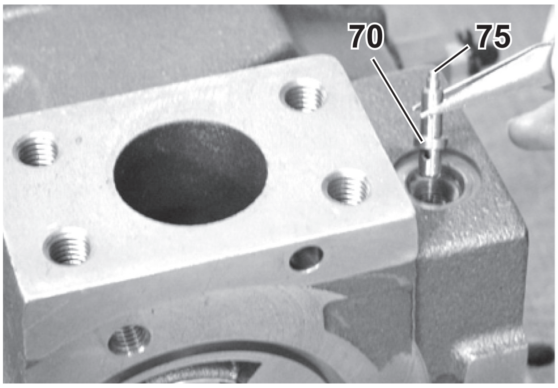
(3) Install the piston assembly **27** into the tapered bore in the center of the retainer plate **29** from its small-diameter side and insert them into the cylinder barrel.

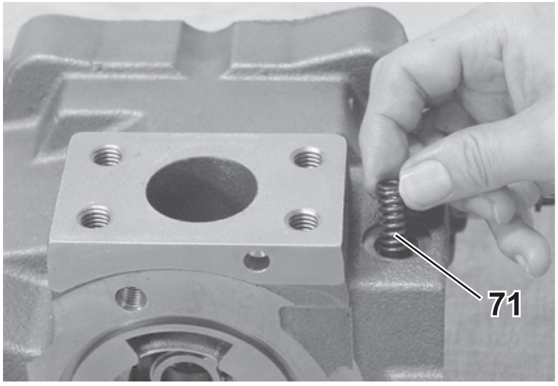
Notes :
- *Confirm that the tapered bore surface in the center of the retainer plate **29** contacts with the side surface of the retainer holder **28**.*
- *When only the small-diameter side end surface of the tapered bore in the center of the retainer plate **29** contacts with the retainer holder **28**, the retainer plate **29** has been installed upside down. Remove and reinstall it in the correct direction.*

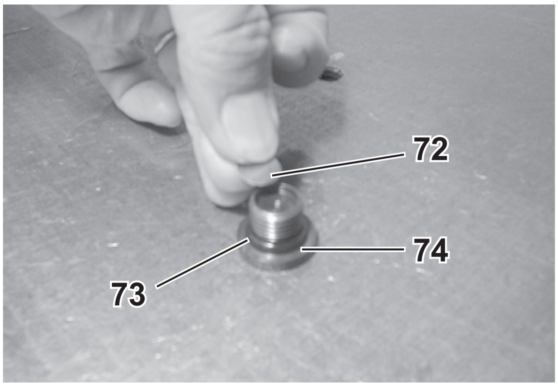


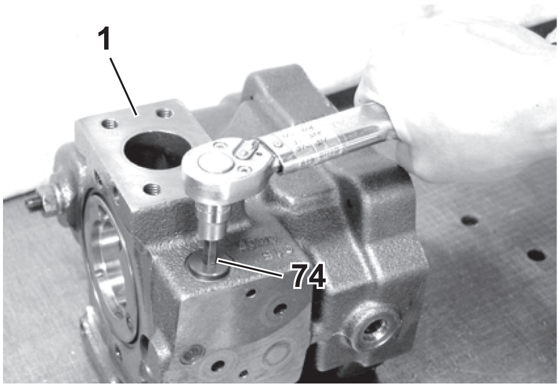
(4) Install the poppet **70** and the pin **75** into the housing **1**.

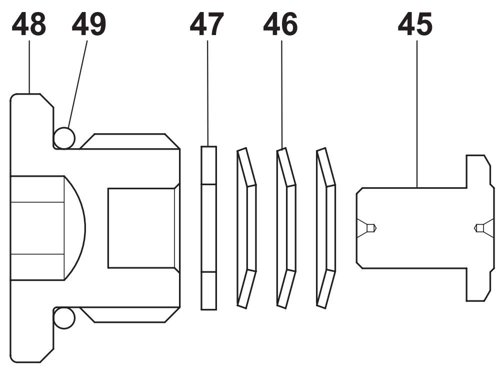
Note :
Take care about the direction of the poppet.

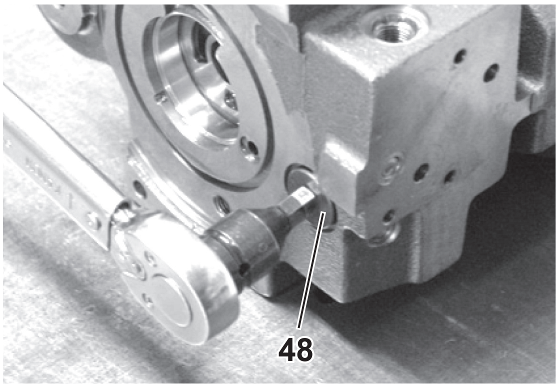
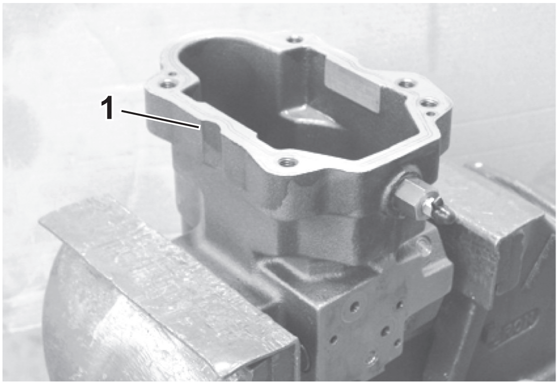
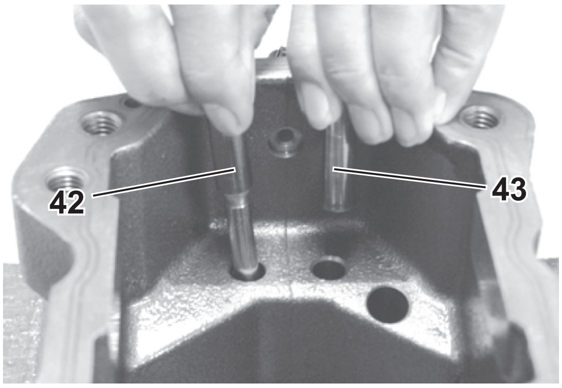
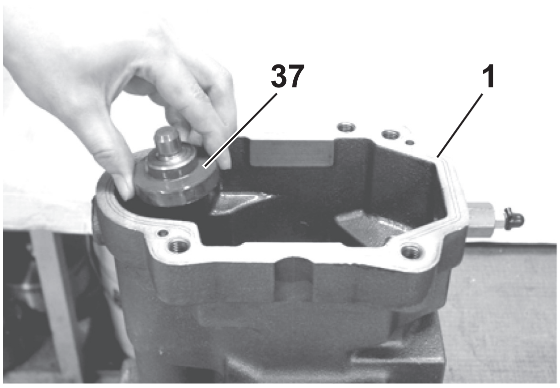


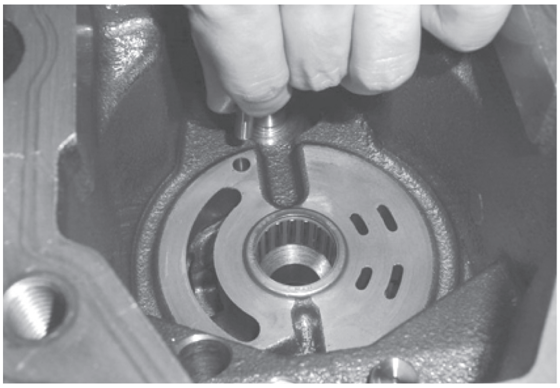
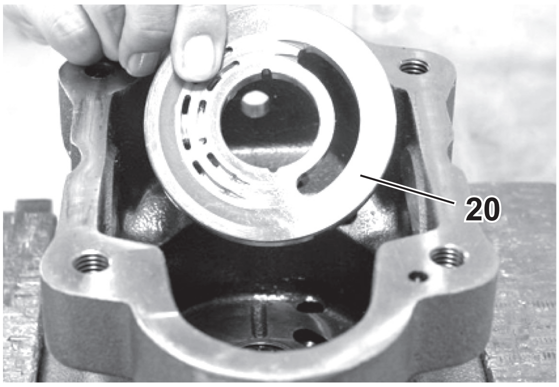
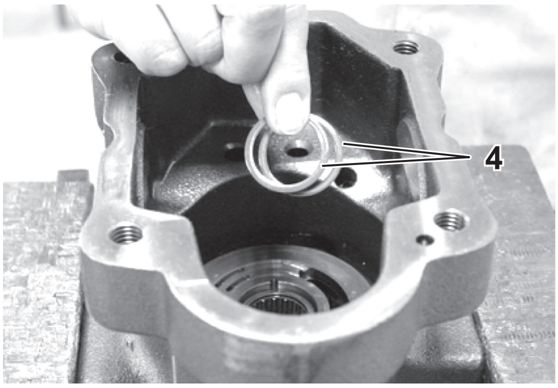
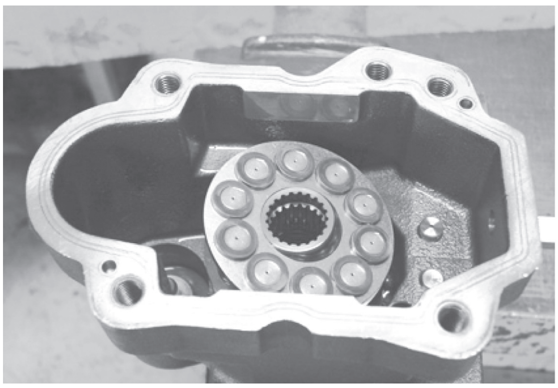
Procedure	
(5) Install the spring **71** into the housing **1**.	

(6) Install the O-ring **73** and the shims **72** onto the plug **74**. ***Note :*** *If the shim drops, the relief set pressure of the pilot pump decreases. Therefor, apply the grease to the shims before installing them to the plug to prevent them from dropping.*	

(7) Install the plug **74** in the housing **1**. Tightening torque : 21.7 ft･lbf (29.4 N･m) ***Note :*** *When installing the plug, be careful not to drop the shims installed on the plug.*	

(8) Install the O-ring **49**, the washer **47**, the disc springs **46** and the stopper **45** onto the plug. ***Note :*** *Take care about the direction of disc springs.*	

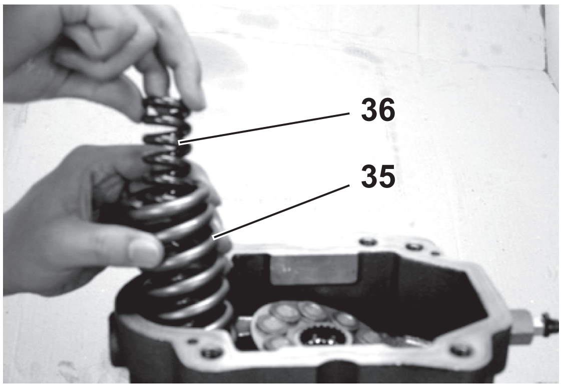
Procedure	
(9) Install the plug **48** in the housing **1**. Tightening torque : 42.0 ft·lbf (57.0 N·m) ***Note :*** *When installing the plug, be careful not to drop the parts installed on the plug.*	
(10) Fix the housing **1** with its larger opening side up. ***Note :*** *When fixing the housing, take care not to damage the mounting surfaces of the intake port and gear pump because oil leak may be caused.*	
(11) Insert the pins **42** and **43** into the housing **1**.	
(12) Insert the spring seat **37** into the housing **1**.	

Procedure	
(13) Install the pin **3** into the housing **1**.	
(14) Install the valve plate **20** with the copper alloy side up into the housing.	
(15) Install the two thrust washers **4** into the housing **1**.	
(16) Place the cylinder barrel assembly **21** to **29** onto the valve plate **20**. ***Note :*** *Install it carefully not to make flaws and dent on the valve plate and rotary parts, which can cause breakage.*	

Procedure

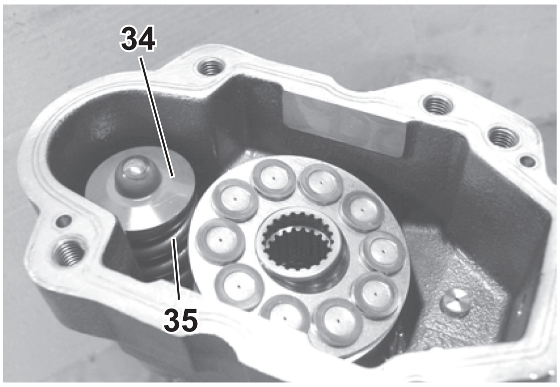
(17) Install the spring seats **35** and **36**.

Note :
*Install them carefully not to make flaws and dent on the valve plate **20** and cylinder barrel assembly, which can cause breakage.*



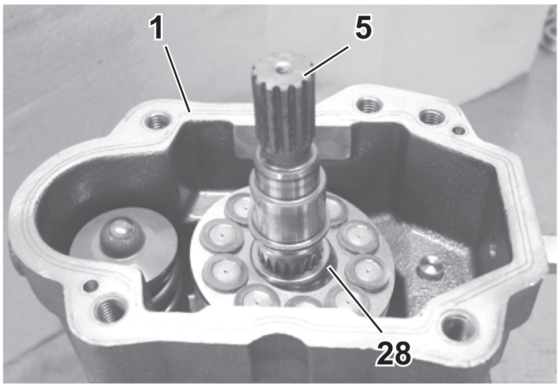
(18) Place the spring seat **34** onto the spring **35**.

Note :
*Install it carefully not to make flaws and dent on the valve plate **20** and cylinder barrel assembly, which can cause breakage.*

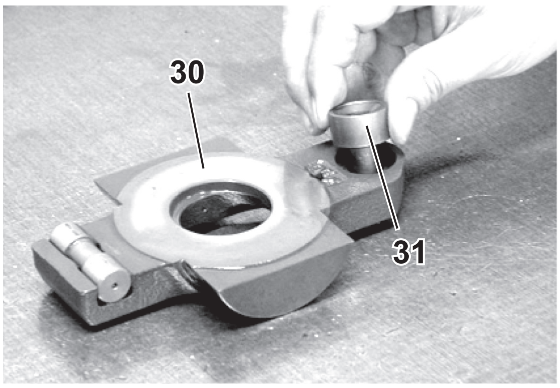


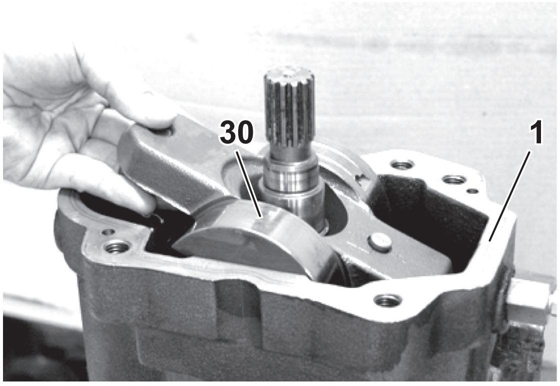
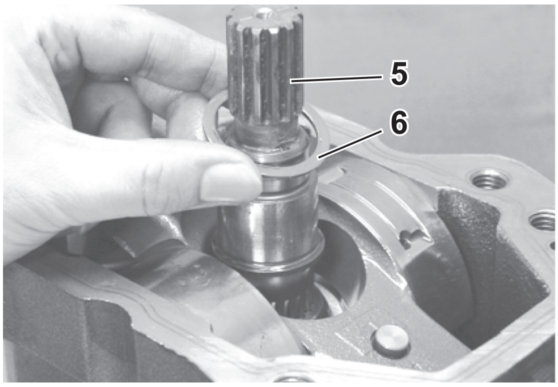
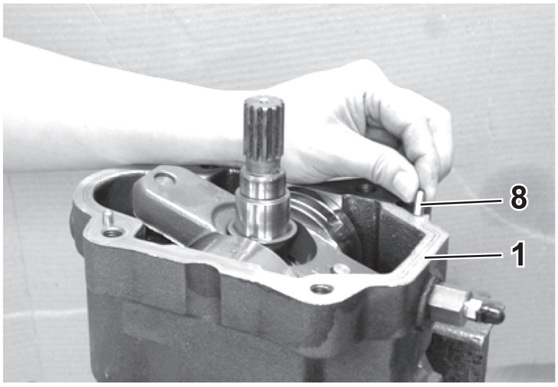
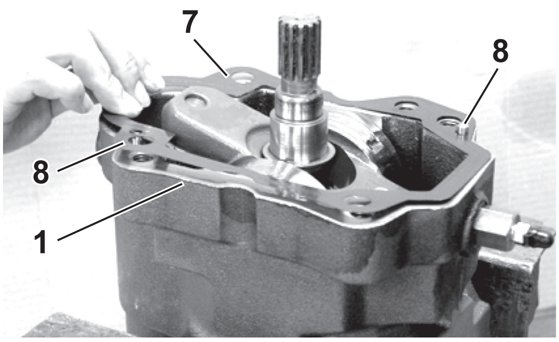
(19) Install the shaft so that the spline of the shaft **5** and bearing **2** are engaged with that of the cylinder barrel **21** and the retainer holder **28**.

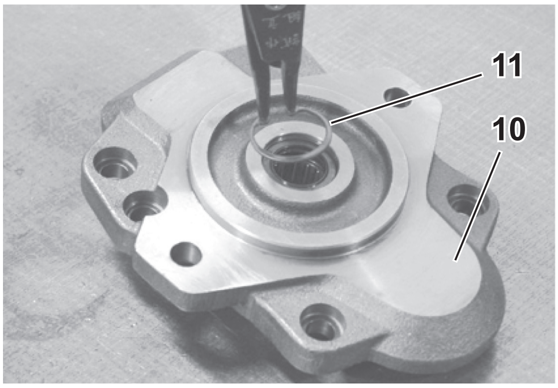
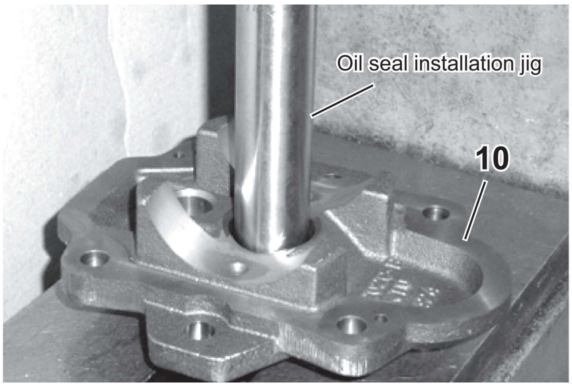
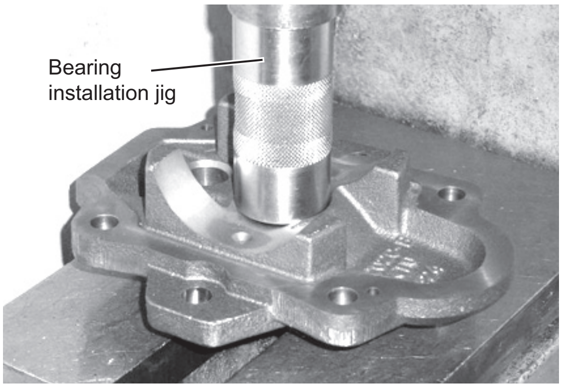
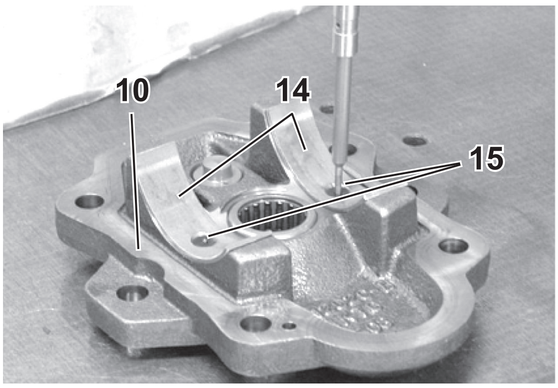
Note :
Install it carefully not to make flaws and dent on the pump internal parts, which can cause breakage.

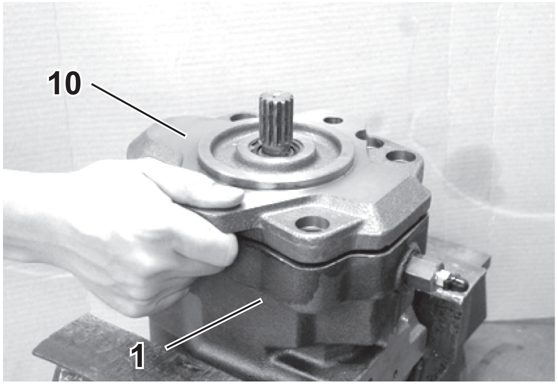


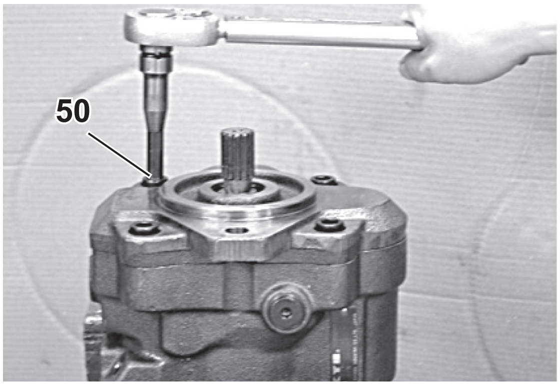
(20) Apply grease to the shaft of holder **31** and insert it into the swash plate **30**.

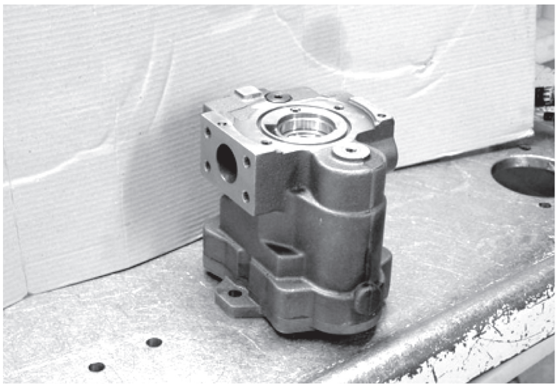


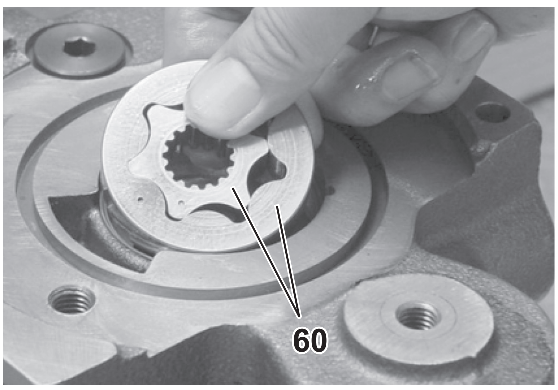
Procedure	
(21) Install the swash plate **30** into housing **1**. ***Note :*** *Take care not to drop the holder when installing it. This can damage the internal parts, such as pistons.*	
(22) Install the thrust washer **6** onto the shaft **5**.	
(23) Install the pins **8** into the housing **1**.	
(24) Install the gasket **7** into the housing **1** aligning with the pins **8**.	

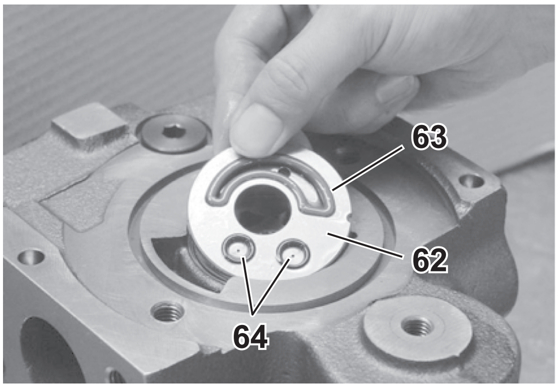
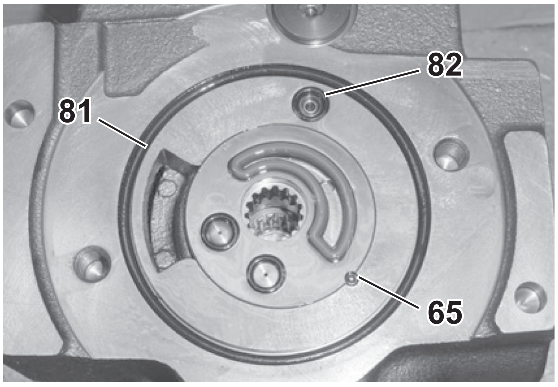
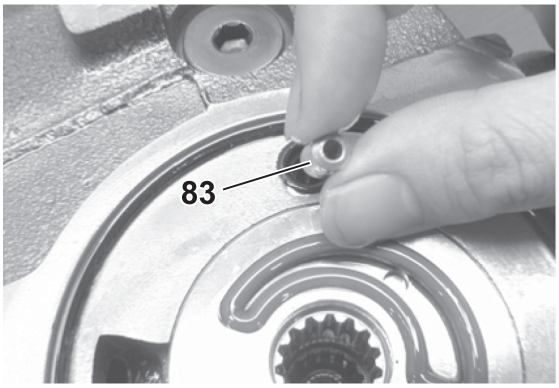
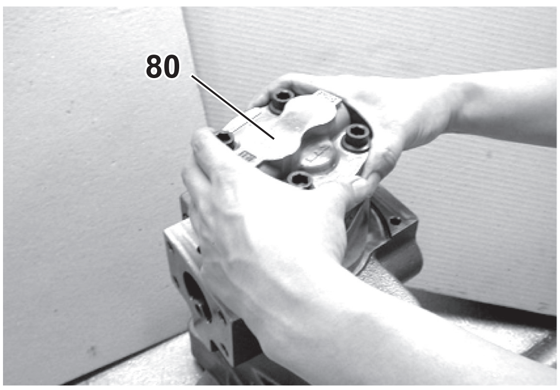
Procedure	
(25) Install the internal snap ring **11** into the flange **10**.	
(26) Install the oil seal **12** into the flange **10** with a jig.	
(27) Install the needle bearing **13** into the flange **10** with a jig. ***Note :*** *Press-fit the needle bearing with the emboss side up.*	
(28) Fix the flange **10**, and tighten the bushes **14** with screws **15**. Tightening torque : 4.34 ft･lbf (5.9 N･m)	

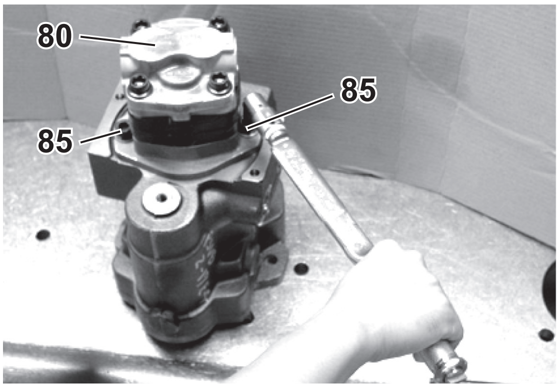
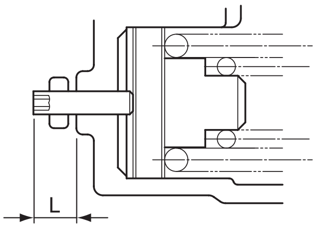
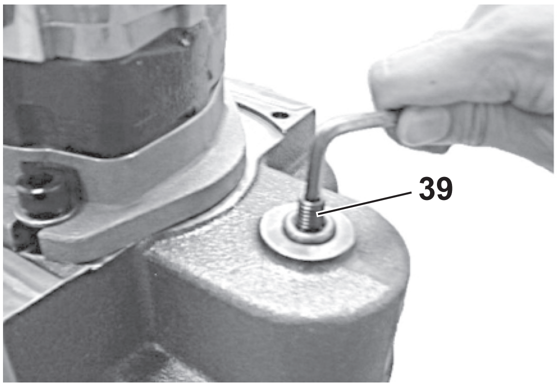
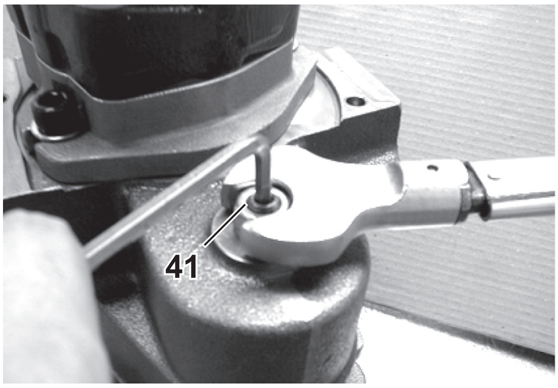
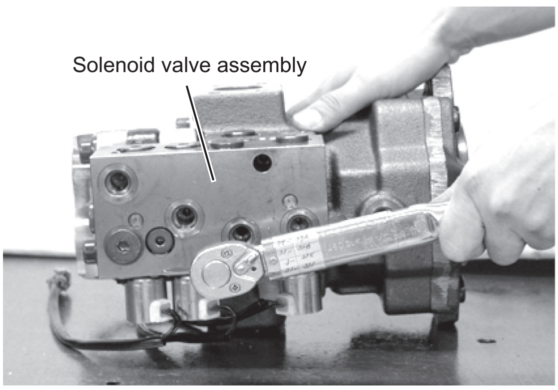
Procedure	
(29) Install the flange **10** into the housing **1**.	

(30) Fasten the flange **10** with the socket head bolts **50**. Tightening torque : 78.8 ft·lbf (106.9 N·m)	

(31) Fix the pump with the input shaft down.	

(32) Install the trochoid rotor assembly **60** into the housing **1**.	

Procedure	
(33) Install the O-rings **63** and **64** into the loading plate **62** and install them into the housing **1**.	
(34) Install the steel ball **65** and the O-rings **81** and **82** into the housing **1**. ***Note :*** *A steel ball is a minute part. Take care not to drop when installing.*	
(35) Install the pin **83** into the housing **1**.	
(36) Align the spline of the trochoid rotor assembly **60** with the internal spline of the shaft **5** and install the gear pump **80**.	

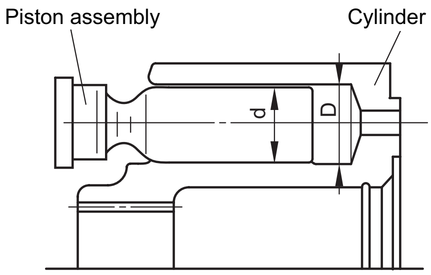
Procedure	
(37) Install the washer **86** into the socket head bolts **85** and then fasten the gear pump **80**. Tightening torque : 32.6 ft·lbf (44.1 N·m)	
(38) Install the set screw **39** and adjust the projection dimension of the set screw to the same as before disassembling. 	
(39) Install the seal washer **40** and then tighten the nut **41**. Tightening torque : 11.6 ft·lbf (15.7 N·m) ***Note :*** *When tightening the nut, hold the set screw **39** with hexagon wrench not to move.* *If the set screw moves, horsepower control characteristic changes.*	
(40) Fasten the solenoid valve assembly with solenoid head bolt. Tightening torque : 9.4 ft·lbf (12.7 N·m) ***Note :*** *Take care not to drop the O-ring installed into the solenoid valve assembly. Dropping O-ring may cause oil leak.*	

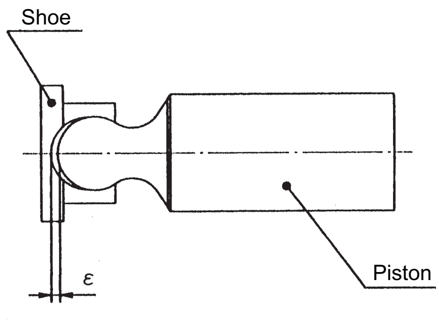
6. Service Standards

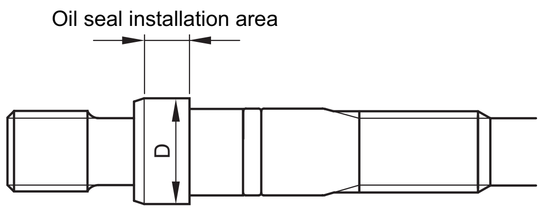
Clean the parts to be checked and completely dry them.

Check the major parts carefully and replace any ones on which excessive wear or damage that may cause malfunction is found.

Replace deformed or damaged seals.

Procedure	
(1) Piston assembly and cylinder barrel • Perform visual inspections for any flaws, scuffing or excessive wear (especially on the sliding parts). • Check the clearance between the outside diameter of each piston and the inside diameter of the cylinder barrel. D–d = 0.00197 in. (0.05 mm)	

(2) Piston shoes and pistons • Check the axial play of each piston and shoe. $\varepsilon \leqq$ 0.00787 in. (0.2 mm)	

(3) Shaft • Check the oil seal installation area. Wear $\leqq$ 0.00098 in. (0.025 mm) (Difference between contact and noncontact parts with oil seal in radius.)	

7. Troubleshooting

Trouble	Cause	Measure
1. Oil is not discharged from pump.	(1) Wrong pump shaft direction.	Reinstall in correct direction.
	(2) Strainer or intake pipe is closed.	Clean strainer. Open intake pipe.
	(3) Tip of intake pipe sticks out of oil surface in tank.	Raise oil surface in tank or put tip of intake pipe under oil surface.
	(4) Damage of pump's main parts. Malfunction of input shaft and coupling.	Disassemble and replace damaged parts with new one. Clean all parts completely and then reassemble.
2. Insufficient volume of oil is discharged from pump. Circuit pressure does not rise.	(1) Pressure does not rise or specified volume of oil does not flow due to hydraulic equipment except for pump, such as hydraulic motor or control valves.	Check hydraulic equipment being in trouble. If necessary, replace or repair it.
	(2) Large quantity of high-pressure oil leak due to wear on sliding area of pump.	Disassemble the pump. If the sliding surface is not smooth, repair with regrinding or wrapping. If wear is beyond repair, replace parts. Clean all parts completely and then reassemble them.
	(3) Air sucked in from intake side of pump.	Check and replace intake piping and packing, or check and retighten tightening area.
	(4) Clogging of strainer or air sucked in due to low oil level.	Clean or replace strainer.
	(5) Cavitation caused by excessive intake resistance due to abnormal oil temperature and hydraulic oil viscosity or other factors.	Reduce intake resistance.
3. Pump creates abnormal sounds.	(1) Air sucked in due to low oil level in tank.	Replenish hydraulic oil and perform air release operation with no load.
	(2) Pump's intake resistance is too large due to improper thickness and length of intake pipe.	Reduce intake resistance.
	(3) Pump cavitation due to clogged strainer.	Clean strainer. When strainer is heavily clogged, flush circuit and replace hydraulic oil.
	(4) Short capacity of strainer.	Select strainer whose capacity is two or three times as much as the max. displacement.
	(5) Too low oil temperature. Pump cavitation due too high viscosity of hydraulic oil.	Refer to the Operation and Maintenance Manual for selecting oil and oil temperature.
	(6) Defective coupling.	Check for core deflection.
	(7) Resonance with others.	Check bolts for looseness.
4. Excessive engine load. (Excessive drop of engine speed or engine stall)	(1) Too high set torque of horsepower-control.	Readjust set screw.
	(2) Clogging of pilot oil passage and orifice inside pump, and seizing and scuffing of parts.	Readjust set screw. If nothing improves, disassemble and check pump.
	(3) Seizing and wear of internal parts of pump.	Repair pump.
5. Oil leak.	(1) Broken oil seal and oil leak due to increase in drain oil volume and rise in internal pressure of pump housing. (Capacity to resistant pressure of oil seal : 42.7 PSI. (0.3 MPa)	Replace with new oil seal. Take great care not to damage lip when inserting oil seal.

Trouble	Cause	Measure
6. Malfunction of valve. • Oil does not flow. • Pressure has no stability.	(1) Low set pressure of relief valve.	Set specified value.
	(2) Poppet of relief valve is clogged with dust.	Dissemble and clean pump and valve. Replace hydraulic oil.
	(3) Damage or wear of relief valve poppet.	Replace poppet. When damage is found on pump case side, replace pump with new one.
	(4) Valve does not switch due to no electric current flowing to solenoid.	Check electric current.
	(5) Spool of solenoid valve is clogged with dust.	Dissemble and clean pump and valve. Replace hydraulic oil.
	(6) Damage or wear of solenoid valve spool.	Replace valve assembly.

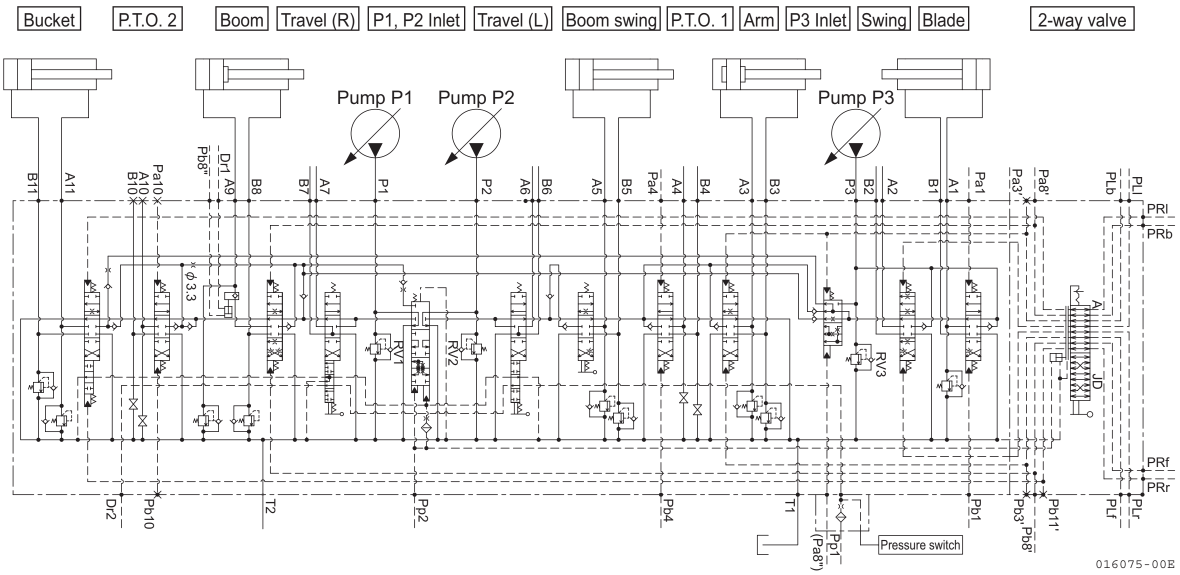
6-2 Control Valve

1. Outline

This control valve is a mono-block valve comprising twelve-series connected three-position directional control valves which control the operation of the actuators by switching the circuit, system relief valves which control the circuit pressure, circuit relief valves, an anti-cavitation valve, load check valves, orifices and others.

1) Circuit Configuration

There are three pump ports at the P1, P2 inlet section and the P3 inlet section. Oil from the port P1 flows to the right travel, boom and bucket spool sections, which are connected via parallel passages. Oil from the port P3 also flows to the boom and bucket sections through the spool of the P3 inlet section (parallel-flow divider).
The parallel passage allows simultaneous operation of more than one spool, however, they cannot always operate in the same motion. Specifically, due to the differences in load and capacity between the actuators, pressures to be generated vary and the spool with a smaller load pressure operates earlier.
To allow the simultaneous operation of the spools in the same motion as a single operation, the spool stroke of the spool section with a heavier load needs to be adjusted to the full stroke while that of the spool section with a lighter load needs to be adjusted to half a stroke or smaller.
Oil from the port P2 flows to the left travel, boom swing, P.T.O. and arm spool sections. Oil from the port P3 also flows to the arm and P.T.O. sections through the spool of the P3 inlet section (parallel-flow divider).
Oil from the port P3 flows to the blade and swing spool sections, which are also connected via parallel passages.



2. Operation

1) Unloaded state (Port Pp2 with No Pilot Oil Supplied)

(1) Oil flow discharged from the pump P1

The oil discharged from the hydraulic pump P1 flows into the control valve through the port P1 and flows out directly to the hydraulic oil tank through the spool of the inlet section. At this time, the spool blocks the line to the by-pass passage, so that the pressure does not rise even if the control levers for the right travel, boom, bucket or P.T.O. 2 are operated.

(2) Oil flow discharged from the pump P2

A part of oil discharged from the hydraulic pump P2 flows into the control valve through the port P2 and flows out directly to the hydraulic oil tank through the spool of the inlet section. At this time, the spool blocks the line to the by-pass passage, so that the pressure does not rise even if the left travel control lever or boom swing pedal is operated.

(3) Oil flow discharged from the pump P3

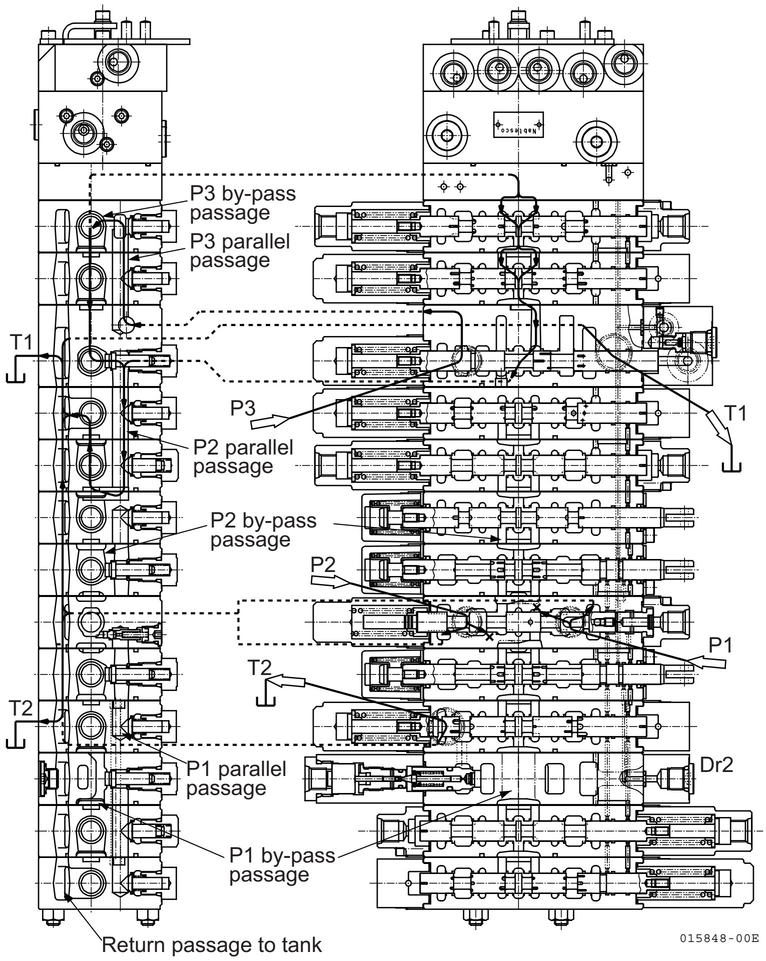
The oil discharged from the hydraulic pump P3 flows into the control valve through the port P3 and flows to the parallel passage of the swing and blade sections.

In the neutral state of the spools, the by-pass passage is not blocked by any spool, so that the oil from the parallel passage flows to the hydraulic oil tank through the by-pass passage of the blade and swing spools, the check valve in the P3 inlet section, the P2 parallel passage, the by-pass passage of the P.T.O. 1 spool and the by-pass passage of the arm section spool.

(4) 2-way valve

When no oil is supplied to the port Pp2, each pilot oil port is led to the return passage to the reservoir in this valve. Refer to "6. 2-way Valve" for more details.

Operation in unload state



2) Neutral State (Port Pp2 with Pilot Oil Supplied)

(1) Oil flow discharged from the pump P1

When the pilot oil is supplied to the port Pp2, it moves the piston to press the spool. Therefore, the line to the return passage is blocked and that to the right travel section is open, so that the oil from port P1 flows to the right travel spool section through the inlet spool land. In the neutral state of the spools, the by-pass passage is not blocked by any spool, so that the oil flows from the right travel spool section to the hydraulic oil tank through the by-pass passage of the right travel, boom and P.T.O. 2 and the by-pass passage of the bucket spool.

(2) Oil flow discharged from the pump P2

When the pilot oil is supplied to the port Pp2, it moves the piston to press the spool. Therefore, the line to the return passage is blocked and that to the left travel section is open, so that the oil from port P2 flows to the left travel spool section through the inlet spool land. In the neutral state of the spools, the by-pass passage is not blocked by any spool, so that the oil flows from the left travel spool section to the hydraulic oil tank through the by-pass passage of the left travel, boom swing and P.T.O. 1 and the by-pass passage of the arm spool.

(3) Oil flow discharged from the pump P3

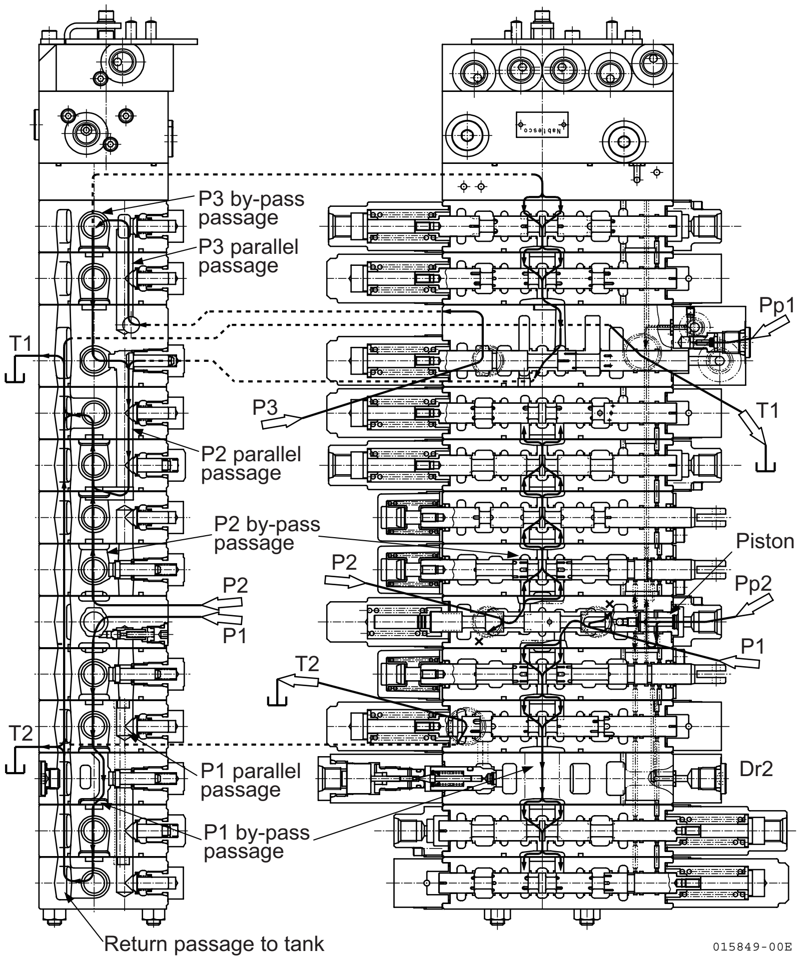
The oil discharged from the hydraulic pump P3 flows into the control valve through the port P3 and flows to the parallel passage of the swing and blade sections.

In the neutral state of the spools, the by-pass passage is not blocked by any spool, so that the oil from the parallel passage flows to the hydraulic oil tank through the by-pass passage of the blade and swing spools, the check valve in the P3 inlet section, the P2 parallel passage, the by-pass passage of the P.T.O. 1 spool and the by-pass passage of the arm section spool.

(4) 2-way valve

When oil is supplied to the port Pp2, all pilot oil ports are connected to respective circuit passages.

Operation in neutral state



3. Operation of Directional Control Valves

1) Travel Operation

When the left [right] control lever is pushed forward, the spool is pulled up. The oil from the port P2 [P1] flows to the by-pass passage of the left [right] travel spool through the inlet spool land.

The oil in the by-pass passage of the left [right] travel spool flows to the port A6 [A7], which is opened as the spool has been moved, and is fed to the travel motor.

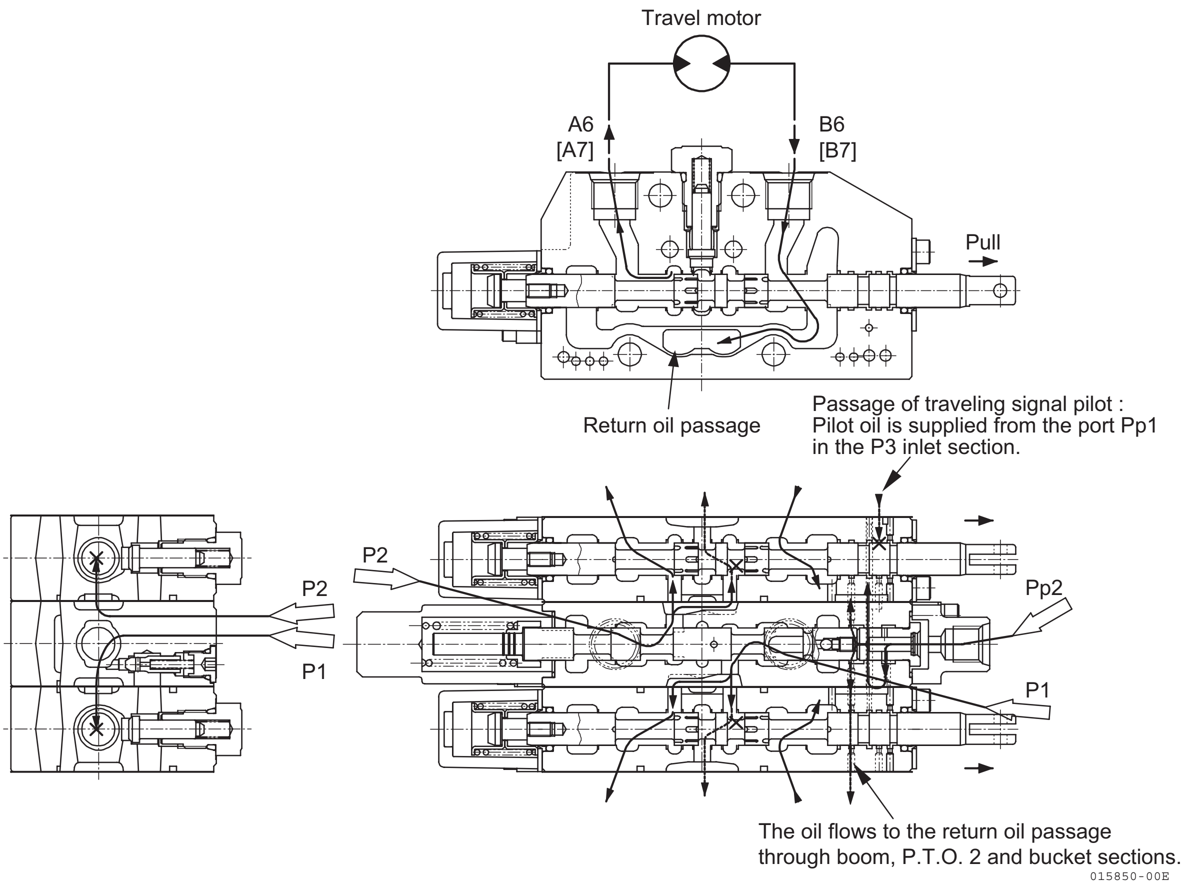
Meanwhile, the return oil from the travel motor flows into the control valve through the port B6 [B7] and flows to the return passage, which is opened as the spool has been moved.

The oil from the port Pp2 flows to the passage of traveling signal pilot through the orifice of the piston in the P1 and P2 inlet section.

The passage opened when the travel section spool is in the neutral position is blocked by its movement, but as long as the bucket section spool is not moved, the pressure in the passage of traveling signal pilot equals to that in the return oil passage because both the passages are connected in the bucket section and the P1, P2 inlet section spool does not move.

Note :

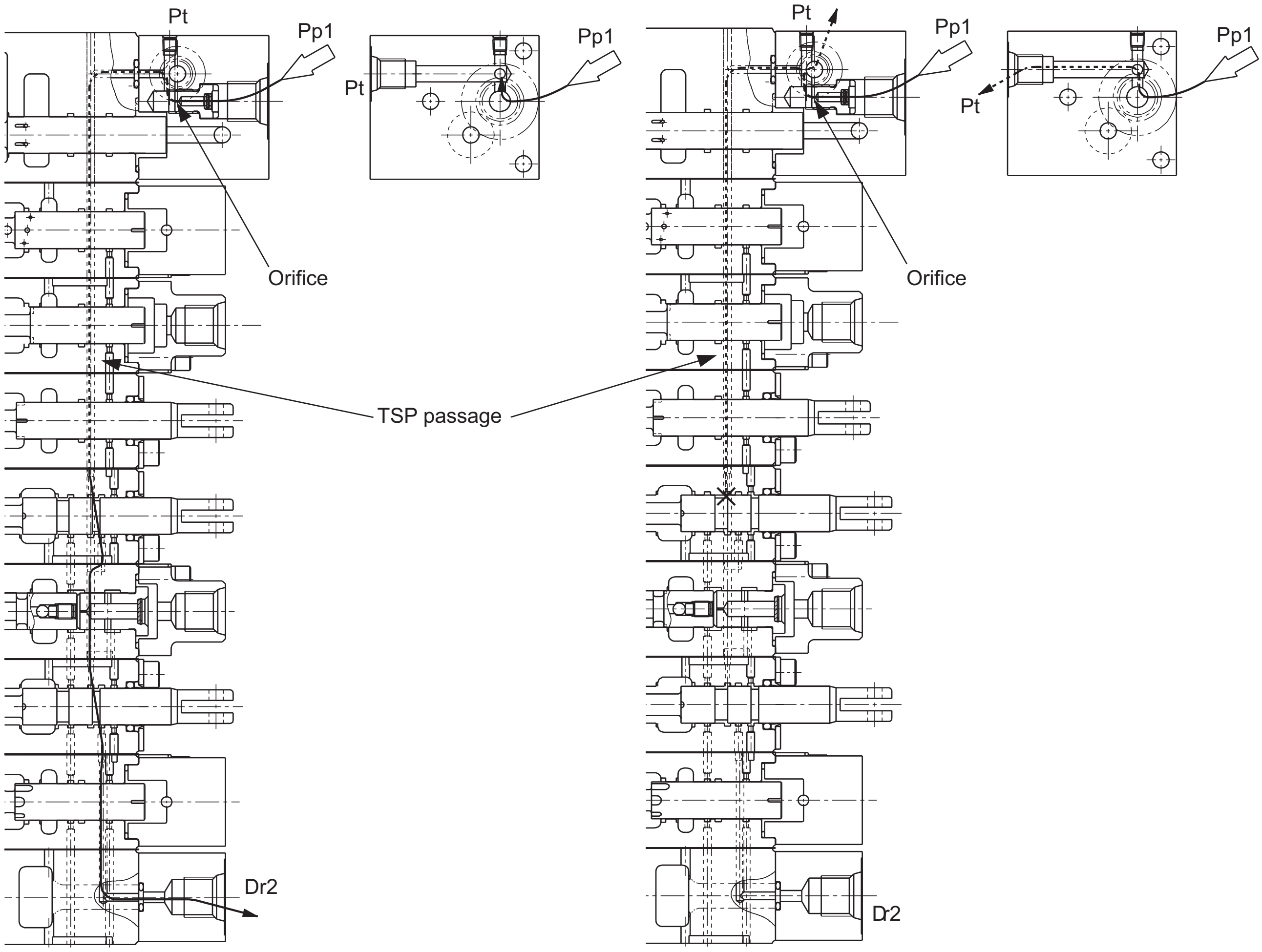
The words in brackets are for the right travel operation.



When the TSP (traveling signal pilot) circuit is used

The oil from the port Pp1 flows to the TSP passage through the orifice in the P3 inlet section. When the travel lever is not moved, the oil in the TSP passage flows to the port Dr2 and its pressure equals at down stream passage of the orifice to that at the port Pt (TSP port) connected to upstream oil passage of the travel section.

When right or left travel lever is moved, TSP passage is blocked in the travel section operated, so that the pressure at the port Pt goes up to that at the port Pp1.



TSP circuit
(with the lever in the neutral)

TSP circuit
(with the lever moved)

2) Operation of Boom

(1) Boom up operation

When the boom control lever is pulled back to raise the boom, the oil from the pilot valve flows to the port Pa8’ to move the spool of the boom section and to the port Pa8" through the port Pa8’ to move the P3 inlet section spool.

Owing to the boom spool movement, the P1 by-pass passage is blocked, so that the oil from the port P1 flows through the parallel oil passage via a check valve in the by-pass oil passage in the travel section to the parallel passage of the boom section.

The oil from the port P3 of the P3 inlet section opens the check valve of the P3 inlet section after passing the P3 parallel passage and P3 by-pass passage to flow into the boom combined oil passage. A part of oil flows from the port P3 to there through the oil passage in the P3 inlet section spool. (Another part of oil flows to the return oil passage through the orifice in the P3 inlet section spool, the by-pass oil passage of the P.T.O. 1 section and that of the arm section.)

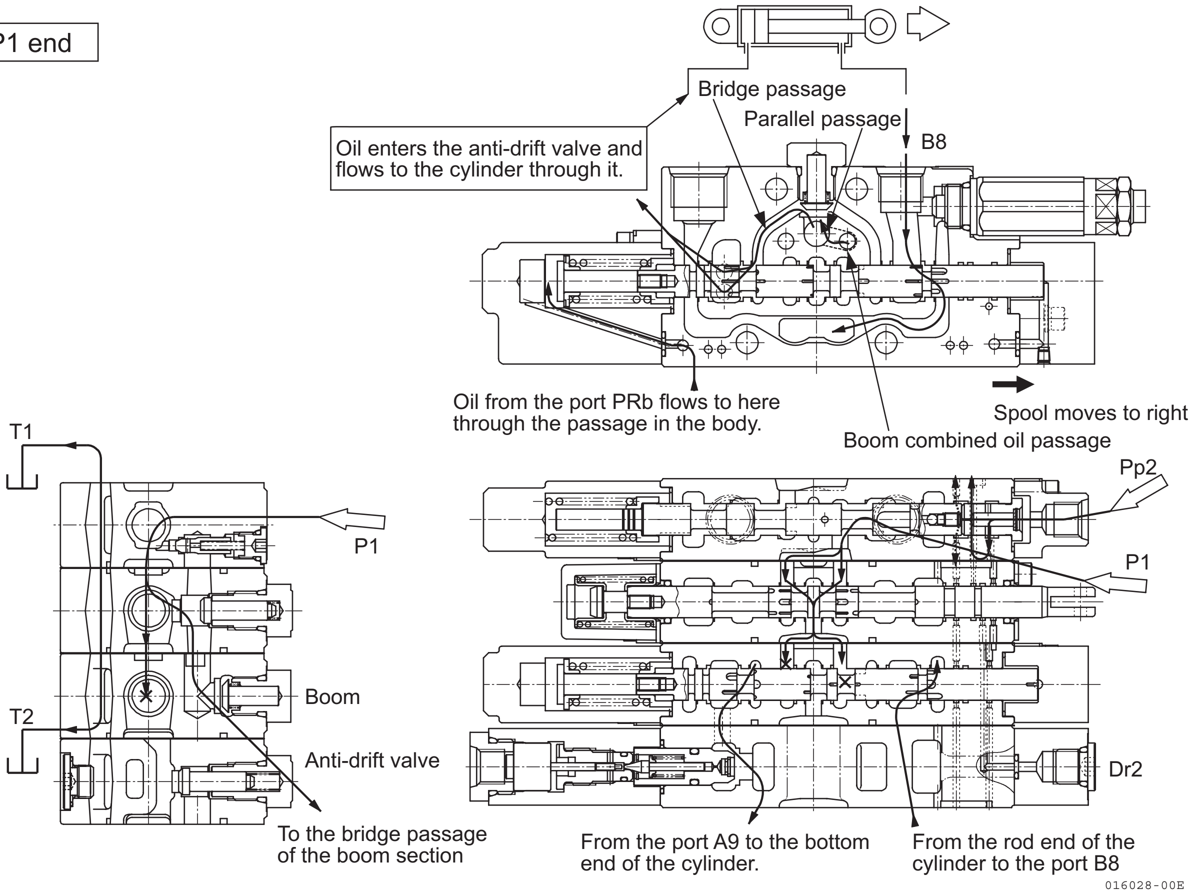
The passage between the anti-drift valve and the bridge passage is opened as the spool has been moved. Therefore, the oil in the parallel passage and the boom combined oil passage flows to the anti-drift valve through the load check valve in the boom section and the bridge passage.

The oil in the anti-drift valve opens the anti-drift valve (in the state of free flow) to flow to the port A9 and the bottom end of the boom cylinder.

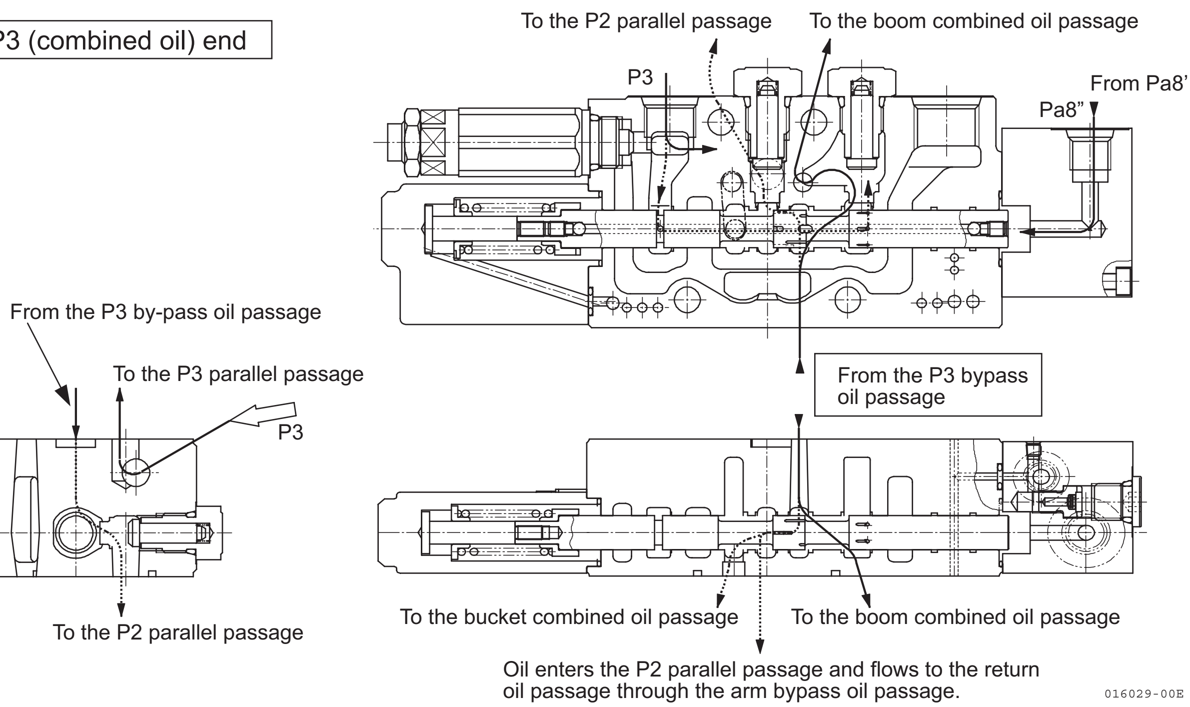
Meanwhile, the return oil from the rod end of the boom cylinder flows to the return oil passage through the port B8 and the notch in the boom spool, which is opened to the tank passage as the spool has been moved.

Thus, the boom cylinder is extended to raise the boom.

P1 end



P3 (combined oil) end



(2) Boom down operation

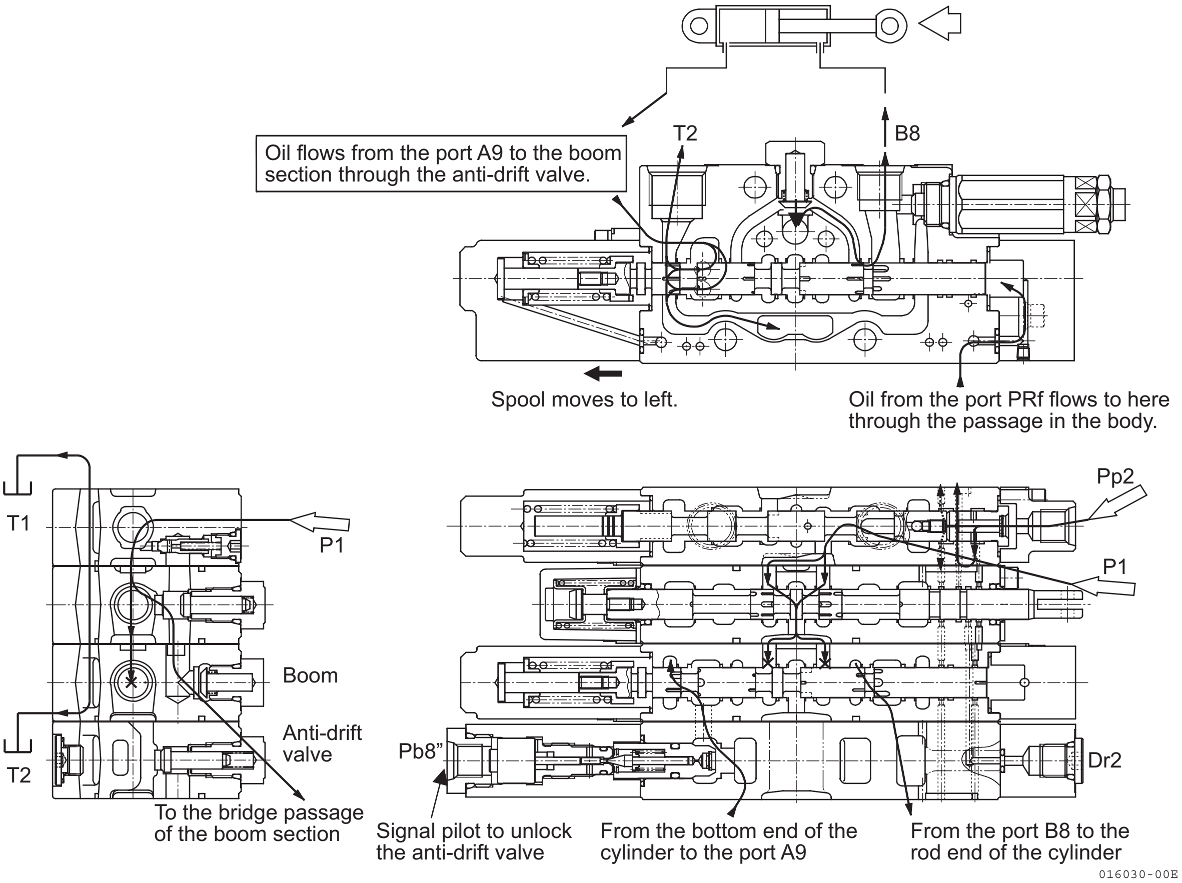
When the boom control lever is pushed forward to lower the boom, the oil from the pilot valve flows to the port PRf to move the spool of the boom section and to the port Pb8" through the port Pb8' to unlock the anti-drift valve.

Owing to the boom spool movement, the P1 by-pass passage is blocked, so that the oil from the port P1 flows through the parallel oil passage via a check valve in the by-pass oil passage in the travel section to the parallel passage of the boom section.

The passage between the port B8 and the bridge passage is opened through the notch in the boom spool as the spool has been moved. Therefore the oil in the parallel passage flows through the load check valve of the boom section and the bridge passage to the port B8 and is fed to the rod end of the boom cylinder.

Meanwhile, the return oil from the bottom end of the boom cylinder flows to the return oil passage through the port A9, the anti-drift valve, which is opened by the pilot pressure from the port Pb8', and the notch in the boom spool which opens the return oil passage as the spool has been moved.

Thus, the boom cylinder is retracted to lower the boom.



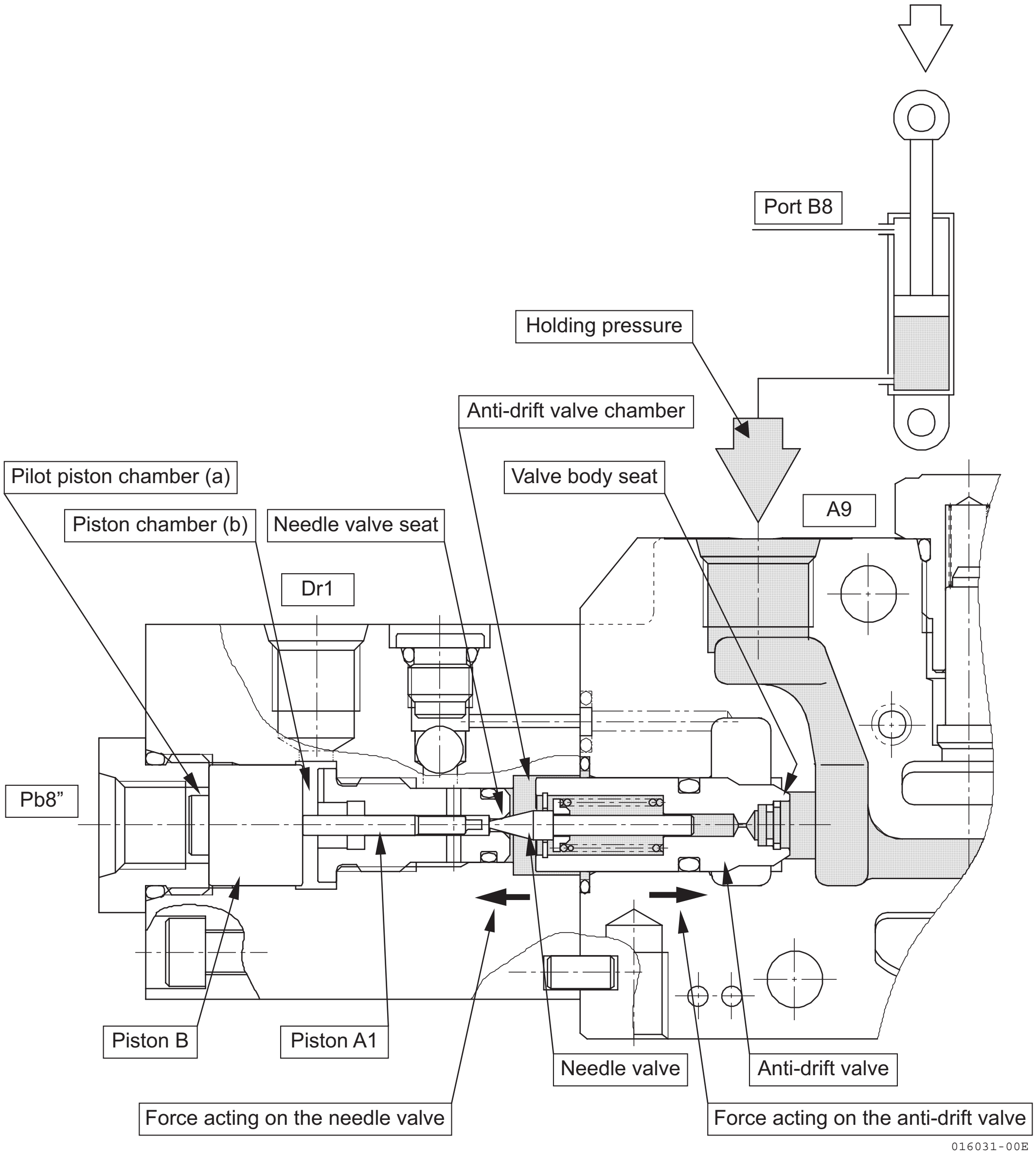
3) Anti-Drift Valve Operation

(1) Holding

In the neutral state of the spool of the boom section, the pilot piston chamber (a) is connected to the drain oil passage through the pilot port Pb8" for anti-drift valve unlock. The piston chamber (b) is also connected to the drain oil passage through the drain port Dr1.

This allows the piston B to stay in the state shown in the figure below.

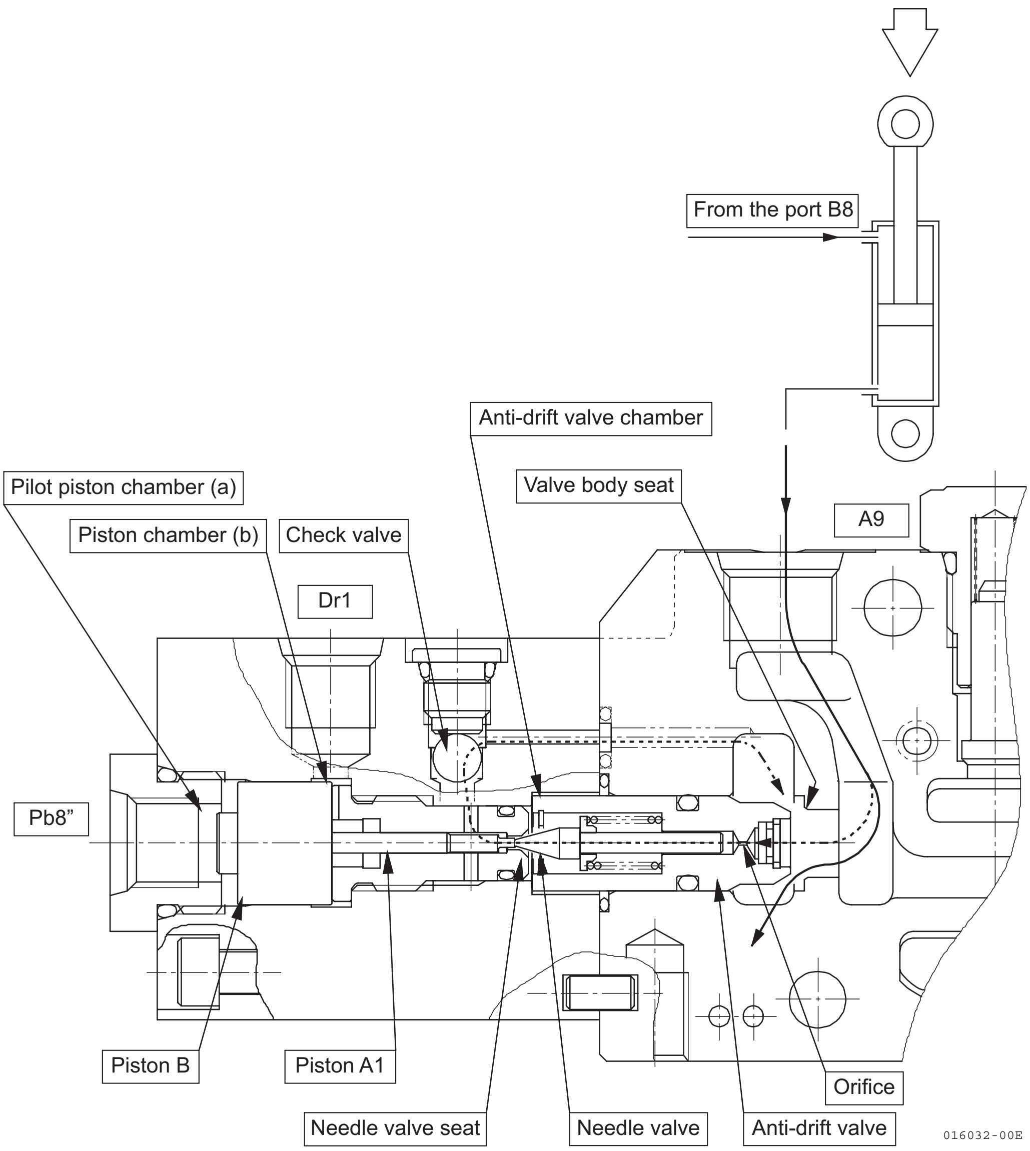
The holding pressure of the boom cylinder works on the anti-drift valve chamber as shown in the figure, pressing the needle valve on the needle valve seat and the anti-drift valve on the section body seat to prevent oil leak from the bottom end of the boom cylinder and the boom cylinder from drifting due to the oil leak.



(2) Releasing (boom down)

When the pilot oil flows to the pilot port (Pb8") for release of the anti-drift valve, the pilot pressure moves the piston B to the right, and it presses the needle valve to open via the piston A1. At that time, the return oil from the boom cylinder flows through the orifice of the anti-drift valve, the anti-drift valve chamber, the needle valve seat, and check valve to the downstream chamber of the anti-drift valve (the boom section).

The downstream chamber connects to the return oil passage according to a boom spool movement and the pressure in the anti-drift valve chamber decreases as the needle valve has been opened, and the return oil from the boom cylinder has opened the anti-drift valve so that the return oil from the boom cylinder flows to the return oil passage through the notch in the boom spool, and the boom cylinder can retract.



4) P.T.O. 2 Operation (for an applicable unit only)

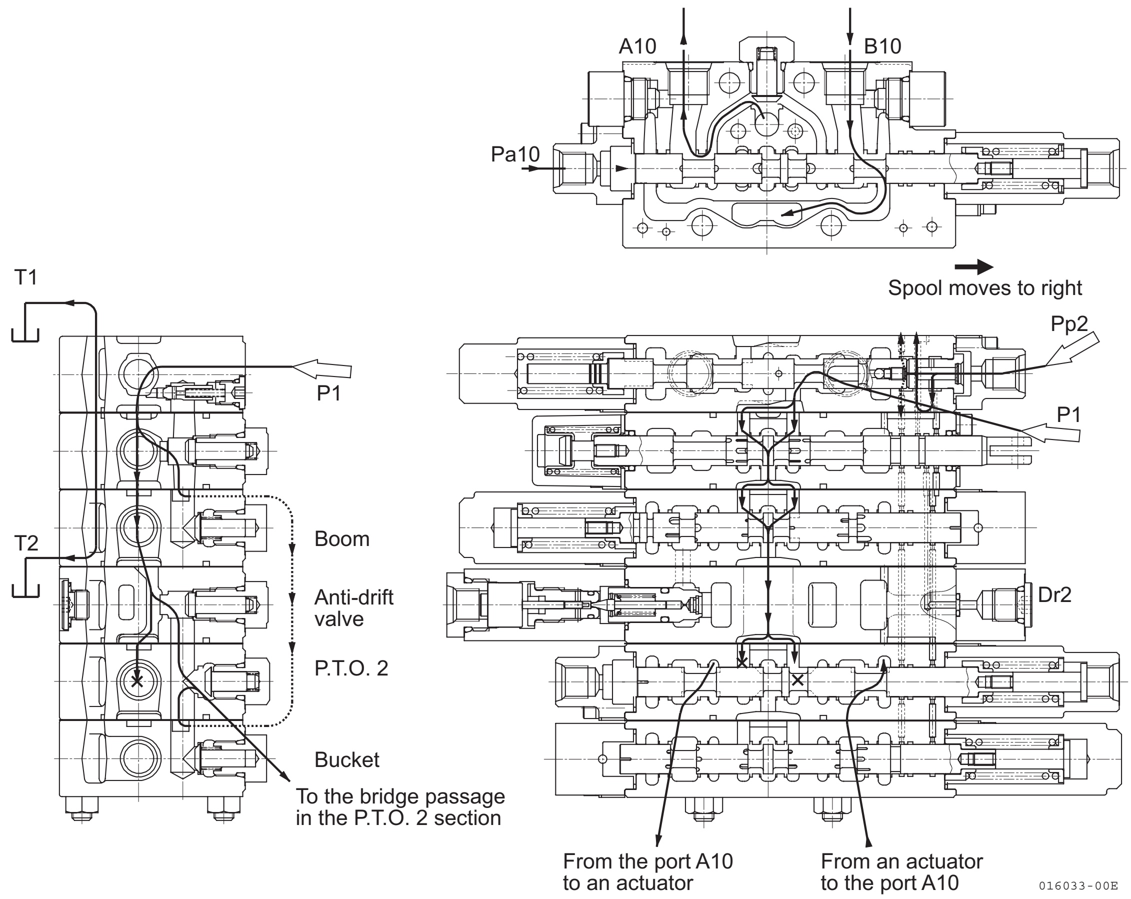
When the P.T.O. 2 is operated, the oil from the pilot valve flows to the port Pa10 to move the spool of the P.T.O. 2 section.

At that time, as the P.T.O. 2 spool blocks the P1 by-pass passage in the P.T.O. 2 section, the oil from the port P1 flows to the parallel passage of the P.T.O. 2 section through the check valve above the by-pass passage in the travel section and the check valve on the by-pass passage of the boom anti-drift valve.

The passage between the port A10 and the bridge passage is opened by the spool movement, the oil from the parallel passage flows to an actuator in the P.T.O. 2 circuit through the load check valve in the P.T.O. 2 section, the bridge passage and the port A10.

Meantime, the return oil from the actuator flows to the return oil passage which is opened as the spool as the spool has been moved through the port B10.

When the spool moves to left, oil flows to the other way but the valve actuation theory is the same.



5) Bucket Operation

(1) Bucket dump operation

When the bucket control lever is moved to the right to dump the bucket, the oil from the pilot valve flows to the port PRr to move the spool of the bucket section.

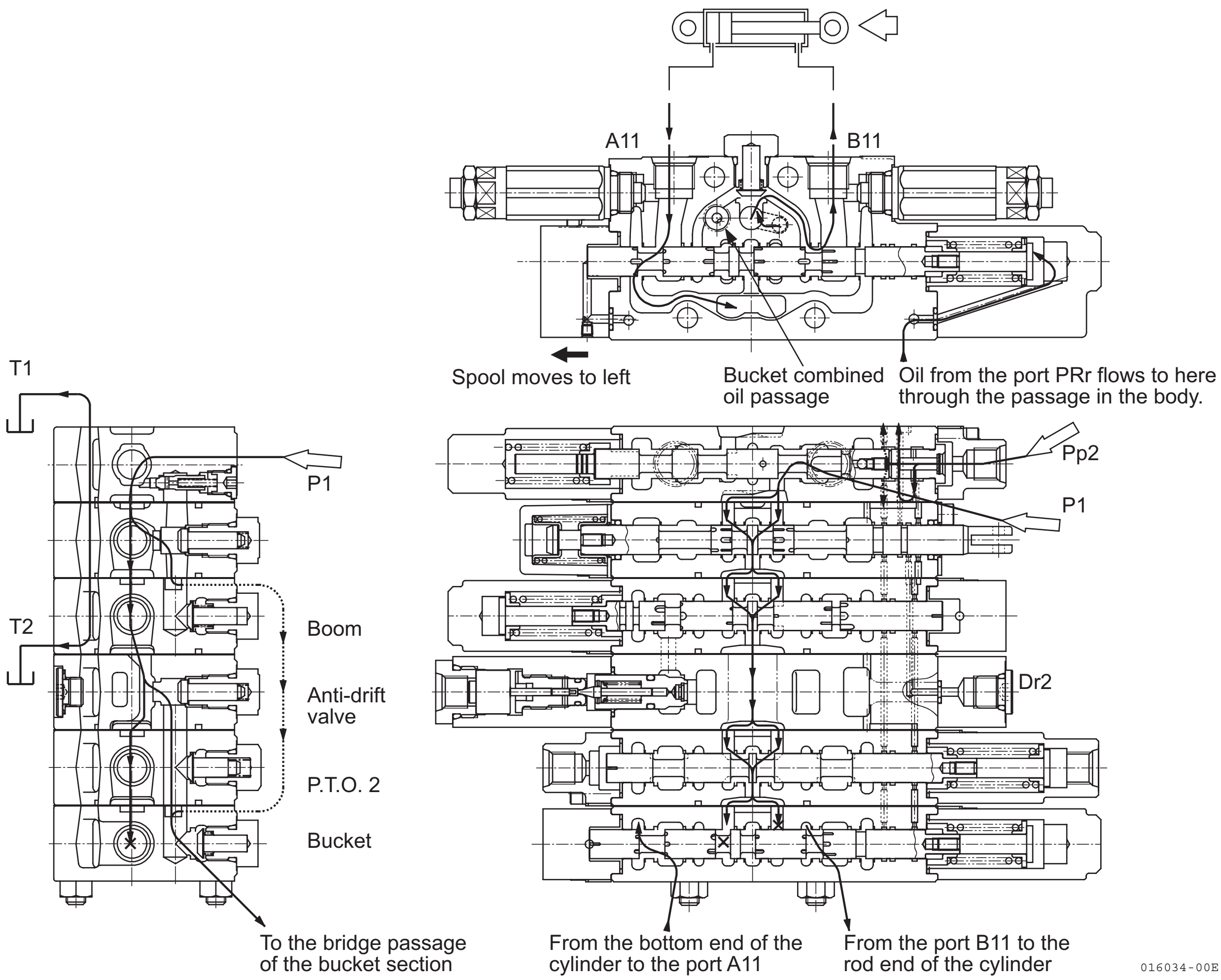
The P1 by-pass passage is blocked by the bucket spool as the spool has been moved, so that the oil from the port P1 flows through the check valve above the by-pass passage in the travel section and the check valve on the by-pass valve of the anti-drift valve to the parallel passage in the section.

The passage between the port B11 and the bridge passage is opened as the bucket spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve in the bucket section and the bridge passage to the port B11, and is fed to the rod end of the bucket cylinder.

Meanwhile, the return oil from the bottom end of the bucket cylinder flows through the port A11 to the return oil passage, which is opened as the bucket spool has been moved.

Thus, the bucket cylinder is retracted to dump the bucket.

The oil from the port Pp2 flows to the TSP (travel signal pilot) passage through the orifice of the piston. Though the return oil passage is blocked by a bucket spool movement, the spool receives no pressure to be moved because the TSP passage is connected with the return oil passage by the lands on the right and left travel section spools as long as no travel section spools are moved.



(2) Bucket curl operation

When the bucket control lever is moved to the right to dump the bucket, the oil from the pilot valve flows to the port PR1 to move the spool of the bucket section.

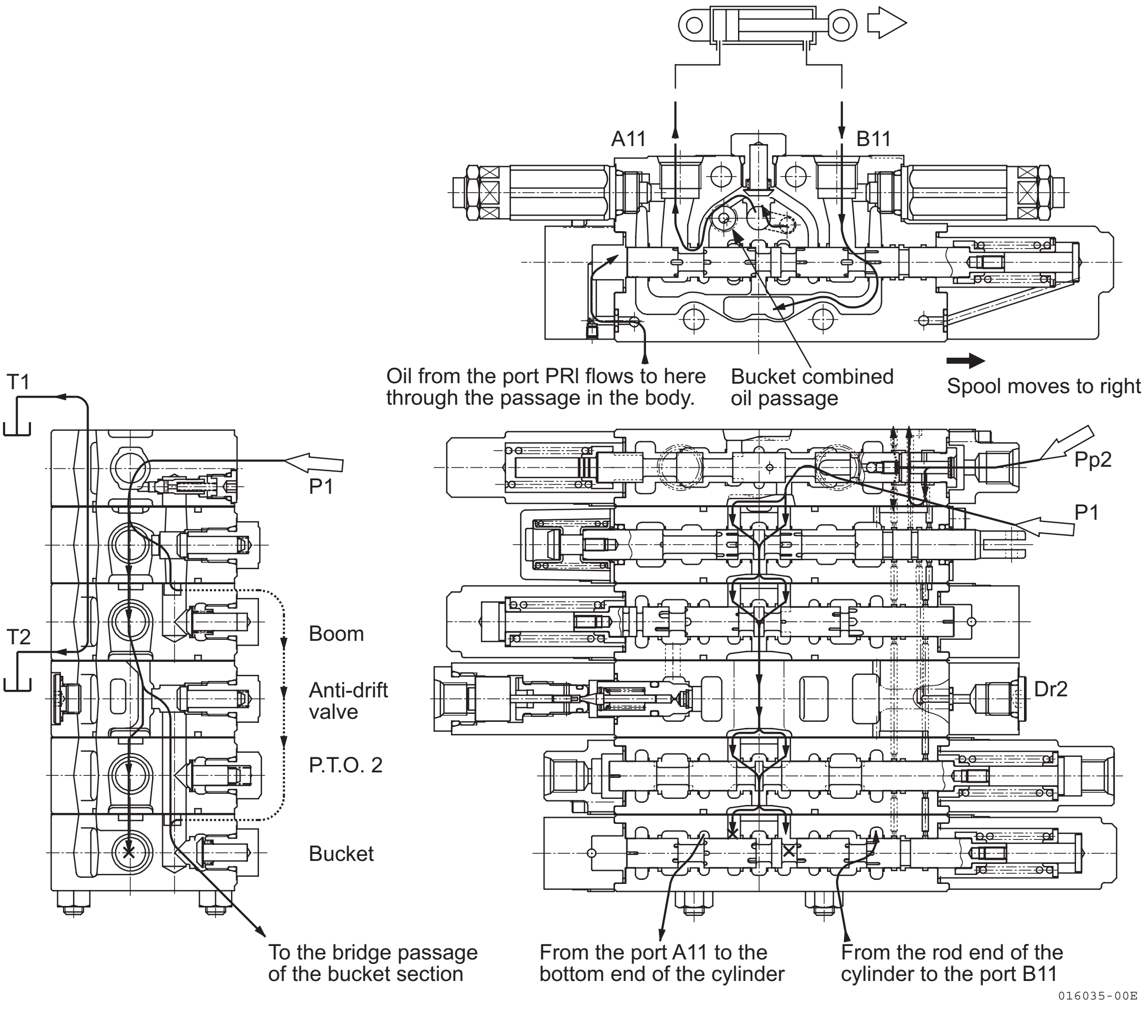
The P1 by-pass passage is blocked by the bucket spool as the spool has been moved, so that the oil from the port P1 flows through the check valve above the by-pass passage in the travel section and the check valve on the by-pass valve of the anti-drift valve to the parallel passage in the section.

The passage between the port A11 and the bridge passage is opened as the bucket spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve in the bucket section and the bridge passage to the port A11, and is fed to the bottom end of the bucket cylinder.

Meanwhile, the return oil from the rod end of the bucket cylinder flows through the port B11 to the return oil passage, which is opened by the notches on the bucket spool as it has been moved.

Thus, the bucket cylinder is extended to curl the bucket.

The oil from the port Pp2 flows to the TSP (travel signal pilot) passage through the orifice of the piston. Though the return oil passage is blocked by a bucket spool movement, the spool receives no pressure to be moved because the TSP passage is connected with the return oil passage by the lands on the right and left travel section spools as long as no travel section spools are moved.



6) Boom Swing Operation

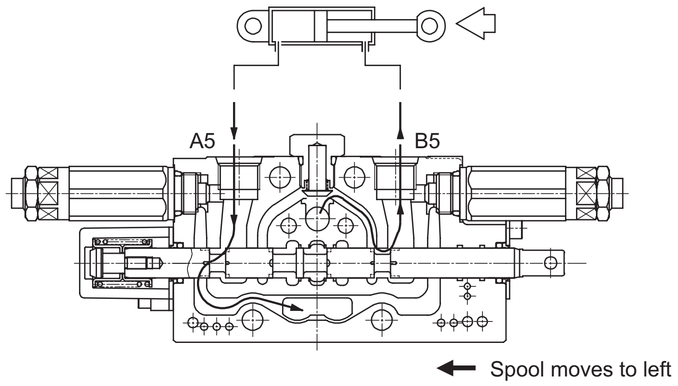
(1) Right boom swing operation

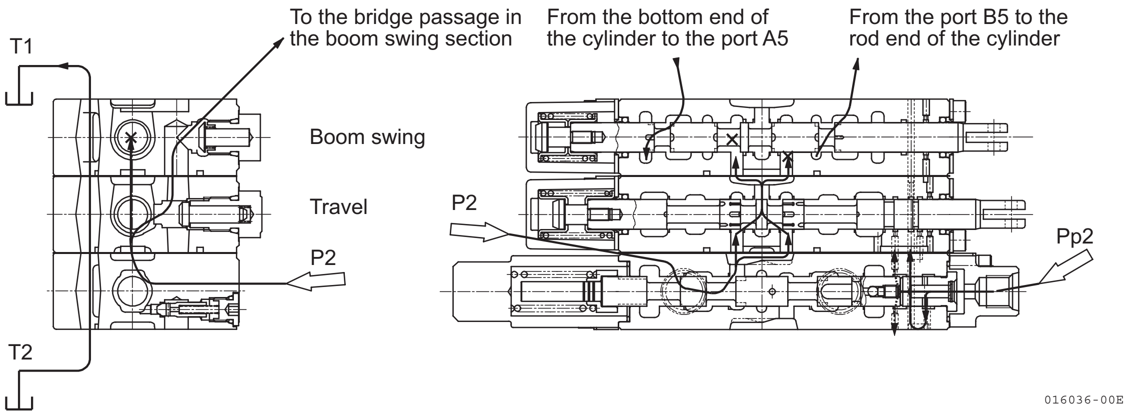
When the boom swing pedal is moved on the right, the spool of the boom swing section is pressed down. The P2 by-pass passage is blocked by the boom swing spool as the spool has been moved, so that the oil from the port P2 flows to the parallel passage of the boom swing section through the check valve installed at the upper part of the by-pass passage of the left travel spool.

The passage between the port B5 and the bridge passage is opened as the boom swing spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve in the boom swing section and the bridge passage to the port B5 and is fed to the rod end of the boom swing cylinder.

Meanwhile, the return oil from the bottom end of the boom swing cylinder flows to the return oil passage, which is opened to the tank passage as the spool has been moved through the port A5 and the notch in the boom swing spool.

Thus, the boom swing cylinder is retracted to swing the boom to the right.





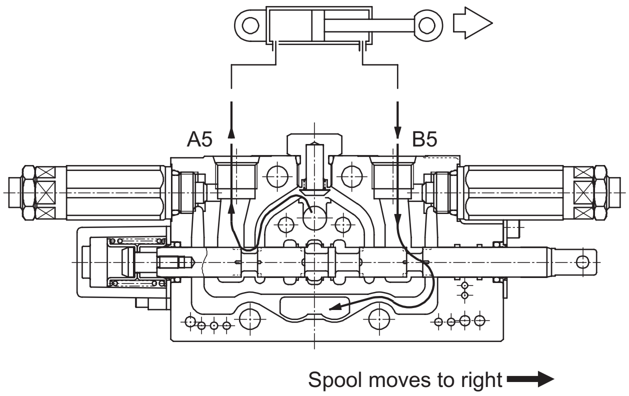
(2) Left boom swing operation

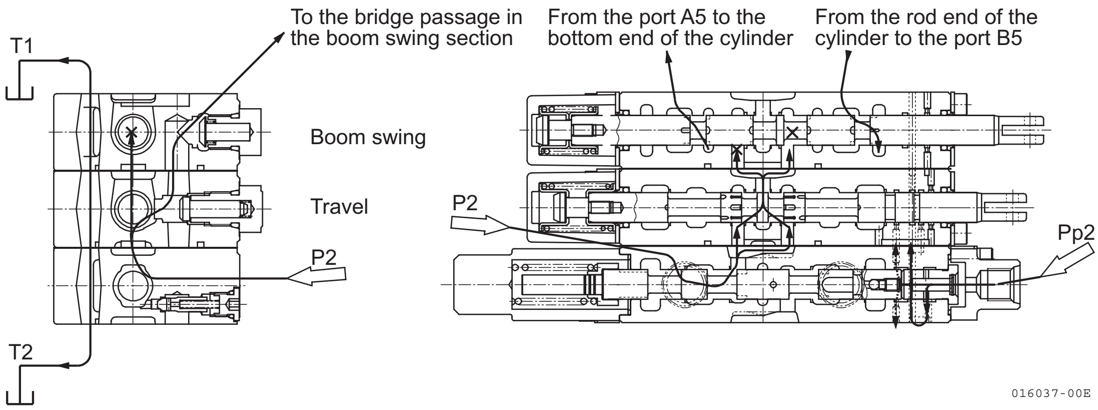
When the boom swing pedal is moved on the left, the spool of the boom swing section is pulled up. The P2 by-pass passage is blocked by the boom swing spool as the spool has been moved, so that the oil from the port P2 flows to the parallel passage of the boom swing section through the check valve installed at the upper part of the by-pass passage of the left travel spool.

The passage between the port A5 and the bridge passage is opened as the boom swing spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve in the boom swing section and the bridge passage to the port A5 and is fed to the bottom end of the boom swing cylinder.

Meanwhile, the return oil from the rod end of the boom swing cylinder flows to the return oil passage, which is opened to the tank passage as the spool has been moved through the port B5 and the notch in the boom swing spool.

Thus, the boom swing cylinder is extended to swing the boom to the left.





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7) P.T.O. 1 Operation

When the P.T.O. 1 is operated, the oil discharged from the pilot oil pump P4 flows through the cut-off valve and the P.T.O. solenoid valve to the port Pa4 to move the spool of the P.T.O. 1 section.

The P2 by-pass passage is blocked by the P.T.O. 1 spool as it has been moved, so that the oil from the port P2 flows through the passage installed between the boom swing section body and the P.T.O. 1 section body to the parallel passage of the P.T.O. 1 section.

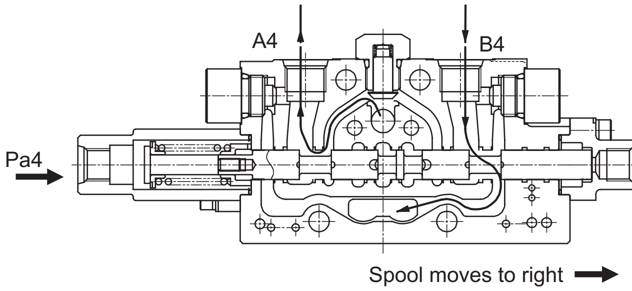
As the P2 by-pass passage is blocked by the P.T.O. 1 section spool as it has been moved, the oil from the port P2 flows to the parallel passage of the P.T.O. 1 section through the oil passage installed between the boom swing section and the P.T.O. 1 section.

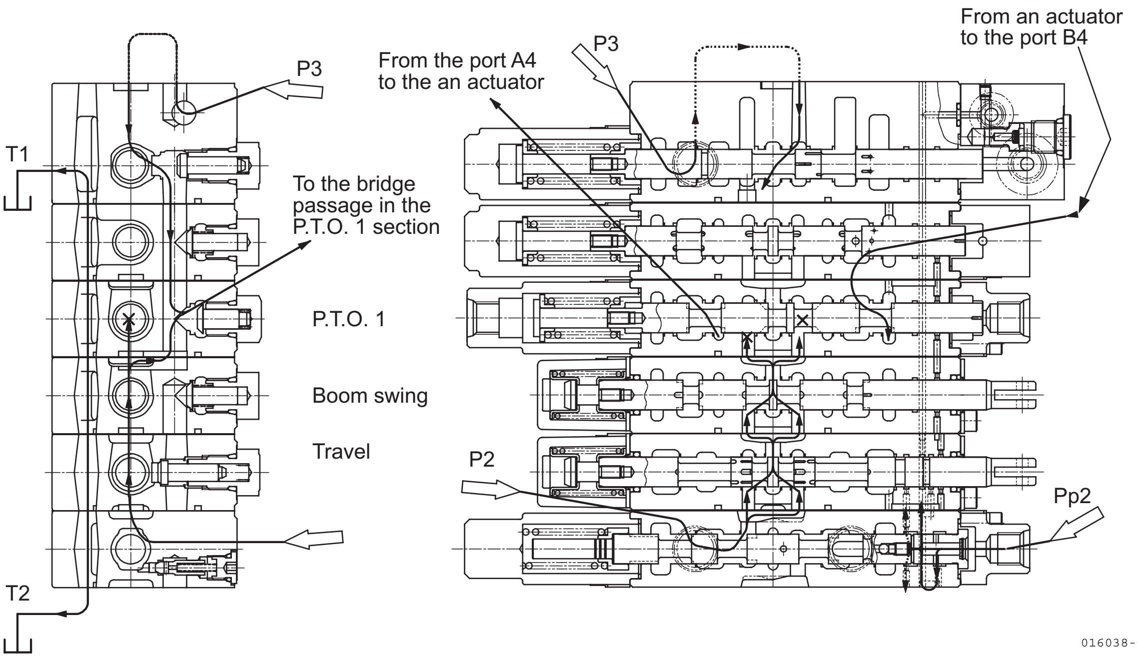
The passage between the port A4 and the bridge passage is opened as the P.T.O. 1 section spool has been moved, so that the oil from the parallel passage flows through the load check valve in the P.T.O. 1 section and the bridge passage to an attachment actuated by the P.T.O. 1.

The oil from the port P3 flows through the swing and blade sections and the check valve in the P3 inlet section to the parallel passage in the P.T.O. 1 section, so that the combined oil discharged from the pumps P2 and P3 is fed to the parallel passage in the P.T.O. 1 section.

Meanwhile, the return oil from the attachment connected to the P.T.O. 1 port flows through the port B4 to the return oil passage, which is opened as the P.T.O. 1 spool has been moved.

When the pilot oil is supplied to the port for the operation of a double acting attachment, oil flows to the other way but the valve actuation theory is the same.





8) Arm Operation

(1) Arm retract (digging) operation

When the arm control lever is pulled back to retract the arm, the oil from the pilot valve flows into the port PLb of the arm section to move the spool of the arm section and the oil also flows to the pilot oil chamber of the P3 inlet section through the passage in its body.

Accordingly, when the boom up is operated simultaneously, the oil from the port P3 cannot move the P3 inlet section spool against the pilot oil pressure for arm digging, so that the oil from the port P3 flows by priority to the arm circuit with no orifice in the P3 inlet section spool.

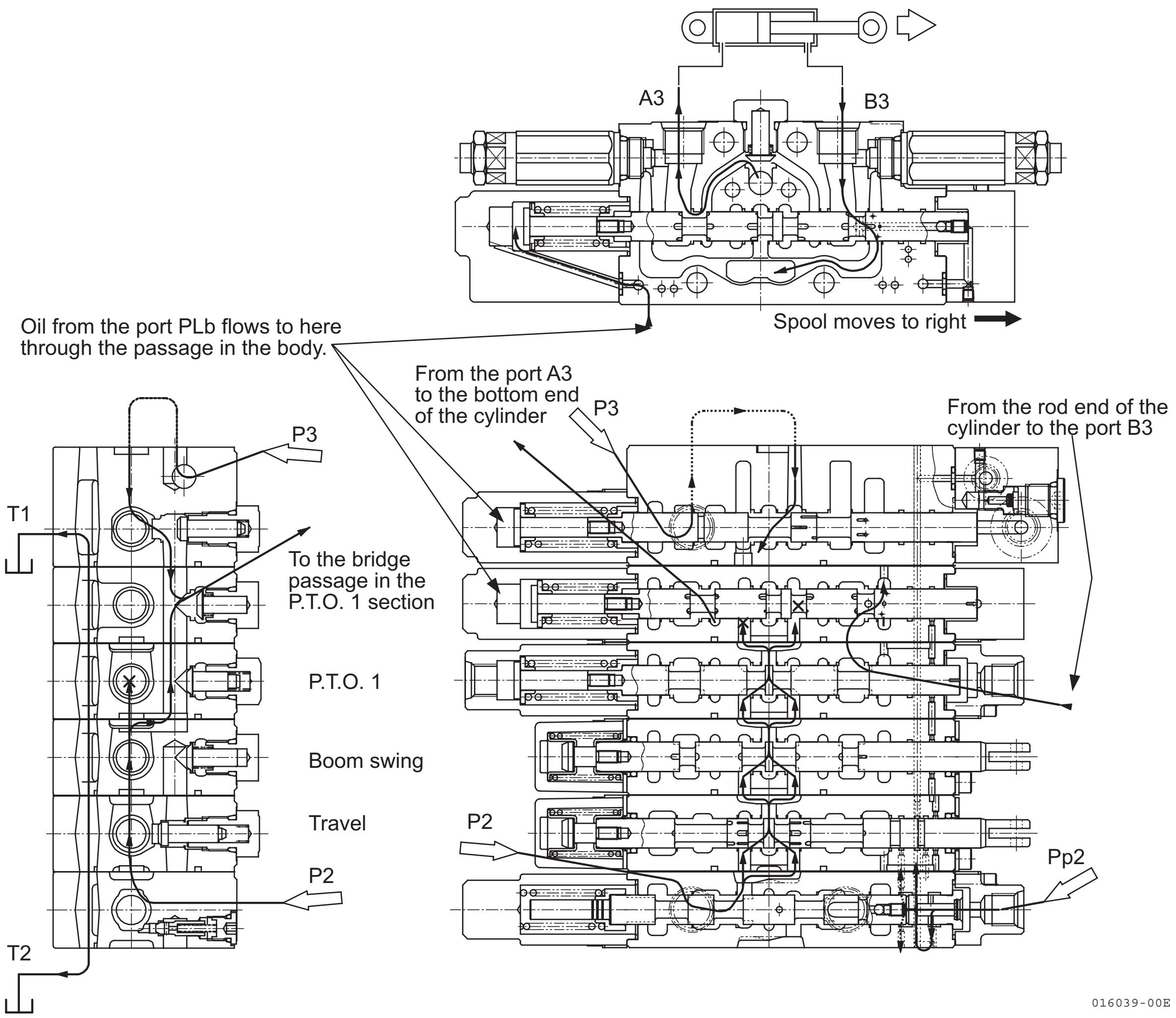
The P2 bypass passage is blocked by the arm spool, the oil from the port P2 flows through the oil passage installed between the boom swing section and arm section to the parallel passage of the arm section.

The passage between the port A3 and the bridge passage is opened as the arm spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve of the arm section and the bridge passage to the port A3 and is fed to the bottom end of the arm cylinder.

The oil from the port P3 also flows through the swing and blade sections and the check valve in the P3 inlet section to the arm circuit and the parallel passage in the P.T.O. 1 section, so that the combined oil discharged from the pumps P2 and P3 flows to the parallel passage in the arm section.

Meanwhile, the return oil from the rod end of the arm cylinder flows to the return oil passage through the port B3 and the notch, which is opened to the return oil passage as the arm spool has been moved.

Thus, the arm cylinder is extended to retract the arm.



(2) Arm extend operation

When the arm control lever is pushed forward to extend the arm, the oil from the pilot valve flows into the port PLf of the arm section to move the spool of the arm section.

Accordingly, when the boom up is operated simultaneously, the oil from the port P3 cannot move the P3 inlet section spool against the pilot oil pressure for arm digging, so that the oil from the port P3 flows by priority to the arm circuit with no orifice in the P3 inlet section spool.

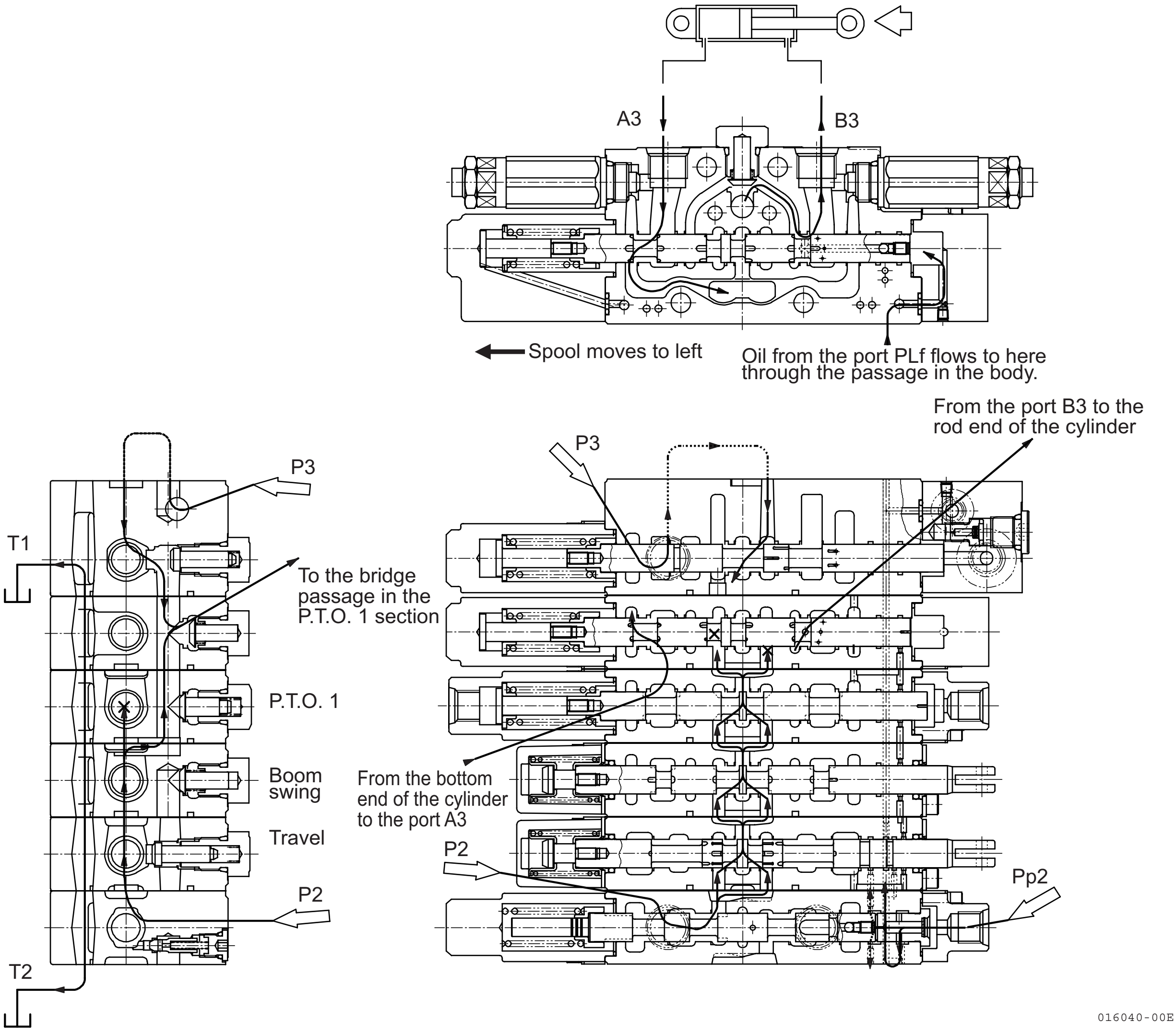
The P2 bypass passage is blocked by the arm spool, the oil from the port P2 flows through the oil passage installed between the boom swing section and arm section to the parallel passage of the arm section.

The passage between the port B3 and the bridge passage is opened as the arm spool has been moved, so that the oil flowed to the parallel passage flows through the load check valve of the arm section and the bridge passage to the port B3 and is fed to the rod end of the arm cylinder.

The oil from the port P3 also flows through the swing and blade sections and the check valve in the P3 inlet section to the arm circuit and the parallel passage in the P.T.O. 1 section, so that the combined oil discharged from the pumps P2 and P3 flows to the parallel passage in the arm section.

Meanwhile, the return oil from the bottom end of the arm cylinder flows to the return oil passage, which is opened to the return oil passage as the arm spool has been moved through the port A3.

Thus, the arm cylinder is retracted to extend the arm.



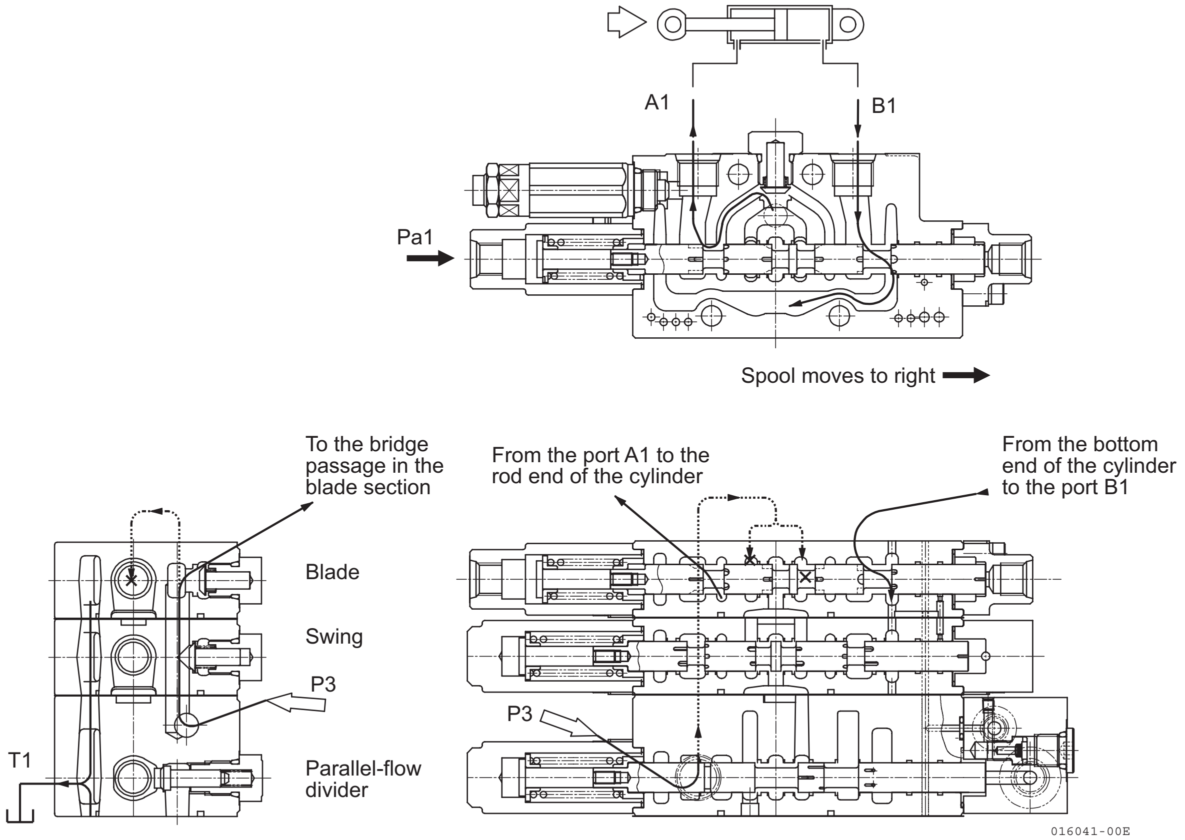
9) Blade Operation

(1) Blade up operation

When the blade lever is pulled back to raise the blade, the oil from the pilot valve flows to the port Pa1 to move the spool of the blade section. Because the P3 by-pass passage is blocked by the blade spool and the passage between the port A1 and the bridge passage is opened as the blade spool has been moved, the oil from the port P3 flows through the P3 parallel passage, the load check valve in the blade section and the bridge passage to the port A1 and is fed to the rod end of the blade cylinder.

Meanwhile, the return oil from the bottom end of the blade cylinder flows through the port B1 to the return oil passage, which is opened as the blade spool has been moved.

Thus, the blade cylinder is retracted to raise the blade.

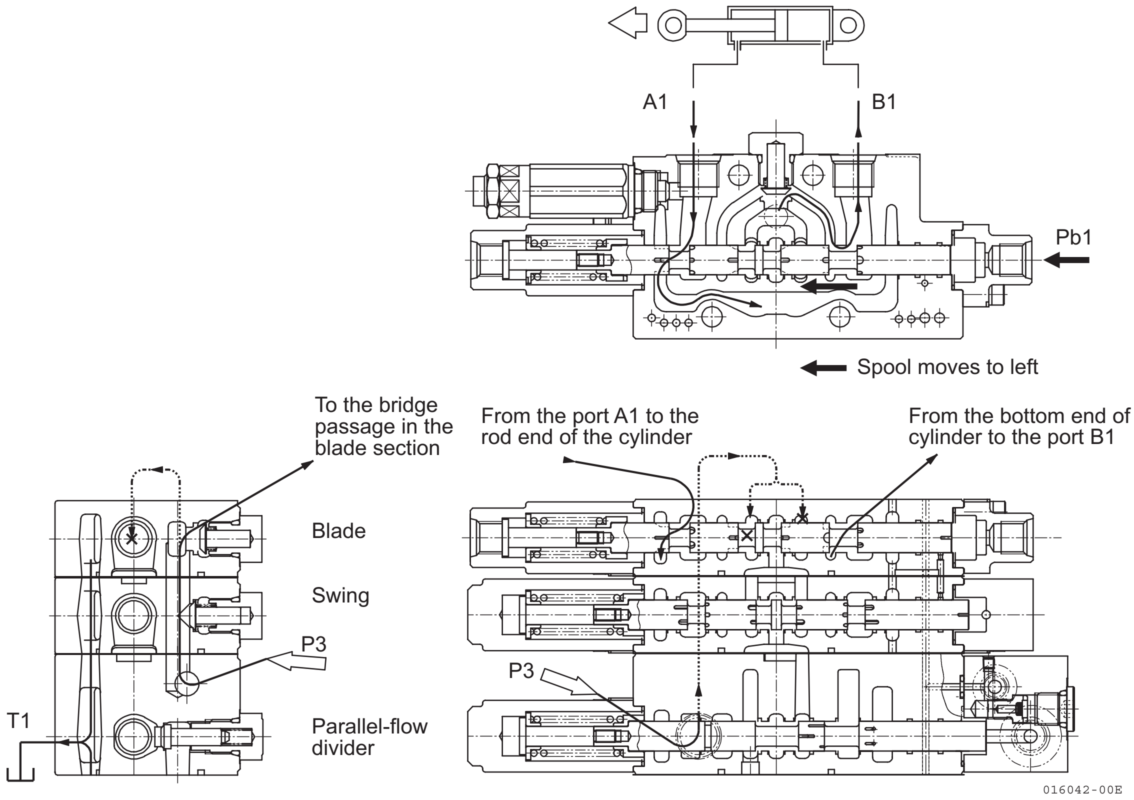


(2) Blade down operation

When the blade lever is pressed forward to lower the blade, the oil from the pilot valve flows to the port Pb1 to move the spool of the blade section. Because the P3 by-pass passage is blocked by the blade spool and the passage between the port B1 and the bridge passage is opened as the blade spool has been moved, the oil from the port P3 flows through the P3 parallel passage, the load check valve in the blade section and the bridge passage to the port B1 and is fed to the bottom end of the blade cylinder.

Meanwhile, the return oil from the rod end of the blade cylinder flows through the port A1 to the return oil passage, which is opened by the notches of the blade section spool as it has been moved.

Thus, the blade cylinder is extended to lower the blade.



10) Swing Operation

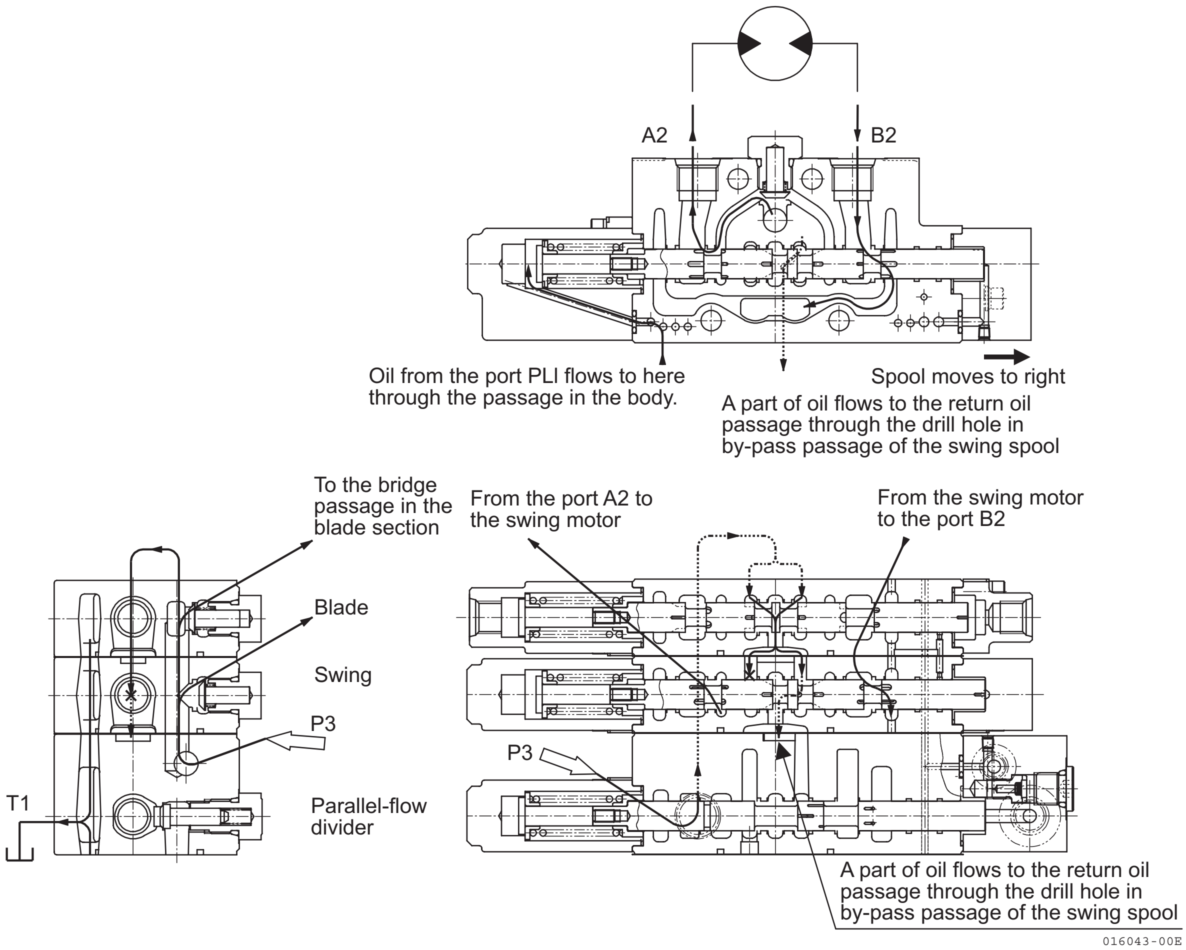
When the swing control lever is moved to the left, the oil from the pilot valve flows to the port PL1 to move the spool of the swing section.

As the P3 by-pass passage is blocked by the spool of the swing section as it has been moved, (a part of oil flows to the return oil passage through the drill hole in by-pass passage of the swing spool.).

The passage between the port A2 and the bridge passage is opened as the swing spool has been moved, the oil flowed to the P3 parallel passage flows through the load check valve in the swing section and the bridge passage to the port A2 and is fed to the swing motor.

Meanwhile, the return oil from the swing motor flows to the return oil passage through the port B2 and the notches in the swing spool, which is opened to the return oil passage as the swing spool has been moved. Consequently, the upper structure swings counter clockwise.

When the swing control lever is moved to the right, oil flows to the other way but the valve actuation theory is the same.



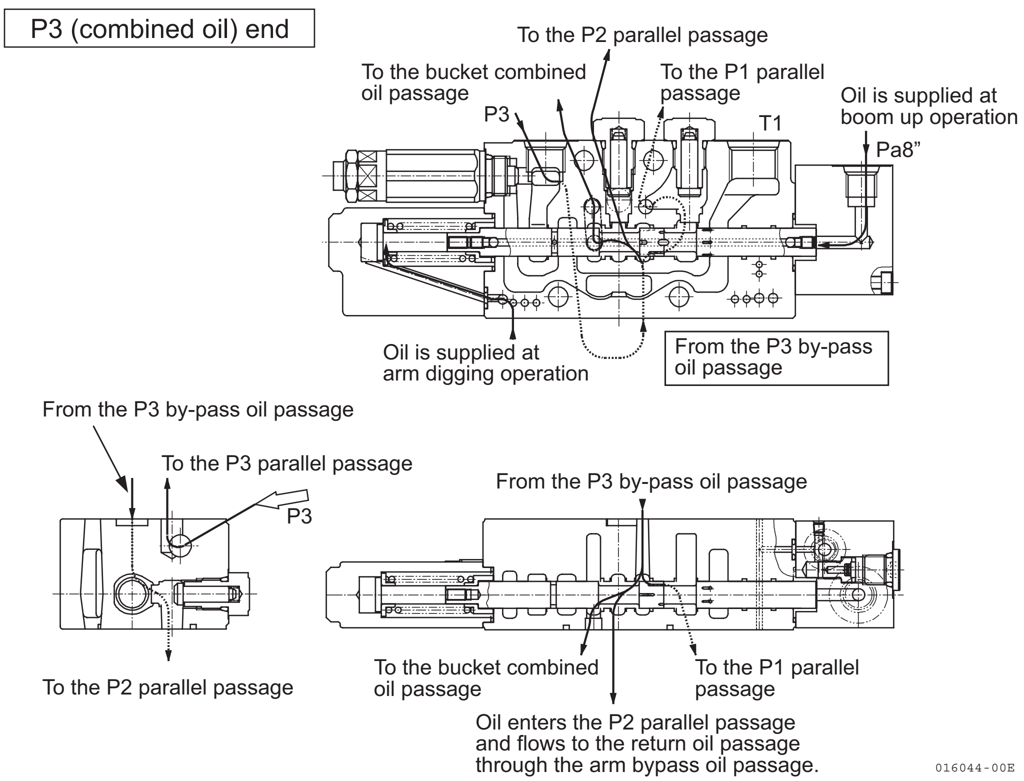
11) Simultaneous Operation

(1) Boom up, arm digging and bucket

At the simultaneous operation of those, the oil from the pilot valve flows to each section to move respective spools. The pilot oil for the arm digging operation flows through the passage in the valve body to the pilot oil chamber of the P3 inlet section, too, so that its spool movement is determined by the pressure difference of the pilot oil for Boom up and Arm digging.

(Pilot oil press. for Boom up) - (Pilot oil press. for Arm digging) = (Pilot oil press. for P3 inlet section spool)

When the control levers are fully moved to do those three operations, the oil from the pump P1 flows to the boom and bucket sections and the pump P2 to the arm section.
More oil from the pump P3 flows through the P3 inlet section to the arm section without passing orifices because the pilot oil pressure for P3 inlet section is nothing and its spool does not move, while a part of the oil flows to the bucket section through an orifice and check valves, or flows to the boom section through another orifice and the P1 parallel passage.
If the arm control lever only is returned to the neutral position, more oil from the pump P3 flows to the boom section because the pilot oil pressure for arm operation lowers, that for the P3 inlet section goes up and its spool is moved to narrow the oil passage to the arm section and that to the boom section is opened up.
That is how the oil from the pump P3 is properly divided and supplied to those cylinders according to lever movement, an operator can get appropriate operation speed with good balance and efficiency.

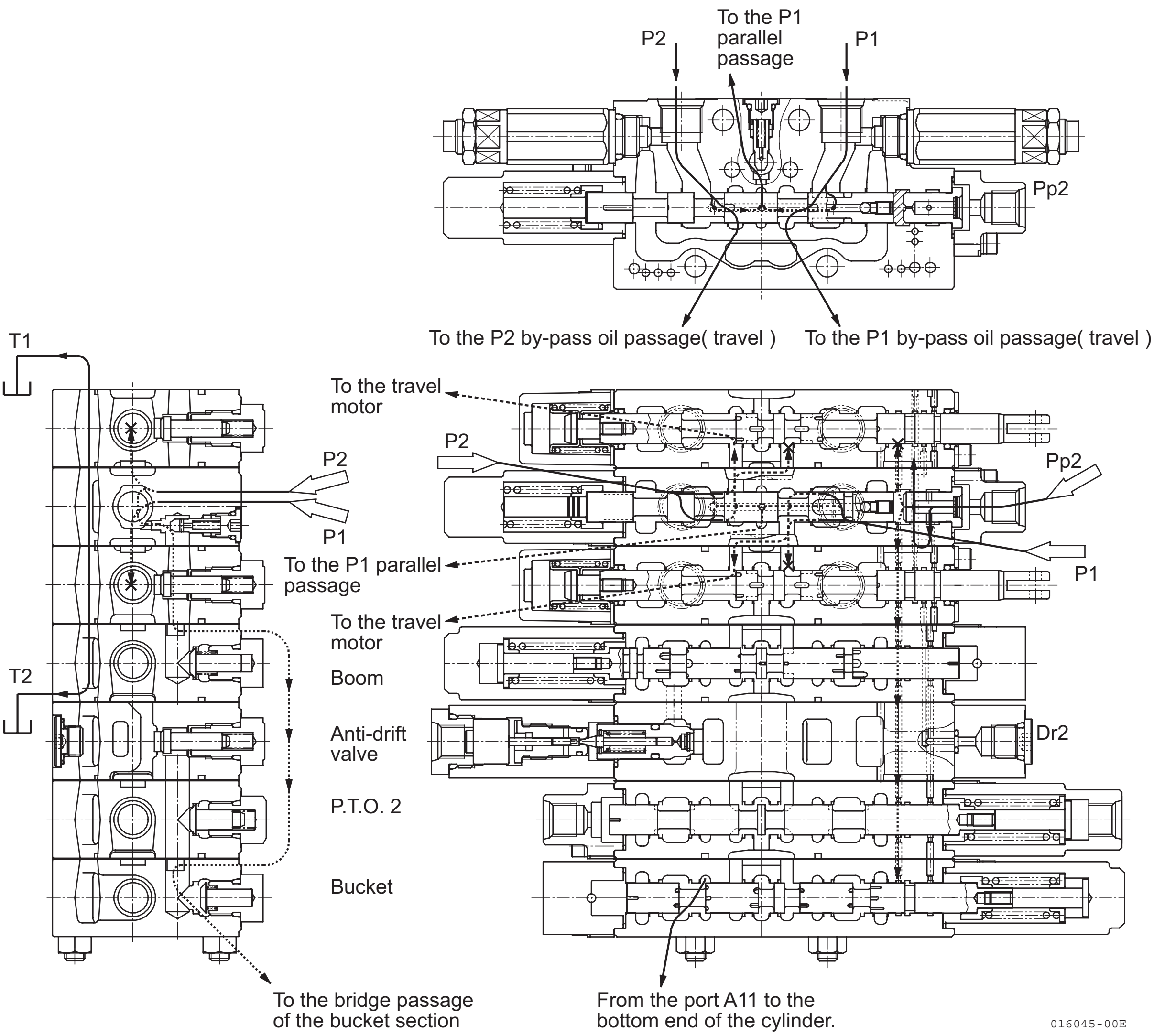


(2) Traveling and bucket

When the bucket is operated while traveling, the oil from the port Pp2 flows into the TSP (traveling signal pilot) passage through the orifice in the piston but the spools of the right and left travel sections and the bucket section move to block their return oil passages. Therefore, the pressure in the TSP passage equals to that at the port Pp2, the spool of the P1, P2 inlet section is moved, the P1, P2 by-pass passages are narrowed and the P1 and P2 circuits are connected by another passage, and connected to the P1 parallel passage through the check valve.

That is how the oil is supplied to the bucket section even while traveling, and simultaneous operation becomes possible.

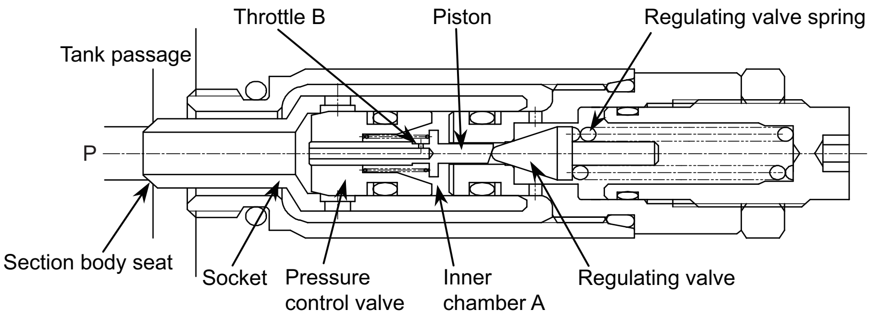
In addition, as there are orifices in the passages to the right and left travel sections and bucket section, high pressure oil is supplied to each section even if pressure differences develop among those circuits, bucket operation while traveling is available.



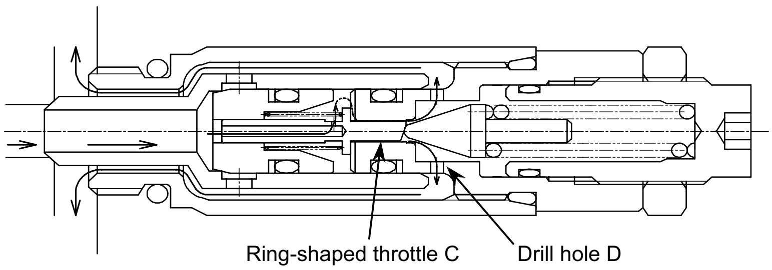
12) System Relief Valves

(1) Relief operation

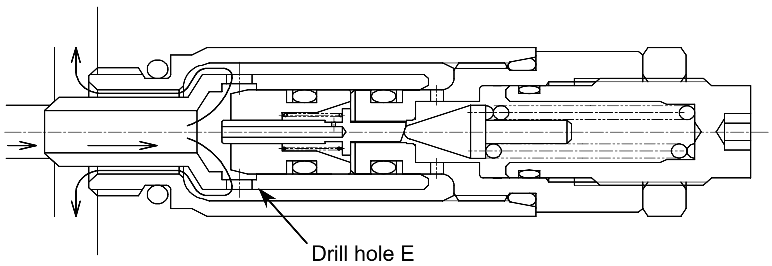
[1] Pressure oil flows through the inside of the piston installed in the pressure control valve (the parent valve) and the throttle B to the inner chamber A, so that it is filled with oil. The pressure control valve and the socket are securely seated, and so are the socket and the section body seat.



[2] When the oil pressure in the port P reaches the set pressure of the regulating valve spring, the pressure oil flows through the piston to the regulating valve to open it.
At this time, the pressure oil passes through the inside of the piston, the throttle B, the inner chamber A, the ring-shaped throttle C and the drill hole D in sequence, and flows outside the socket to the tank passage.



[3] When the regulating valve opens, the pressure in the inner chamber A is lowered, and consequently, the pressure control valve is opened and the pressure oil in the port P flows directly to the tank passage through the drill hole E.



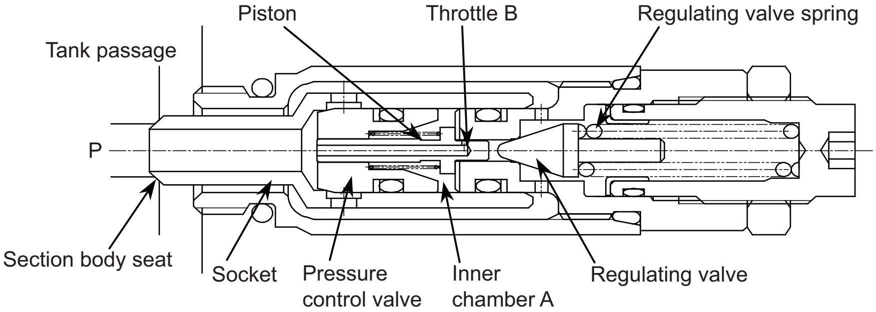
[4] When the pressure in the port P lowers to less than the set pressure of the regulating valve spring, the regulating valve is pressed on the seat with the force of the regulating valve spring and the pressure in the inner chamber A becomes equal to that in the port P. Therefore, the pressure control valve is also pressed on the seat portion of the socket and returned to the original state ([1]).

13) Circuit Relief Valves

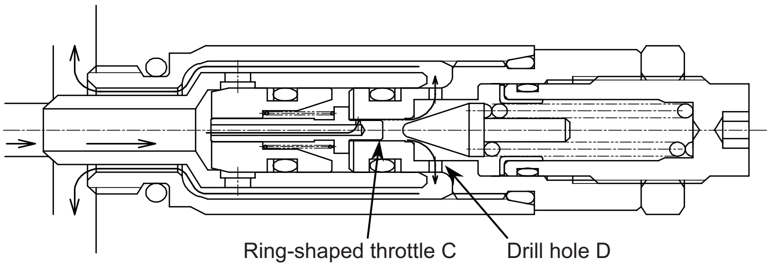
The circuit relief valve is installed in the rod and bottom sides of the bucket, boom and arm cylinders and the rod side of the boom swing and blade cylinders.

(1) Relief operation

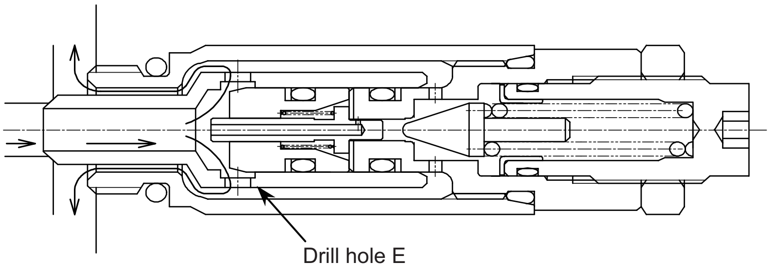
[1] Pressure oil flows through the inside of the piston installed in the pressure control valve (the parent valve) and the throttle B to the inner chamber A, so that it is filled with oil. The pressure control valve and the socket are securely seated, and so are the socket and the section body seat.



[2] When the oil pressure in the port P reaches the set pressure of the regulating valve spring, the pressure oil flows to the regulating valve to open it.
At this time, the pressure oil passes through the inside of the piston, the throttle B, the inner chamber A, the ring-shaped throttle C and the drill hole D in sequence, and flows outside the socket to the tank passage.



[3] When the regulating valve opens, the pressure in the inner chamber A is lowered, and consequently, the pressure control valve is opened and the pressure oil in the port P flows directly to the tank passage through the drill hole E.

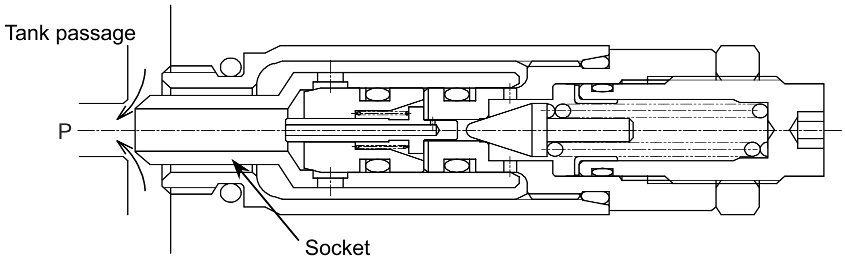


[4] When the pressure in the port P lowers to less than the set pressure of the regulating valve spring, the regulating valve is pressed on the seat with the force of the regulating valve spring and the pressure in the inner chamber A becomes equal to that in the port P. Therefore, the pressure control valve is also pressed on the seat portion of the socket and returned to the original state ([1]).

(2) Suction operation

When negative pressure is generated in the port P, the port P is supplied with oil from the tank passage to prevent negative pressure.

When the pressure in the tank passage exceeds that in the port P, upward force is applied to the socket. This creates an opening between the section body seat and the socket, and oil flows from the tank passage to the port P, so that the space in the port P is filled with oil.



4. Disassembly and Reassembly

1) Precautions for Disassembly and Reassembly

(1) Precautions for disassembly

[1] Since the parts of the hydraulic equipment are generally precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean area that is free from dust.

[2] Prepare clean tools and treated oil, and handle them carefully.

[3] First clean the external surface of removed assemblies.

[4] Before beginning, review the drawings of the internal construction and prepare the required parts according to the purpose and extent of the disassembly. After disassembly, replace the removed seals and O-rings with new ones in principle. As some replacement parts are available only as subassemblies, see the parts catalogue to prepare the necessary subassemblies in advance.

(2) Precautions for reassembly

[1] Handling the O-rings

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

2] The O-rings may not have any defects in molding, or be damaged in handling or distorted by heat.

3] Do not stretch any O-rings with such great force as to permanently deform them.
Prevent any O-ring from being damaged when it is set to the spool from its sharp end.

4] Avoid rolling the O-rings when fitting them.
A distorted O-ring may not return to its original shape; therefore it may cause oil leakage.

[2] Before beginning reassembly, check that there is no treated oil or hydraulic oil on the outer surface of the O-ring groove in the mating face of each section. If reassembly is performed without cleaning such oil, it may be mistaken for oil leakage.

[3] Reassembly of control valve sections
Put the control valve sections with the actuator port down in the order shown in the figure below.

Note :

The symbol representing for each valve section is as follows and is carved on the upper surface (the actuator port side) of each valve body except the end cover.

No.	Section	ViO45-5	ViO55-5
1	End cover	(E/C)	←
2	Blade	SA	←
3	Swing	GA	←
4	P3 inlet	UA	←
5	Arm	FA	←
6	P.T.O. 1	TA	←
7	Boom swing	FB	←
8	Travel (L)	CA	←
9	P1, P2 inlet	AB	←
10	Travel (R)	BA	←
11	Boom	EA	←
12	Anti-drift valve	KA	KI
13	P.T.O. 2	GB	←
14	Bucket	VA	←

2) Tools for Disassembly and Reassembly

Tool	Q'ty	Size
Hexagon bar wrench (mm)	1 (for each)	4, 5, 6, 8
Wrench (mm)	1 (for each)	10, 13, 19, 21, 22, 26
Socket wrench (mm)	1 (for each)	13, 19, 21, 22, 26
Torque wrench [ft·lb (N·m)]	1	1.5 to 15 (1.96 to 19.6)
Torque wrench [ft·lb (N·m)]	1	15 to 75 (19.6 to 98.1)
Magnet	1	
Pliers	1	
Screwdriver	1	
Tweezers	1	

3) Separation of Valve Sections

(1) Loosen four M8 nuts **1** on the bucket section with a wrench (13 mm).

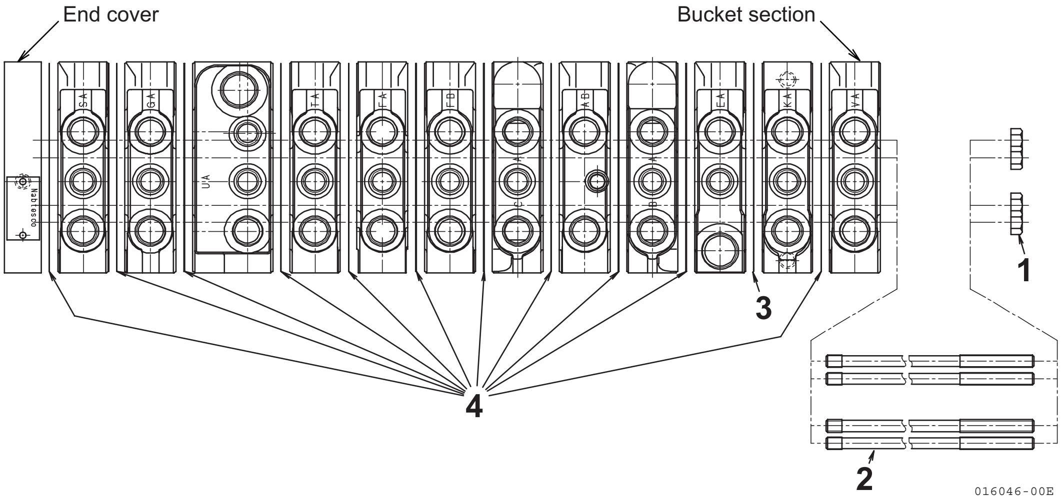
(2) Remove four tie rods **2**.

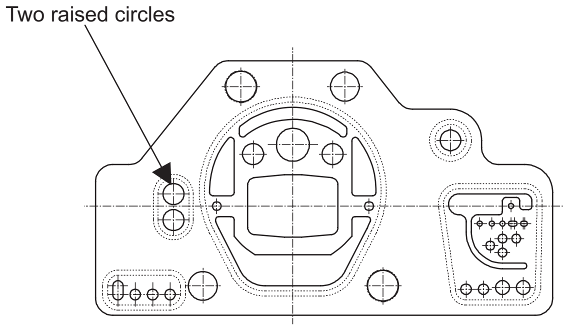
Note :

Do not reuse the gaskets.

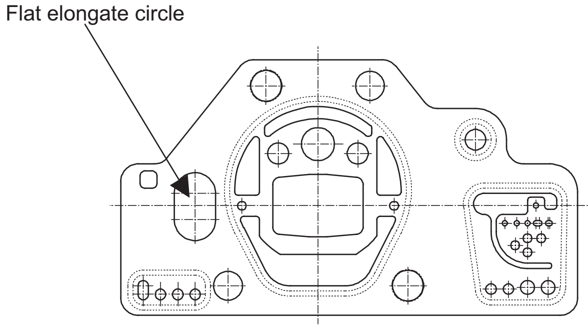
If a gasket coating sticks on the valve body, completely remove it before reassembling.

- Do not remove any plugs from the end cover unless necessary.





Gasket A **3**



Gasket B **4**

4) Disassembly

4)-1. Removal of spools

(1) Pilot operated type (blade, P.T.O. 1, and P.T.O. 2)

Remove each spool as in example of the removal procedure of the blade spool given below.

[1] Remove the two hexagon socket head bolt and SWP washer assemblies **10** with a hexagon bar wrench (4 mm).

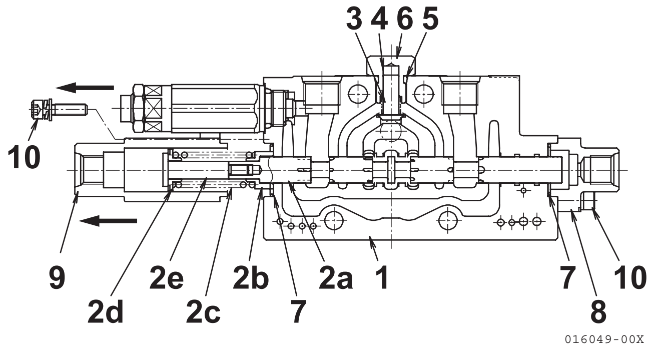
[2] Remove the pilot oil chamber case A1 **9.**

[3] Slowly pull the spool assembly (**2a-2e**) out of the valve holding it by the spring part in the level direction with the spool bore.

[4] The other pilot spools (for P.T.O. 1, and P.T.O. 2) are able to be removed in the same procedure and the same direction.
The return spring of the P.T.O. 2 spool is installed on the other end, so that the spool has to be pulled out from the other direction.

Note :

At this time, check the O-ring ***7*** *is installed at the bottom of the flange for pilot case on the body side.*



Pilot operated type
(Blade, P.T.O. 1 and P.T.O. 2 sections)

No.		Part
1		Body (symbol SA)
2		Blade spool assembly
	a	Spool (for blade)
	b	Return spring retainer
	c	Return spring
	d	Return spring retainer
	e	Spool end
3		Check valve
4		Check valve spring
5		O-ring 1B P11
6		Check valve retainer
7		O-ring 1B S22
8		Pilot oil chamber case B1
9		Pilot oil chamber case A1
10		Hexagon socket head bolt M5×20 flows washer assembly

(2) Pilot operated type
(swing, P3 inlet, boom, bucket, and arm sections)

Remove each spool as in example of the removal procedure of the swing spool given below.

[1] Remove the two hexagon socket head bolt and SWP washer assemblies **10** with a hexagon bar wrench (4 mm).

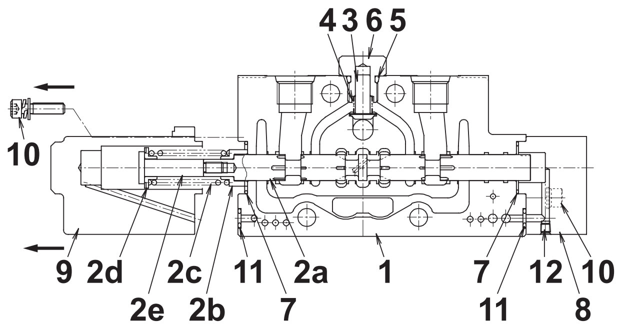
[2] Remove the pilot oil chamber case A1 **9.**

[3] Slowly pull the spool assembly (**2a-2e**) out of the valve holding it by the spring part in the level direction with the spool bore.

[4] The other pilot spools (for P3 inlet, boom, bucket and arm sections) are able to be removed in the same procedure and the same direction.
The return spring of the bucket spool is installed on the other end, so that the spool has to be pulled out from the other direction.

Note :

*At this time, check the O-ring **7** is installed at the bottom of the flange for pilot case on the body side.*



Pilot operated type
(Swing, P3 inlet, boom, bucket and arm sections)

No.		Part
1		Body (symbol GA)
2		Swing spool assembly
	a	Spool (for swing)
	b	Return spring retainer
	c	Return spring
	d	Return spring retainer
	e	Spool end
3		Check valve
4		Check valve spring
5		O-ring 1B P11
6		Check valve retainer
7		O-ring 1B S22
8		Pilot oil chamber case AS
9		Pilot oil chamber case AL
10		Hexagon socket head bolt M5×20 flows washer assembly
11		O-ring 1A P6
12		Screw plug GPM 1/32

(3) Manual operated type (boom swing and travel)

Remove the spool of the boom swing section following the procedure below.

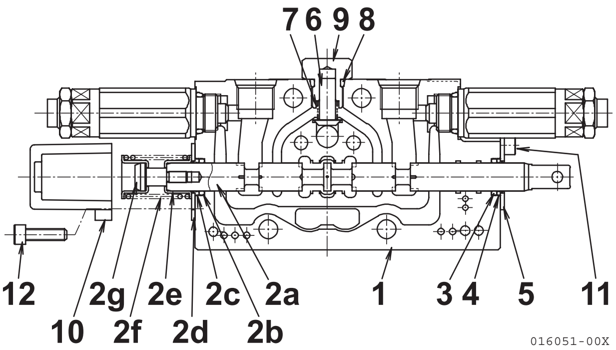
[1] Remove the two hexagon socket head bolts **12** with a hexagon bar wrench (4 mm).

[2] Remove the return spring case **10**.

[3] Slowly pull the boom swing spool assembly (**2a-2g**) out of the valve holding it by the spring part in the level direction with the spool bore.

Note :

*Take care in pulling out of the spool assembly, otherwise the spool seal [dust wiper (**2c**) and O-ring (**2b**)] can move to a spool edge and the rip area can be damaged.*



Manual operated type
(Boom swing and travel sections)

No.		Part
1		Body (symbol FB)
2		Boom swing spool assembly
	a	Spool (boom swing)
	b	O-ring 1A P12
	c	Dust wiper
	d	Seal plate
	e	Return spring retainer
	f	Return spring
	g	Spool end
3		O-ring 1A P12
4		Dust wiper
5		Seal plate
6		Check valve
7		Check valve spring
8		O-ring 1B P11
9		Check valve retainer
10		Return spring cap
11		Hexagon socket head bolt M5×10
12		Hexagon socket head bolt M5×18

(4) P1, P2 inlet

[1] Remove the two hexagon socket head bolt and SWP washer assemblies **15** with a hexagon bar wrench (4 mm).

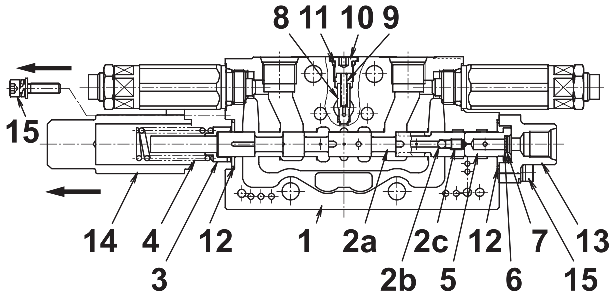
[2] Remove the pilot oil chamber case A1 **14.**

[3] Remove the return spring **4** and the return spring retainer.

[4] Slowly pull the spool assembly **2** out of the valve holding it by its end in the level direction with the spool bore.

Note :

*At this time, check the O-ring **12** is installed at the bottom of the flange for pilot case on the body side.*



P1, P2 inlet section

No.		Part
1		Body (symbol AB)
2		P1, P2 inlet spool assembly
	a	Spool (P1, P2 inlet)
3		Return spring retainer
4		Return spring
5		Piston
6		Filter
7		Internal snap ring
8		Check valve
9		Check valve spring
9		Check valve spring
10		Plug
11		O-ring 1B P8
12		O-ring 1B S22
13		Pilot oil chamber case B5
14		Pilot oil chamber case A2
15		Hexagon socket head bolt M5×20 flows washer assembly

4)-2. Disassembly of load check valve

(1) Standard type

[1] Remove the check valve retainer **4** from the central part of the upper surface of the valve with an open end wrench or socket wrench (19 mm).

Note :

*The check valve can difficult to loosen due to the O-ring **3** caught in the thread part. In that time, do not force it loosen, but retighten and loosen it again.*

[2] Remove the check valve spring **2** and the check valve **1** in the bore, which the check valve retainer has been removed from, with tweezers or a magnet.

[3] The other valve sections can be disassembled in the same procedure.

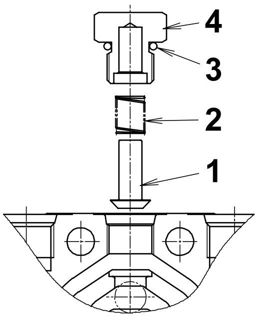


Fig.1 Check valve section
(Blade, Swing, Arm, Boom Swing,
Boom and Bucket Sections)

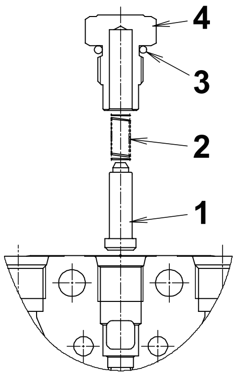


Fig. 2 Check valve section
(P3 Inlet, Travel,
and Anti-drift Valve Sections)

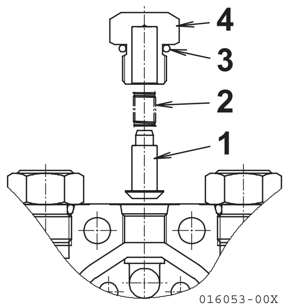


Fig. 3 Check valve section
(P.T.O. 1 and P.T.O. 2 Sections)

No.	Part
1	Check valve
2	Check valve spring
3	O-ring
4	Check valve retainer

(2) Particular type

[1] Remove the check valve retainer **4** from the central part of the upper surface of the valve with a hexagon bar wrench (4 mm).

[2] Remove the check valve spring **2** and the check valve **1** in the bore, which the check valve retainer has been removed from, with tweezers or a magnet.

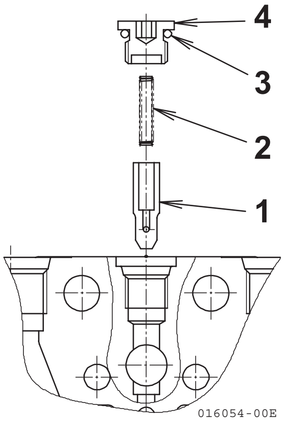


Fig. 4 Check valve section
(P1, P2 Inlet section for TSP System)

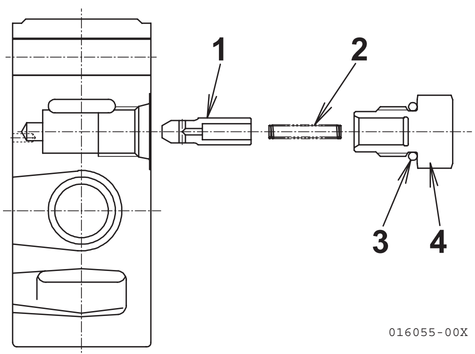


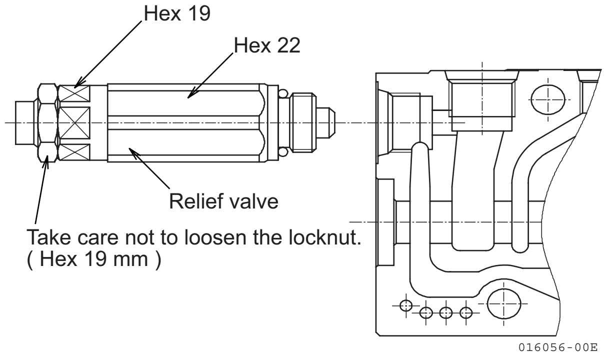
Fig. 5 Check valve section
(Bucket Section for Combined Oil)

4)-3. Disassembly of relief valve and plug

(1) Relief valve

Blade section is shown below for example.

- Loosen the valve with a wrench (22 mm).
- When a 22 mm wrench is unavailable, a 19 mm wrench can be used to loosen the valve.

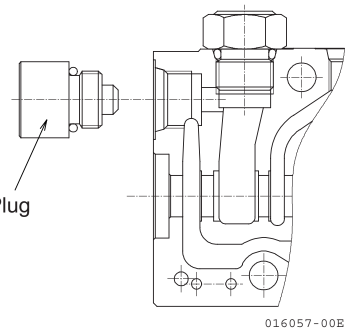


Note :

Do not fit the 19 mm wrench on the locknut, or the relief set pressure changes, causing poor performance or system damage.

(2) Relief valve port plug

Loosen the plug with a hexagon bar wrench (8 mm).



Note :

After disassembling, take care not to damage oil seat surfaces of the relief valve, plug and valve body.

4)-4. Disassembly of anti-drift valve

When the anti-drift valve malfunctions, replace it as an anti-drift valve assembly. For reference, the disassembly procedure for examination is shown below.

[1] Remove the two hexagon socket head bolts **A** with a hexagon bar wrench (5 mm).

[2] Remove the anti-drift valve case **B**.

[3] Take care not to drop the two dowel pins **C** on the anti-drift valve body side.

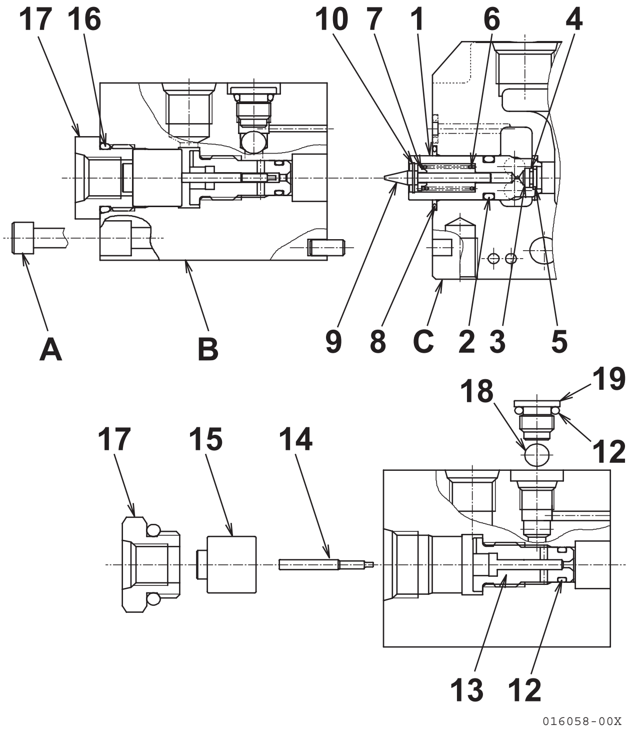
Note :

Take care not to lose and damage the pins.

[4] Remove the anti-drift valve **1** and the needle valve **9**.

Notes :

- *Remove the needle valve **9** first and keep it as it is easily removed.*
- *The anti-drift valve should not be disassembled but it should be kept as an anti-drift valve assembly (**1**-**7**, **10**).*



[5] Hold the anti-drift valve case with a vice and remove the bush **17** with a wrench or socket wrench (26 mm).

Note :

Set the vice on any side face other than the port side to hold the anti-drift valve.

[6] Remove the piston B **15** and piston A1 **14** in the bore, which the bush has been removed from, with tweezers or a magnet.

Notes :

- *Make marks on the piston B and the piston A1 so that they can be reassembled in the same direction as it was before.*
- *The piston guide **13** should not be disassembled, but it should be kept together with the anti-drift valve case B.*

[7] Remove the ball retainer **19** with a hexagon bar wrench (4 mm).

[8] Remove the steel ball **18** of Ø 0.28 in. (7 mm) from the bore, which the ball retainer has been removed from, using a magnet.

No.	Part
1	Anti-drift valve
2	Cap seal 1 BE10
3	Filter
4	Spacer
5	Snap ring AR7
6	Anti-drift valve spring A
7	Spring holder
8	O-ring AS 1B17
9	Needle valve
10	Internal snap ring 9
11	O-ring 1A P6
12	O-ring 1B P8
13	Piston guide
14	Piston A1
15	Piston B
16	O-ring 1B P18
17	Bush PF1/2×1/4
18	Steel ball Ø0.28 in. (7 mm)
19	Ball retainer

5. Disassembly and Reassembly of Relief Valves

1) Disassembly and Reassembly

Any of the relief valve must be replaced as an assembly in principle. However, only in an emergency case, the relief valve may be disassembled and reassembled.

(1) Cleaning and Inspection

Clean all the parts using clean treated oil (mineral oil), dry them using compressed air and inspect all of them.

[1] No defect must be found on the seat surface of the poppet. The contact surface must be uniform.
[2] No scratch must be found on the outer surface of the sliding part of the poppet tip.
[3] No damage, distortion or wear must be found on the spring.
[4] No distortion or wear must be found on the O-ring and the backup ring.
If any defect is found in the above inspection, replace the whole relief valve assembly. However, a defective O-ring can only be replaced with a new one.

(2) Precautions for reassembly

When installing the parts of a relief valve assembly, observe the following precautions for handling O-rings.

[1] Lubricate O-rings with clean grease or hydraulic oil.
[2] O-rings may not have any defects in molding, or be damaged in handling or distorted by heat.
[3] Do not stretch any O-rings with such great force as to permanently deform them.
[4] Avoid rolling the O-rings when fitting them. A distorted O-ring may not return to its original shape, and therefore, may cause oil leak.

2) Disassembly and Reassembly of System Relief Valves

(1) Disassembly

[1] Lightly hold the body **5** by the hexagonal part of the width across flats **22** with a vice stand.

[2] Remove the locknut **8** with a wrench (19 mm).

[3] Remove the adjust screw **7** with a hexagon bar wrench (4 mm).

[4] Remove the spring **9** and the pilot poppet **6** using tweezers or the like.

[5] Remove the plug **4** with a wrench (19 mm), and the other parts can be removed at this time.

[6] Remove the socket **1**, the piston **3**, the spring **10** and the poppet **2** in this order.

(2) Reassembly

[1] Install the pilot poppet **6** and the spring **9** into the plug **4** and tighten the adjust screw lightly. At this time, also tighten the locknut **8** lightly.

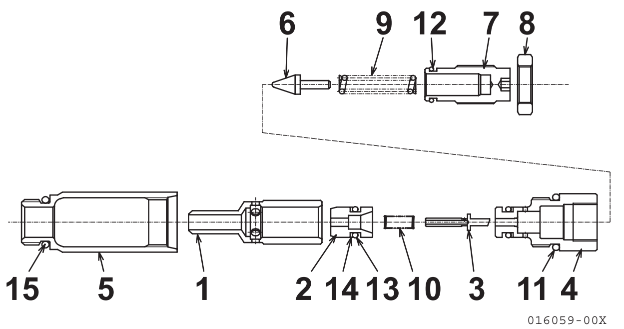
[2] Install the spring **10** and the piston **3** into the poppet **2**, and install them into the socket **1**.

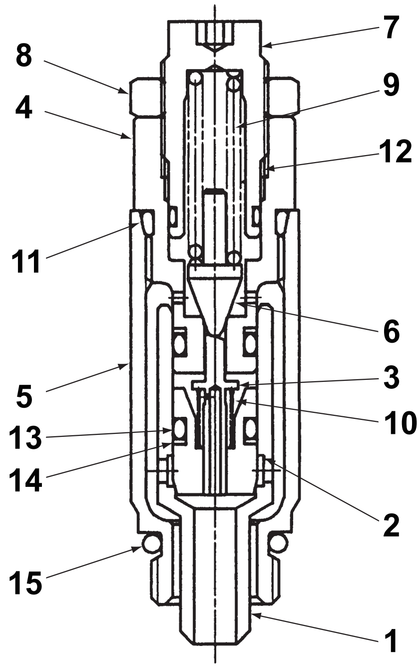
[3] Make sure that the piston **3** is put into the hole in the tip of the plug **4** and screw the plug **4** to the body **5** at the specified torque.

Tightening torque : 43.4 ft·lbf (58.8 N·m)

[4] Adjust the pressure with adjust screw **7** using a hexagon bar wrench (4 mm) and tighten the locknut **8** at the specified torque.

Tightening torque : 14.5 ft·lbf (19.6 N·m)





No.	Part
1	Socket
2	Poppet
3	Piston
4	Plug
5	Body
6	Pilot poppet
7	Adjust screw
8	Locknut
9	Spring
10	Spring
11	O-ring 1B P15
12	O-ring 1B S10
13	O-ring 1A P7
14	Backup ring
15	O-ring 1B P14

3) Disassembly and Reassembly of Circuit Relief Valves

(1) Disassembly

[1] Lightly hold the body **5** by the hexagonal part of the width across flats **22** with a vice stand.

[2] Remove the locknut **8** with a wrench (19 mm).

[3] Remove the adjust screw **7** with a hexagon bar wrench (4mm).

[4] Remove the spring **9**, the pilot poppet **6** and the spring guide using tweezers or the like.

[5] Remove the plug **4** with a wrench (19 mm), and the other parts can be removed at this time.

[6] Remove the socket **1**, the piston **3**, the spring **10** and the poppet **2** in this order.

(2) Reassembly

[1] Install the spring guide **16** to the adjust screw **7** and install the spring **9**.

[2] Install the pilot poppet **6** into the plug **4** and lightly tighten the adjust screw **7** (with the spring guide **16** and the spring **9** installed). At this time, also tighten the nut M14 **8** lightly.

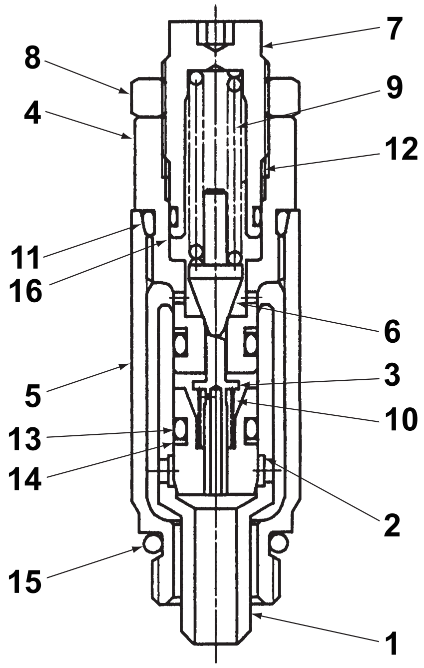
[3] Install the spring **10** and the piston **3** into the poppet **2**, and install them into the socket **1**.

[4] Make sure that the piston **3** is put into the hole in the tip of the plug 4 and screw the plug **4** to the body **5** at the specified torque.

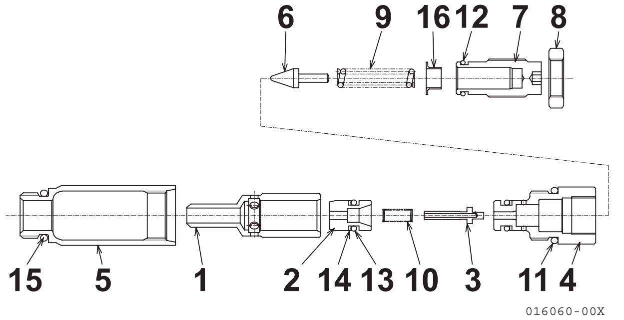
Tightening torque : 43.4 ft·lbf (58.8 N·m)

[5] Adjust the pressure with adjust screw **7** using a hexagon bar wrench (4 mm) and tighten the nut M14 **8** at the specified torque.

Tightening torque : 14.5 ft·lbf (19.6 N·m)

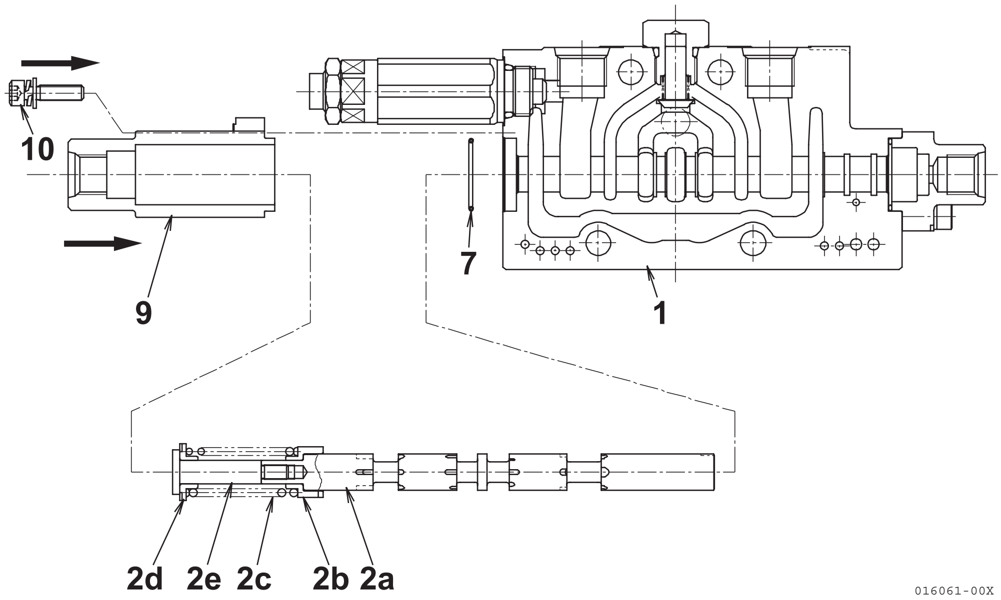


No.	Part
1	Socket
2	Poppet
3	Piston
4	Plug
5	Body
6	Pilot poppet
7	Adjust screw
8	Locknut
9	Spring
10	Spring
11	O-ring 1B P15
12	O-ring 1B S10
13	O-ring 1A P7
14	Backup ring
15	O-ring 1B P14
16	



4) Reassembly of Spool Assembly

(1) Pilot operated type (blade, P.T.O. 1 and P.T.O. 2 sections)



[1] Make sure that there is no dust or the like in any spool assemblies and any spool bores in the valve section bodies and that the O-ring **7** is securely installed in the bottom of the flange on the front and rear sides of each valve section body. Then, install each spool assembly into the spool bore in the respective valve section body taking care not to install it in a wrong position and a wrong direction.

Notes :

Apply a little hydraulic oil to the spools before installing them.

[2] Slowly put in and out the spool several times by hand to see if the spool moves lightly without a feeling of scratching.

Note :

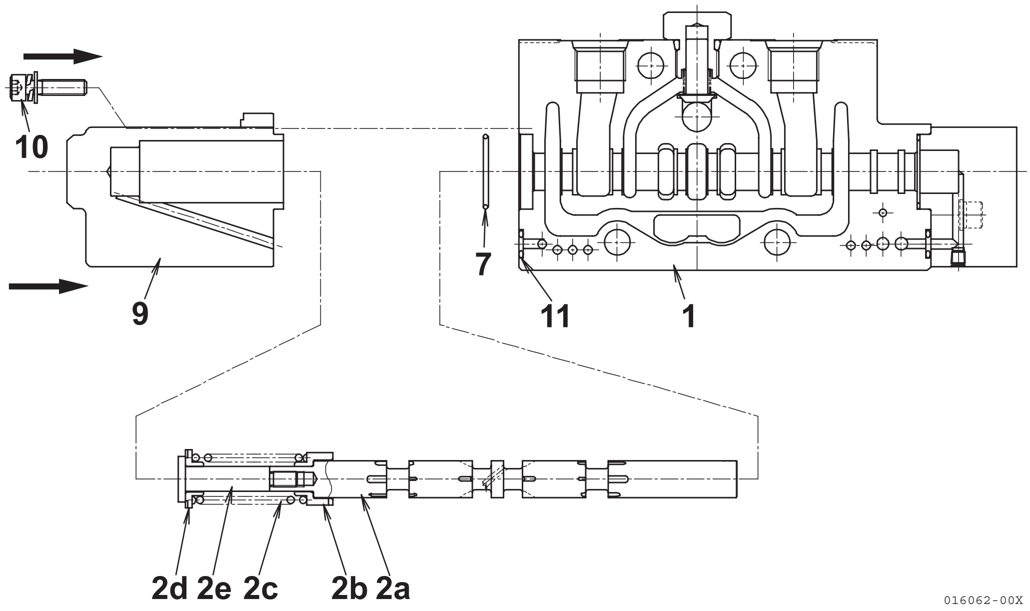
If you feel something is wrong, replace the spool assembly and the valve section body as a set.

[3] Securely install the pilot case **9** to the flange of the valve section body from the spring side of the spool assembly, and tighten the hexagon socket head bolt and washer assemblies **10** with a hexagon bar wrench (4 mm) at the specified torque.

Tightening torque : 4.3 to 5.1 ft·lbf (5.9 to 6.9 N·m)

No.		Part
1		Body (symbol SA)
2		Blade spool assembly
	a	Spool (for blade)
	b	Return spring retainer
	c	Return spring
	d	Return spring retainer
	e	Spool end
3		Check valve
4		Check valve spring
5		O-ring 1B P11
6		Check valve retainer
7		O-ring 1B S22
8		Pilot oil chamber case B1
9		Pilot oil chamber case A1
10		Hexagon socket head bolt M5×20 flows washer assembly

(2) Pilot operated type (swing, P3 inlet, boom, bucket, and arm sections)



[1] Make sure that there is no dust or the like in any spool assemblies and any spool bores in the valve section bodies and that the O-rings **7** and **11** are securely installed in the bottom of the flange on the front and rear sides of each valve section body. Then, install each spool assembly into the spool bore in the respective valve section body taking care not to install it in a wrong position and a wrong direction.

Notes :

Apply a little hydraulic oil to the spools before installing them.

[2] Slowly put in and out the spool several times by hand to see if the spool moves lightly without a feeling of scratching.

Note :

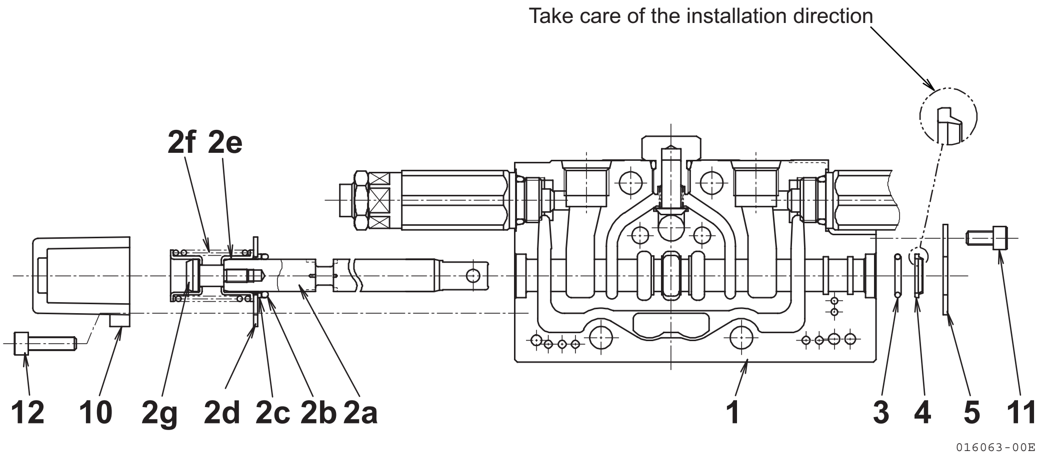
If you feel something is wrong, replace the spool assembly and the valve section body as a set.

[3] Securely install the pilot case **9** to the flange of the valve section body from the spring side of the spool assembly, and tighten the hexagon socket head bolt and washer assemblies **10** with a hexagon bar wrench (4 mm) at the specified torque.

Tightening torque : 4.3 to 5.1 ft·lbf (5.9 to 6.9 N·m)

No.		Part
1		Body (symbol GA)
2		Swing spool assembly
	a	Spool (for swing)
	b	Return spring retainer
	c	Return spring
	d	Return spring retainer
	e	Spool end
3		Check valve
4		Check valve spring
5		O-ring 1B P11
6		Check valve retainer
7		O-ring 1B S22
8		Pilot oil chamber case AS
9		Pilot oil chamber case AL
10		Hexagon socket head bolt M5×20 flows washer assembly
11		O-ring 1A P6
12		Screw plug GPM 1/32

(3) Manually operated type (boom swing and travel)



[1] Make sure that there is no dust or the like in any spool assemblies and any spool bores in the valve section bodies. Then, install each spool assembly into the spool bore in the respective valve section body taking care not to install it in a wrong position and a wrong direction.

[2] Slowly put in and out the spool several times by hand to see if the spool moves lightly without a feeling of scratching.

[3] Install the return spring case **10** to the spring side of the spool assembly, and tighten the hexagon socket head bolts **12** with a hexagon bar wrench (4 mm) at the specified torque.

Tightening torque : 4.3 to 5.1 ft·lbf (5.9 to 6.9 N·m)

Note :
Do not tighten each bolt at a time, but alternatively tighten the two bolts little by little so that the return spring case is installed evenly.

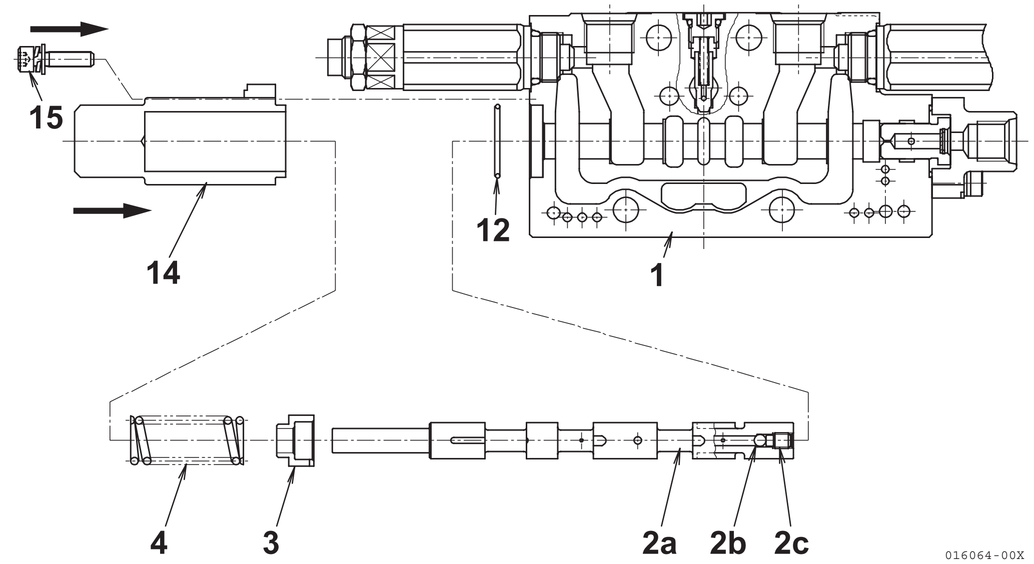
[4] Install the O-ring **3** and dust wiper **4** on the spool from the spool clevis end.

Note :
*Take care of the installation direction of the dust wiper **4**.*

[5] Press in the O-ring **3** and the dust wiper **4** with the seal plate **5**, and then tighten the hexagon socket head bolts with a hexagon bar wrench (4 mm) to the specified torque.

No.		Part
1		Body (symbol FB)
2		Boom swing spool assembly
	a	Spool (boom swing)
	b	O-ring 1A P12
	c	Dust wiper
	d	Seal plate
	e	Return spring retainer
	f	Return spring
	g	Spool end
3		O-ring 1A P12
4		Dust wiper
5		Seal plate
6		Check valve
7		Check valve spring
8		O-ring 1B P11
9		Check valve retainer
10		Return spring cap
11		Hexagon socket head bolt M5×10
12		Hexagon socket head bolt M5×18

(4) P1, P2 inlet section



[1] Make sure that there is no dust or the like in the inlet spool and the spool bore in the inlet section body and that the O-ring **12** is securely installed in the bottom of the flange on the front and rear sides of P1 and P2 inlet section body. Then, install the inlet spool assembly into the spool bore in the inlet section body taking care not to install it in a wrong direction.

Note :
Apply a little hydraulic oil to the spool before installing it.

[2] Install the return spring holder **3** and the return spring **4**.

[3] Securely install the pilot case **14** to the flange of the inlet section body and tighten the hexagon socket head bolt and washer assembly **15** with a hexagon bar wrench (4 mm) at the specified torque.

Tightening torque : 4.3 to 5.1 ft·lbf (5.9 to 6.9 N·m)

No.		Part
1		Body (symbol AB)
2		P1, P2 inlet spool assembly
	a	Spool (P1, P2 inlet)
3		Return spring retainer
4		Return spring
5		Piston
6		Filter
7		Internal snap ring
8		Check valve
9		Check valve spring
9		Check valve spring
10		Plug
11		O-ring 1B P8
12		O-ring 1B S22
13		Pilot oil chamber case B5
14		Pilot case A2
15		Hexagon socket head bolt M5×20 flows washer assembly

5) Reassembly

5)-1. Reassembly of load check valve

- Put each section on the work table with the actuator port side up.

(1) Standard type (blade, swing, arm, boom swing, boom and bucket sections (See Fig. 1))

(2) Standard type (P3 Inlet, travel, and anti-drift valve sections (See Fig. 2))

(3) Standard type (P.T.O. 1 and P.T.O. 2 sections (See Fig. 3))

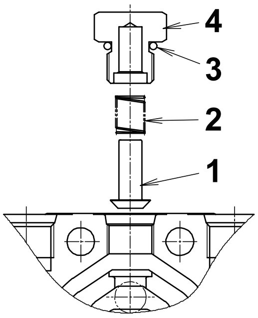


Fig.1 Check valve section (Blade, Swing, Arm, Boom Swing, Boom and Bucket Sections)

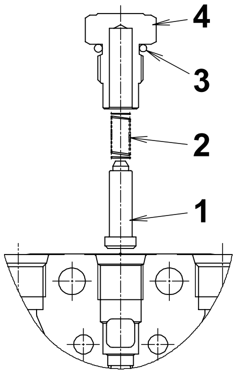


Fig. 2 Check valve section (P3 Inlet, Travel, and Anti-drift Valve Sections)

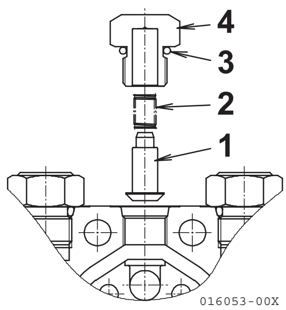


Fig. 3 Check valve section (P.T.O. 1 and P.T.O. 2 Sections)

[1] Install the check valve **1** into the bore in the center of the valve section in the regular direction (with the umbrella side down), and make sure that it is completely inserted into the central part.

[2] Install the check valve spring **2** to the check valve guide.

[3] Tighten the check valve retainer **4** by hand so that the check valve guide is installed in the guide of the check valve retainer, and the check valve spring **2** into the guide of the check valve retainer.

Note :

*Make sure the O-ring **3** is installed to the check valve retainer **4**.*

[4] After tightening the check valve retainer to some extent, tighten it with a wrench or socket wrench (19 mm) at the specified torque.

Tightening torque : 28.9 ft·lbf (39.2 N·m)

No.	Part
1	Check valve
2	Check valve spring
3	O-ring
4	Check valve retainer

(4) Particular type **1** (P1, P2 inlet section (See Fig.4))

[1] Install the check valve **1** and the check valve spring **2** in order into the sections.

[2] Make sure the O-ring **3** is installed on the check valve retainer **4** and screw it in the section.

[3] Tighten the check valve retainer **4** with a hexagon bar wrench (4 mm) to the specified torque.

Tightening torque : 5.8 to 7.2 ft·lbf (7.9 to 9.8 N·m)

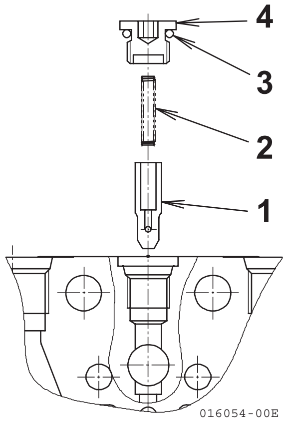


Fig. 4 Check valve section
(P1, P2 Inlet section for TSP System)

(5) Particular type **2** (bucket section (see Fig.5))

[1] Install the check valve **1** and the check valve spring **2** in order into the sections.

[2] Make sure the O-ring **3** is installed on the check valve retainer **4** and screw it in the section.

[3] Tighten the check valve retainer **4** with a wrench (14 mm) to the specified torque.

Tightening torque : 13.0 to 13.7 ft·lbf (17.6 to 18.6 N·m)

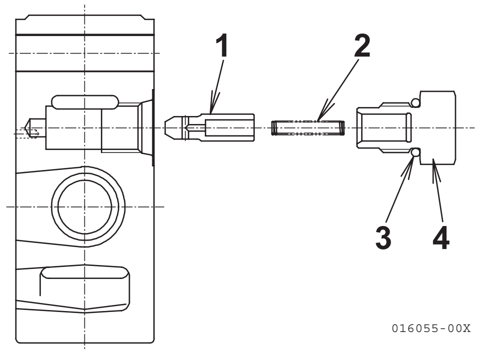


Fig. 5 Check valve section
(Bucket Section for Combined Oil)

5)-2. Reinstallation of Relief Valve and Plug

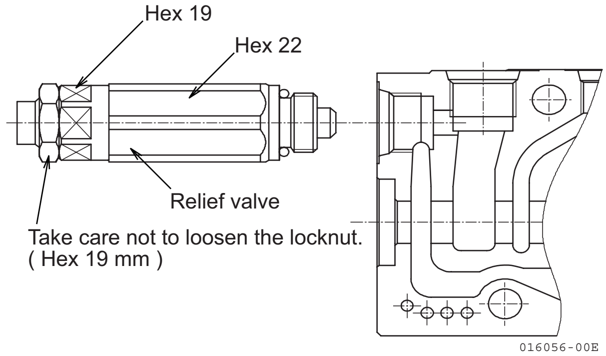
(1) Relief valve

Blade section is shown below for example.

- Reinstall the relief valve on the section body and tighten it with a wrench (22 mm) to the specified torque.

Tightening torque : 27.5 to 30.0 ft·lbf (37.3 to 41.2 N·m)

- When a 22 mm wrench is unavailable, a 19 mm wrench can be used to loosen the valve.



Note :

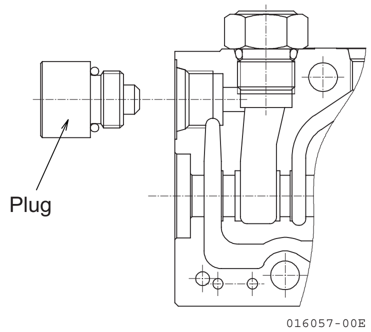
Do not fit the 19 mm wrench on the locknut, or the relief set pressure changes, causing poor performance or system damage.

(2) Relief valve port plug.

P.T.O. section is shown below for example.

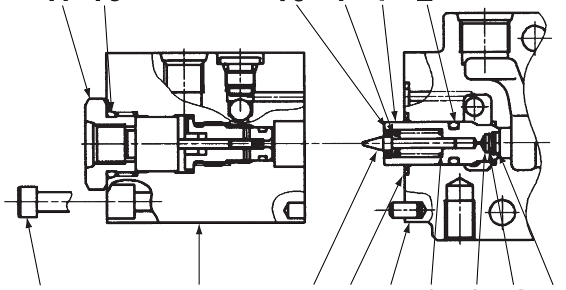
- Tighten the plug with a hexagon bar wrench (8 mm) to the specified torque.

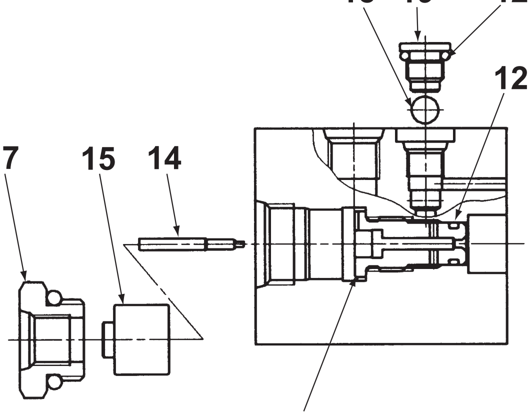
Tightening torque : 27.5 to 30.0 ft·lbf (37.3 to 41.2 N·m)



5)-3. Reassembly of anti-drift valve

When the anti-drift valve malfunctions, replace it as an anti-drift valve assembly. For reference, the reassembly procedure after disassembled for examination is shown below.





[1] Hold the anti-drift valve case **B** by any side face other than the port side with a vice.

[2] After holding the anti-drift valve case, insert the piston A1 **14** into the bore in the piston guide **13** in the correct direction.

[3] Insert the piston B **15** into the bore in the anti-drift valve case **B** in the correct direction, and then tighten the bush **17** with a wrench or socket wrench (26 mm) at the specified torque.

Tightening torque : 43.4 to 50.6 ft·lbf (58.8 to 68.6 N·m)

Notes :

- *Be sure to check the bush **17** for the O-ring **16**.*
- *Slowly put in and out the pistons **14** and **15** several times by hand to see if the pistons move lightly without a feeling of scratching. If you feel something is wrong, replace the pistons **14** and **15** and the anti-drift valve as a set.*

[4] Gently set the steel ball **18** on the steel ball seat on the upper surface of the anti-drift valve case and tighten the ball retainer **19** with a hexagon bar wrench (4 mm) at the specified torque.

Tightening torque : 5.8 to 7.2 ft·lbf (7.8 to 9.8 N·m)

Note :

*Be sure to check the ball retainer for the O-ring **12**.*

[5] Check the side face of the valve section body on the anti-drift valve side for the O-ring. Then, assemble the anti-drift valve assembly (**1**-**7**, **10**) and the needle valve 9 and insert them into the bore for the anti-drift valve.

[6] Align the two positioning pins **C** on the anti-drift valve body side to the positioning holes in the anti-drift valve case and slowly push the anti-drift valve case until it contacts with the anti-drift valve section body.

Note :

*Make sure that the needle valve **9** is put into the seat section inside the anti-drift valve case.*

[7] Tighten the hexagon socket head bolts **A** with a hexagon bar wrench (5 mm) at the specified torque.

Tightening torque : 7.2 to 8.0 ft·lbf (9.8 to 10.8 N·m)

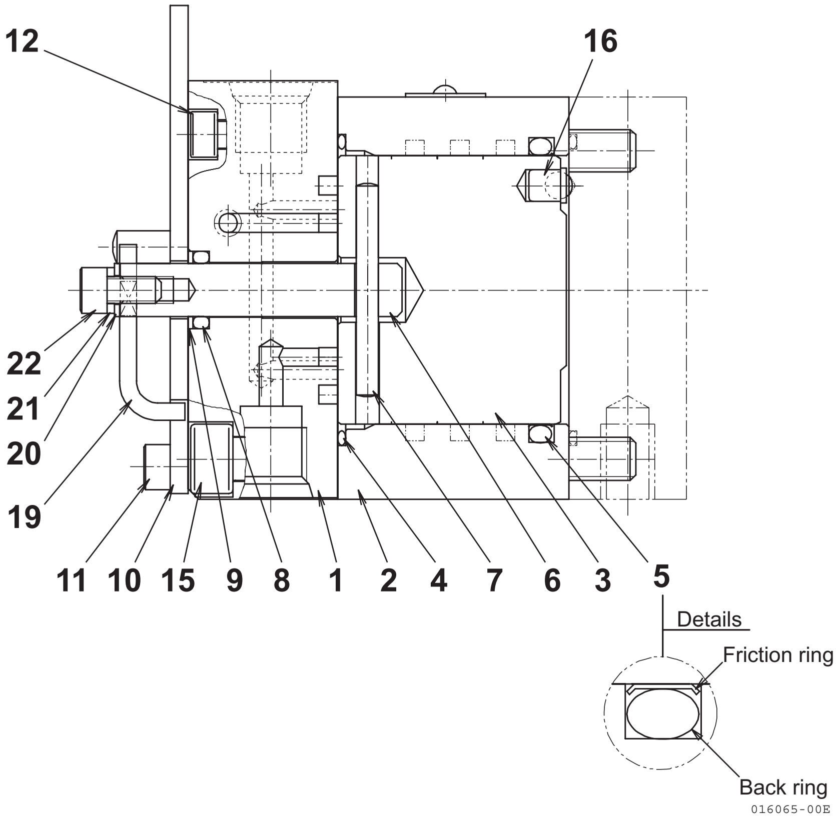
Note :

Do not tighten each bolt to the specified torque at a time, but alternatively tighten the two bolts little by little so that the anti-drift valve case is installed evenly.

No.	Part
1	Anti-drift valve
2	Cap seal 1 BE10
3	Filter
4	Spacer
5	Snap ring AR7
6	Anti-drift valve spring A
7	Spring holder
8	O-ring AS 1B17
9	Needle valve
10	Internal snap ring 9
11	O-ring 1A P6
12	O-ring 1B P8
13	Piston guide
14	Piston A1
15	Piston B
16	O-ring 1B P18
17	Bush PF1/2×1/4
18	Steel ball Ø0.28 in. (7 mm)
19	Ball retainer

6. 2-way Valve

1) Structure



No.	Part	No.	Part
1	Body A3	12	Hexagon socket head cap screw M5×30
2	Body B2	13	Plug GPM1/32
3	Cylinder	14	Plug NPT1/16
4	O-ring 1B S55	15	Hexagon socket head cap screw M8×75
5	Rod packing SPNC50	16	Plunger Ø6
6	Shaft	17	O-ring 1B P11
7	Needle roller Ø4×39.8	18	Plug PF1/4
8	O-ring 1A P10A	19	Stopper
9	Back-up ring T3P10A	20	Washer 5
10	Plate	21	Spring washer 5
11	Hexagon socket head cap screw M5×10	22	Hexagon socket head cap screw M5×10

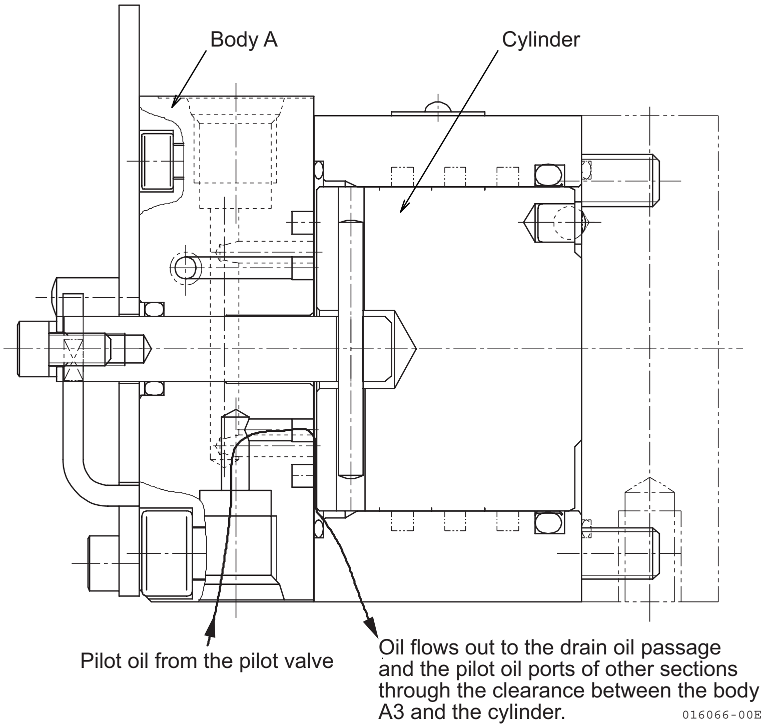
Notes :

- *The plugs **13** and **14** are not shown in the figure.*
- *Pattern change lever handle is installed on an US spec machine instead of the stopper **19**.*

2) Operation

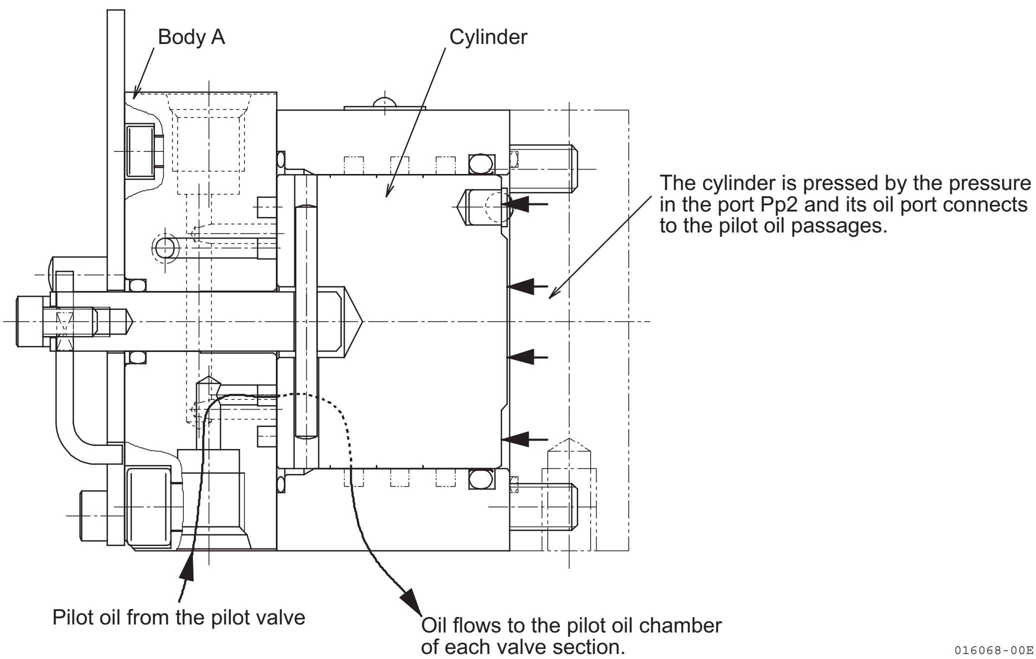
(1) Unloaded state (port Pp2 with no pilot oil supplied)

As long as no pilot oil is supplied to the port Pp2, the cylinder is not pressed to the body A3 and each pilot oil port is led to the drain oil passage in this valve.



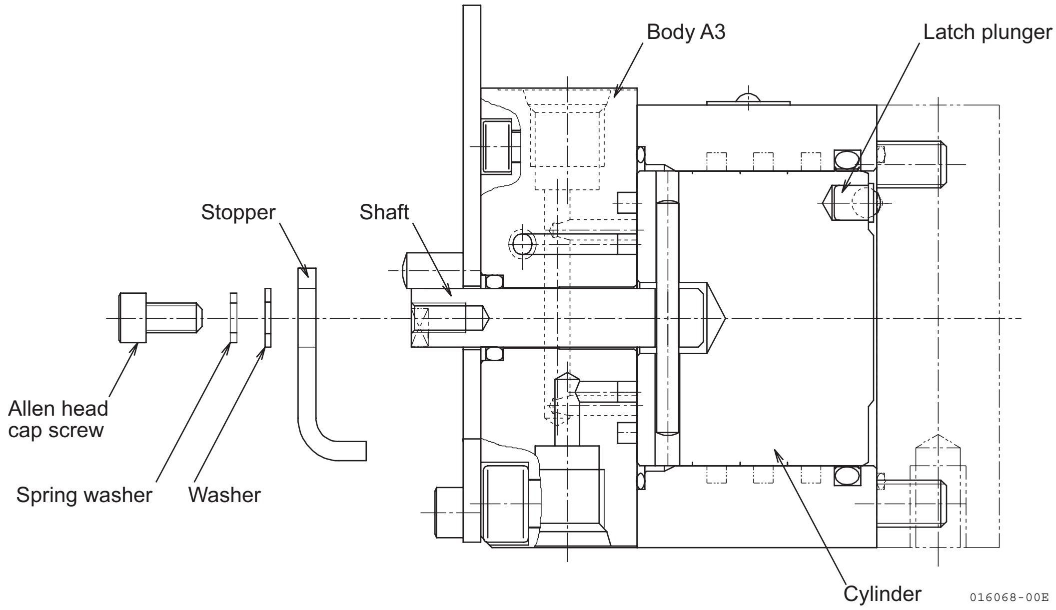
(2) Neutral state (port Pp2 with pilot oil supplied)

When the pilot oil is supplied to the port Pp2, it flows to the cylinder of the 2-way valve through the oil passage in the control valve. The cylinder is pressed to the body A3 by the pilot oil and each pilot oil port connects to its pilot oil passage.



(3) Pattern change

Turn the shaft in the center of the 2-way valve to change the control lever pattern from the standard (SAE) pattern to the option (JD) pattern and vice versa.



3) Disassembly

(1) Precautions for disassembly

Precautions for disassembly

[1] Since the parts of the hydraulic equipment are generally precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean area that is free from dust.

[2] Prepare clean tools and treated oil, and handle them carefully.

[3] First clean the external surface of removed assemblies.

[4] Before beginning, review the drawings of the internal construction and prepare the required parts according to the purpose and extent of the disassembly. After disassembly, replace the removed seals and O-rings with new ones in principle. As some replacement parts are available only as subassemblies, see the parts catalogue to prepare the necessary subassemblies in advance.

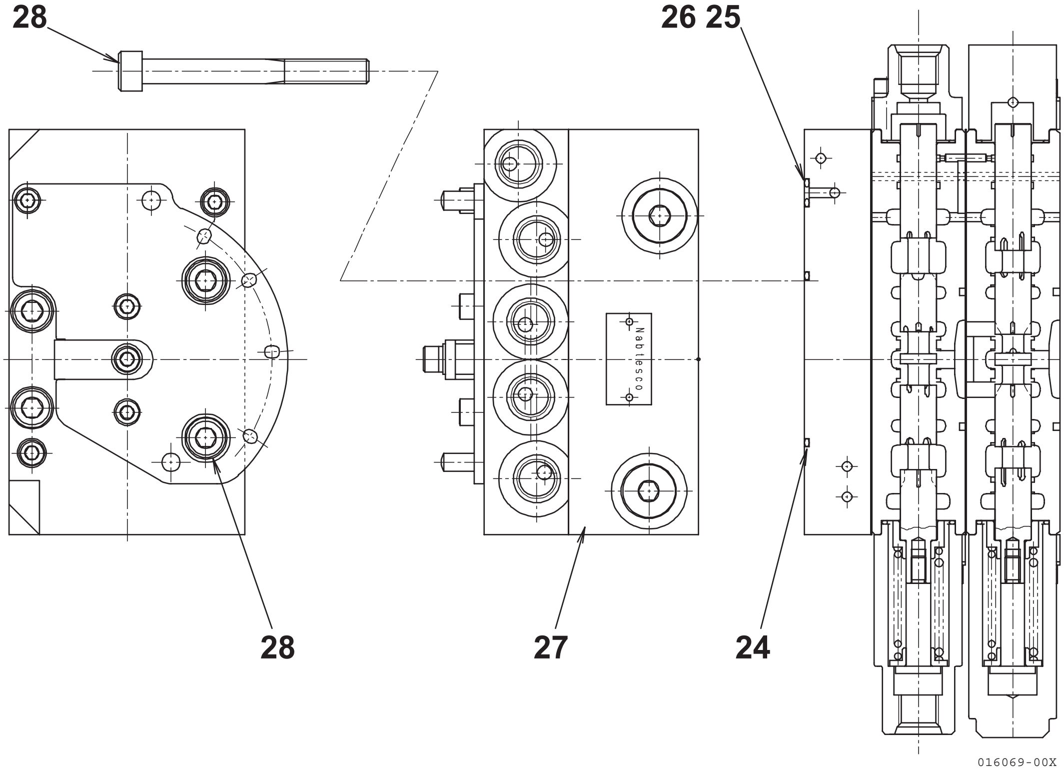
(2) Tools

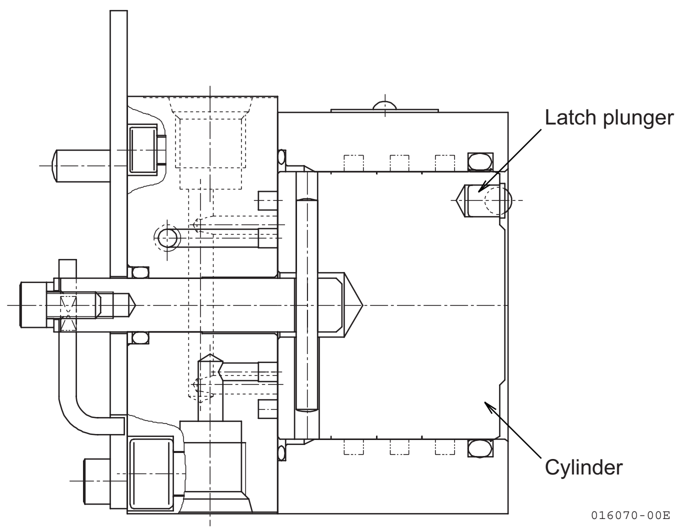
Tool	Q'ty	Size
Hexagon bar wrench (mm)	1 (for each)	2, 3, 4, 6
Torque wrench [ft·lb (N·m)]	1	1.5 to 151 (1.96 to 19.6)
Torque wrench [ft·lb (N·m)]	1	15 to 75 (19.6 to 98.1)
Magnet	1	
Pliers	1	
Screwdriver	1	
Tweezers	1	

(3) Removing the 2-way valve from the control valve assembly

Loosen four hexagon socket head cap screws **28** with a hex bar wrench (6 mm) to remove the 2-way valve assembly **27**.

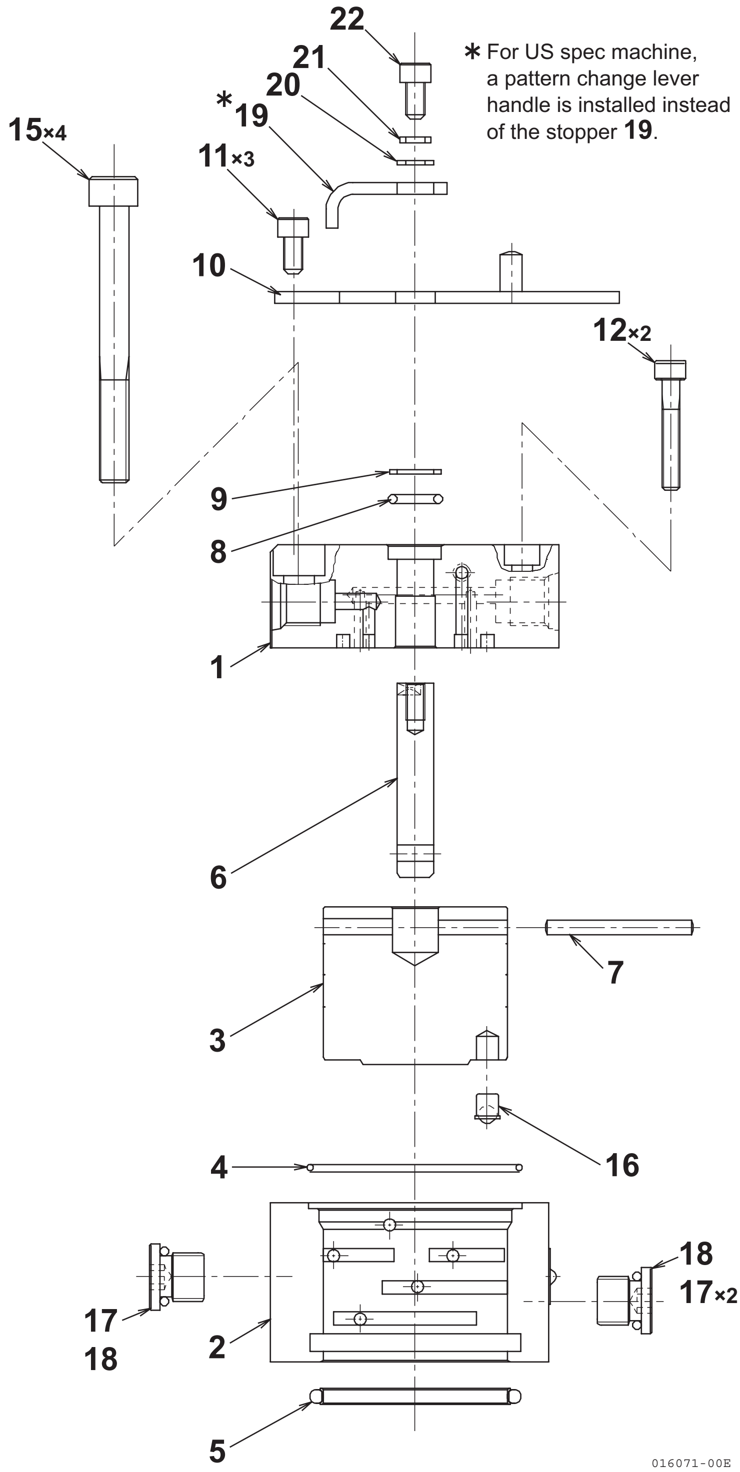
- Make sure the O-rings **24**, **25**, **26** are in the grooves.
- Check the latch plunger for coming off from the cylinder end surface.





(4) Disassembly

Before disassembling, clean the 2-way valve and put it on a work table five pilot oil ports side up.



[1] Hold the 2-way valve with a vise.

[2] Remove three plugs **18** with a hexagon bar wrench (6 mm).

[3] Loosen the hexagon socket head cap screw **22** with a hexagon bar wrench (4 mm) to remove the spring washer **21** and the washer **20**.

[4] Remove the stopper **19** (pattern change lever handle assembly).

[5] Loosen three hexagon socket head cap screws **11** with a hexagon bar wrench (4 mm) to remove the plate **10**. Unless the O-ring **8** or back-up ring **9** is inspected or replaced, removing the plate **10** is not always necessary.

[6] Loosen two hexagon socket head cap screws **12** with a hexagon bar wrench (4 mm).

[7] Separate the body A3 **1** from the body B2 **2**.

[8] Press the cylinder **3** from the latch plunger side to remove it from the body B2 **2**. As it may not be very easy to remove the cylinder **3** because of the rod packing **5** and its fitting clearance, carefully press out the cylinder **3** or sliding surfaces of the cylinder **3** and body B2 **2** may be damaged.

Note :

*The rod packing **5** cannot be reused. Do not remove the cylinder from the body **2** unless necessary. If removed, always replace the rod packing **5** with new ones.*

[9] Remove the needle roller **7** which connects the cylinder **3** and shaft **6**.

[10] Remove the back-up ring **9** and O-ring **8** with tweezers or a small screw driver.

[11] Remove the O-ring **4**.

4) Reassembly

(1) Precautions for reassembly

1] Handling the O-rings

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

[2] The O-rings may not have any defects in molding, or be damaged in handling or distorted by heat.

[3] Do not stretch any O-rings with such great force as to permanently deform them.
Prevent any O-ring from being damaged when it is set to the spool from its sharp end.

[4] Avoid rolling the O-rings when fitting them.
A distorted O-ring may not return to its original shape; therefore it may cause oil leakage.

2] Before beginning reassembly, check that there is no treated oil or hydraulic oil on the outer surface of the O-ring groove in the mating face of each section. If reassembly is performed without cleaning such oil, it may be mistaken for oil leakage.

3] Reassembly of control valve sections
Put the control valve sections with the actuator port down in the order shown in the figure below.

Note :

The symbol representing for each valve section is as follows and is carved on the upper surface (the actuator port side) of each valve body except the end cover.

(2) Tools

Tool	Q'ty	Size
Hexagon bar wrench (mm)	1 (for each)	2, 3, 4, 6
Torque wrench [ft·lb (N·m)]	1	1.5 to 151 (1.96 to 19.6)
Torque wrench [ft·lb (N·m)]	1	15 to 75 (19.6 to 98.1)
Magnet	1	
Pliers	1	
Screwdriver	1	
Tweezers	1	

(3) Reassembly

[1] Separate each rod packing **5** to the back ring and friction ring.

[2] Install the back ring in the groove of the body B2 **2** and get the friction ring on the back ring to securely install the friction ring in the groove.

[3] Install the O-ring **4** onto the body B2 **2**.

[4] Install the cylinder **3** in the body B2 **2** until it contacts the rod packing **5**.

[5] Install the shaft **6** into the center hole of the cylinder **3** and install the needle roller **7** in the through hole on the cylinder **3** side to connect the shaft **6** to it.

[6] Fully install the cylinder **3** in the body B2 **2**.

[7] Connect the body A3 **1** to the above assembly.

[8] From the body A3 side, tighten two hexagon socket head cap screws **12** to 4.4 to 5.0 ft•lb (5.9 to 6.9 N•m) with a hexagon bar wrench (4 mm).

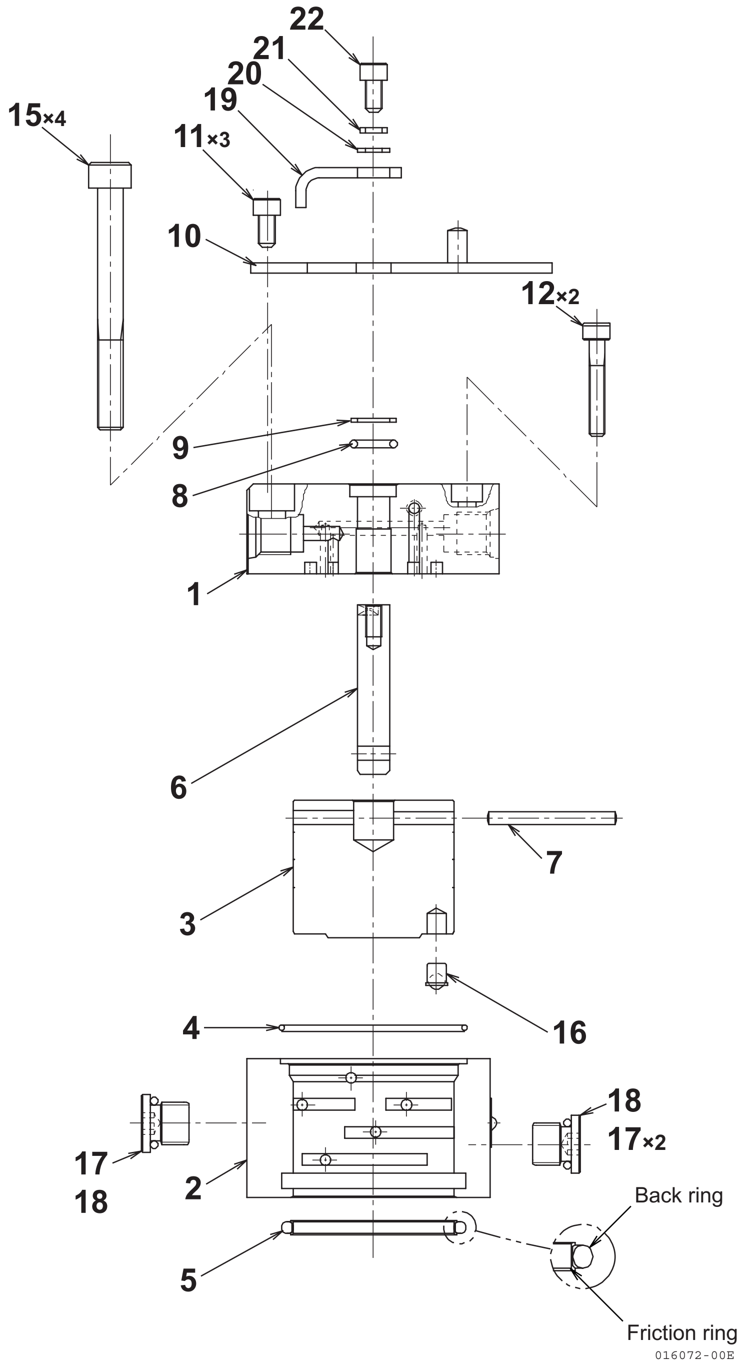
[9] Install the O-ring **8** and back-up ring **9** on the shaft **6**.

[10] Install the plate **10** and tighten three hexagon socket head cup screws **11** to 4.4 to 5.0 ft•lb (5.9 to 6.9 N•m) with a hexagon bar wrench (4 mm).

[11] Turn the shaft **6** to bring the plunger hole on the back side of the cylinder **3** to its regular position.

[12] Install the stopper **19**, washer **20** and spring washer in order on the shaft **6**, and then tighten the hexagon socket head cap screw **22** to 4.4 to 5.0 ft•lb (5.9 to 6.9 N•m) with a hexagon bar wrench (4 mm).

[13] Install the plunger **16** on the cylinder **3**.



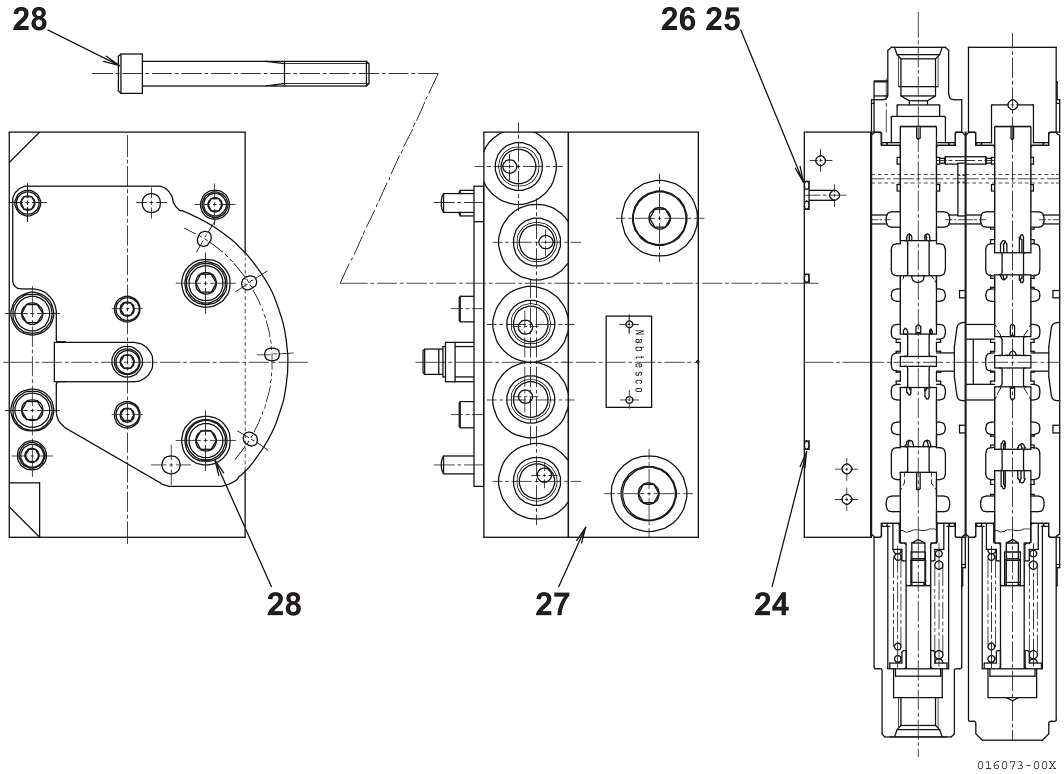
(4) Reinstallation on the control valve

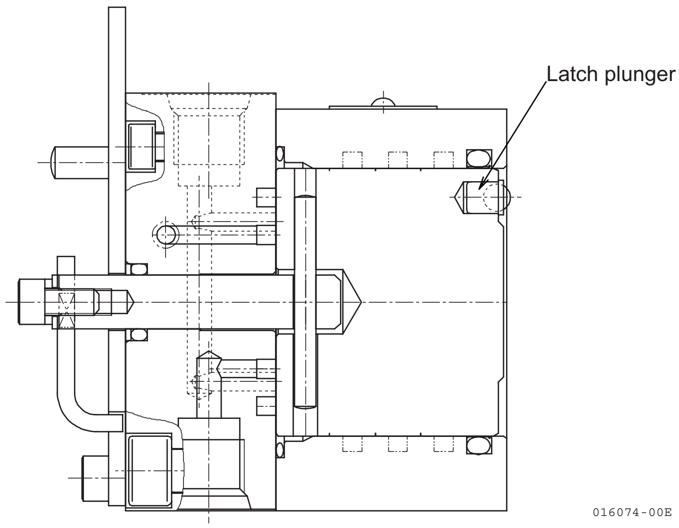
[1] Securely install the O-rings **24**, **25** and **26** on the end cover.

[2] Put four hexagon socket head cap screws **28** in the holes of the 2-way valve assembly, press it to the end cover and tighten the cap screws **28** to 14.1 to 14.8 ft•lb (19.5 to 20.0 N•m) with a hexagon bar wrench.

Note :

Make sure the latch plunger is in place and in the upper side. If not, the latch loses its function and the lever position cannot be determined.





7. Service Standard

Inspection of parts

Parts	Check Points	Remedies
Body A3	(1) Check for scars, rusting and corrosion	Replace if damage is found in the following parts. • Mating surface with the cylinder and contact area of its outside O-ring. • Sealing area of the O-ring contacting ports. • Other damages which is likely to spoil normal functions.
Body B2	(1) Check for scars, seizure, rusting and corrosion. (2) Install cylinder and rotate it.	• Replace the body B2 and cylinder with new ones if nail feels any groove or asperity on the inner surface. • Replace the body B2 and cylinder with new ones if rotation is not smooth.
Cylinder	(1) Check for scars, seizure, rusting and corrosion. (2) Install cylinder in the body B2 and rotate it.	• Replace the cylinder and the body B2 if any damage is found on the mating surface with the body A3 or on outside surface. • Replace the cylinder and the body B2 if rotation is not smooth.
Shaft	(1) Check for scars, seizure, rusting and corrosion. (2) Deformed or broken	• Replace if any damage is found on the shaft seal area. • Replace

8. Troubleshooting

Causes and prevention

(1) When anything is wrong with pattern change function, check the control valve, pump, cylinder, motor or another reason in the circuit with measuring the pressures of the pilot oil, system relief valve and circuit relief valve.

(2) Always keep dust out of valve area.

(3) Carefully handle the inner parts.

(4) Take care of O-rings so as not to damage them.

Trouble	Causes	Measure
Actuator malfunction, slow movement, lack of power or poor response	(1) Low pilot oil pressure due to poor sealing. • Dust between cylinder and body A3. • Out of position of cylinder.	(1) Measure the pilot oil pressure. • Disassemble to clean (Replace if damaged). • Adjust pattern change position.

6-3 Pilot Valve

Pilot valve unit for arm rest installation
Type 4TH5

Maintenance Instructions

1. Introduction

1) Foreword

This manual deals with the instructions relative to servicing and maintenance operations for the hydraulic pilot control unit 4TH5 for the inspections and servicing operations associated with the hydraulic system of the machine to which they are connected. Please consult the maintenance manual supplied by the equipment manufacture.

It is recommended that only qualified personnel perform the installation, connection and maintenance of this device, and that all operations shall be carried out in compliance with the technical standards in force and the cleanliness regulations specific to this type of installation.

To ensure maximum performance and safety during maintenance operations we advise you to **Read this manual thoroughly**

All information, illustrations, instructions and characteristics contained in this document are based on the latest product information available at the time of publication. In its attempts to maintain a high-quality product, MANNESMANN REXROTH reserves the right to make design or technical modifications at any time and without prior notification.

2) Safety Instructions

Please pay a special attention to the signals of safety alerts and special instructions in this manual. They are indicated in the following manner:

⚠ **Indicates information or instructions which must be followed to guarantee your safety during operations.**

CAUTION :
Warning against possible equipment damage.

Note :
Useful information.

2. Troubleshooting

CAUTION :

Before starting any procedures of troubleshooting or removing the hydraulic pilot control unit, inspect the global machine's hydraulic system to eliminate all possible malfunctions not related to the pilot control unit.

Abnormal operation of equipment connected to the hydraulic pilot unit

Malfunction	Probable case	Additional checks	Remedy
No machine movement (for hydraulic signal receivers only)	(1) Leak	See <Visual defects>	
	(2) Control valve seized or blocked		Replace pilot unit
Lack of speed of one or several machine movement(s) (for hydraulic signal receivers only)	(1) Poor pressure signal		Replace pilot unit
	(2) Leak	See <Visual defects>	
No machine movement (for electric signal receivers only)	(1) Electric function failure		Replace handle
	(2) Handle poorly connect	Check the connection	

Abnormal Hydraulic Pilot Unit Operation

Malfunction	Probable case	Additional checks	Remedy
Handle does not automatically return to neutral position: (1) Manual return with friction	(1) Faulty cardan		Replace cardan
Handle does not automatically return to neutral position: (2) Manual return without friction	(1) Lip seal too hard inside guide		Replace guides + plungers
	(2) Regulation unit setting spring broken	Remove the regulation unit for visual inspection	Replace pilot control unit
	(3) Regulation unit plater broken		
Handle turns	(1) Handle parts loose		Tighten all handle parts

Visual Defects

Malfunction	Probable case	Additional checks	Remedy
Handle push buttons worn out			Replace push buttons
Rubber boot damaged			Replace boot
Leak on arm rest originating from under the boot	Leak between guide and push buttons	Lift the boot to perform a visual inspection	Replace guides + plungers
Seepage on body	Porous body		Replace the pilot unit

3. Fundamental Rules

1) General Information Concerning Pilot Control Unit Connection

When removing the pilot control unit, all openings must be plugged immediately to prevent any contamination of the hydraulic system.

When replacing the pilot control unit, remove the plastic plugs from the openings and lines just before making the connections.

Do not tighten connectors to a torque greater than that specified in the assembly instructions.

Check the hydraulic installation's oil quality and filtration capacity during all servicing/maintenance operations.

The use of teflon tape, hemp and joint filler is prohibited.

Hydraulic lines and connections must not be under any strain whatsoever.

4. Removal / Installation of the Pilot Control Unit Connection

1) General Recommendations

CAUTION :

Before removing the pilot control unit from the machine, the block and its surroundings must be thoroughly cleaned with a high-pressure cleaner.

No impurities must enter the hydraulic system. Plastic plugs are to be fitted on lines and orifices immediately following their removal.

Wear protective clothing and use suitable equipment to prevent accidents, particularly concerning the hydraulic fluid.

Set all actuators connected to the machine in neutral position (on the ground, at lower limit...) to avoid accidents which could result from uncontrolled movements of the equipment when the hydraulic system is disconnected.

With the machine off, release the pressure remaining in the system by manipulating all of the distribution spools. This is performed by moving the handle in all directions.

2) Pilot Control Unit Removal

Immediately after disconnecting the lines from the control device, fit the sealing plugs. Make sure to collect any possible oil leakage in a suitable receptacle.

Unscrew the mounting screws and remove the control device.

3) Installation of the Hydraulic Pilot Control Unit

Contact faces must be perfectly clean.

Check the evenness of the support area on the machine (tolerance : 0.5 mm).

Check the condition of the line connector seals.

Clean the pilot control unit if it has been in storage for a long period of time.

Correctly place and secure the pilot control unit onto the machine with the mounting screw (maxi torque : 10 N·m).

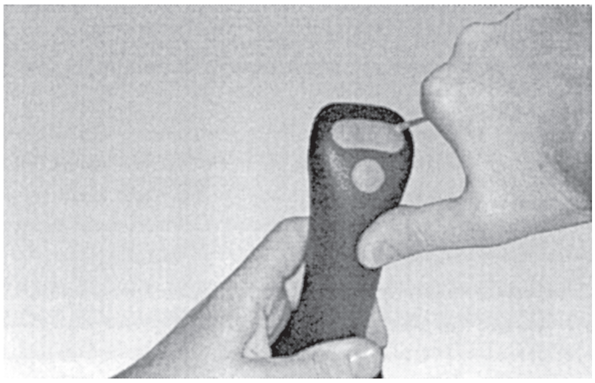
Connect the lines to the control unit as per the connecting diagram and tighten to the torque specification (maxi torque : 30 N·m).

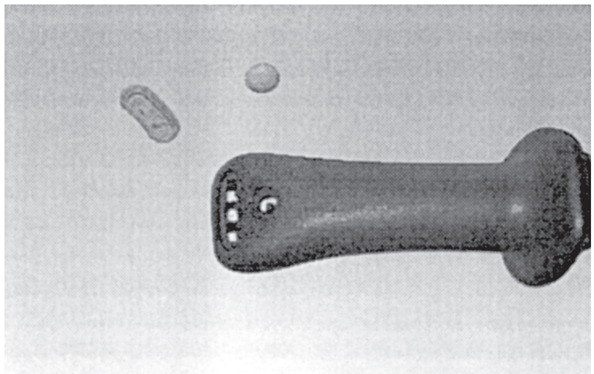
Ensure that the hoses are not twisted or rubbed.

Once correctly installed, the unit can be placed into operation.

5. Pilot Control Unit Repair Procedures

1) Push Button Replacement

Procedure	
Note : *The pilot control unit does not need to be removed from the machine to perform this operation.* **Machine off :** **- place all of the machine's equipment connected to the pilot control unit in neutral position,** **- release stored pressure by operating all of the pilot unit's control valves by moving the handle in all directions.** Remove worn out push button (s) using a small screwdriver.	

The installation of new elements is performed without any special tools ; the parts are simply pressed into place.	

2) Boot or Handle Replacement

Procedure

Preliminary operations

Remove the pilot control unit from the machine's arm rest of free the unit by unscrewing the 4 screws fixing the plate in order to release the electrical cable.

Hold the pilot control unit using a vice or a vice-grip wrench (clamp onto the body above the arm rest, 65 opening).

Note :

The pilot control unit does not need to be removed from the machine to release the cable. However, it is recommended to lift the control unit by undoing the 4 fixing screws on the arm rest.

It is unnecessary to remove the units without electrical functions.

Machine off :

- place all of the machine's equipment connected to the pilot control unit in neutral position,

- release stored pressure by operating all of the pilot unit's control valves by moving the handle in all directions.

Handle removal

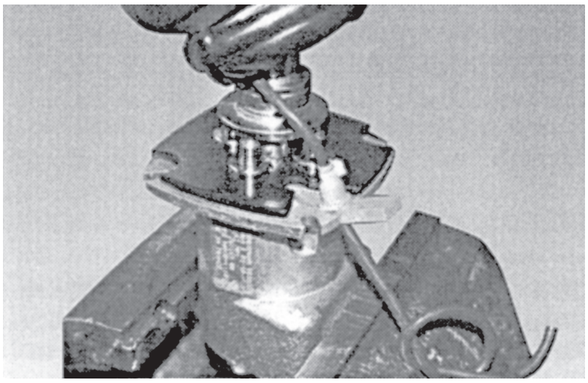
Lift and turn the boot inside out.

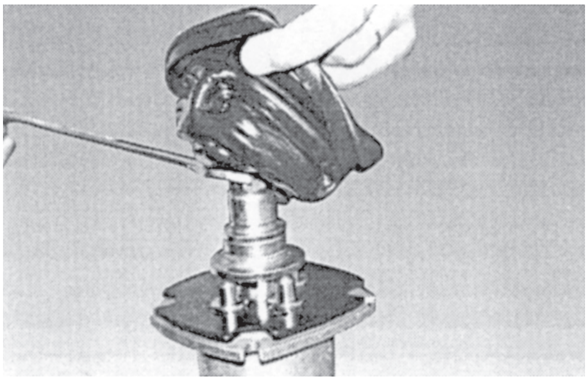
Remove the grommet from its emplacement to free the cable.

Loosen the handle mounting nut (19 mm open-end wrench).

Reassembly : torque : 30±3 N·m

Unscrew and remove the handle.

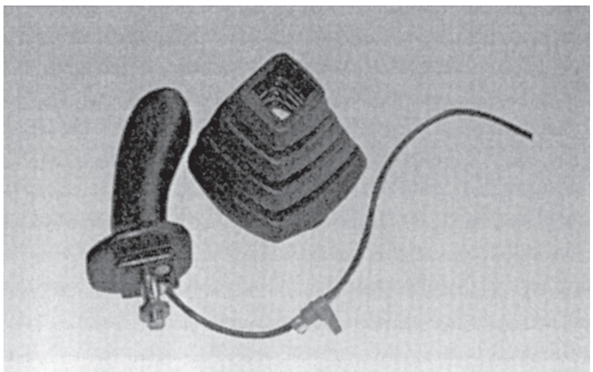


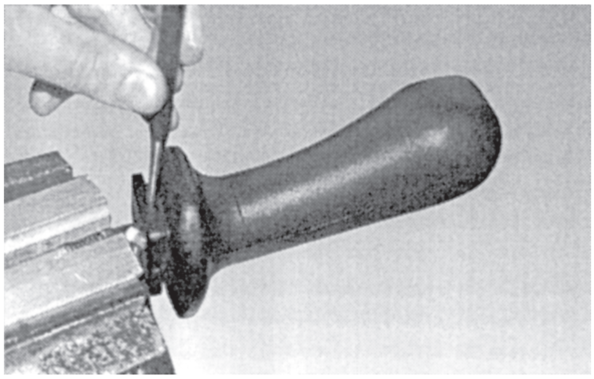


Boot replacement

Remove the faulty boot and replace it with a new boot.

Replace the handle following the disassembly instructions in reverse order.



<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>Handle replacement
Clamp the threaded section of the bent lever in a vice fitting with V-shaped vice clamps.
Remove the pin (5 mm pin driver)</td><td></td></tr>
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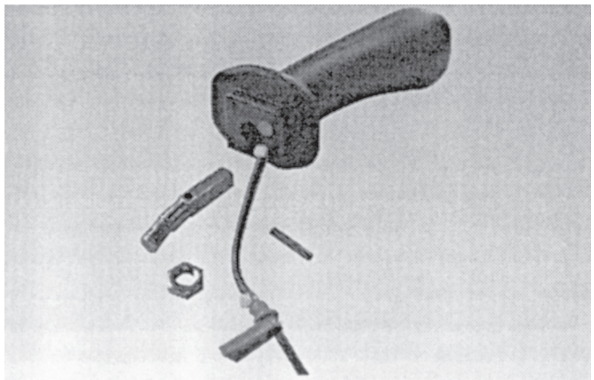
<tr><td>Remove : - pin,
- bent lever,
- handle.
Replace the bent lever onto the new handle and secure it with the pin (5 mm pin driver)

Note :
Respect the position of the bent lever to ensure that the handle is correctly oriented as indicated by the machine's technical specifications.

Replace the nut on the threaded section and replace the boot.</td><td></td></tr>
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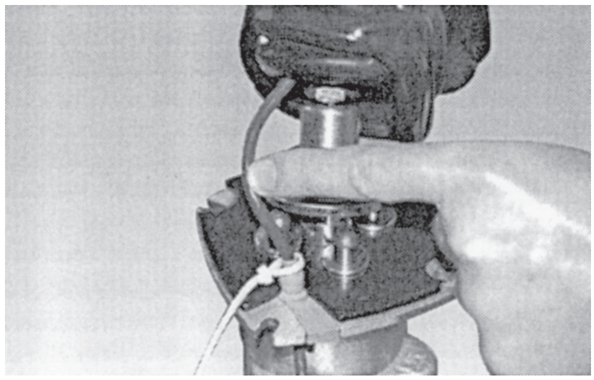
<table>
<tr><td>Screw the handle onto the pilot control unit and tighten the nut (19 mm open-end wrench).
Connect the new handle's electrical wiring to the machine's electric system.
Fit the grommet into its emplacement while leaving enough cable length so as to enable the correct handle operation.</td><td></td></tr>
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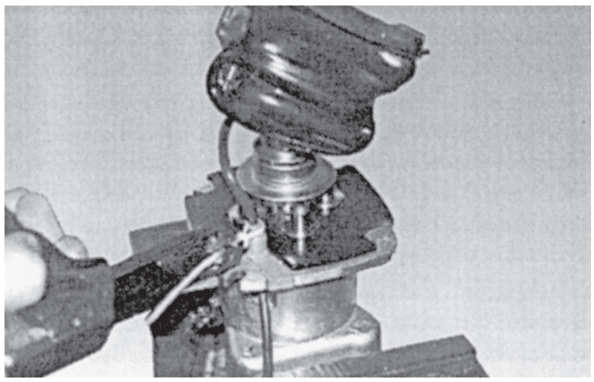
<tr><td>Secure the cable to the grommet with a cable clamp.
Fold down the boot.</td><td></td></tr>
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3) Cardan Replacement

Procedure

Preliminary operations
Remove the pilot control unit from the machine's arm rest.
Secure the pilot control unit in a vice (clamp onto the body).
Remove the handle.

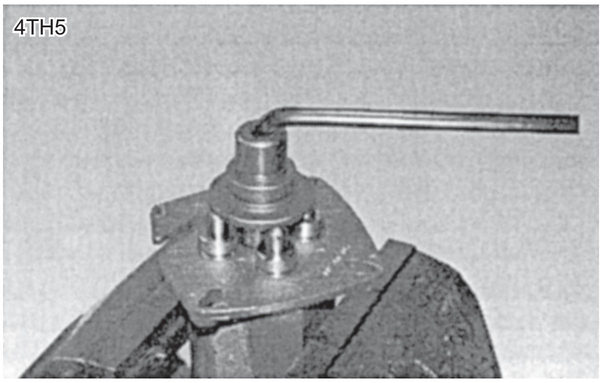
Note :
It is recommended to remove the pilot control unit from the machine. Nevertheless, the servicing on machine is possible by securing the unit into a vice-grip wrench (65 opening). This is performed by extracting the body from the arm rest so as to clamp the vice-grip wrench onto the body in order to hold it above the arm rest.

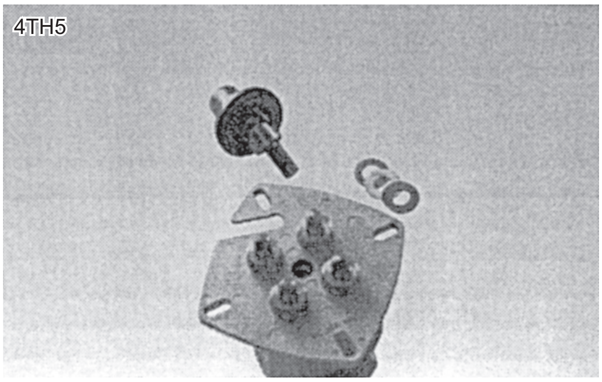
Removal of the cardan
Fit an Allen wrench into the assembly screw and unscrew it (8 mm Allen wrench).

Reassembly : torque : 45±4 N·m
Remove : - the cardan,
- the shim (s)

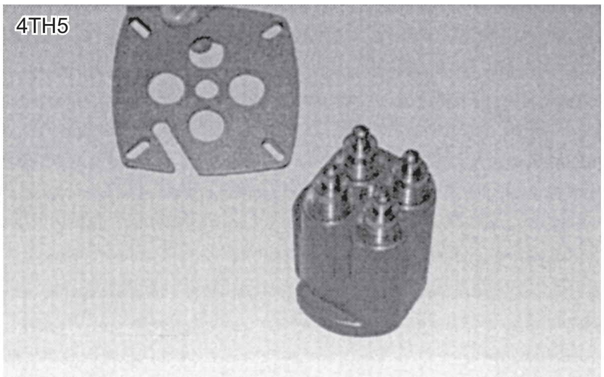
Reassembly : Adjust the pre-depression of the cardan by selecting the shims necessary to obtain play-free contact between the switch-plate and the plungers. In neutral position, the depression of the plungers must not exceed 0.2 mm. In order to check this value, observe the displacement of the plunger located opposite to the one being pressed.

Note :
The pre-depression may be difficult to achieve on site. Could be necessary to readjust it after reassembly and system working control.

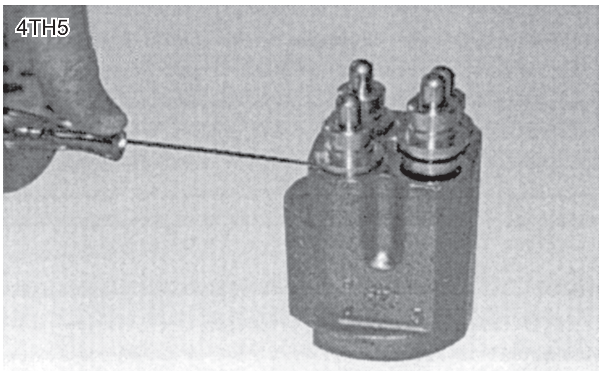




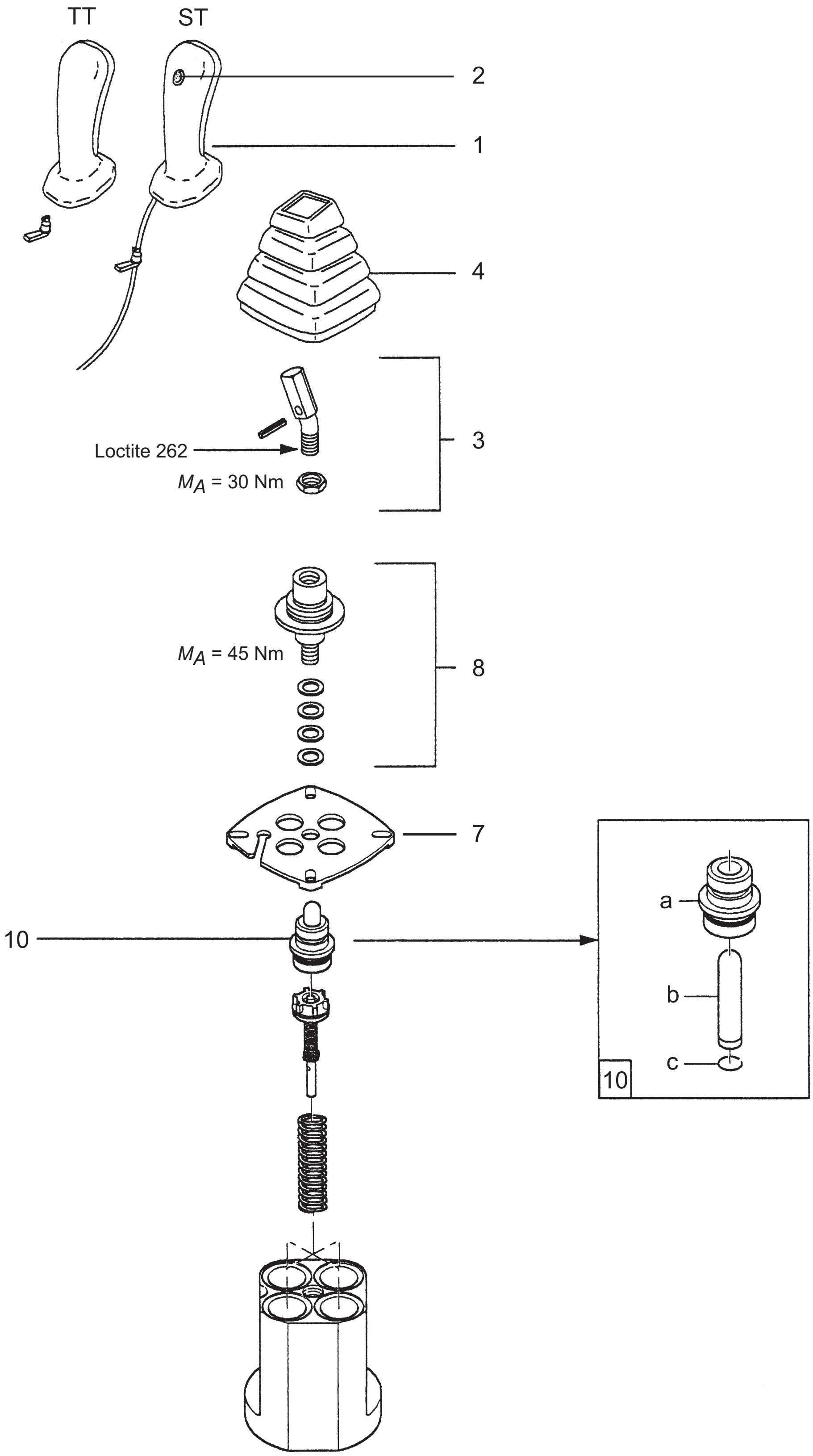
4) Guide / Plunger and Regulation Unit Replacement

Procedure	
Preliminary operations Remove the pilot control unit from the machine's arm rest. Remove the handle. Remove the cardan. ***Note :*** *It is recommended to remove the pilot control unit from the machine. Nevertheless, the servicing on machine is possible by securing the unit into a vice-grip wrench (65 opening). This is performed by extracting the body from the arm rest so as to clamp the vice-grip wrench onto the body in order to hold it above the arm rest.*	

Removal Secure the pilot control unit to a vice. Remove the retaining plate. Reassembly : Line up the notches for the grommet in both the plate and the body.	

Insert the end of a thin screwdriver between the guide and the body, carefully lift the guide to remove it from the body. ***Note :*** *Hold the guide with the other hand during the extraction operation to limit the effect of the return spring.* Remove the guide / plunger assembly. Repeat the operation for the other 3 sub-assemblies. Reassembly : Use the retaining plate to insert the 4 guides into the body simultaneously and perpendicularly. Reassemble in reverse order.	

Regulation unit verification Extract the regulation units from the body (using flat nose pliers). Visually check that the guides / plungers are in good condition. If defects are present, replace the 4 sub-assemblies. Inspect the regulation units and particularly their spring. If defects are detected, replace the 4 units.	


TT
ST
2
1
4
3
Loctite 262
M_A = 30 Nm
M_A = 45 Nm
8
7
10
a
b
c
10

Item	Description	Reference N°	Dimensions
1	Handle TT	07 213 322	
3	Lever kit	07 213 213	
4	Rubber boot	07 259 959	
7	Retaining plate	07 261 225	
8	Cardan kit composed of : 1 cardan + shims	07 213 399	
10	Plunger kit composed of : 4 plunger guides a 4 plain plungers b 4 spring rings c	07 213 396	

Item	Description	Reference N°	Dimensions
1	Handle ST with cable socket AMP	08 200 133	
2	Push button kit	07 213 314	
3	Lever kit	07 213 213	
4	Rubber boot	07 259 959	
7	Retaining plate	07 261 225	
8	Cardan kit composed of : 1 cardan + shims	07 213 399	
10	Plunger kit composed of : 4 plunger guides a 4 plain plungers b 4 spring rings c	07 213 396	

6-4 Swing Motor

1. Structure and Functions

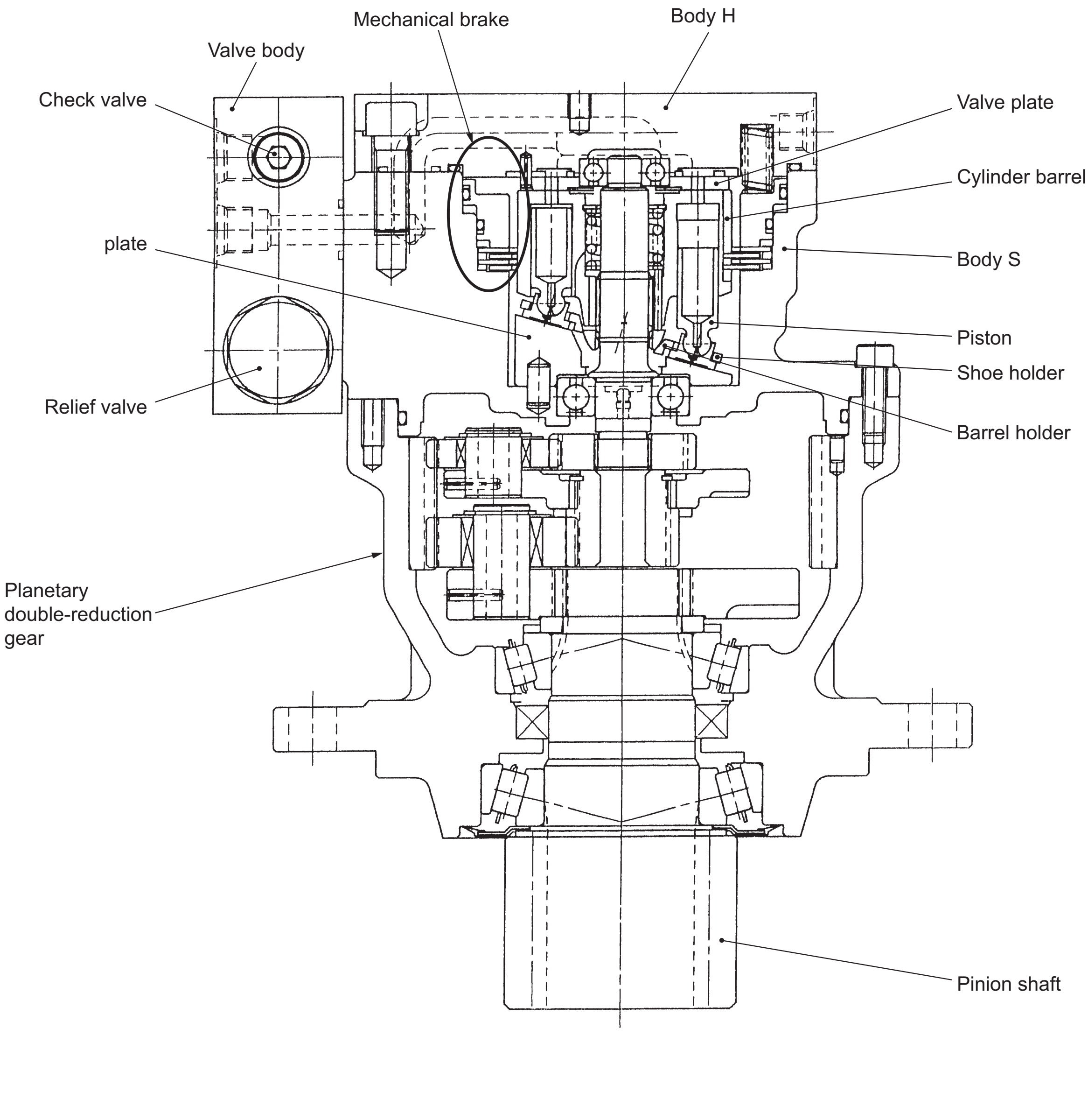
The swing motor consists of a swash plate type axial piston motor, a relief valve, a check valve, a mechanical brake, a planetary double- reduction gear and other parts.

The rotary group of the piston motor consists of a cylinder barrel integrated with a drive shaft and nine pistons located in the cylinder barrel. The cylinder barrel is supported by bearings at both ends.

The piston is guided by a shoe holder and a barrel holder, which ensures that the piston slides smoothly along the swash plate.

There are housed a relief valve for relieving excessive pressure (cushion relief) and a check valve for preventing cavitation in the body H.

The mechanical brake, which consists of disc plates and steel plates, is installed between the cylinder barrel and the body S as a parking brake.

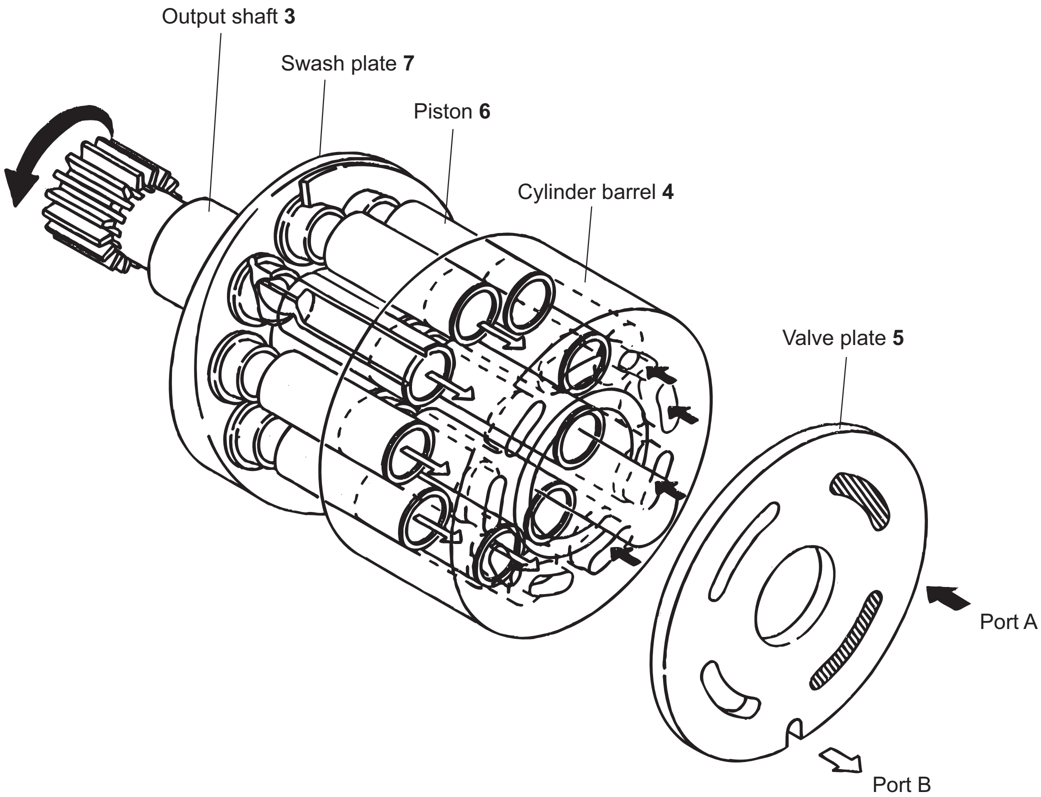


2. Theory of Operation

1) Hydraulic Motor

Hydraulic oil supplied from the pump through the control valve is fed to the valve plate **5** through the relief valve. When the hydraulic oil is supplied to the port **A**, the oil flows into the cylinder ports of the cylinder barrel **4** which correspond to the port **A**, and presses the piston **6**. The pressing force the piston receives from the hydraulic oil is converted into rotating force through the swash plate **7** and transmitted to the output shaft **3** splined to the cylinder barrel **4**.

The return oil from the cylinder ports flows out of the port **B** of the valve plate **5**. In the opposite rotation to the above, the hydraulic oil is taken in from the port **B** and the return oil flows out of the port **A**.

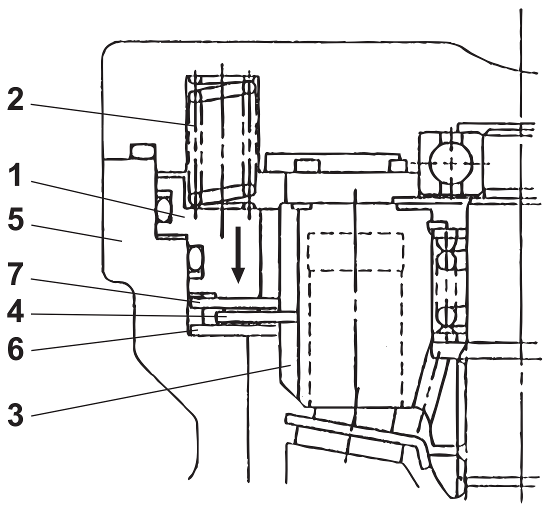


2) Mechanical Brake

The mechanical brake serves to mechanically lock the output shaft of the swing motor while the motor is stopped.

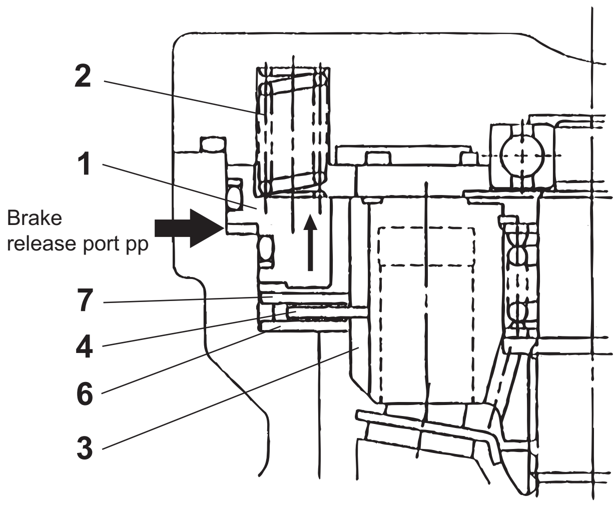
When the brake release pressure is in the OFF state, the brake piston **1** is kept pressed by the spring **2** in the arrowed direction in Fig. **A**. In this state, the disc plate **4** fixed to the cylinder barrel **3** by the semicircular groove is put between the steel plates **6** and **7** fixed to the body S **5** in the same way as the disc plate. Consequently, the frictional force between the disc plate **4** and the steel plates **6** and **7** disables the rotation of the cylinder barrel **3**, and therefore, the output shaft of the swing motor is locked. (See Fig. **A**.)

When the brake release pressure is turned ON, the hydraulic oil is led to the brake release port and the oil pressure which exceeds the force of the spring **2** moves the brake piston **1** in the arrowed direction in Fig. **B**. Consequently, the disc plate **4** and the steel plates **6** and **7** are disengaged and the frictional force between them is lost, and therefore, the cylinder barrel **3** can be rotated. (See Fig. **B**.)



Brake release pressure : OFF

(Fig. A)

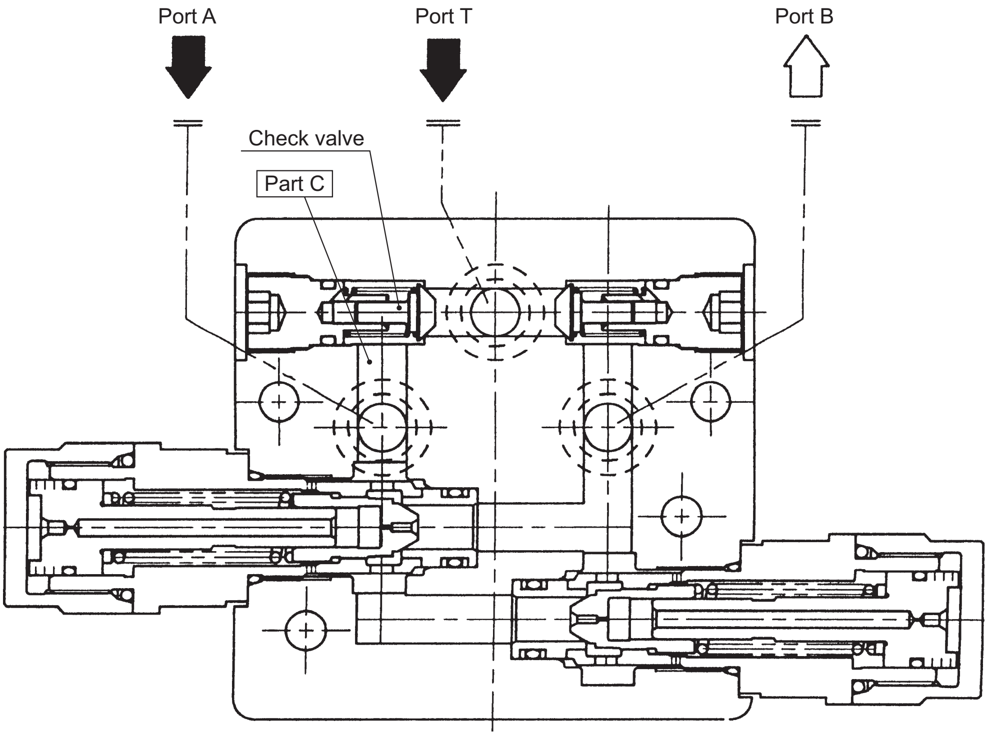


Brake release pressure : ON

(Fig. B)

3) Check Valve

When the swing unit is slowed down with the control lever after accelerated, the amount of the oil supplied from the pump to the port **A** is reduced. At this time, if the swing unit is rotating at a relatively high speed, the swing motor is swung from the swing unit, pumping begins, the pressure in the part **C** becomes negative, and it becomes necessary to feed oil. If the pressure at the port **B** is smaller than the working pressure of the relief valve, all of the oil that has flowed into the part **C** through the port **A** is discharged into the control valve through the port **B**. Thus the amount of the oil from the control valve is smaller than the amount needed for the part **C**. To prevent cavitation caused by such a shortage of oil in the part **C**, oil is supplied to the part **C** through the port **T** and the check valve from the hydraulic oil tank.



4) Relief Valve

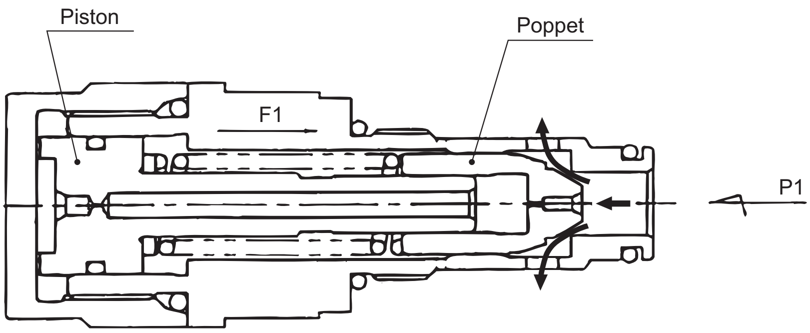
(1) Shockless relief valve

The shockless relief valve consists of a direct relief valve (poppet) and a piston for switching the spring force between two stages.

Even after the hydraulic motor is stopped and the IN and OUT ports of the motor are closed, the motor continues to rotate under its own inertia. This causes the motor pumping which develops pressure (brake pressure) at the OUT port. The shockless relief valve relieves the brake pressure through the following two stages, so that the shock at the motor stop is reduced and damage to the motor is also prevented. The relief valve also serves to reduce the shock at the motor start.

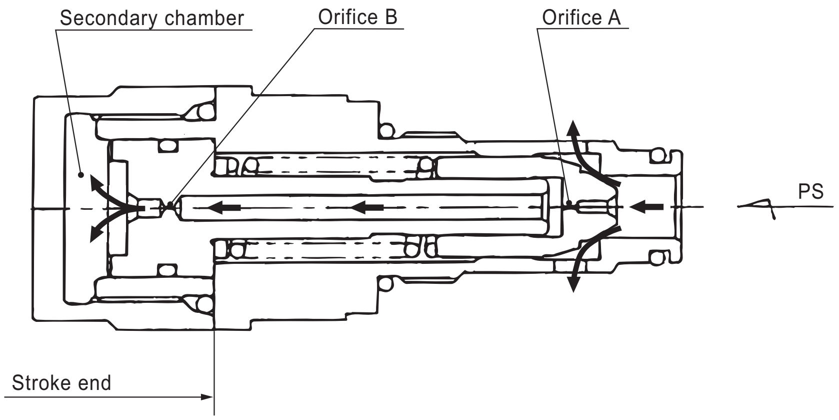
[1] First stage

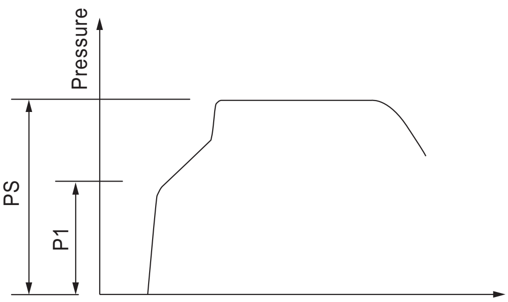
When the pressure P1 becomes high, the poppet is opened by the pressure equivalent to the spring force : F1.



[2] Second stage

The hydraulic oil having the pressure P1 flows into the secondary chamber through the orifices **A** and **B**, and the piston is moved to its stroke end. This increases the spring force, which in turn increases P1 to the set pressure : PS.

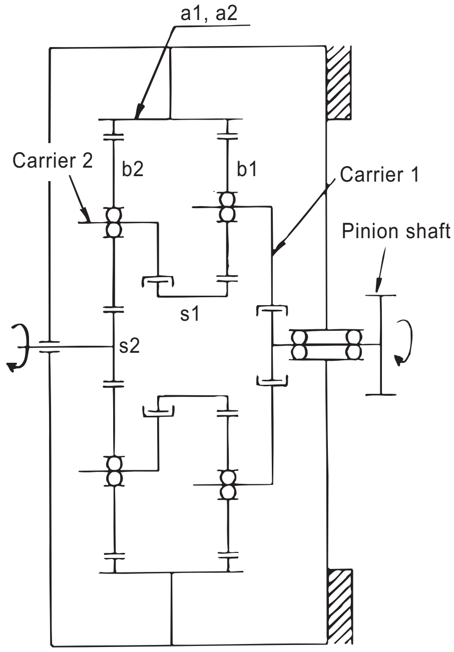


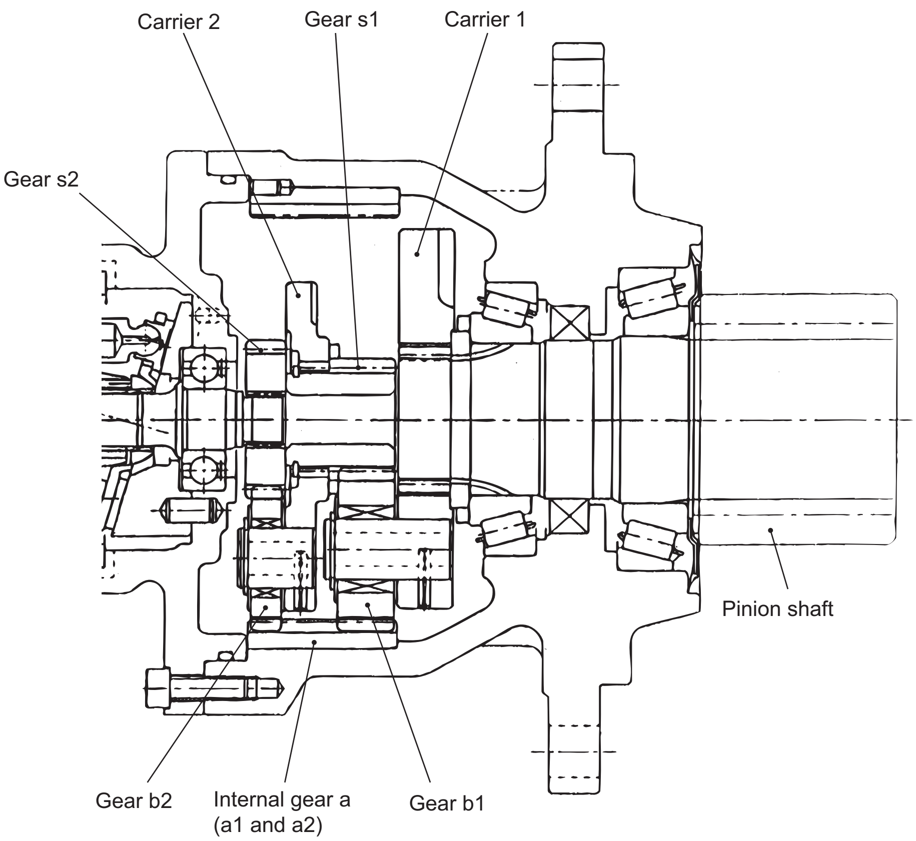


The shock at the motor start and stop is reduced through the above two stages.

3. Reduction Gear

The gear s2 is splined to the output shaft of the hydraulic motor, and the rotation of the gear s2 is reduced to the first level between the gears s2, b2 and a2. The one level-reduced rotation is transmitted to the gear s1 splined to the carrier 2 and reduced to the second level between the gears s1, b1 and a1. This rotation is transmitted to the pinion shaft splined to the carrier 1 as a driving force for swing.





4. Disassembly and Reassembly

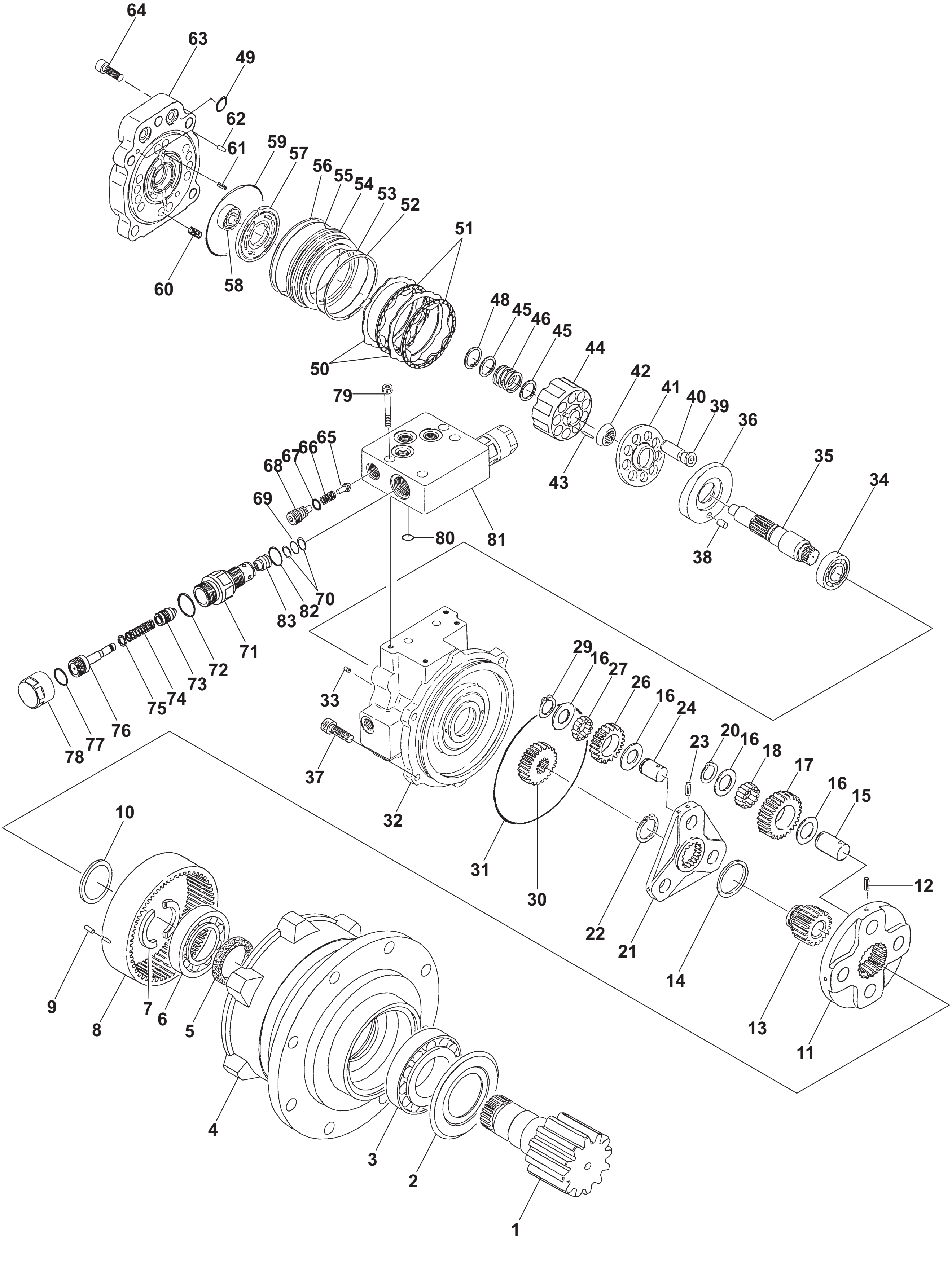
1) Precautions for Disassembly and Reassembly

(1) Since the parts of this hydraulic equipment are precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean area that is free from dust.
(2) Prepare clean tools and cleaning oil and handle the parts carefully.
(3) First clean the external surface of the removed assemblies.
(4) Before beginning disassembly, review the drawings of the internal construction and prepare the required parts according to the purpose and extent of the disassembly.
(5) After disassembly, replace the removed seals and O-rings with new ones in principle. As some replacement parts are available only as subassemblies, see the parts catalog to prepare the necessary subassemblies in advance.
(6) Handling O-rings
[1] Lubricate the O-rings and the O-ring fitting seats with clean grease or hydraulic oil.
[2] The O-rings may not be damaged in handling or distorted by heat.
[3] Do not permanently deform the O-rings.
[4] Avoid rolling the O-rings when fitting them.
A distorted O-ring may not return to its original shape, and therefore, may cause oil leak.

2) Tools for Disassembly and Reassembly

No.	Tools		Size
1	Torque wrench (preset type)	N·m	Nominal size : 90 Nominal size : 45
2	Torque wrench (preset type)	N·m	Nominal size : 180
3	Hexagon bar bit for the above wrench	mm	Width across flats : 6 Width across flats : 10
4	Hexagon bar bit for the above wrench	mm	Width across flats : 8
5	Torque wrench (for wrench)	N·m (kgf·m) mm	127.5 to 166.7 (13 to 17) Width across flats : 36
6	Hexagon bar wrench	mm	Width across flats : 6 Width across flats : 10
7	Hexagon bar wrench	mm	Width across flats : 8
8	Wrench	mm	Width across flats : 36
9	Screw driver	mm	Width : 6 to 10
10	Snap ring pliers	mm	Ø28 for internal snap ring
11	Snap ring pliers	mm	Ø20 and Ø30 for external snap ring
12	Hammer		
13	Plastic hammer		
14	Others		Grease Oil (specified hydraulic oil) Wire brush Sand paper Adhesive for screw (Three Bond #1305 or its equivalent)

3) Exploded View and Component Parts



No.	Parts	Q'ty	No.	Parts	Q'ty
1	Pinion shaft	1	44	Cylinder barrel	1
2	Ring	1	45	Retainer	2
3	Taper-roller bearing	1	46	Spring C	1
4	Main body	1	48	Internal snap ring	1
5	Oil seal	1	49	O-ring	2
6	Taper-roller bearing	1	50	Steel plate	2
7	Preload collar	2	51	Disc plate	2
8	Internal gear a	1	52	Backup ring	1
9	Dowel pin	4	53	O-ring	1
10	Ring	1	54	Brake piston	1
11	Carrier 1	1	55	O-ring	1
12	Spring pin	4	56	Backup ring	1
13	Gear S1	1	57	Valve plate	1
14	Thrust collar	1	58	Deep groove ball bearing	1
15	Pin b1	4	59	O-ring	1
16	Thrust washer	14	60	Spring B	12
17	Gear b1	4	61	Spring pin	1
18	Roller	68	62	Dowel pin	1
20	External snap ring	1	63	Body H	1
21	Carrier 2	1	64	Hexagon socket head bolt	4
22	External snap ring	1	65	Check valve	2
23	Spring pin	3	66	Spring	2
24	Pin b2	3	67	O-ring	2
26	Gear b2	3	68	Hexagon socket head plug	2
27	Roller	39	69	O-ring	2
29	External snap ring	3	70	O-ring	2
30	Gear S2	1	71	Retainer	2
31	O-ring	1	72	O-ring	2
32	Body S	1	73	Poppet	2
33	Filter	2	74	Spring	2
34	Deep groove ball bearing	1	75	Spacer	*
35	Shaft	1	76	Piston	2
36	Swash plate	1	77	O-ring	2
37	Hexagon socket head bolt	6	78	Cap	2
38	Dowel pin	1	79	Hexagon socket head bolt	4
39	Shoe	9	80	O-ring	2
40	Piston	9	81	Valve body	1
41	Shoe holder	1	82	O-ring	1
42	Barrel holder	1	83	Seat	1
43	Pin	3			

4) Disassembly

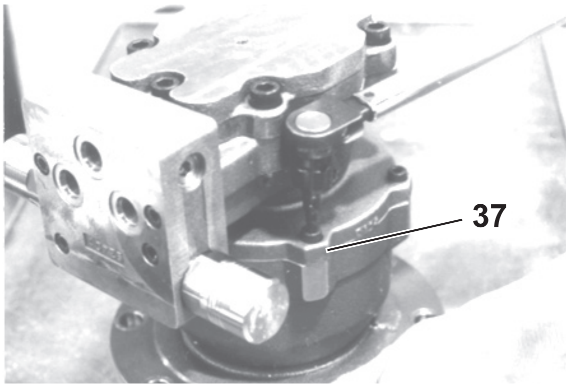
1. Hydraulic Motor [(1) - (13)]

Procedure

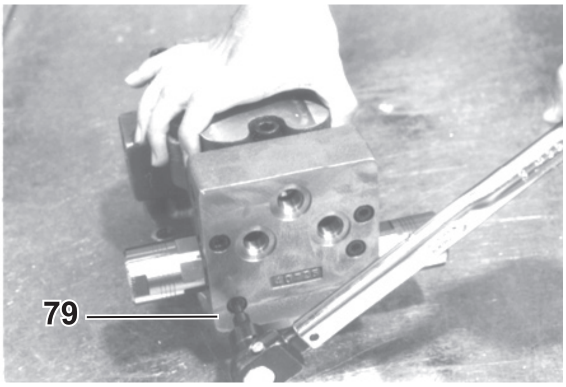
(1) Loosen hexagon socket head bolts **37** to remove hydraulic motor assembly from reduction gear body.

Tool : Hexagon bar bit : 0.236 in. (6 mm)

Notes :
- *Remove hydraulic motor assembly from reduction gear body with drain port opened.*
- *If hydraulic motor assembly cannot be removed from reduction gear body easily, insert screwdriver or the like into mating surfaces of assembly and body to remove it. If there are any fins created by the use of screwdriver, cut away all the fins.*



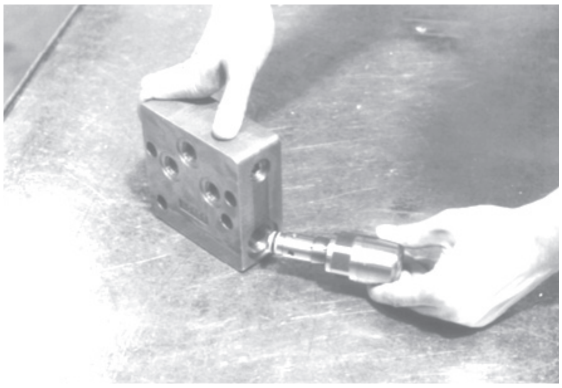
(2) Loosen hexagon socket head bolts **79** to remove hydraulic valve assembly.



(3) Remove relief valve assembly.

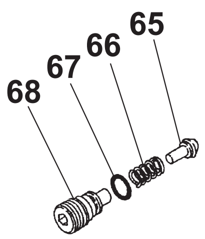
Tool : Wrench : 1.417 in. (36 mm)

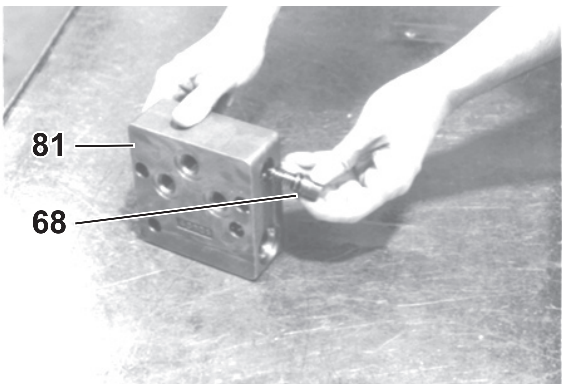
Note :
Do not disassemble relief valve assembly if not required.

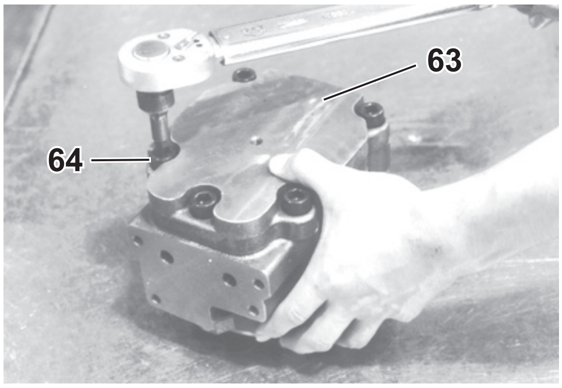
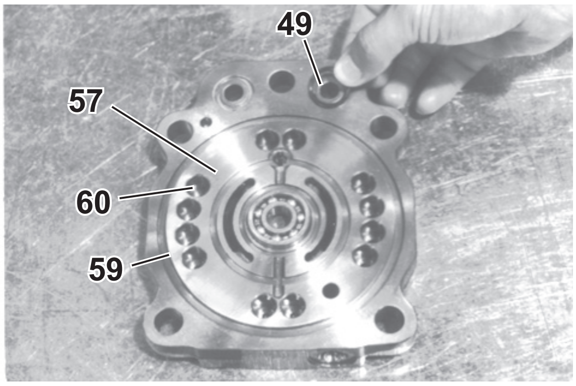
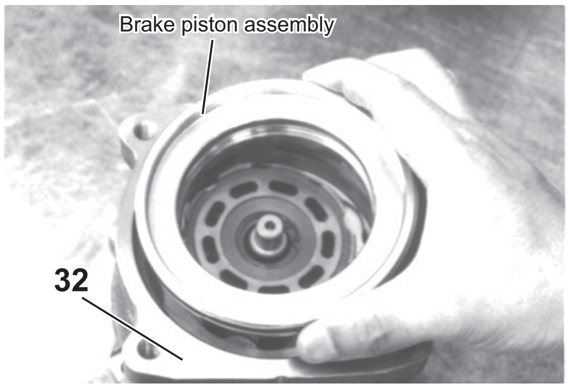
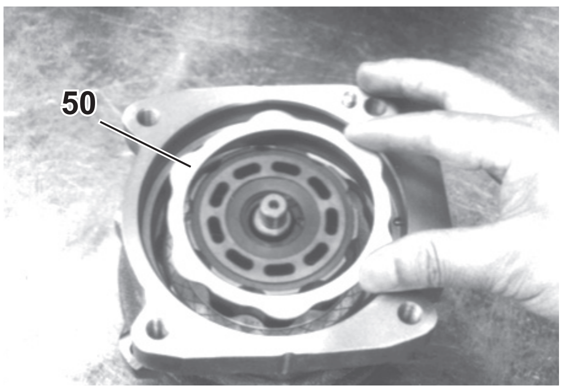


(4) Remove hexagon socket head plugs **68** to remove O-rings **67**, springs **66** and check valves **65**.

Tool : Hexagon bar bit : 0.315 in. (8 mm)



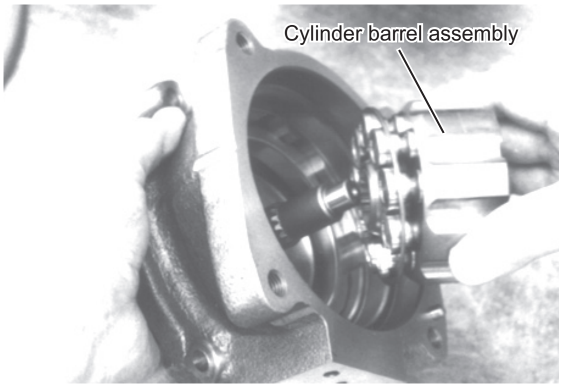


Procedure	
(5) Loosen hexagon socket head bolts **64** to remove body H **63**. Tool : Hexagon bar bit : 0.394 in. (10 mm) ***Note :*** *Take care that valve plate and springs do not drop.*	
(6) Remove valve plate **57**, springs **60** and O-ring **49** and **59**.	
(7) Remove brake piston assembly from body S **32** and then O-rings **53** and **55** and backup rings **52** and **56**. ***Notes :*** • *Brake piston can be pulled out by gradual air blow from port PP.* • *Blow air gradually to prevent brake piston from jumping out suddenly.*	
(8) Remove two steel plates **50** and two disc plates **51**.	

Procedure

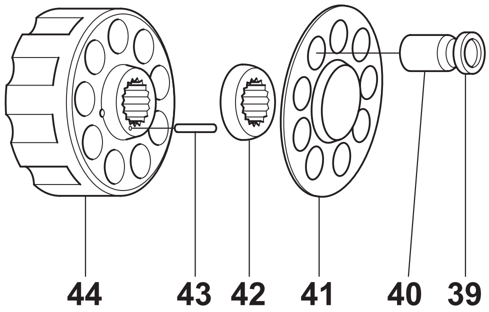
(9) Remove cylinder barrel assembly.

Note :
Take care not to lose small parts which are apt to be missing.

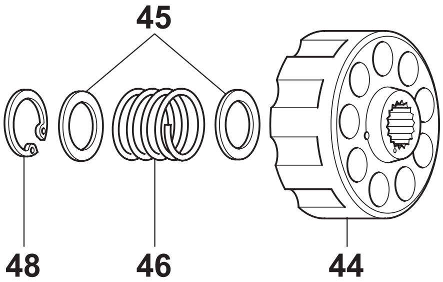


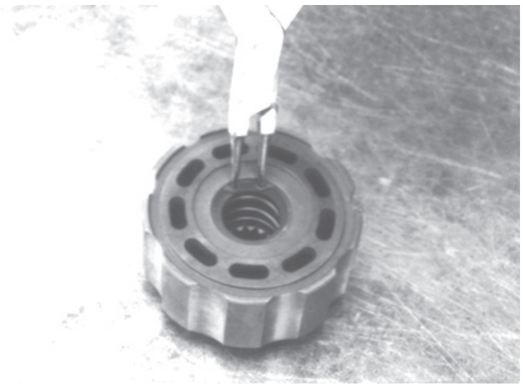
(10) Remove piston **40** and shoe **39** assemblies, shoe holder **41**, barrel holder **42** and three pins **43**.

Note :
Since piston and shoe are caulked, they cannot be disassembled.



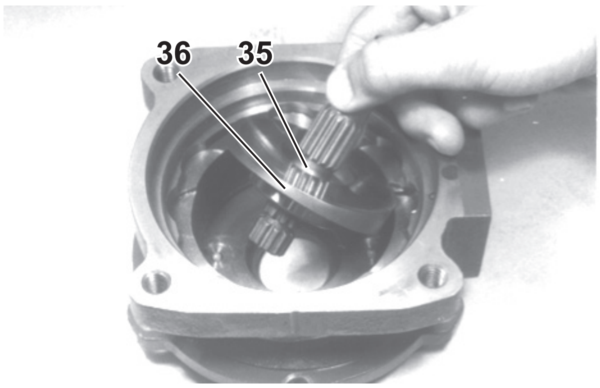
(11) Remove internal snap ring **48**, two retainers **45** and spring **46**.

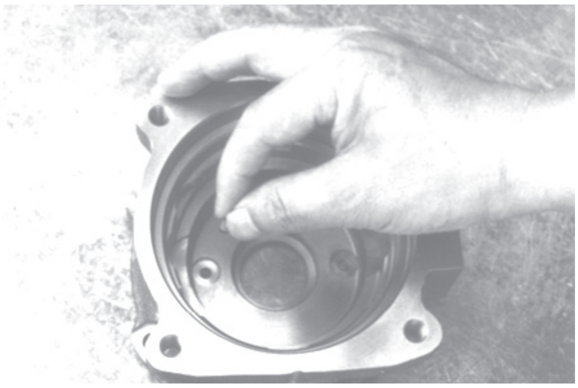




(12) Remove shaft **35** and swash plate **36**.

Notes :
- *If shaft cannot be taken off easily, tap shaft on the opposite end lightly with plastic hammer.*
- *Do not remove bearing press-fitted into shaft unless it needs to be replaced.*



<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(13) Remove two filters 33 and dowel pin 62.</td><td></td></tr>
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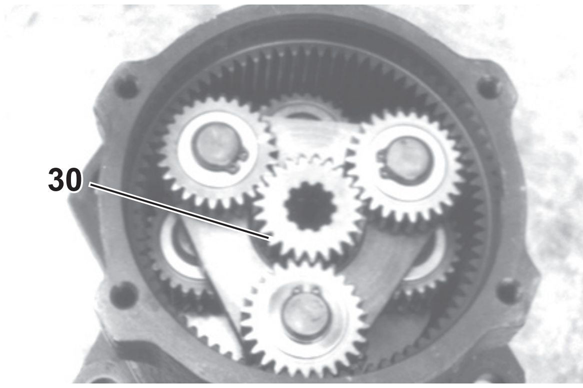
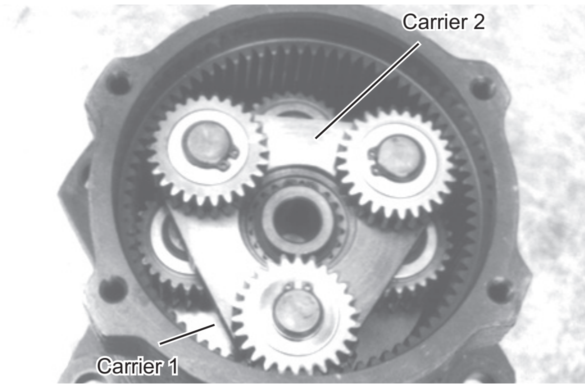
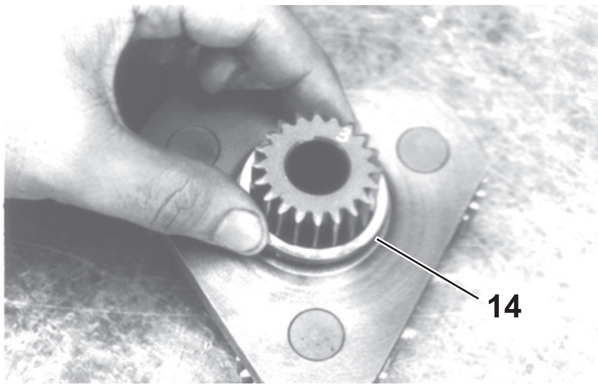
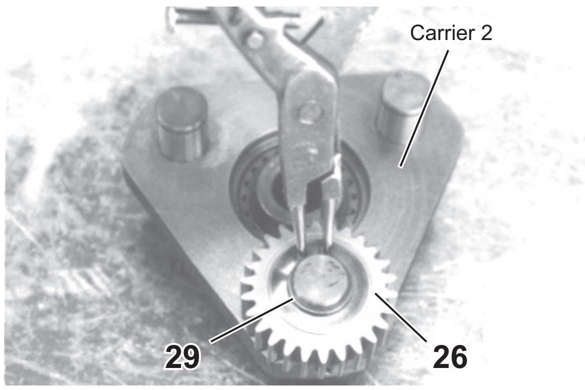
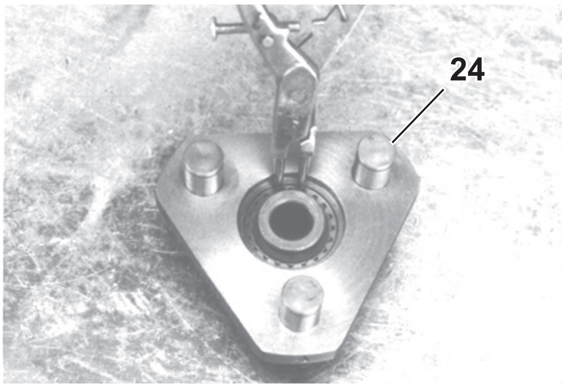
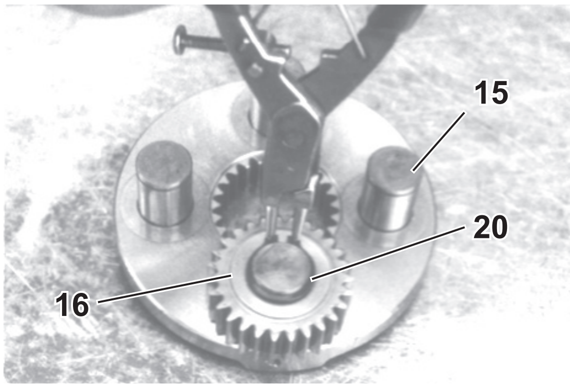
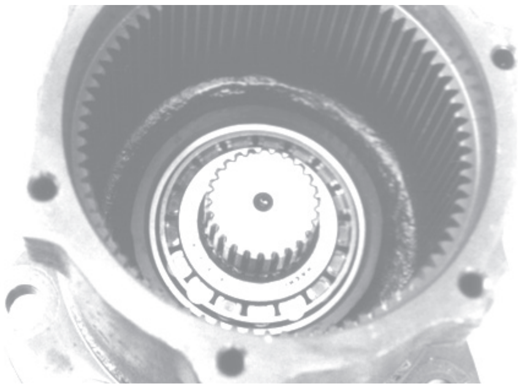
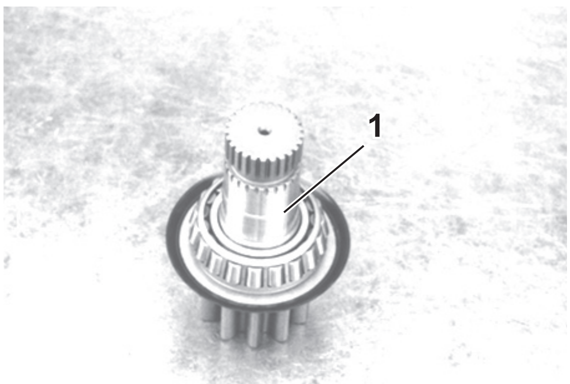
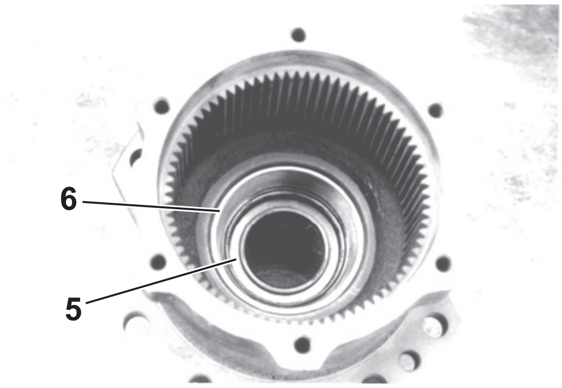
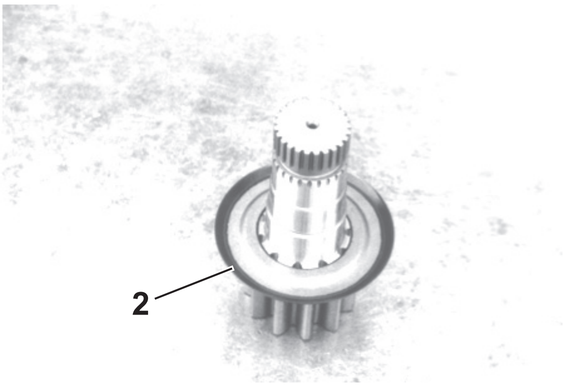
2. Reduction Gear [(14) - (23)]

Procedure	
(14) Remove gear s2 **30**.	
(15) Remove carrier 2 assembly and carrier 1 assembly.	
(16) Remove thrust collar **14**.	
(17) Remove external snap rings **29**, then thrust washers **16**, gears b2 **26** and rollers **27** from carrier 2 assembly. ***Note :*** *Number of rollers : 13 pcs. per gear b2*	

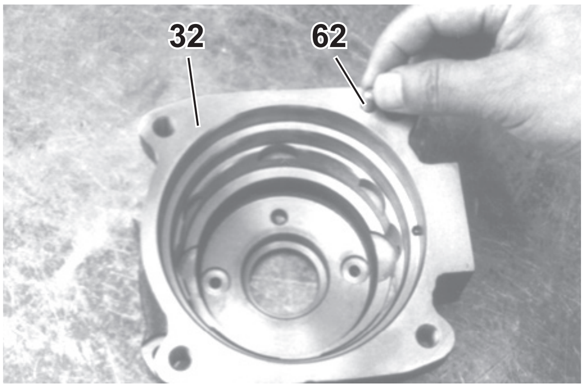
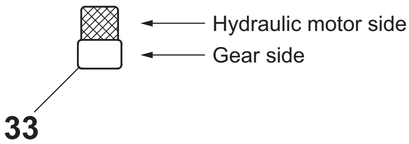
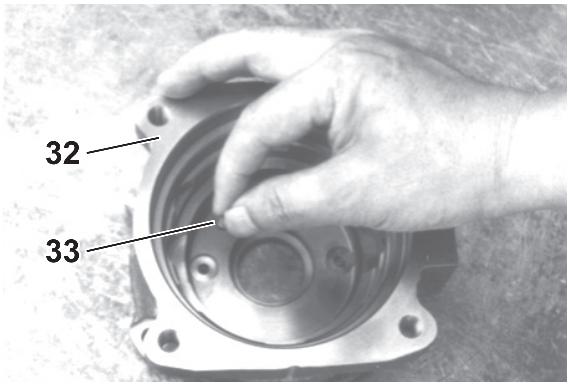
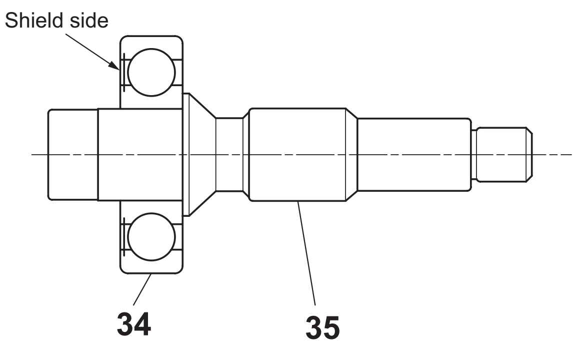
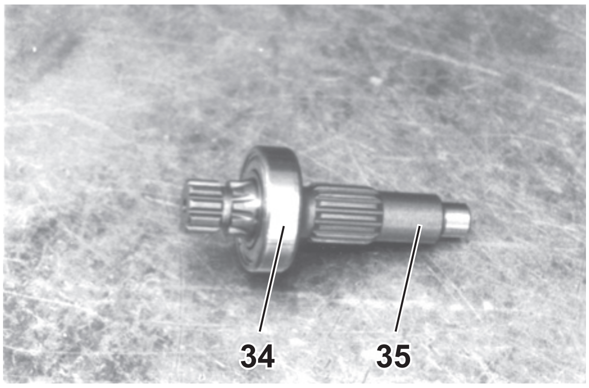
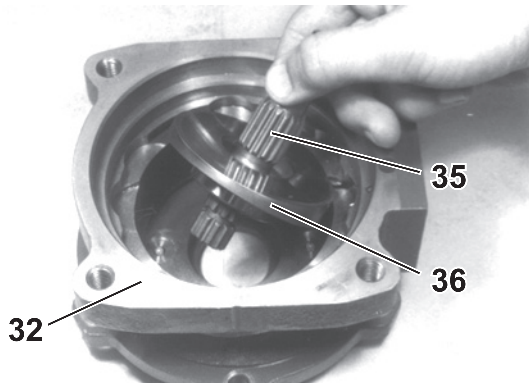
Procedure	
(18) Remove external snap ring **22** and then gear s1 **13**. ***Note :*** *Do not remove pins b2* ***24*** *press-fitted into assembly.*	
(19) Remove external snap rings **20**, then thrust washers **16,** gears b1 **17** and rollers **18** from carrier 1 assembly. ***Notes :*** • *Number of rollers :* ***17*** *pcs. per gear b1* • *Do not remove pins b1* ***15*** *press-fitted into carrier 1.*	
(20) Remove ring **10** and two preload collars **7**. ***Notes :*** • *Put top end of screw driver between the two preload collars and tap screw driver on the head with hammer to remove the collars.* • *Do not remove these parts because of adjusted clearances between them and bearing if not required.*	
(21) Remove pinion shaft **1**. ***Note :*** • *Press pinion shaft at the end with press by using pad (about 5.91 in. (150 mm) in length) to secure a space for removing pinion shaft.*	

Procedure	
(22) Remove outer races of taper-roller bearings **3** and **6**, and oil seal **5**. ***Notes :*** • *Do not remove outer races of bearings because of its difficulty if not required.* • *Replace removed oil seal with a new one.*	

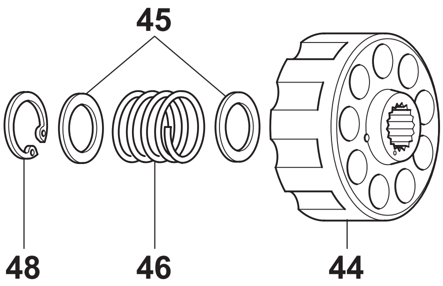
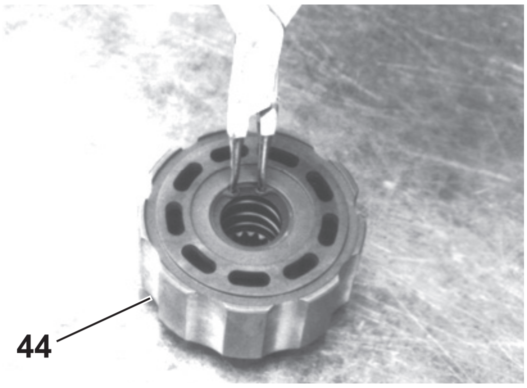
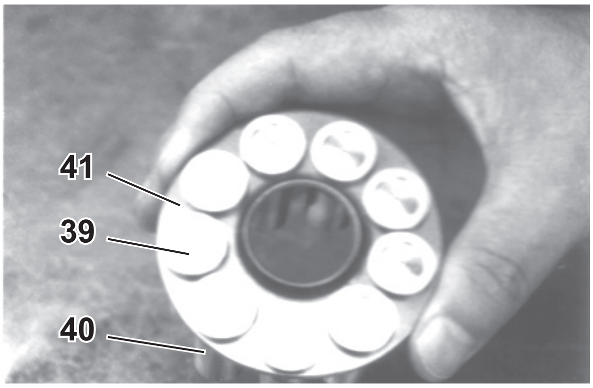
(23) Remove inner race of taper-roller bearing **3** and ring **2**. ***Notes :*** • *Do not remove inner race press-fitted to pinion shaft if not required.* • *Replace removed ring with a new one.*	

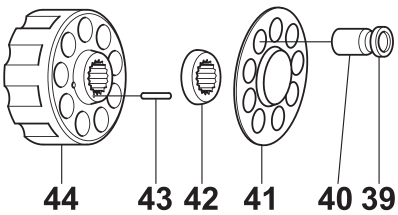
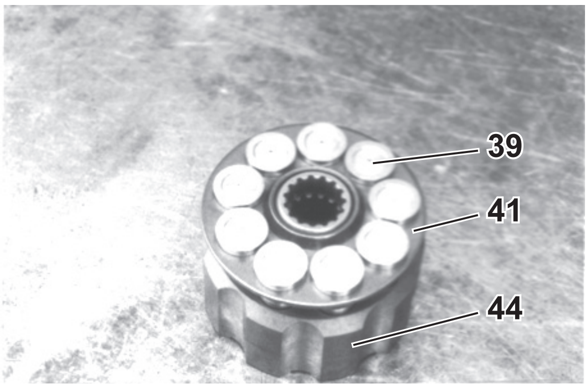
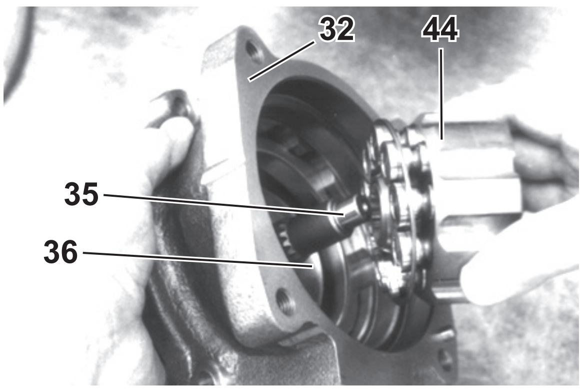
5) Reassembly

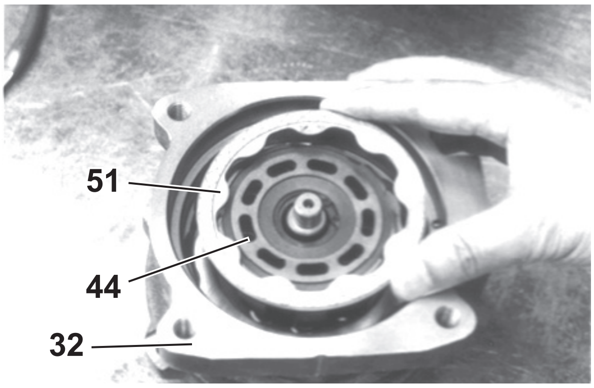
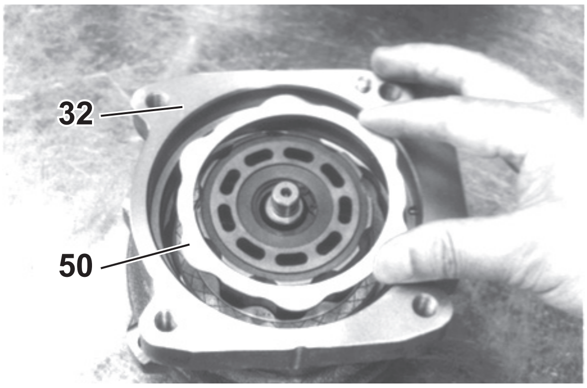
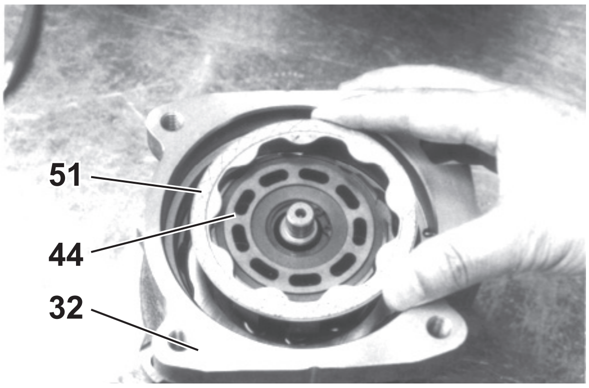
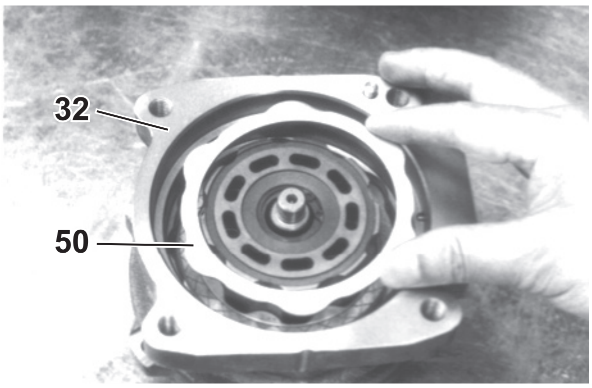
1. Hydraulic Motor [(1) - (24)]

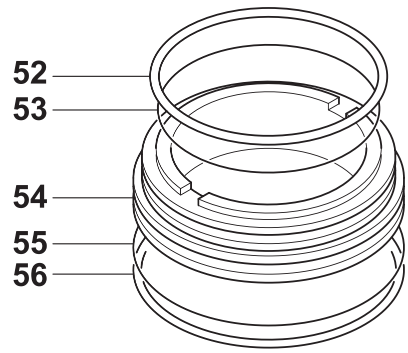
Procedure	
(1) Knock dowel pin **62** into body S **32**.	
(2) Install two filters **33** into body S **32**. ***Note :*** *The installing direction of filters **33** is shown below.* 	
(3) Press-fit deep groove ball bearing **34** onto shaft **35**. 	
(4) Set swash plate **36** on shaft **35** and install it in body S **32**. ***Note :*** *Set pin of swash plate in hole of body S **32**.*	

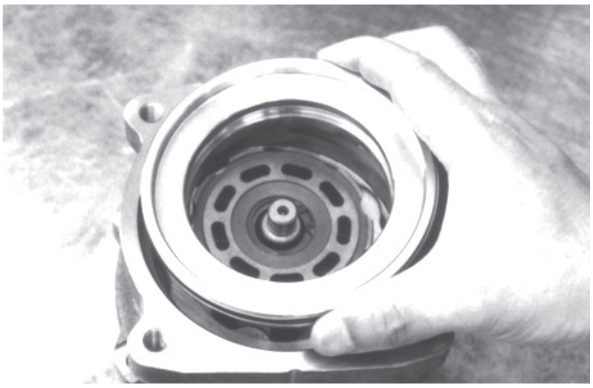
<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(5) Install two retainers **45** and spring **46** into cylinder barrel **44**, and fix them with internal snap ring **48**.

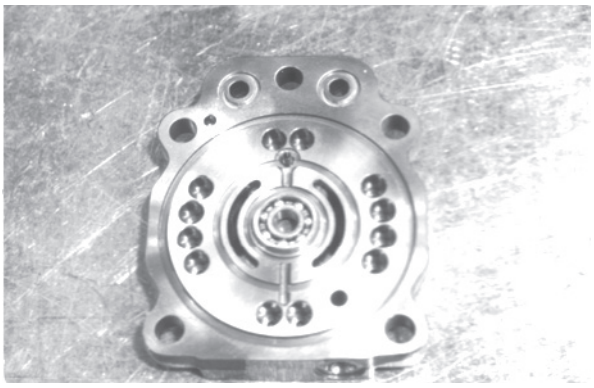

</td><td>
</td></tr>
<tr><td>(6) Install piston **40** and shoe assemblies **39** on shoe holder **41** to assemble shoe holder assembly.</td><td>
</td></tr>
<tr><td>(7) Insert three pins **43** into cylinder barrel **44** and install shoe holder assembly and barrel holder **42** to assemble cylinder barrel assembly.

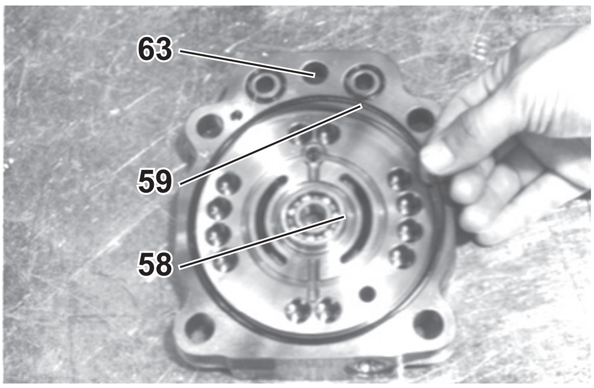

</td><td>
</td></tr>
<tr><td>(8) Install cylinder barrel assembly into body S **32** with shaft **35** put through cylinder barrel assembly until shoes **39** reach swash plate **36**.</td><td>
</td></tr>
</table>

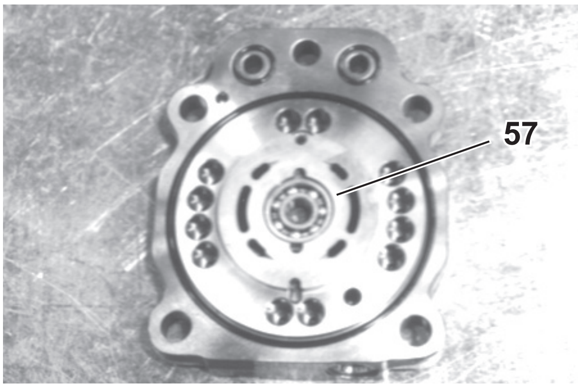
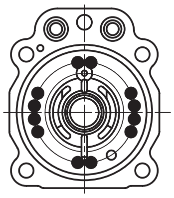
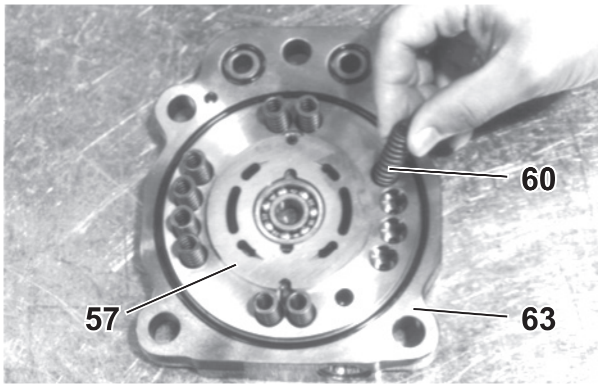
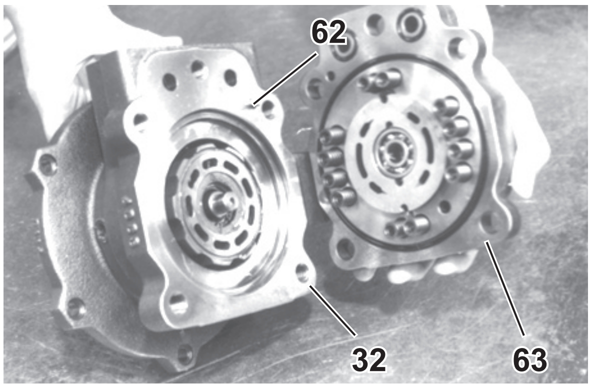
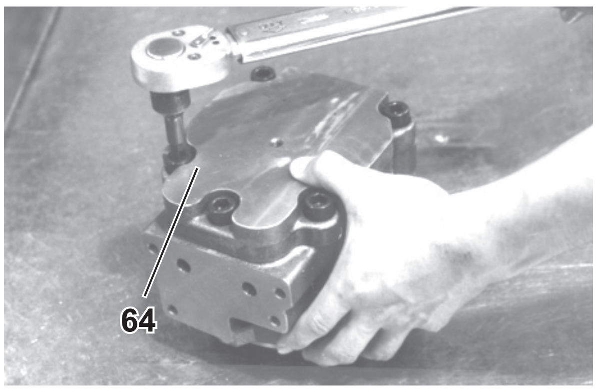
Procedure	
(9) Install one of disc plates **51** in groove of cylinder barrel **44**.	
(10) Install one of steel plates **50** in groove of body S **32**.	
(11) Install the other disc plate **51** in groove of cylinder barrel **44**.	
(12) Install the other steel plate **50** in groove of body S **32**.	

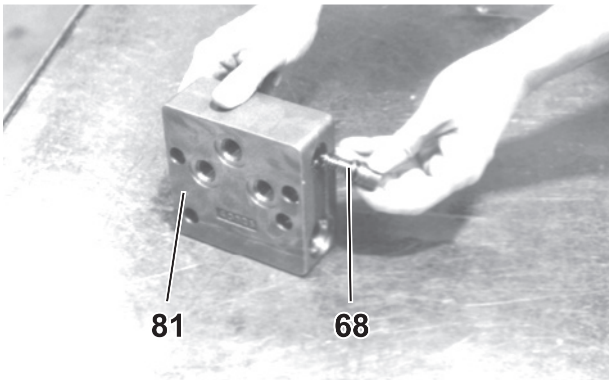
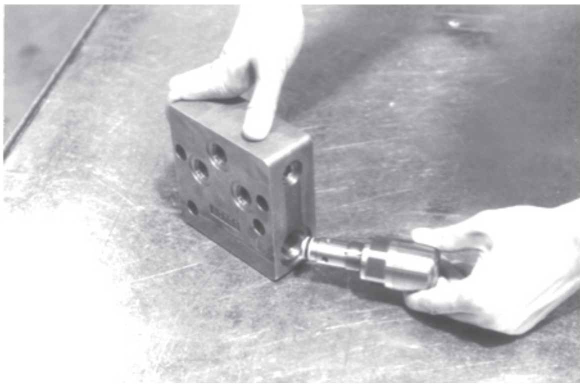
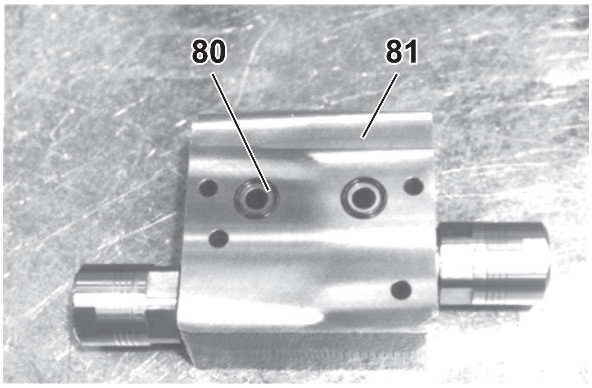
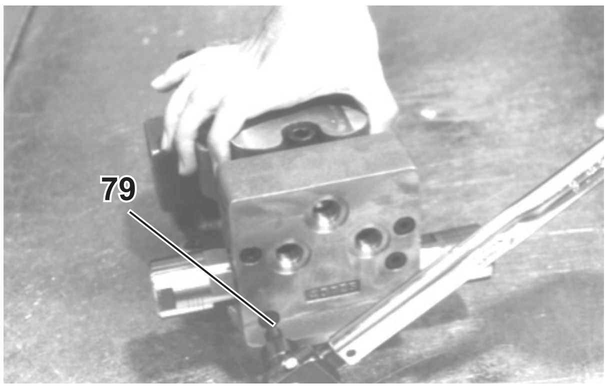
Procedure	
(13) Install O-rings **53** and **55**, backup rings **52** and **56** onto brake piston **54** to assemble brake piston assembly.	

(14) Install brake piston assembly into body S **32**. ***Note :*** *Apply grease to O-rings thinly and take care not to get them caught between brake piston and body S.*	

(15) Install spring pin **61** and deep groove ball bearing **58** into body H **63**.	

(16) Install O-ring S **49** and **59** on body H **63**.	

Procedure	
(17) Install valve plate **57** on body H **63**. ***Notes :*** • *Set lining surface of valve plate to cylinder barrel side.* • *Apply grease thinly to body H **63** side of valve plate in advance to prevent valve plate **57** from dropping when body H is combined with body S.*	
(18) Install twelve springs B **60** into holes in body H **63**. ***Note :*** • *Apply grease to both fitting areas of each spring to prevent them from falling out in installation.* 	
(19) Combine body S **32** with body H **63**. ***Notes :*** • *Apply hydraulic oil to sliding surface of valve plate facing cylinder barrel.* • *Set hole in the body H to pin **62** in the body S.* • *Take care not to drop or bend any springs.*	
(20) Tighten hexagon socket head bolts **64**. Tool : Hexagon bar bit : 0.394 in. (10 mm) Tightening torque : 65.1 to 83.2 ft･lbf (88.3 to 112.8 N･m)	

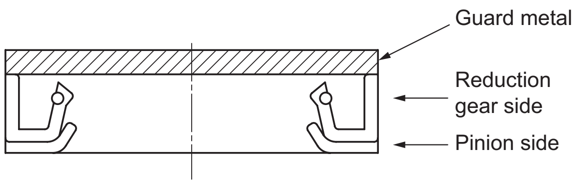
Procedure	
(21) Install O-rings **67** into hexagon socket head plugs **68**, and then install springs 66 and check valves **65**. Insert both of them into valve body **81** and screw them. Tool : Hexagon bar bit : 0.315 in. (8 mm) Tightening torque : 41.2 to 45.6 ft·lbf (55.9 to 61.8 N·m)	
(22) nstall relief valve assembly into valve body **81** to assemble hydraulic valve assembly. Tool : Wrench : 1.417 in. (36 mm) Relief valve assembly tightening torque : 94.0 to 123.0 ft·lbf (127.5 to 166.7 N·m)	
(23) Install O-rings **80** into hydraulic valve assembly.	
(24) Fasten hydraulic valve assembly with hexagon socket head bolts **79**. Tool : Hexagon bar bit : 0.236 in. (6 mm) Tightening torque : 18.8 to 23.9 ft·lbf (25.5 to 32.4 N·m)	

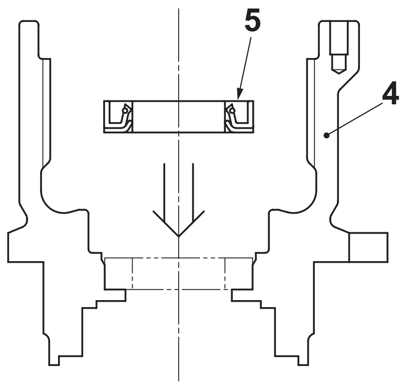
2. Reduction Gear [(25) - (48)]

Procedure

(25) Press-fit oil seal **5** into main body **4**.

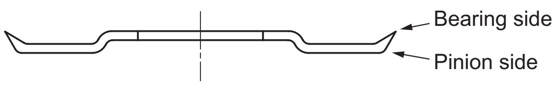
Note :
Install oil seal in the correct direction and by using guard metal to prevent oil seal from slanting.
(Outer diameter of guard metal : Ø2.93 in. (Ø74.5 mm)

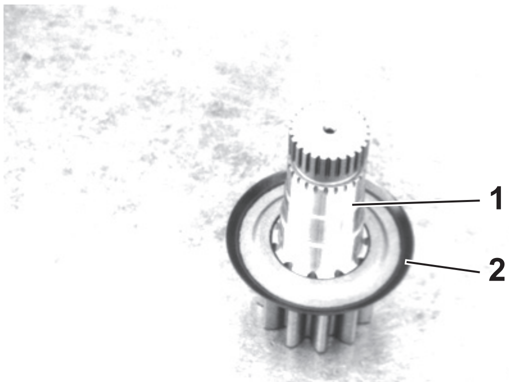




(26) Install ring **2** onto pinion shaft **1**.

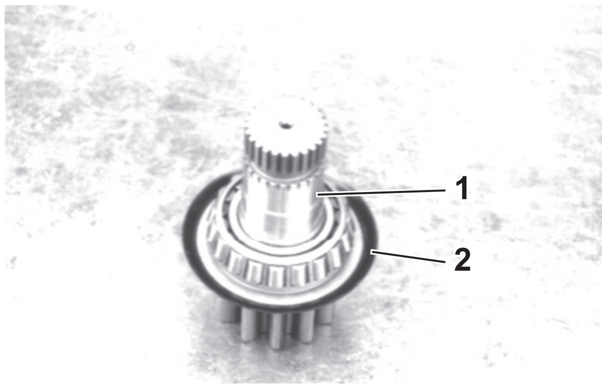
Note :
The installing direction of ring is shown below.



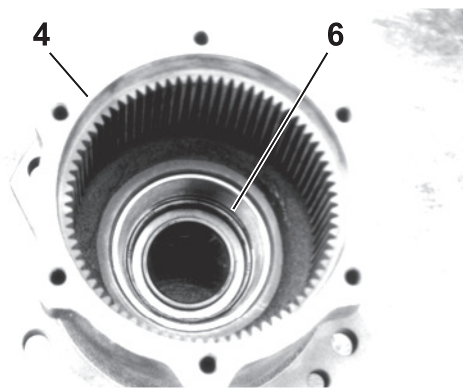


(27) Press-fit inner race of taper-roller bearing **3** onto pinion shaft **1**.

Note :
After press-fitting, apply grease to surfaces of rollers of bearing and rotate rollers to spread grease on whole areas of rollers.

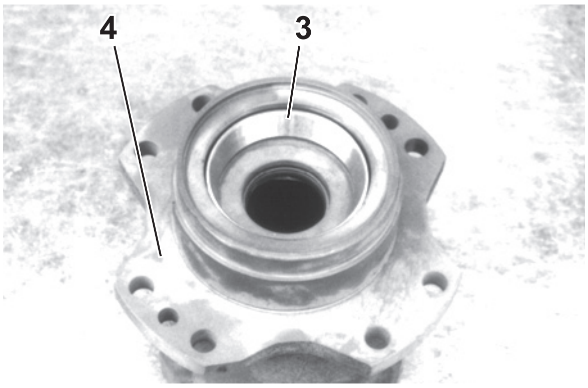


(28) Press-fit outer race of taper-roller bearing **6** into main body **4**.

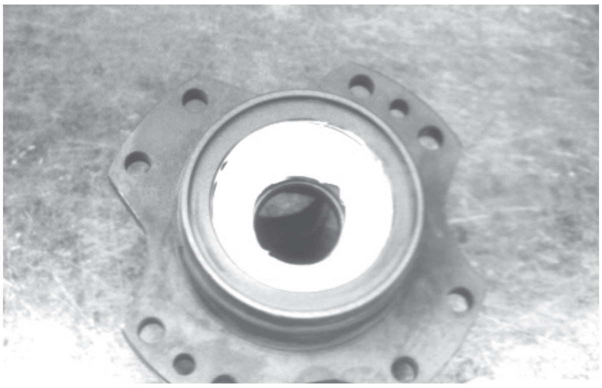


Procedure

(29) Press-fit outer race of taper-roller bearing **3** into main body **4**.

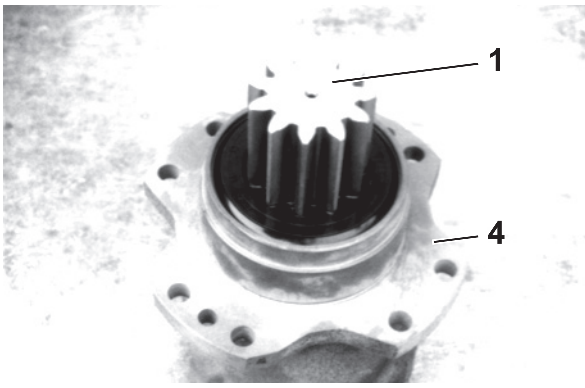


(30) Fill 80% of installation groove for taper-roller bearing **3** on main body **4** with grease.

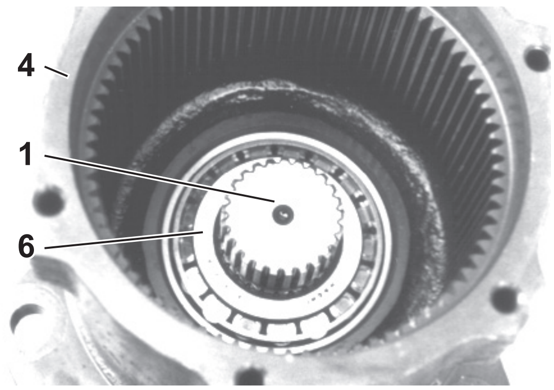


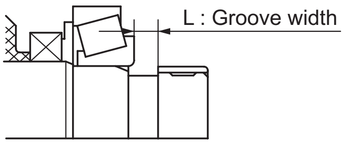
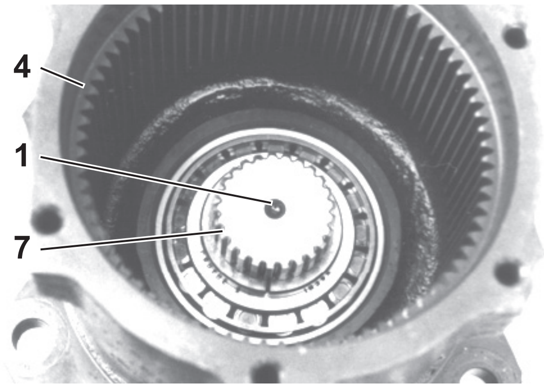
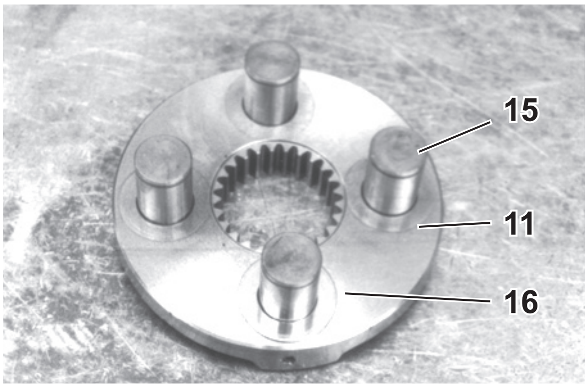
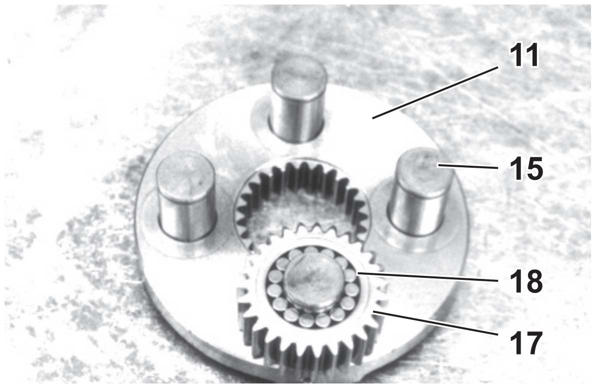
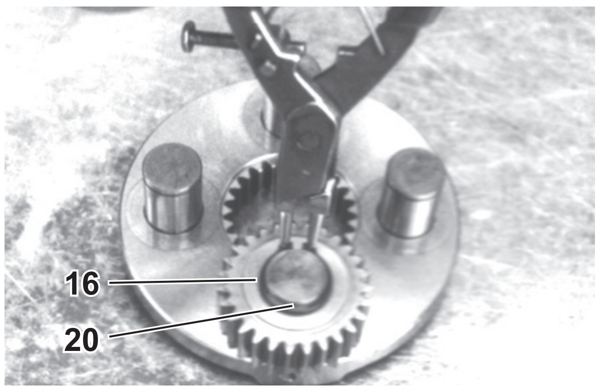
(31) Install pinion shaft **1** into main body **4**.

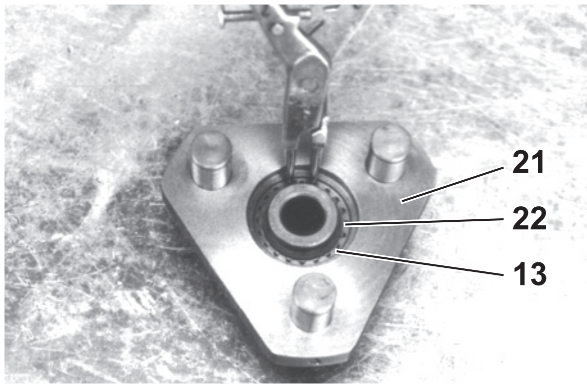
Note :
Take care not to damage lip of oil seal.

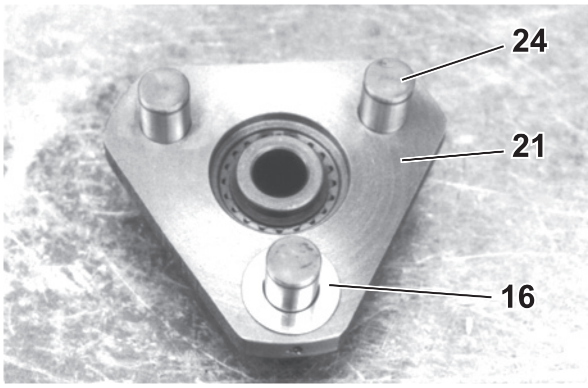


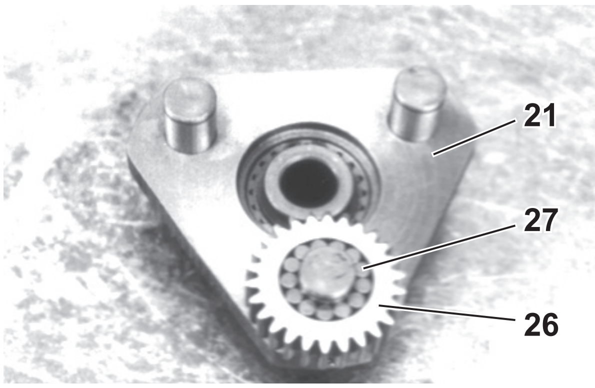
(32) Turn main body **4** upside down to press-fit inner race of taper-roller bearing **6** into it.

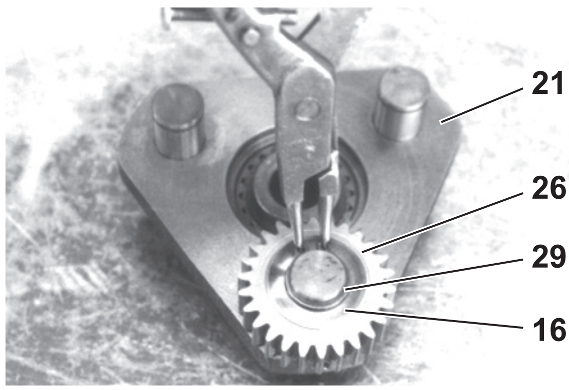


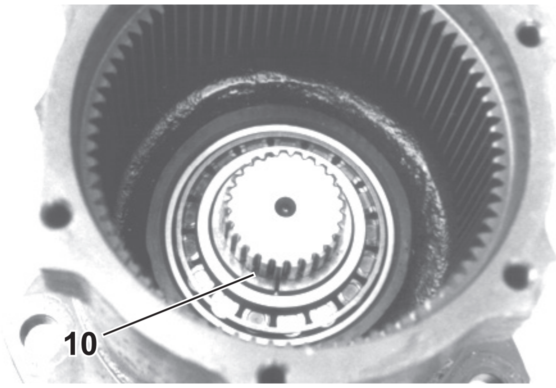
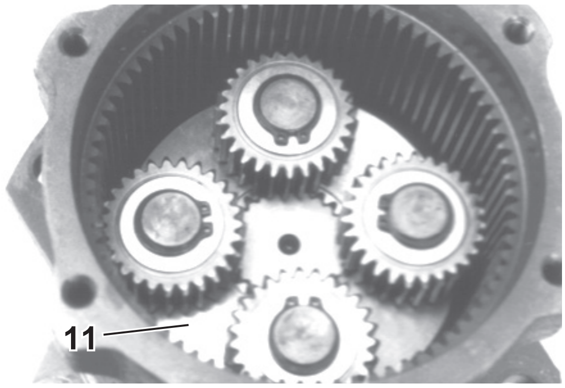
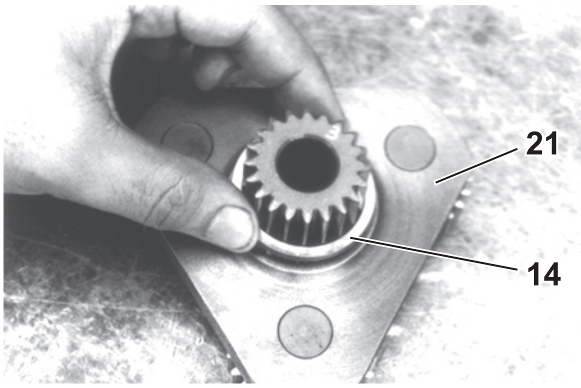
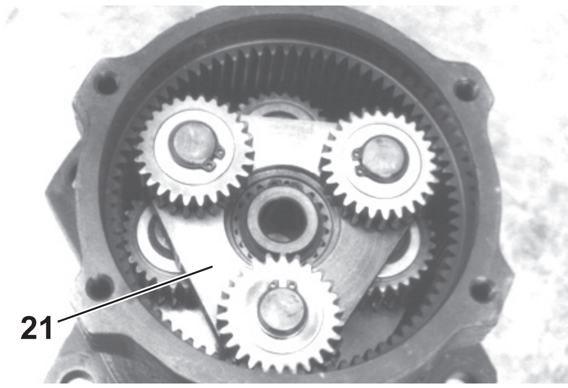
Procedure	
(33) Install two preload collars **7**. ***Note :*** *The thickness of preload collar should be 0 to +0.00197 in. (0 to +0.05 mm) larger than groove width : L between end face of taper-roller bearing and that of pinion shaft.* 	
(34) Install thrust washers **16** onto pins b1 **15** of carrier 1 **11**.	
(35) Install gears b1 **17** and insert rollers **18** between pins b1 and gears b1. ***Note :*** *Number of rollers : 17 pcs. per gear b1*	
(36) Install thrust washers **16** and then external snap rings **20** to assemble carrier 1 assembly.	

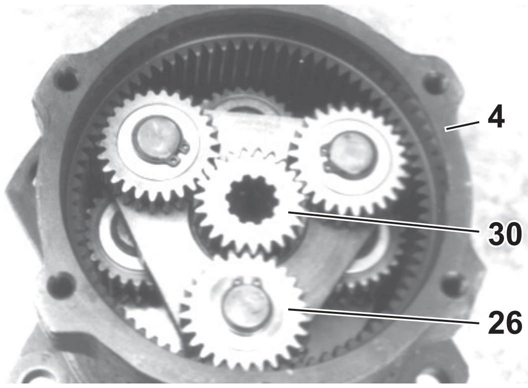
Procedure	
(37) Install gear s1 **13** on carrier 2 **21** and fix it with external snap ring **22**.	

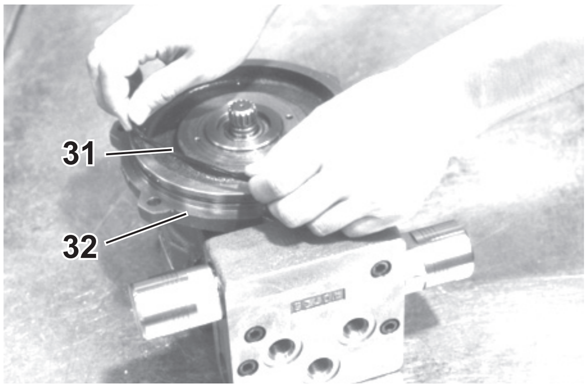
(38) Install thrust washers **16** onto pins b2 **24** of carrier 2 **21**.	

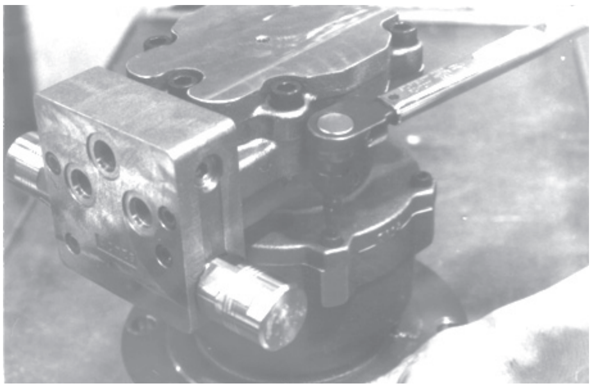
(39) Install gears b2 **26** and insert rollers **27** between pins b2 and gears b2. ***Note :*** *Number of rollers : 13 pcs. per gear b2*	

(40) Install thrust washers **16** and then external snap rings **29** to assemble carrier 2 assembly.	

Procedure	
(41) Install ring **10**.	
(42) Install carrier 1 assembly.	
(43) Install thrust collar **14** on carrier 2 assembly.	
(44) Install carrier 2 assembly. ***Note :*** *Take care that thrust collar does not come off.*	

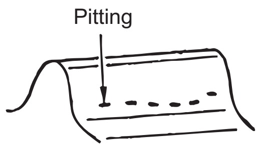
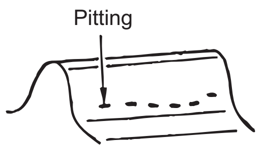
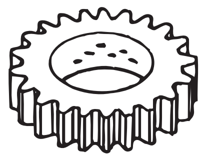
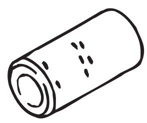
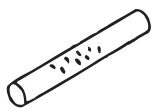
Procedure	
(45) Install gear s2 **30** at the center of carrier 2 assembly in main body **4**. (46) Pour hydraulic oil into main body **4**. ***Notes :*** • *Oil type : ISO VG46 or its equivalent* • *Oil quantity : Supplied oil level should be higher than the center of tooth width of gear b2* ***26*** *but lower than upper surface of gear b2* ***26****.*	

(47) Install O-ring **31** onto engaged area of hydraulic motor. ***Note :*** *Apply grease to O-ring thinly.*	

(48) Install hydraulic motor on reduction gear body and tighten hexagon socket head bolts **37**. Tool : Hexagon bar bit : 0.236 in. (6 mm) ***Notes:*** • *Insert shaft of hydraulic motor into spline hole of gear S2.* • *Apply Three Bond 1305 or its equivalent to hexagon socket head bolts.* • *Hexagon socket head bolt tightening torque : 19.5 to 23.9 ft·lbf (26.5 to 32.4 N·m)*	

6) Service Standards

(1) Reduction gear

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

(2) Hydraulic motor

No.	Parts	Inspection item	Inspection standard	Remedy
1	Shaft	Wear of spline	Wear : 25 μm or more	Replace hydraulic motor assembly.
2	Cylinder barrel	Wear of surface contacted with valve plate	Wear : 20 μm or more	Replace cylinder barrel kit.
3	Valve plate	Wear of surface contacted with cylinder barrel	Wear : 20 μm or more	Replace cylinder barrel kit.
4	Piston and shoe	Caulked area of shoe	Looseness : 0.3 mm or more	Replace cylinder barrel kit.
5	Swash plate	Wear of sliding surface of shoe	Wear : 0.1 mm or more	Replace swash plate kit.
6	Others (Screws, bolts, O-rings, etc.)	Damage and excessive rust		Replace part.

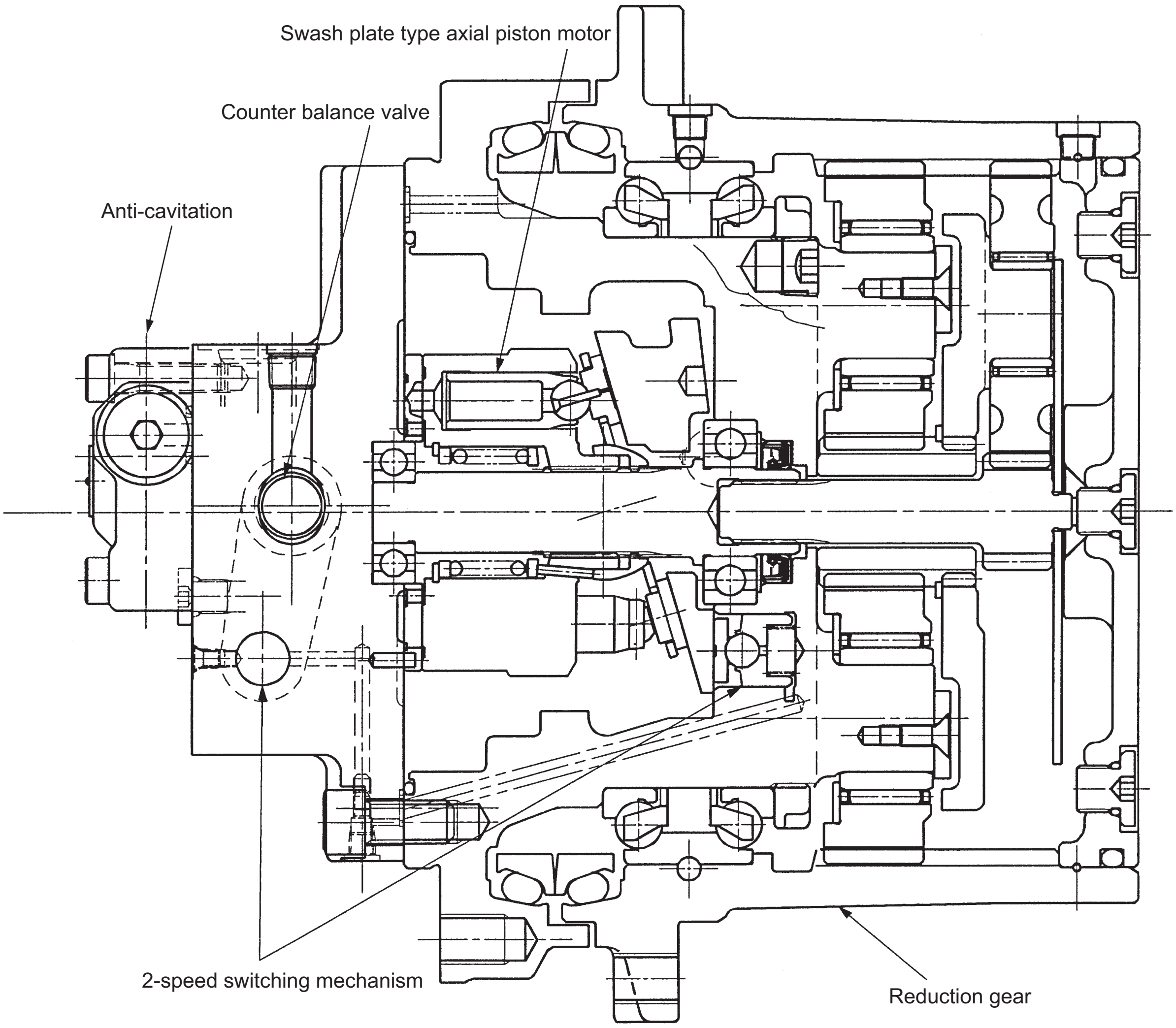
7) Troubleshooting

Phenomenon	Cause		Remedy
1. Does not start. (Oil pressure is normal.)	(1) Relief valve	Low set pressure	Replace relief valve assembly
		Malfunction	
	(2) Hydraulic motor	Seizure of sliding area	Replace hydraulic motor assembly.
		Internal oil leak	
	(3) Reduction gear	Damaged gear	Replace reduction gear assembly.
	(4) Over load		Reduce load.
2. Insufficient torque (Oil pressure is normal.)	(1) Relief valve	Low set pressure	Replace relief valve assembly
		Malfunction	
	(2) Hydraulic motor	Worn sliding area	Replace hydraulic motor assembly.
		Internal oil leak	
	(3) Reduction gear	Damaged gear	Replace pinion kit and carrier kit.
		Damaged bearing	
3. Abnormal sound	(1) Cavitation sound	Insufficient oil flow	Adjust piping.
	(2) Hydraulic motor	Damaged sliding part	Replace hydraulic motor assembly.
	(3) Reduction gear	Damaged gear	Replace pinion kit and carrier kit.
		Damaged bearing	
	(4) Pinion	Damaged tooth surface	Replace pinion kit.
4. Oil leak	(1) Mating surface of hydraulic motor	Damaged O-ring	Replace O-ring.
		Loosened screw	Tighten screw.
	(2) Mating surface of reduction gear	Damaged O-ring	Replace O-ring.
		Loosened screw	Tighten screw.
	(3) Pinion	Damaged oil seal	Replace pinion kit.
5. Delay in start or stop	(1) Relief valve	Malfunction	Replace relief valve assembly.
	(2) Check valve	Internal oil leak	Replace body H kit.
6. Abnormal heating	(1) Hydraulic motor	Damage or seizure of sliding area	Replace hydraulic motor assembly.
	(2) Reduction gear	Defective teeth	Replace pinion kit and carrier kit.
		Defective bearing	

6-5 Travel Motor

1. Structure

The travel motor consists of a swash plate type axial piston motor, a counter balance valve, an anti-cavitation valve, a 2-speed switching mechanism and a reduction gear.
The swash plate type axial piston motor has 9 pistons and a 2-speed (low and high) switching mechanism.
The counter balance valve and the anti-cavitation valve are integrated with the piston motor which is housed in the reduction gear.
The reduction gear reduces the output speed of the piston motor through the planetary double-reduction mechanism and increases the output torque to transmit it to the sprocket.

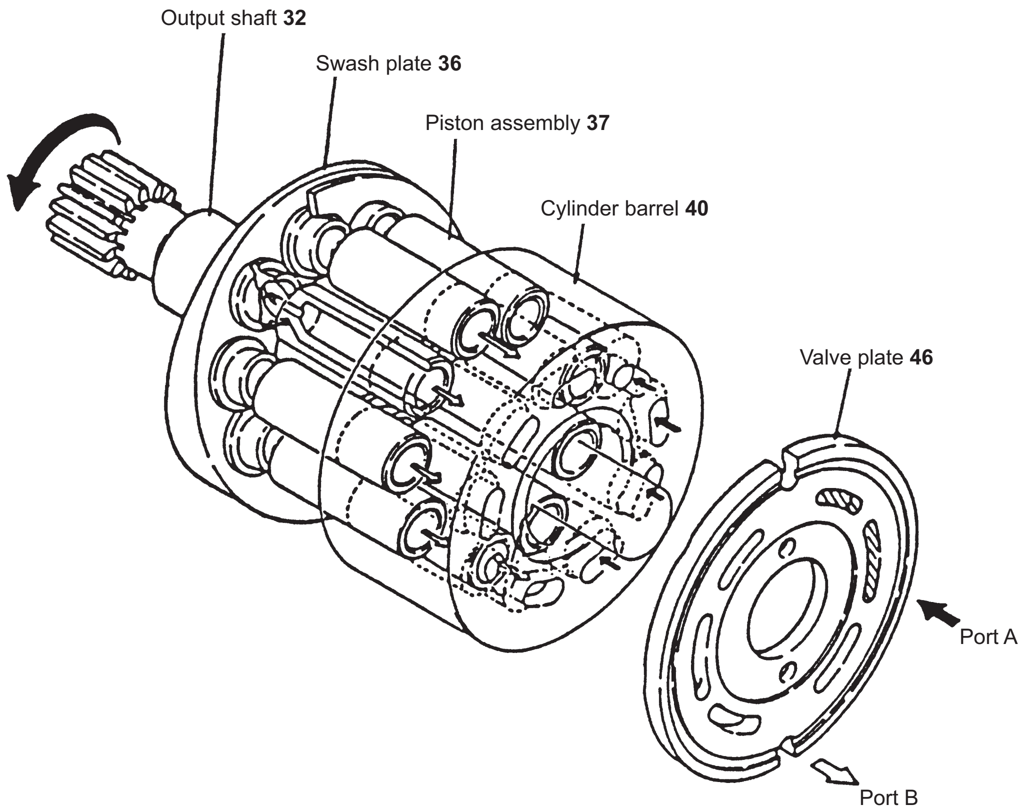


Structure of travel motor

2. Theory of Operation

1) Motor

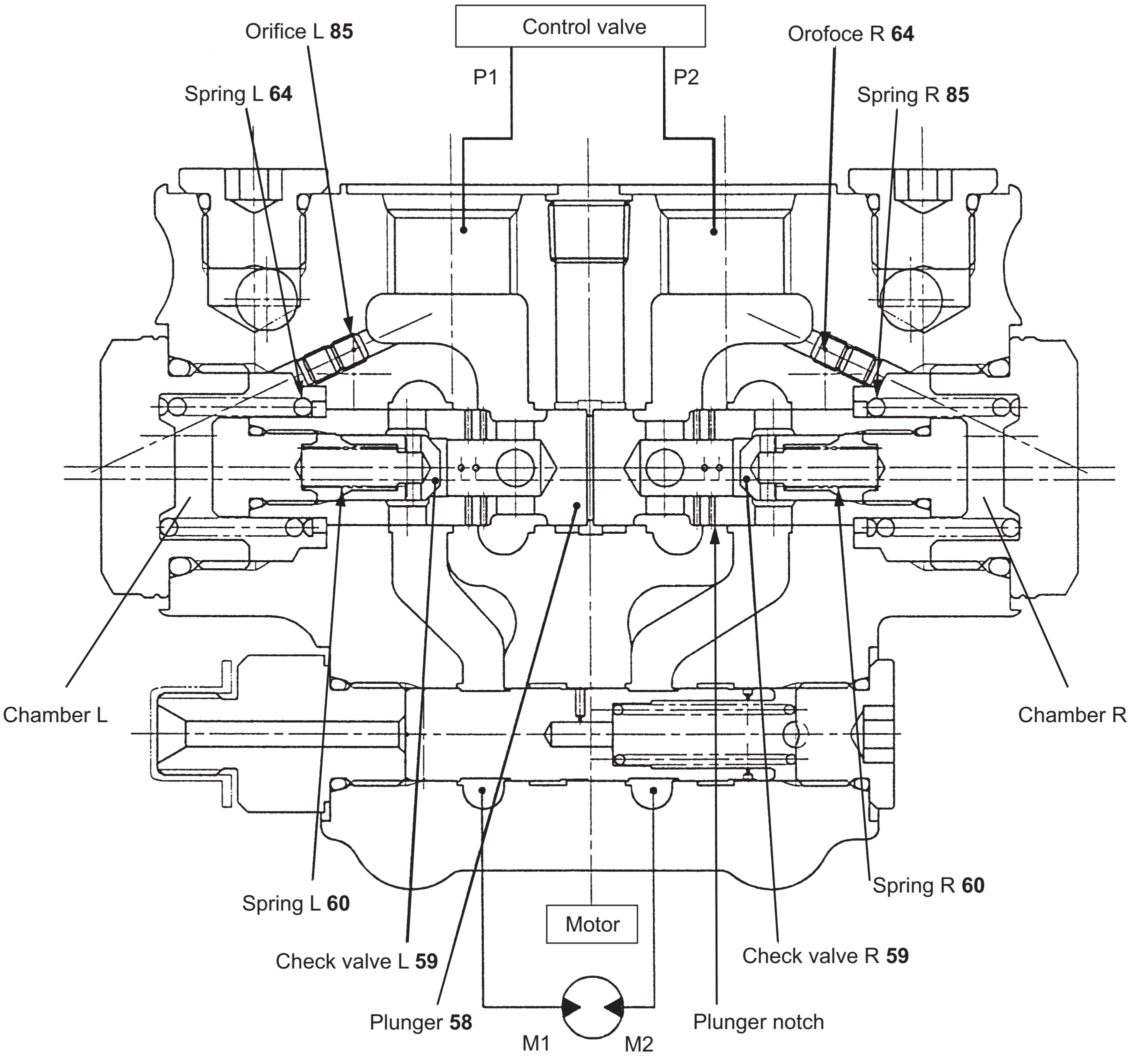
When the travel section of the control valve is switched to "Travel", the hydraulic oil flows through the counter balance valve to the port A of the valve plate **46**.
When the pressure at the port A rises, the hydraulic oil flows into the bores corresponding to the port A in the cylinder barrel **40**.
When the hydraulic oil flows into the bores, the pistons are pressed against the sliding surface of the swash plate **36**, and the shoes fitted on the pistons slide on the sliding surface of the swash plate **36** towards the circumference. That motion of more than one piston on the high pressure side is converted into the rotational motion of the cylinder barrel **40**.
The output shaft splined to this cylinder barrel **40** also starts to rotate together with the rotation of the cylinder barrel **40**.
When the pistons move to the low pressure side, the pistons are pushed into the bores and discharge hydraulic oil from them. The hydraulic oil discharged from the cylinder barrel **40** flows through the port B of the valve plate **46** to the return passage.
When the travel section of the control valve is switched to the opposite side, the pressure at the port B becomes high and the pressure at the port A becomes low, so that the rotation of the output shaft is reversed.



2) Counter Balance Valve

The counter balance valve works to reduce the shock caused when the piston motor stops and to prevent it from overrunning a specified speed due to external loading.

When the control valve is moved to the neutral position, the hydraulic oil flow to the ports P1 and P2 is blocked. This causes the pressures in the chambers R and L to fall to nearly zero, and the plunger is returned to the neutral position by the force of the springs on both sides. When the plunger **58** is returned to the neutral position, the ports M1 and M2 of the piston motor are blocked by the plunger **58** and the check valve **59**, and the motor is stopped rotating.



Structure of counter balance valve

(1) Counter balance

When the hydraulic oil discharged from the hydraulic pump is led to the port P1 of the counter balance valve through the control valve, the hydraulic oil flows through the check valve L **59** and the port M1 to the piston motor to rotate the piston motor.

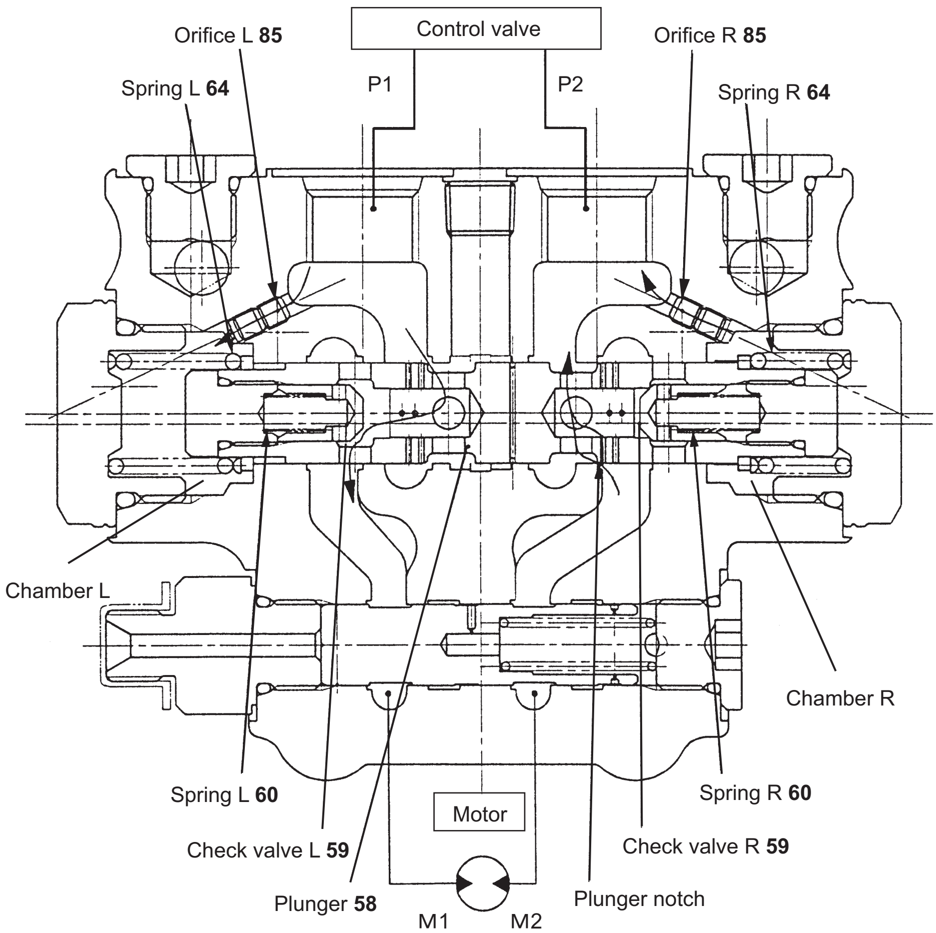
The return oil from the piston motor flows to the counter balance valve from the port M2, but the flow is blocked by the check valve R **59**. This causes the pump's discharge pressure rise.

The hydraulic oil with its pressure rise at the port P1 passes through the orifice L **85** and flows into the chamber L. When the pressure in the chamber L reaches a specified pressure, the plunger **58** starts moving to the right. Then, the hydraulic oil at the port M2 flows through the notch on the circumference of the plunger **58** to the port P2, while causing back pressure on the port M2 side, and returns to the hydraulic oil tank through the control valve.

While the plunger **58** is moving, the hydraulic oil in the chamber R is pressured by the plunger **58** and flows through the orifice R **85** to the port P2. The volume of the hydraulic oil flowing out from the chamber R is kept below a specified volume by this orifice and the moving speed of the plunger **58** does not exceed a specified speed.

When the discharge pressure of the pump rises, the opening of the plunger **58** notch becomes large and the back pressure at the port M2 is reduced.

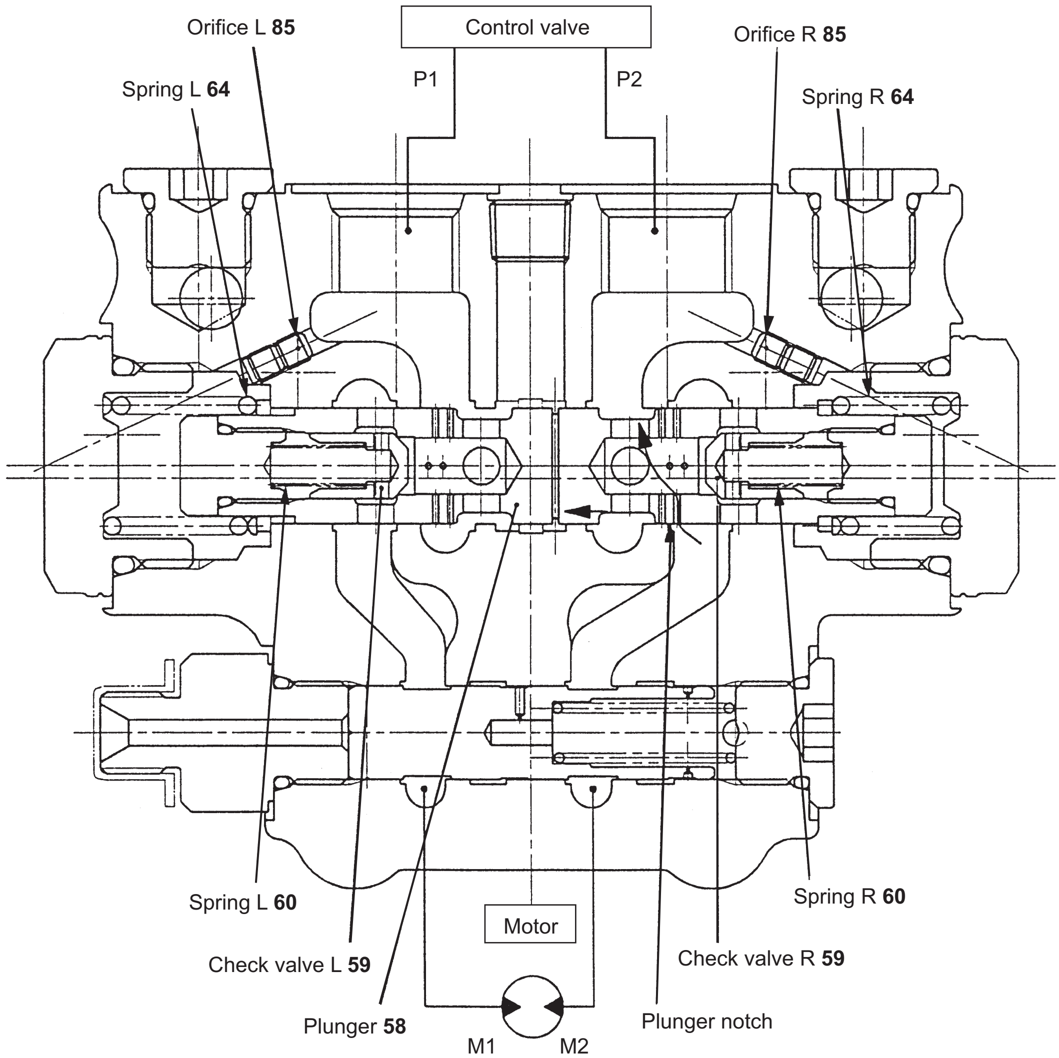
Thus, the piston motor revolves at a speed which corresponds to the pressure at the port P1, i.e., the oil volume flowing from the port P1.



Counter balbance valve (Counter balancing operation)

(2) Brake function

When the control valve is returned to the neutral position, the flow of pressure oil from the pump is blocked and the pressures at the ports P1 and P2 become equal. Consequently, the plunger **58** starts returning to the neutral position through the force of the spring R **60**. When the plunger **58** moves, the opening of the plunger **58** notch becomes small, and since the piston motor still continues to rotate through the inertial force (the pumping of the motor), the pressure at the port M2 rises. The relief valve R2 is activated by this pressure and lets the oil escape to the port M1 so that the shock due to the inertial force at the port M2 is absorbed, and at the same time, the cavitation at the port M1 is prevented.



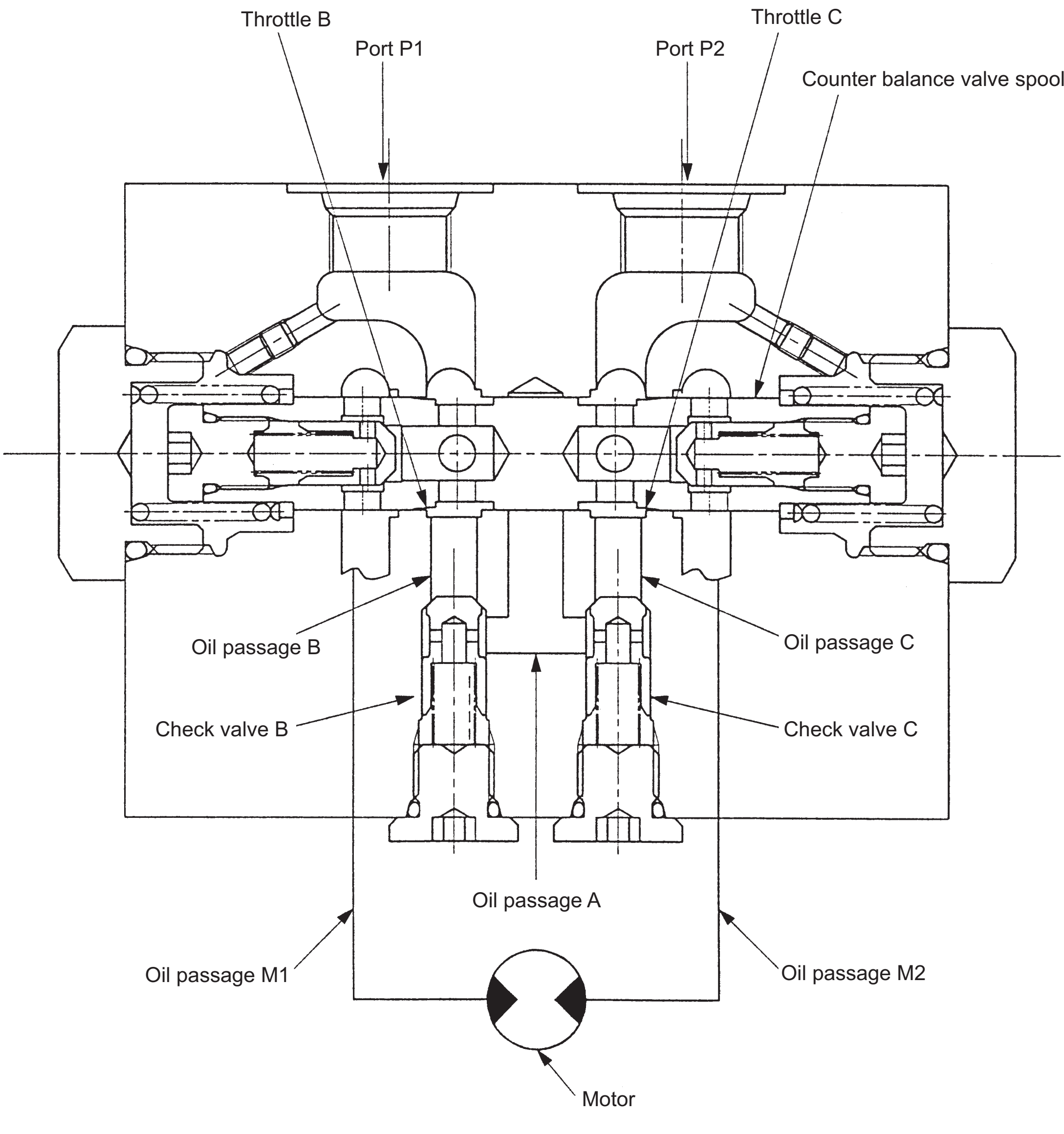
Counter balance valve (Braking operation)

3) Anti-Cavitation Valve

(1) Anti-cavitation mechanism

This anti-cavitation mechanism works together with the counter balance valve.

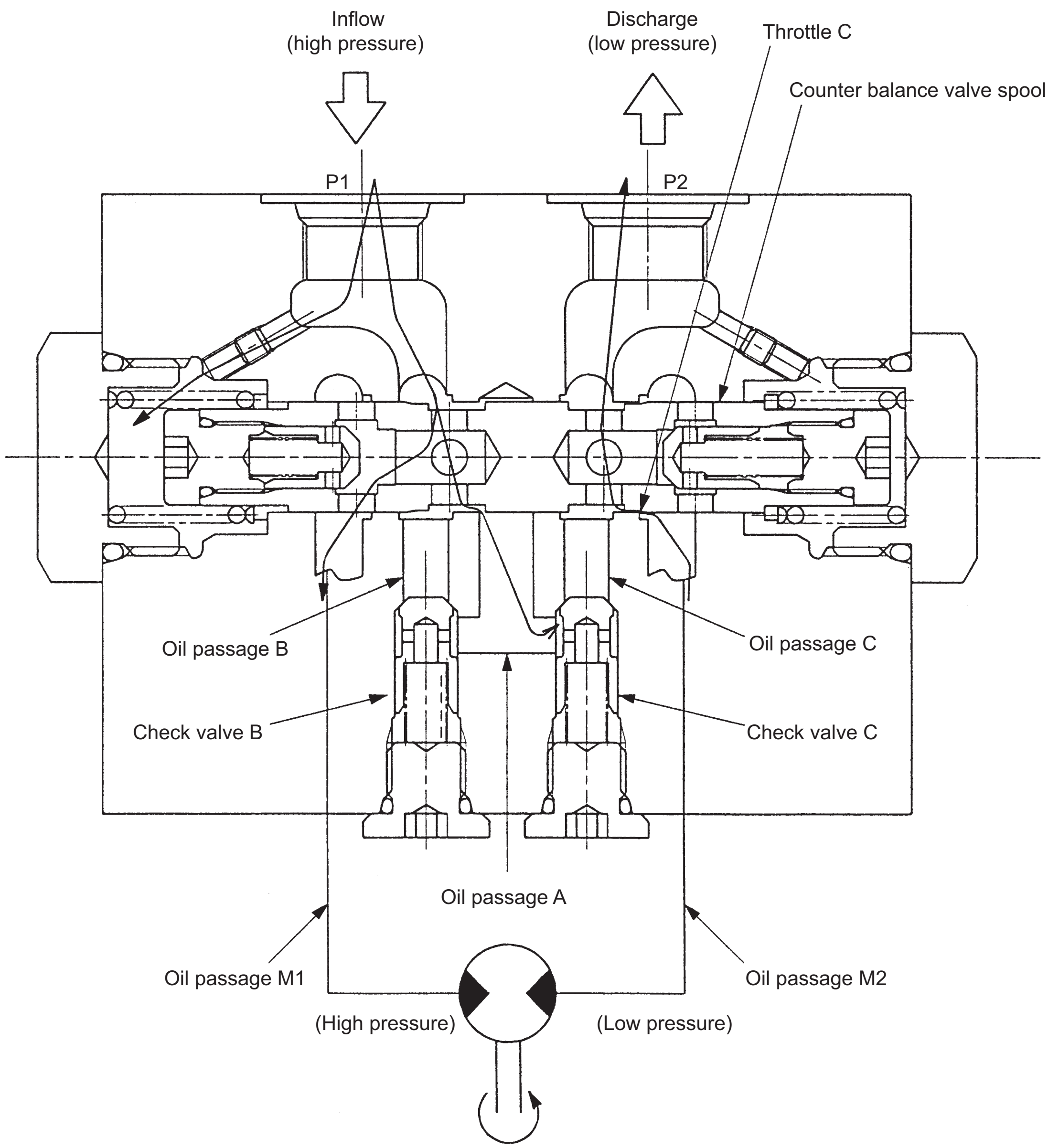
Compared with conventional counter valance mechanism, this mechanism has oil passages A, B and C and check valves B and C in addition.



Anti-cavitation valve (In neutral state)

(2) Motor stop → start

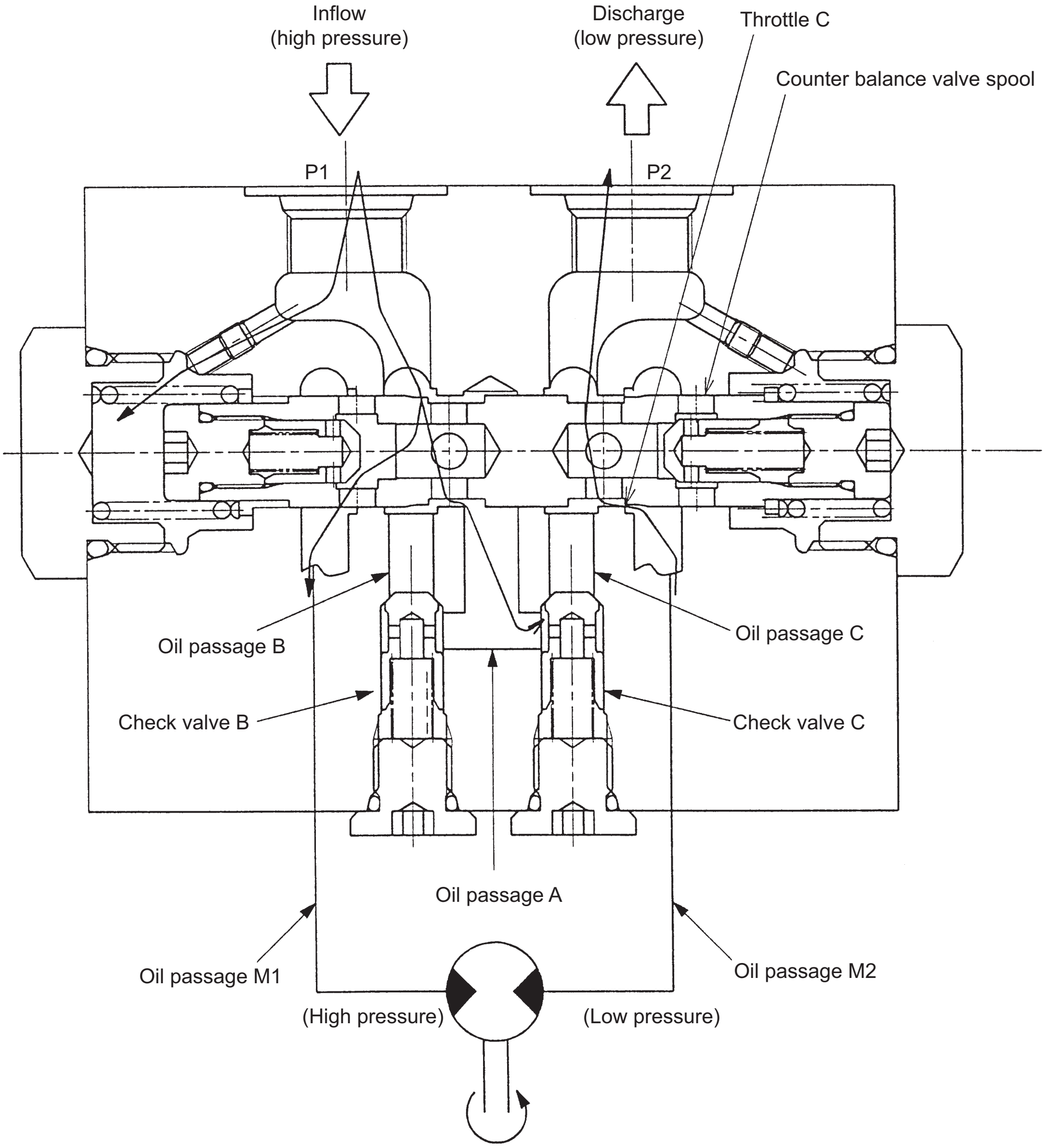
When the oil pressure force is applied to the port P1, the counter balance valve spool exceeds the force of the spring and moves to the right as shown in the figure below. This causes the hydraulic oil in the port P2 to flow thorough the oil passage M2 to the hydraulic motor and rotate it. (refer to 2)-(1) Counter balance) Although the high pressure oil flows to the oil passage A at the same time of this, the pressure oil does not leak to the low pressure side (the oil passage C side) due to the operation of the check valve C.



Anti-cavitation valve (In starting)

(3) In regular rotation of motor

Although the high pressure also flows to the oil passage A while the motor is rotating regularly, the pressure oil does not leak to the low pressure side due to the operation of the check valve C. Therefore, the anti-cavitation mechanism has no effect on the motor operation.

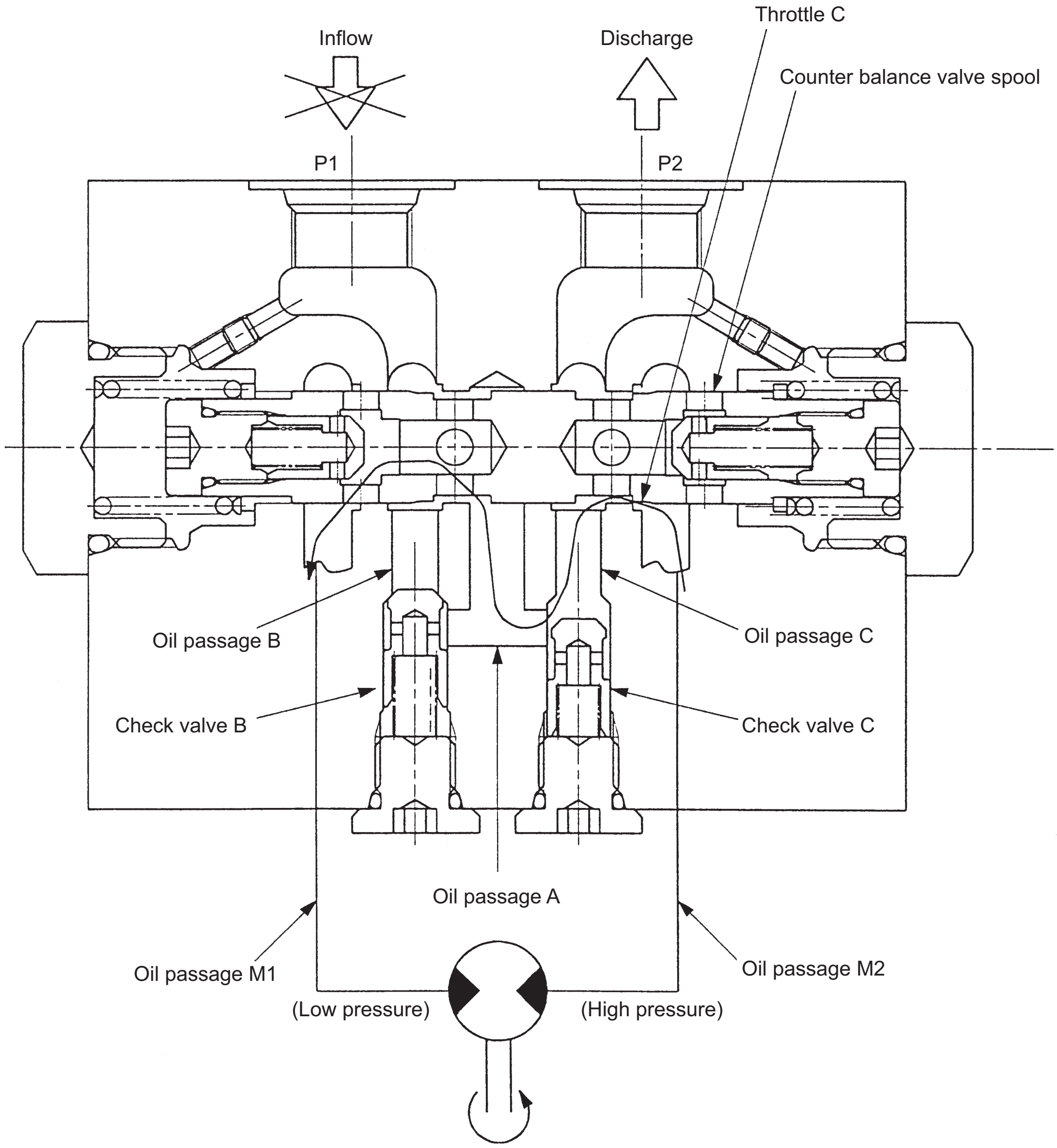


Anti-cavitation valve (In regular rotation of motor)

(4) Regular rotation of motor → in speed reduction

When reducing the motor speed, the hydraulic oil flows through the oil passage M2 out of the port P2 while the counter balance valve is open although the motor still keeps rotating with the inertia force. Then the cavitation occurs on the oil passage M1 side due to the shortage of oil supply from the port P1.

However, with this anti-cavitation mechanism, the hydraulic oil passes through the oil passage M2, the counter balance valve throttle C, the oil passage C, the check valve C, the oil passage A, and the oil passage M1, and returns to the motor to reduce the cavitation while the counter balance valve spool is returning to the neutral position.

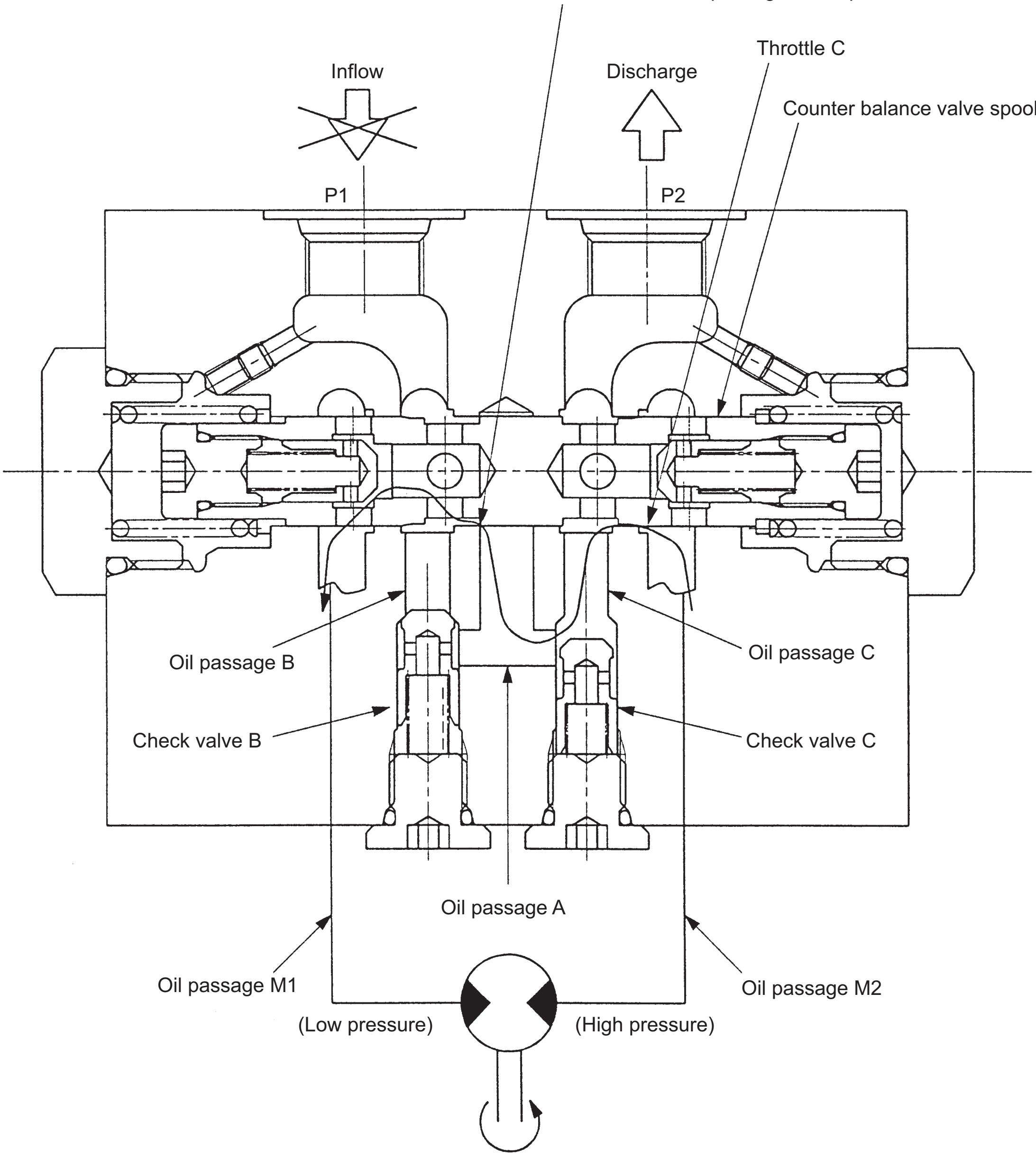


Anti-cavitation valve (In speed reduction)

(5) In motor speed reduction → stop

The anti-cavitation mechanism works until the oil flow from the passage A to the port P1 port is blocked at the point shown in the figure below.

ılve in stop

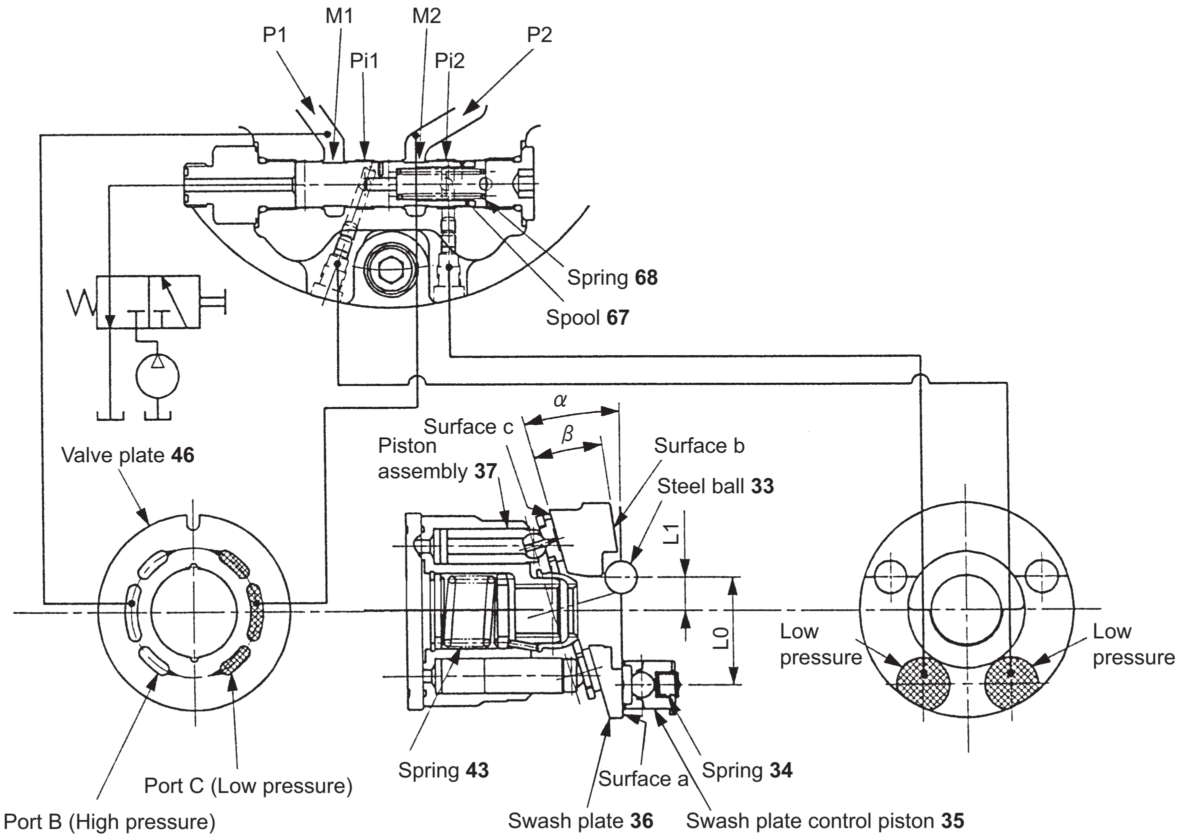


Anti-cavitation valve in stop

4) 2-Speed Switching Mechanism

(1) 1st speed (low speed)

The swash plate **36** has three surfaces a, b and c, as shown in the figure below, and is installed on the flange holder **1** with two steel balls **33** so that it can move. When the control valve is in the 1st speed position, since the spool **67** is located in the position as shown in the figure below by the force of the spring **68** and the swash plate control piston **35** is connected to the port T via Pi1 and Pi2, the low pressure of the return passage only works on the swash plate control piston **35**. In this condition, the swash plate control piston **35** does not push up the swash plate **36**. Accordingly, the surface a at the rear of the swash plate **36** is pressed against the vertical surface by the thrust force of the motor and the force of the springs **34** with the steel balls as the inclination axis. The inclination angle of the swash plate **36** is "α" as shown in the figure.



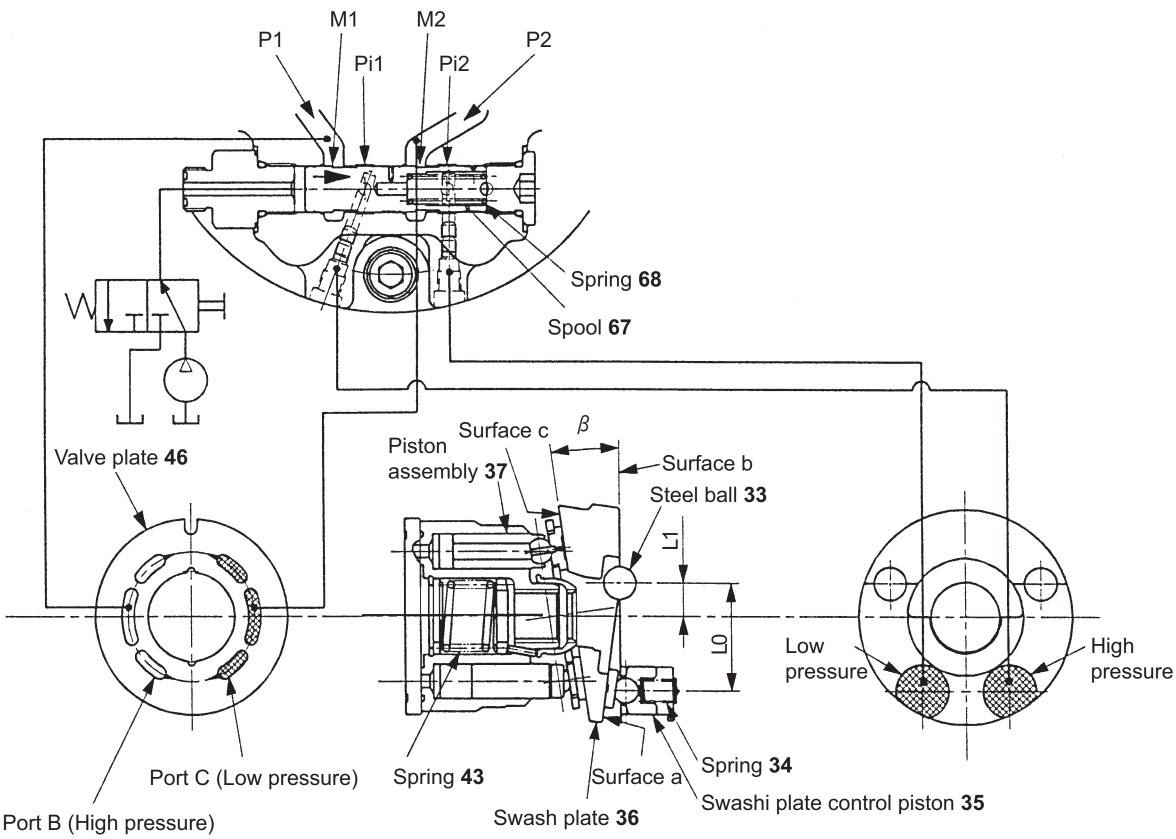
2-speed switching mechanism

(2) 2nd speed (high speed)

When the control valve is switched to the 2 nd speed position, the pressure oil from the pump is led to the end face of the spool **67** and the spool is shifted to the position as shown in the figure below. This causes the ports M1 and M2 to open and the hydraulic oil from the port A (high pressure) in the valve plate **46** of the motor is supplied to the swash plate control piston **35** though the valve port M1. This pressure oil pushes up the swash plate control piston **35**, which overcomes the motor thrust force and the spring force, and the surface a of the swash plate **36** is detached from the vertical surface with the steel balls as the inclination axis to cause the surface b to be contacted with the vertical surface tightly. When the surface b contacts with the vertical surface, the inclination angle of the surface c, which is the sliding surface of the swash plate **36**, is reduced to "β". Accordingly, the stroke of the piston **37** is reduced to lower the motor displacement. The motor with smaller displacement rotates faster (2 nd speed).

When the motor revolves in reverse, the same action as the above occurs, except that the high and low pressure ports are reversed.

When the engine is stopped, since no pumps work, no pressure oil is supplied to the end face of the spool **67** and the spool **67** returns to the 1st speed position by the spring **43** force. Accordingly, no force is applied to the swash plate control piston **35** to press the swash plate **36**, and the swash plate **36** maintains its 1st speed inclination angle "α" through the spring force. Thus, the 1st speed condition is always maintained at starting.



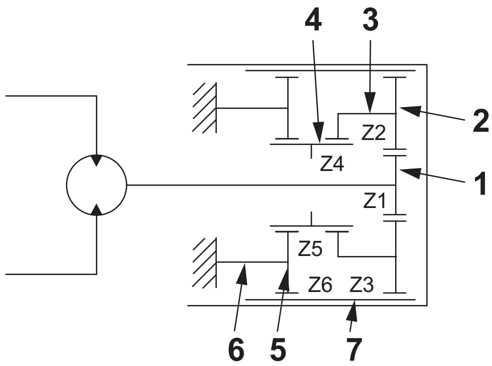
2nd speed (High speed)

5) Reduction Gear

The reduction gear comprises a planetary double-reduction mechanism.

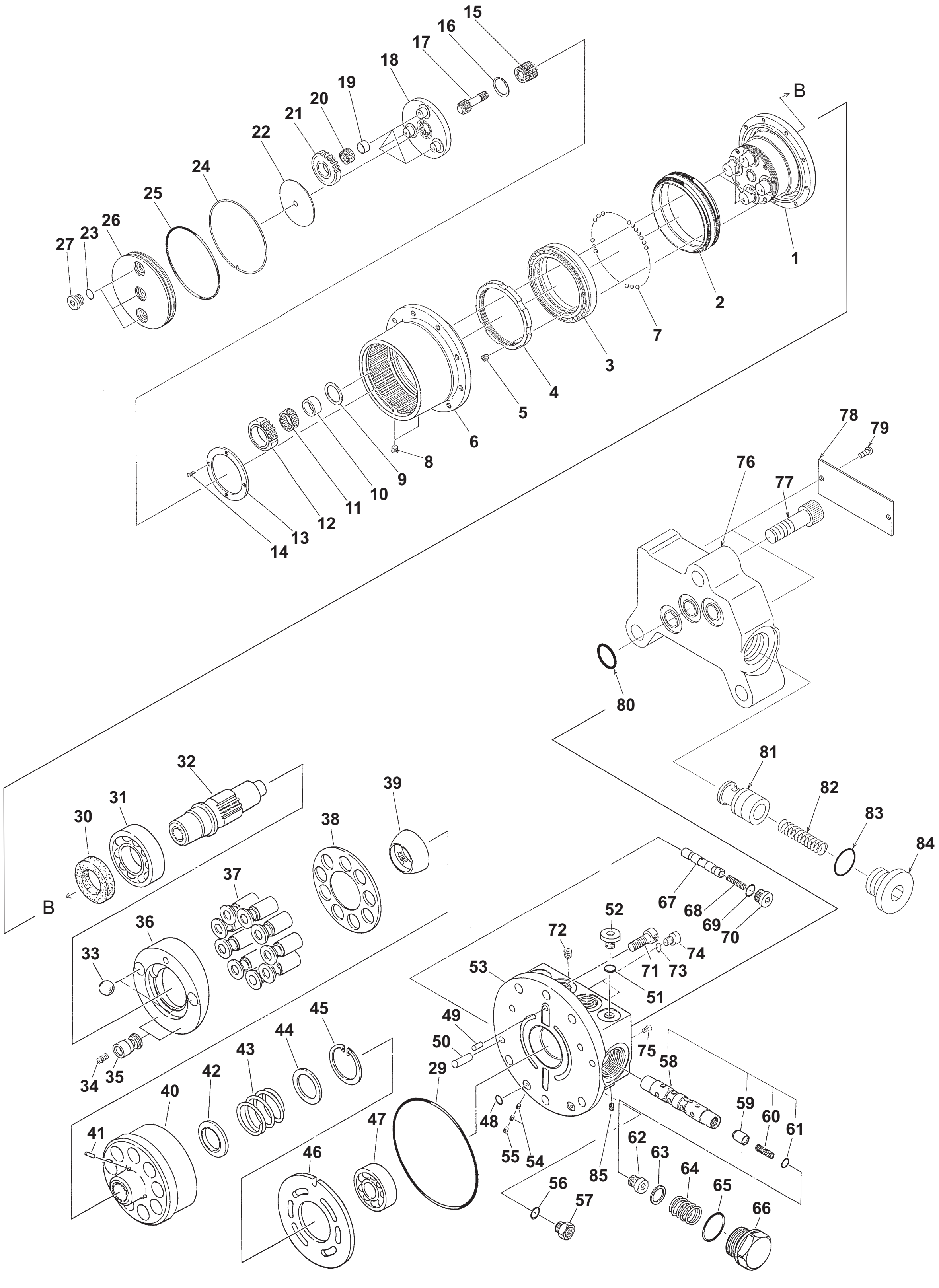
The drive gear **1** engages with the 1st-stage planetary gear **2** and the 2nd-stage sun gear **4** engages with the 2nd-stage planetary gear **5**. The 2nd-stage planetary carrier **6** is fastened to the machine body. The planetary gears **2** and **5** engage with the ring gear (housing) **7**.

The driving force from the piston motor is transmitted to the drive gear **1** and reduced by the gears. The reduced driving force is then transmitted to the ring gear **7** though the planetary gear **5** of the 2nd-stage planetary carrier **6** fastened to the machine body. (Driving force is also transmitted from the 1st-stage planetary gear **2**.) The input and output revolutions are opposite to each other.



Structure

3. Exploded View and Component Parts

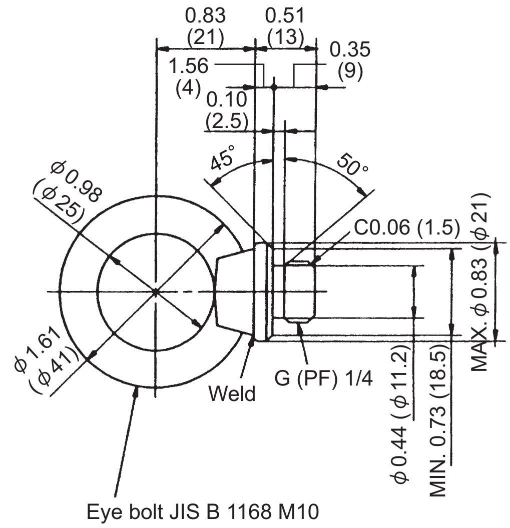


No.	Parts	Q'ty	No.	Parts	Q'ty
1	Flange holder	1	44	Washer	1
2	Floating seal	1	45	Internal snap ring	1
3	Angular bearing	1	46	Valve plate	1
4	Ring nut	1	47	Ball bearing	1
5	Plug PT 3/8	2	48	O-ring 1B P7	3
6	Housing	1	49	Pin	1
7	Steel ball	99	50	Pin	2
8	Plug PT 1/8	2	51	O-ring 1B P14	2
9	Thrust washer	4	52	Plug	2
10	Inner race	4	53	Base plate	1
11	Needle bearing	4	54	Orifice	4
12	Planetary gear B	4	55	Plug	2
13	Thrust plate	1	56	O-ring 1B P14	1
14	Screw	4	57	Plug	1
15	Sun gear	1	58	Plunger	1
16	Snap ring	1	59	Check valve	2
17	Drive gear	1	60	Spring	2
18	Holder	1	61	O-ring 1B P10	2
19	Inner race	3	62	Plug	2
20	Cage & roller	3	63	Spring seat	2
21	Planetary gear A	3	64	Spring	2
22	Thrust plate	1	65	O-ring 1B P29	2
23	O-ring 1B P11	2	66	Cap	2
24	Wire	1	67	Spool	1
25	O-ring	1	68	Spring	1
26	Cover	1	69	O-ring 1B P14	1
27	Plug PF 1/4	2	70	Plug	1
29	O-ring	1	71	Hexagon socket head bolt	6
30	Oil seal	1	72	Plug PT 1/4	1
31	Ball bearing	1	73	O-ring 1B P8	2
32	Shaft	1	74	Plug PF 1/8	2
33	Steel ball	2	75	Plug	2
34	Spring	2	76	Valve body	1
35	Piston assembly	2	77	Hexagon socket head bolt	3
36	Swash plate	1	78	Name plate	1
37	Piston assembly	9	79	Drive screw	2
38	Retainer plate	1	80	O-ring 1B P12	3
39	Retainer holder	1	81	Check valve	2
40	Cylinder barrel	1	82	Spring	2
41	Pin	3	83	O-ring 1B P14	2
42	Collar	1	84	Plug PF 3/8	2
43	Spring	1	85	Orifice	2

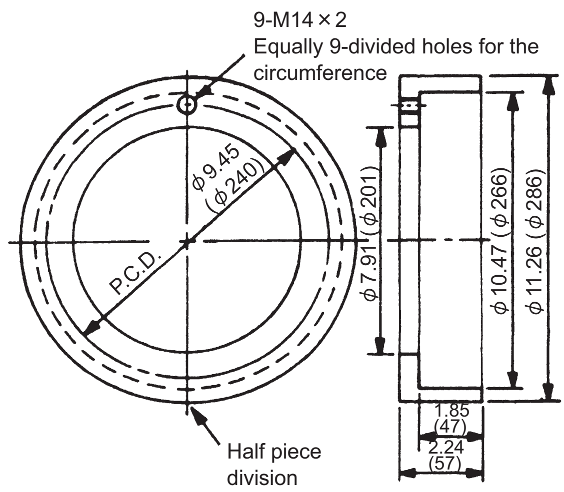
4. Special Tools

Unit : in. (mm)

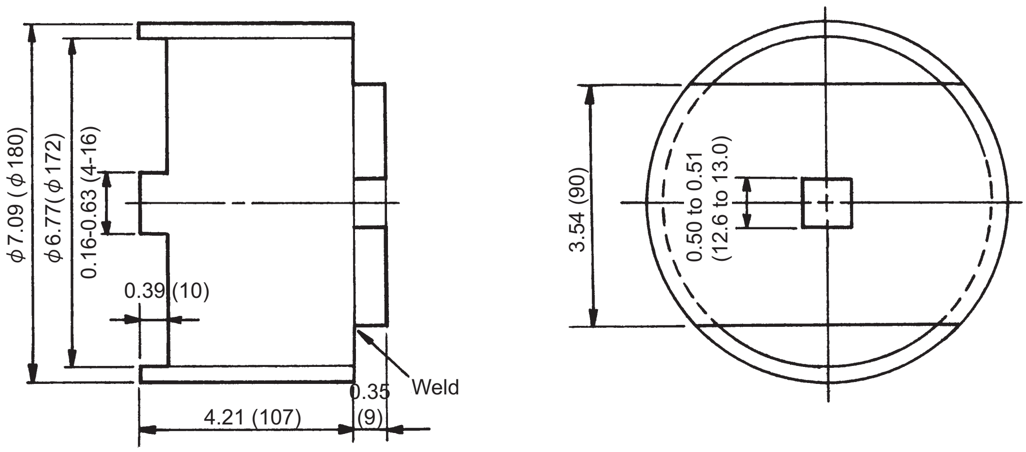
S-1 : Eye bolt



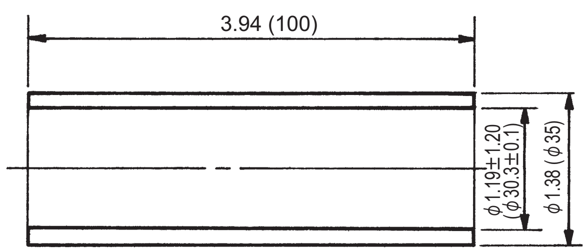
S-2 : Housing disassembly jig



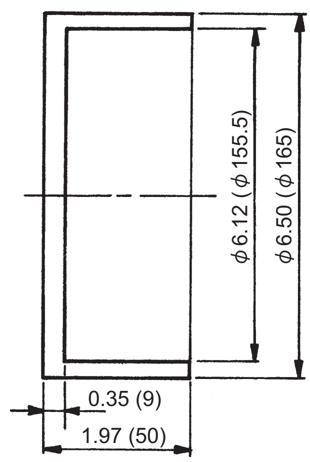
S-3 : Ring nut tightening jig



S-4 : Ball bearing disassembly jig

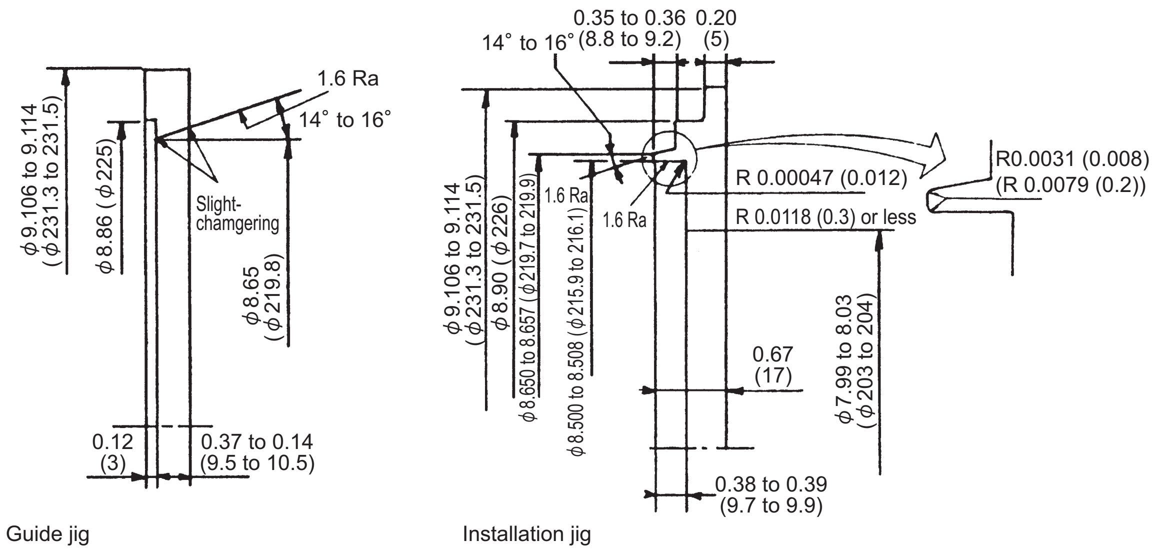


S-5 : Angular bearing press-fitting jig

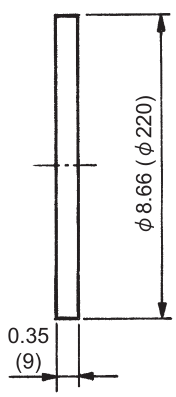


Unit : in. (mm)

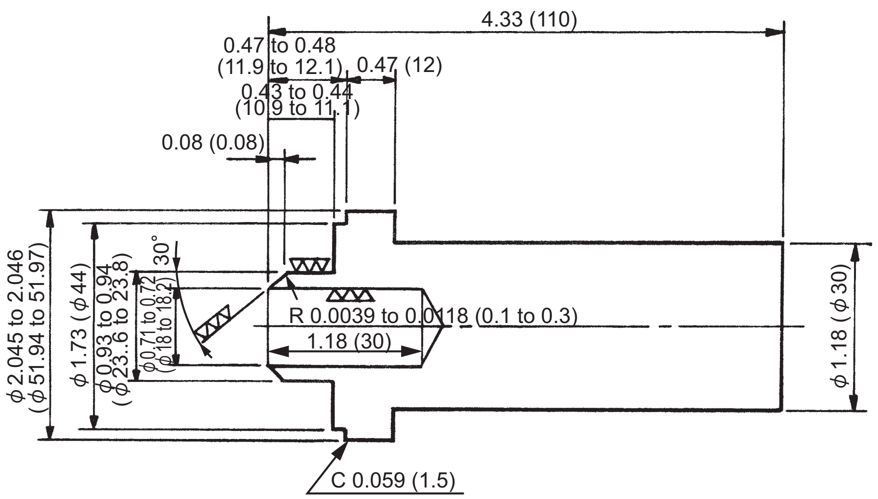
S-6 : Floating seal installation jig



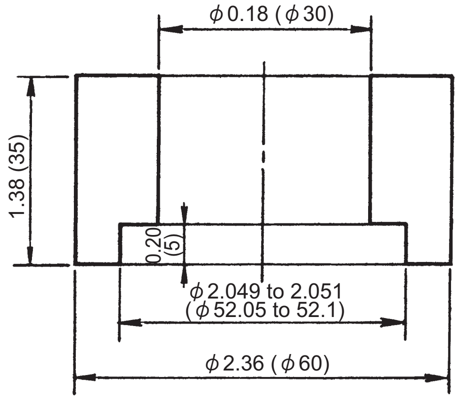
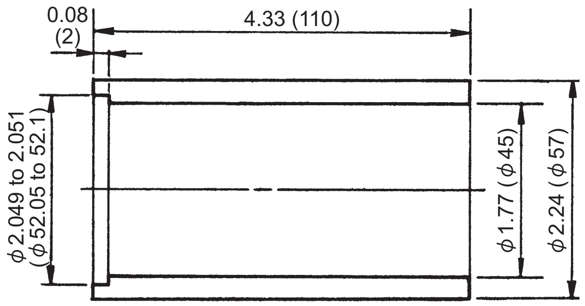
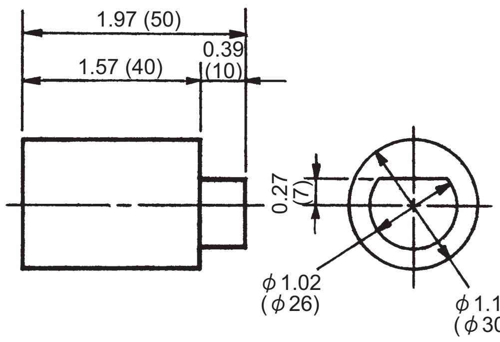
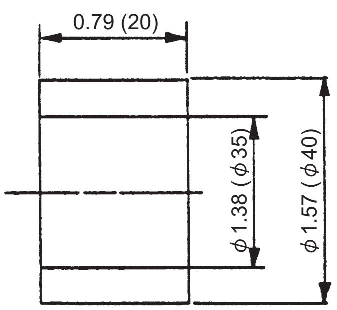
S-7 : Flange holder press-fitting jig



S-8 : Oil seal press-fitting jig



Unit : in. (mm)

S-9 : Ball bearing press-fitting jig	S-10 : Shaft assembly press-fitting jig
	
S-11 : Snap ring installation jig	S-12 : Ball bearing press-fitting jig
	

S-13 : Pin Ø0.20×1.18 (Ø5×30)
S-14 : Round rod Ø0.39×5.91 (Ø10×150)
S-15 : Round rod Ø0.79×39.37 (Ø20×1000)
S-16 : Piano wire Ø0.008×27.56 (Ø0.2×700)
S-17 : Spring scale

5. Disassembly and Reassembly

1) Precautions for Disassembly and Reassembly

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

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

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

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

(5) After disassembly, replace the removed seals and O-rings with new ones in principle. As some replacement parts are available only as subassemblies, see the parts catalog to prepare the necessary subassemblies in advance.

(6) Handling O-rings

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

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

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

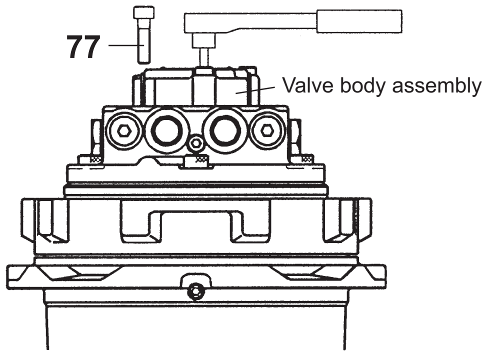
[4] Avoid rolling the O-rings when fitting them.
A distorted O-ring may not return to its original shape, and therefore, may cause oil leak.

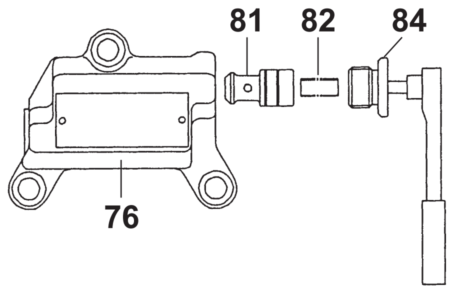
(7) Before beginning reassembly, check the mating surface of each section to be sure that there is no cleaning oil or hydraulic oil on the surface of the outer side from the O-ring groove. If reassembly is performed without cleaning such oil, it may be mistaken for oil leak.

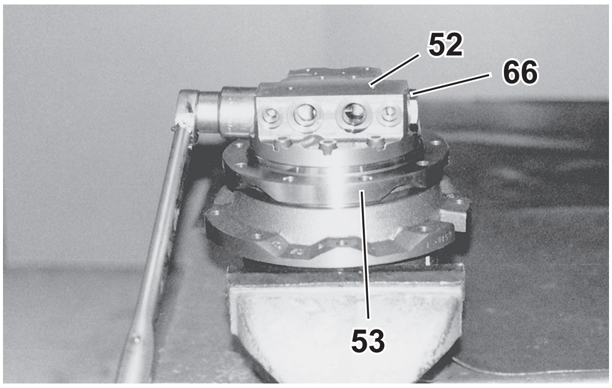
2) Tools for Disassembly and Reassembly

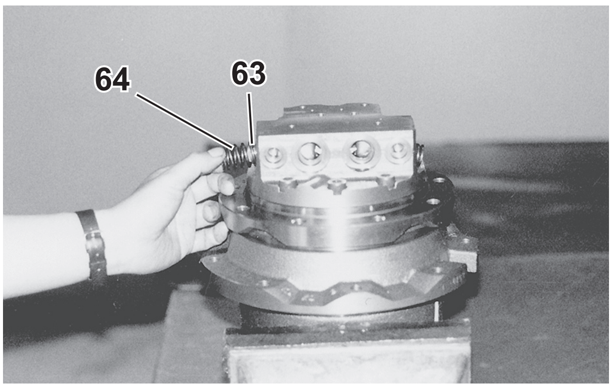
No.	Tool	Nominal size	Applicable part
1	Torque wrench (Preset type) (for wrench) (kgf·m)	2.3	
2		4.5	
3		18	
4		28	
5		4.5	
6	Hexagon bit for torque wrench (Width across flats) (Width across flats) (mm)	4	
7		5	
8		6	
9		8	
10		10	
11		12	
12	Socket for torque wrench (Width across flats) (mm)	22	
13		36	
14	Wrench for torque wrench (mm)	12	
15	Screwdriver		
16	Hammer		
17	Plastic hammer		
18	Pliers		
19	Snap ring pliers		
20	Punch		

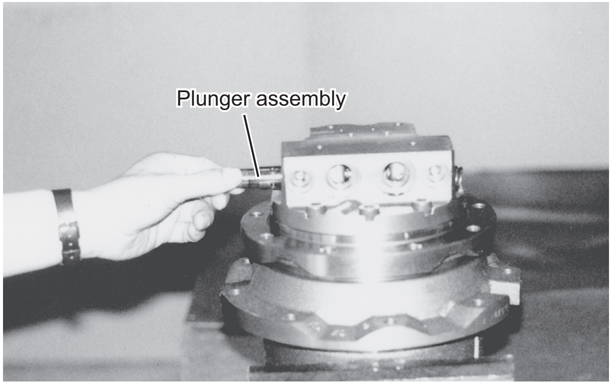
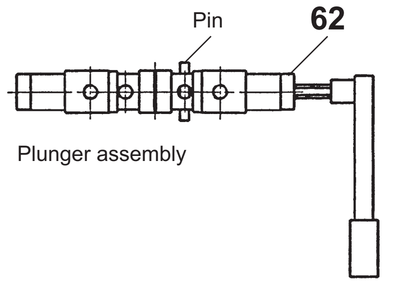
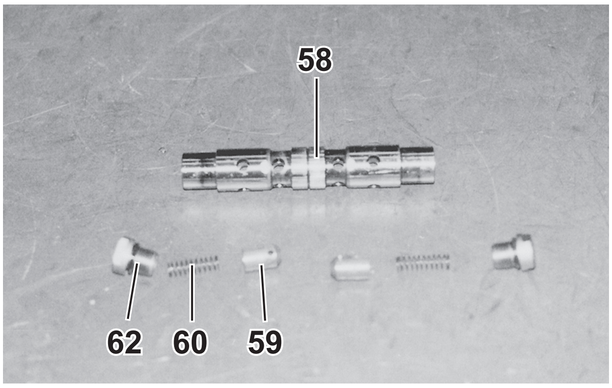
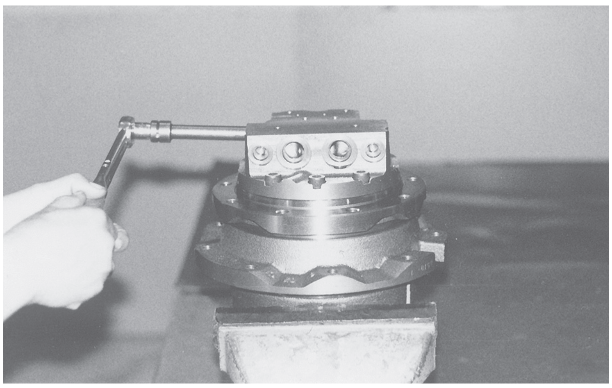
3) Disassembly

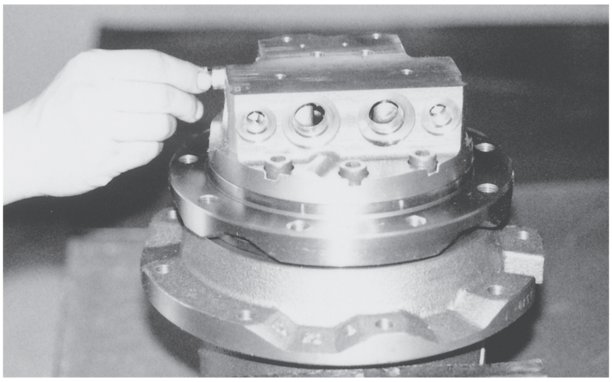
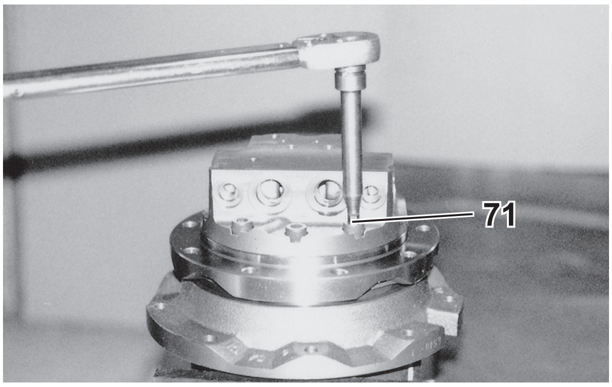
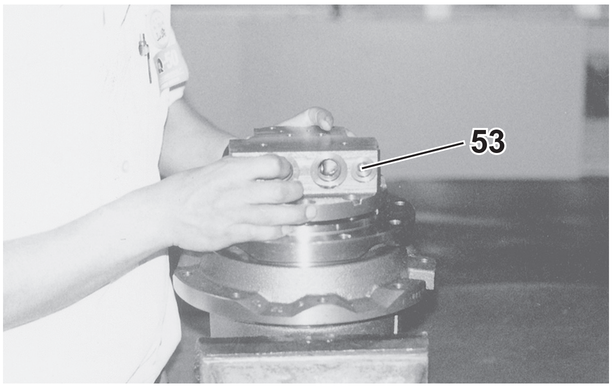
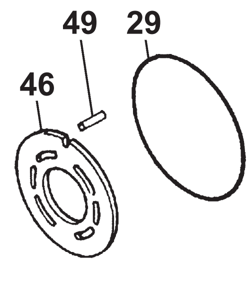
Procedure	
(1) Hold the motor with a vice to remove three hexagon socket head bolts **77** and then valve body assembly. **Tools :** • Torque wrench (2) • Hexagon bit (7)	

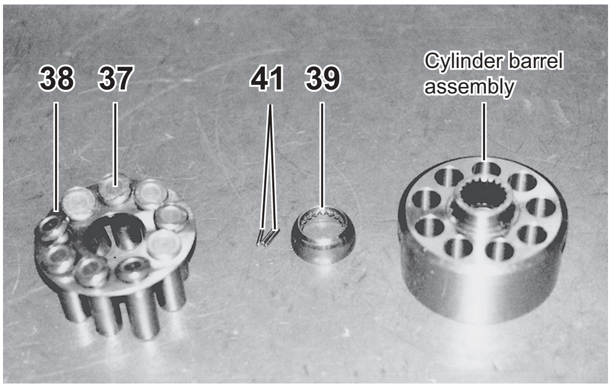
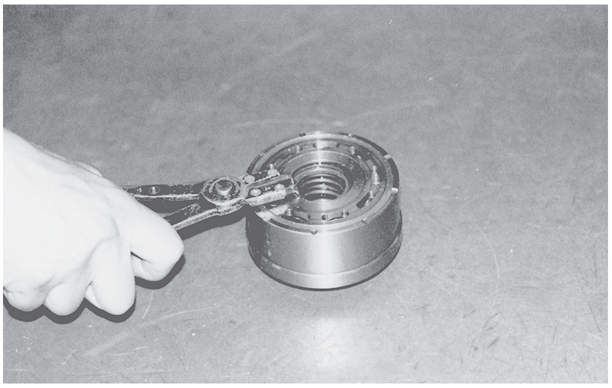
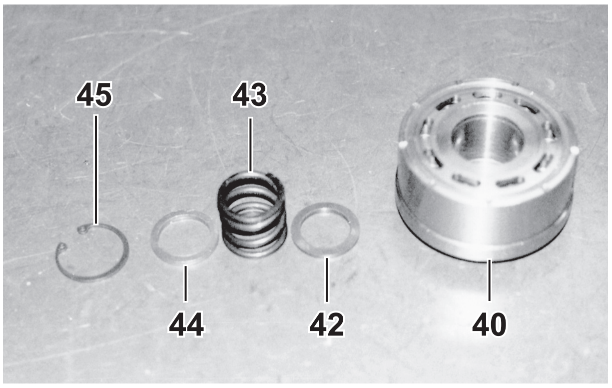
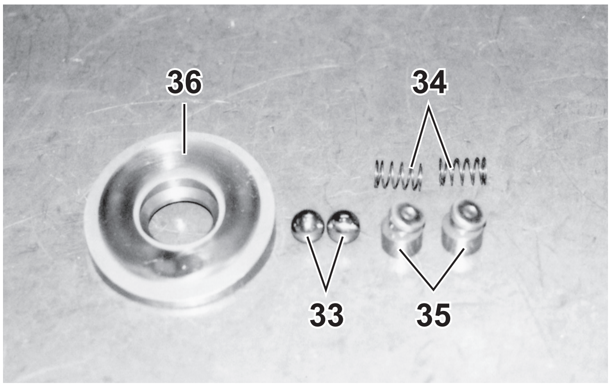
(2) Hold the valve body **76** with a vise. Remove the plug **84** to remove the spring **82** and the check valve **81**. ***Note :*** *Disassemble the valve body assembly only when required.* **Tools :** • Torque wrench (3) • Hexagon bit (9)	

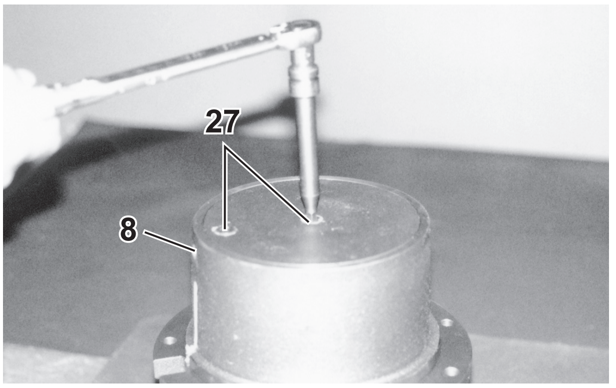
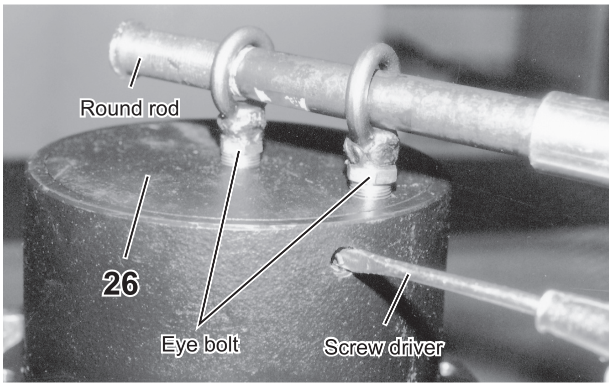
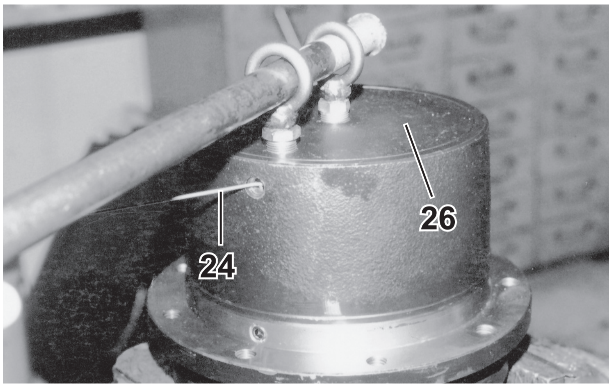
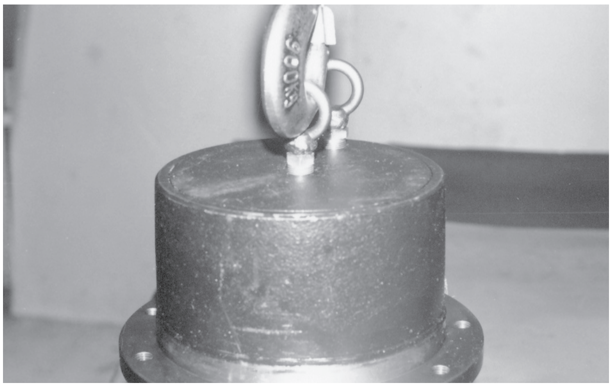
(3) Remove plugs **52** and caps **66**. ***Note :*** *Be careful not to loose shims **91** inside caps **66**.* **Tools :** • Torque wrenches (2) and (4) • Hexagon bit (11) • Socket (13)	

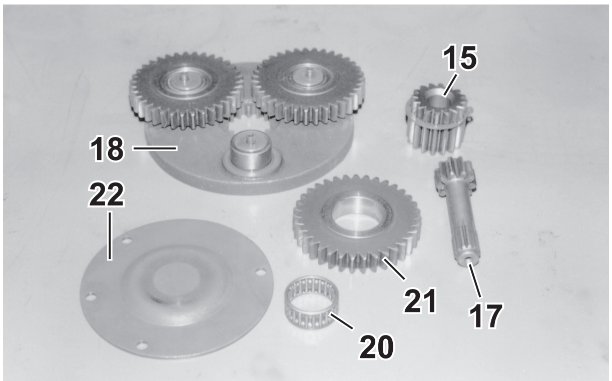
(4) Remove spring **64** and spring seat **63**.	

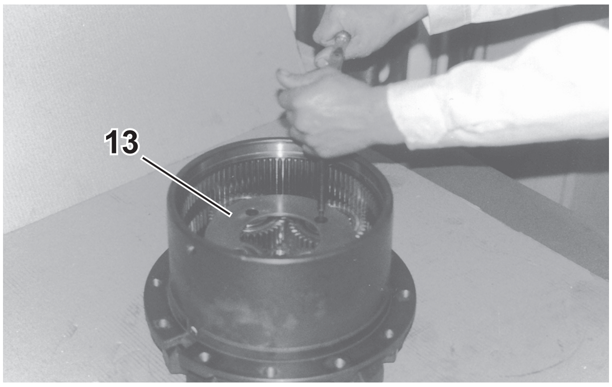
Procedure	
(5) Turn plunger assembly slowly to remove it. ***Note :*** *Take care not to damage or dent the outside of plunger **58**.*	
(6) Insert a pin Ø0.2×1.2 in. (Ø5×30 mm) into the through hole 0.2 in. (Ø6 mm) in the plunger assembly. Hold it with a vice to remove plug **62**. ***Note :*** *Disassemble the plunger assembly only when required.* **Tools :** • Torque wrench (5) • Wrench (14) • Pin 0.2×1.2 in. (Ø5×30 mm) (S-13)	
(7) Remove spring **60** and check valve **59**. ***Note :*** *Keep the right check valve and the left one separately to identify them with regard to the plunger for correct reassembly.*	
(8) Remove plugs **70** and **57**. **Tools :** • Torque wrench (3) • Hexagon bit (9) • Socket (12)	

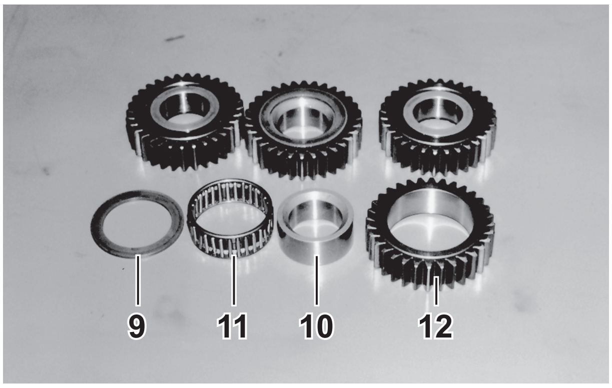
Procedure	
(9) Remove spring **68** and spool **67**. ***Note :*** *Take care not to damage or dent the outside of the spool.*	
(10) Remove six hexagon socket head bolts **71**. **Tool :** • Torque wrench (3) • Hexagon bit (10)	
(11) Remove base plate **53**. ***Notes :*** • *When the base plate cannot be removed easily, tap it in the pulling-out direction with a plastic hammer. If it is still not be removed, pry it up lightly with a screwdriver.* • *Take care that the cylinder barrel is not pulled out.* **Tools :** • Plastic hammer (17) • Screwdriver (15)	
(12) Remove valve plate **46**, O-ring **29** and pin **49**.	

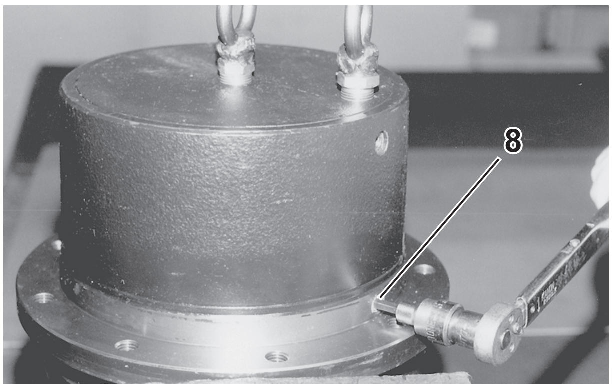
Procedure	
(13) Remove cylinder barrel assembly, pins **41**, retainer holder **39**, retainer plate **38** and piston assemblies **37**. ***Note :*** *Take care not to damage the sliding surface of the cylinder barrel.*	
(14) Remove internal snap ring **45** from cylinder barrel **40**. ***Note :*** *Take care not to damage the sliding surface of the cylinder barrel.* **Tools :** • Snap ring pliers (19)	
(15) Remove washer **44**, spring **43** and collar **42**.	
(16) Remove swash plate **36**, steel balls **33**, piston assemblies **35** and springs **34**.	

Procedure	
(17) Remove plugs **8** and **27**. **Tools :** • Torque wrenches (1) and (2) • Hexagon bit (7) and (8)	
(18) Fit eye bolts (PF 1/4) into the tapped holes for plugs 27 and put a round rod [approx. 39.4 in. (1 m) in length] through the eye bolt holes. Turn cover **26** until wire **24** can be seen from the tapped hole for plug **8**. **Tools :** • Eye bolt (S-1) • Round rod (S-15) (19) When the end of wire **24** E can be seen, draw the wire outside the hole with a screwdriver. **Tool :** • Screwdriver (15)	
(20) Turn cover **26** while pulling the end of wire **24** with pliers to draw the wire out. **Tool :** • Pliers (18)	
(21) Put a hook through the eye bolt holes to hang up and remove cover **26** (or remove the cover using a round rod). **Tools :** • Eye bolt (S-1) • Round rod (S-14)	

Procedure	
(22) Remove sun gear **15**, holder **18**, planetary gears A **21**, cage & rollers inner races **20** inner races **19** drive gear **17** and thrust plate **22**.	

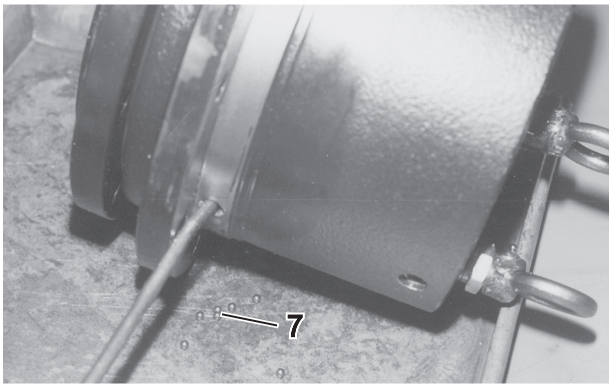
(23) Remove thrust plate **13** and four screws **14**. **Tools :** • Torque wrench (1) • Hexagon bit (7)	

(24) Remove thrust washers **9**, planetary gears B **12**, inner races **10** and needle bearings **11**. ***Note :*** *Take care not to damage the gear tooth surfaces and the rolling contact surfaces of the inner races.*	

(25) Remove plug **8**. **Tools :** • Torque wrench (1) • Hexagon bit (7)	

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(26) Pull all steel balls 7 out of the tapped hole for plug 8.

Notes :
• After removing oil and grease with thinner, white gasoline or the like, blow compressed air over the steel balls to remove them.
• It is hard to remove them, tap the outside of housing 6 with a hammer.
• Insert a piano wire through the tapped hole for the plug to make sure that all the steel balls have been removed.

Tools :
• Hammer (16)
• Piano wire (S-16)</td><td>
</td></tr>
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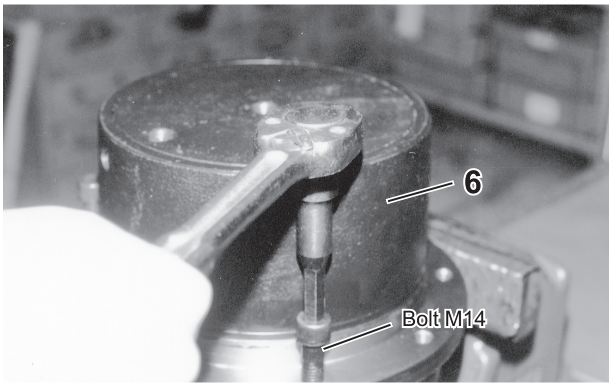
<table>
<tr><td>(27) Put a metal plate or a jig between flange holder 1 and housing 6, and tighten three M14 bolts evenly from the housing side.

Tools :
• Torque wrench (3)
• Hexagon bit (11)
• Metal plate or housing disassembly jig (S-2)</td><td>
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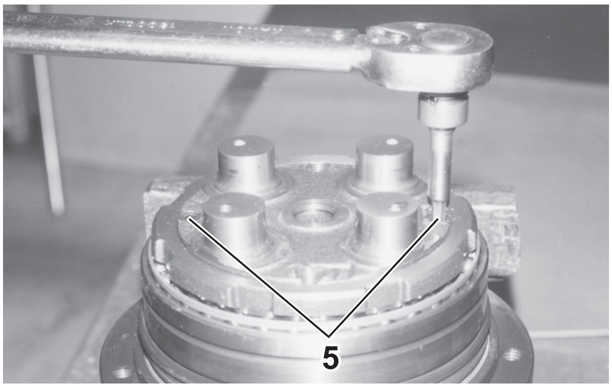
<table>
<tr><td>(28) Remove two plugs 5.

Tools :
• Torque wrench (2)
• Hexagon bit (9)</td><td>
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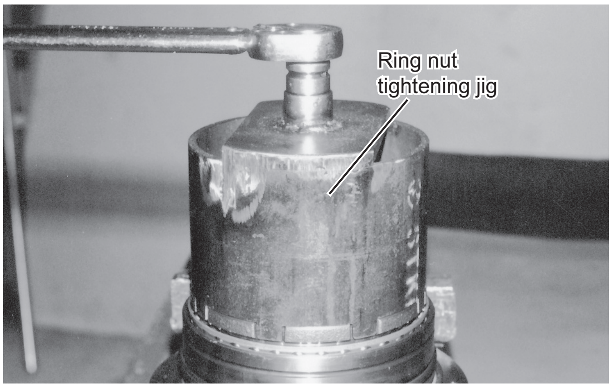
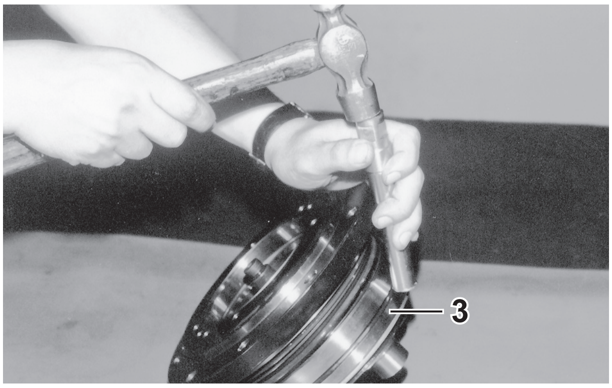
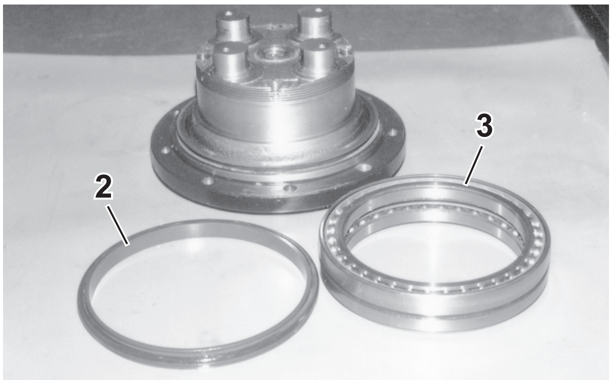
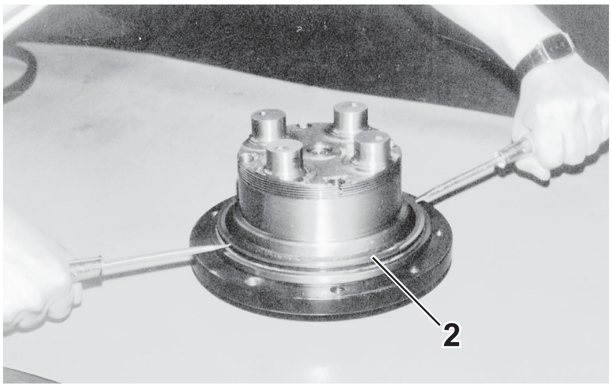
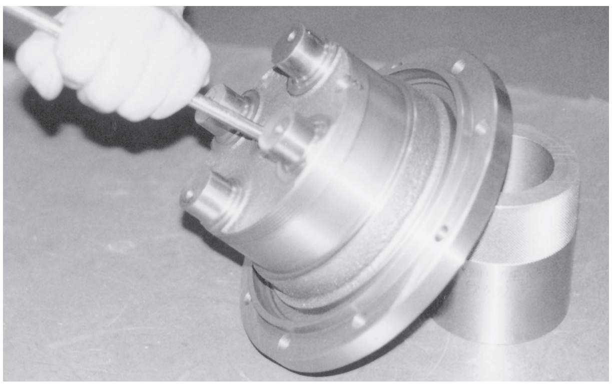
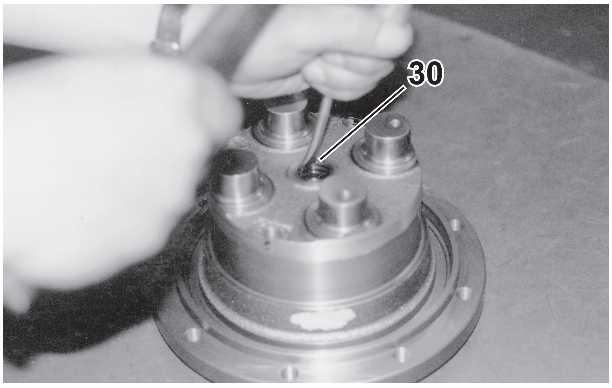
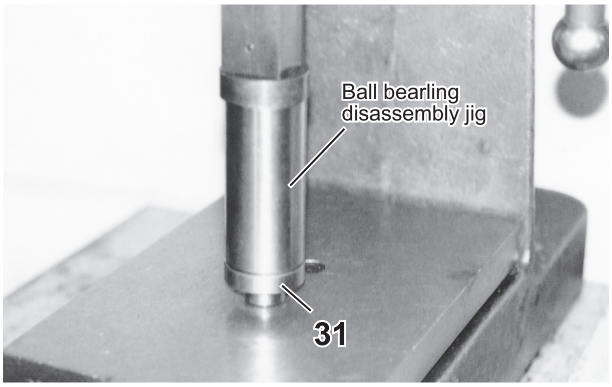
<table>
<tr><td>(29) Remove ring nut 4.

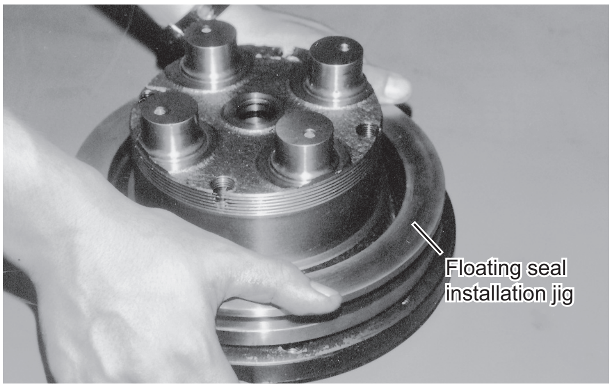
Tools :
• Torque wrench (3)
• Ring nut tightening jig (S-3)</td><td>
</td></tr>
</table>

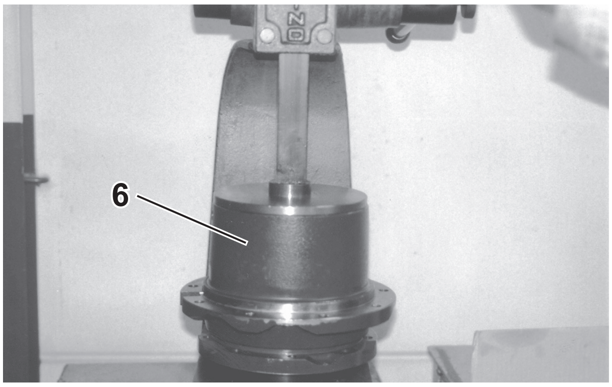
Procedure	
(30) Place a round rod on the groove for steel balls **7** and tap it lightly with a hammer to remove angular bearing **3**. **Tools :** • Hammer (16) • Round rod (S-14)	
(31) Remove one half of floating seal **2** and angular bearing **3**.	
(32) Remove the other half of floating seal **2** using two screw drivers. **Tools :** • Screw driver (15)	
(33) Place a round rod on the hole for shaft **32** and tap the rod lightly with a hammer to remove the shaft **32**. **Tools :** • Hammer (16) • Round rod (S-14)	

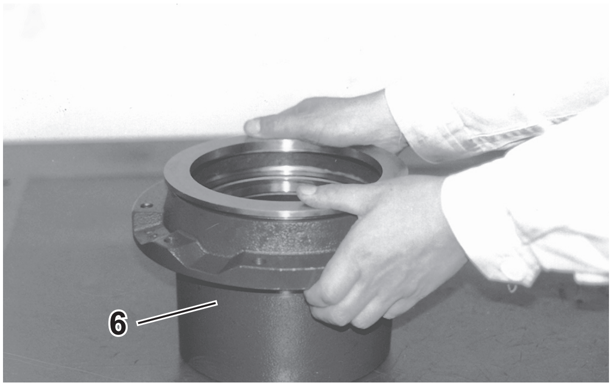
Procedure	
(34) Remove oil seal **30**. **Tools :** • Hammer (16) • Screw driver (15)	

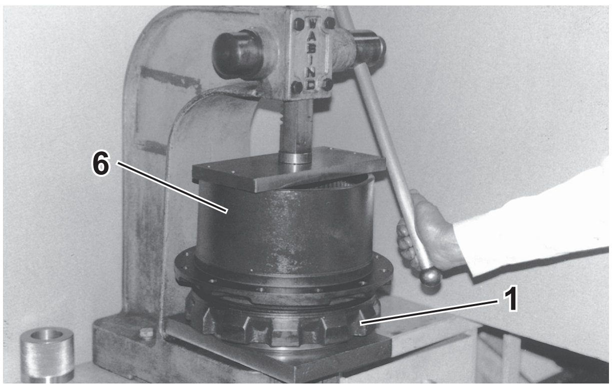
(35) Remove ball bearing **31** from shaft **32**. **Tool :** • Ball bearing disassembly jig (S-4)	

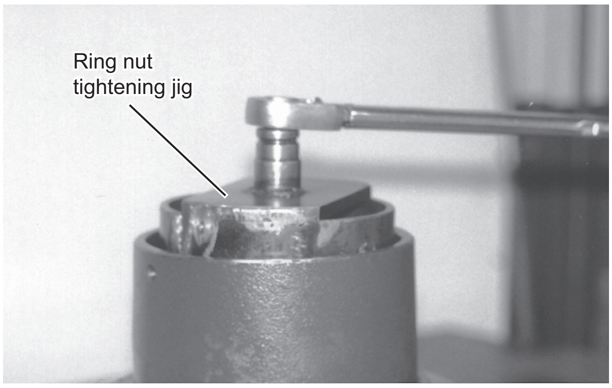
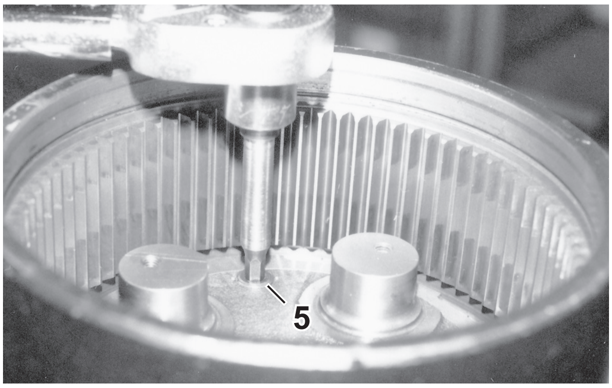
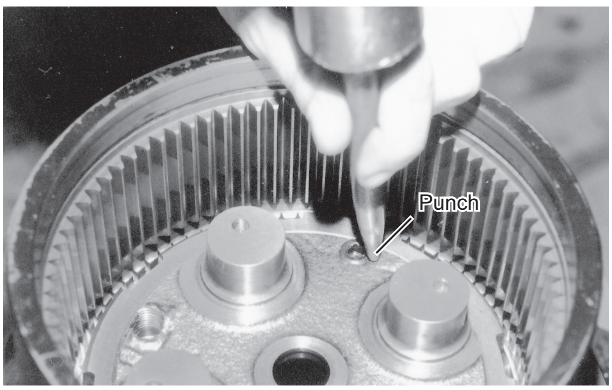
4) Reassembly

Procedure	
(1) Apply grease to one half of floating seal **2** and install it onto flange holder **1**. **Tool :** • Floating seal installation jig (S-6)	

(2) Press-fit angular bearing **3** onto housing **6**. **Tool :** • Angular bearing press-fitting jig (S-5)	

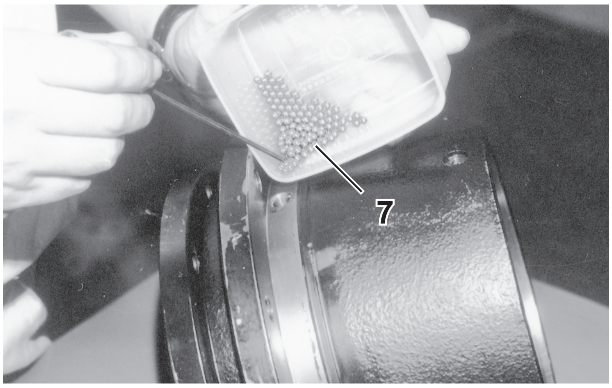
(3) Apply grease to the other half of floating seal **2** and install it onto housing **6**. **Tool :** • Floating seal installation jig (S-6)	

(4) Press-fit flange holder **1** onto housing **6**. **Tool :** • Flange holder press-fitting jig (S-7)	

Procedure	
(5) Tighten angular bearing **3** with ring nut **4**. Tightening torque : 166.4 to 180.8 ft·lbf (225.6 to 245.2 N·m) **Tools :** • Torque wrench (4) • Ring nut tightening jig (S-3)	
(6) Tighten plugs **5**. Tightening torque : 21.7 to 28.9 ft·lbf (30 to 39 N·m) ***Note :*** *Do not wind a seal tape around these plugs.* **Tools :** • Torque wrench (1) • Hexagon bit (8)	
(7) Caulk each plug **5** at two places with a punch to prevent it from loosening. **Tools :** • Hammer (16) • Punch (20)	

Procedure

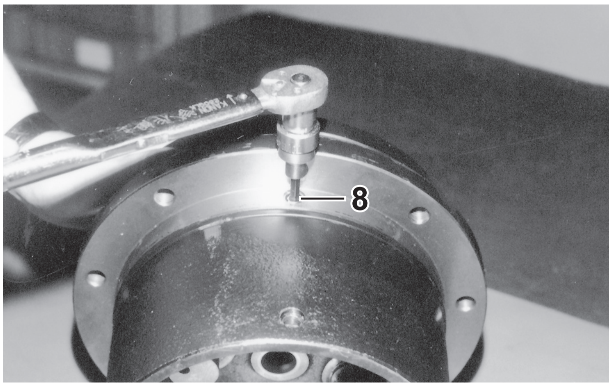
(8) Insert steel balls **7** (99 pcs.).



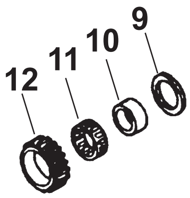
(9) Wind a seal tape around plug **8** and tighten it.

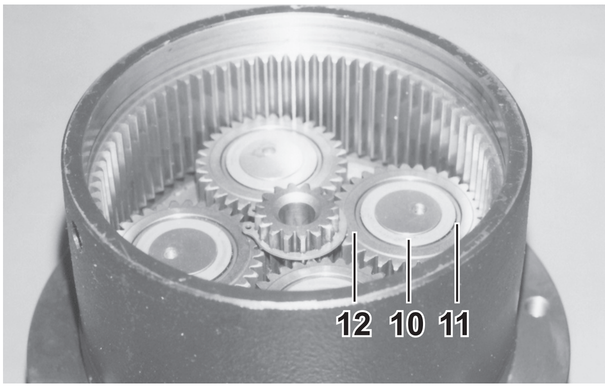
Tightening torque : 50.6 to 88.3 ft·lbf (7 to 9 N·m)

Tools :
- Torque wrench (1)
- Hexagon bit (7)



(10) Install thrust washers **9**, inner races **10**, needle bearings **11** and planetary gears B **12**.



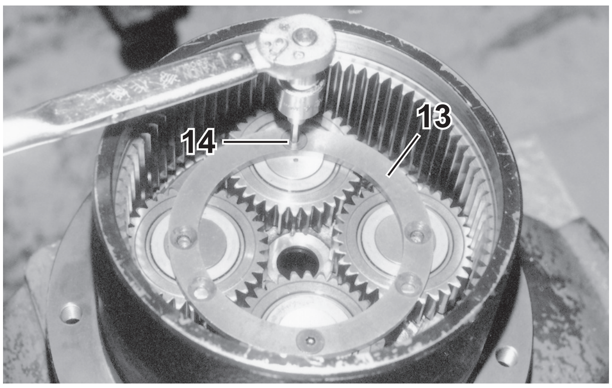


(11) Fit thrust plate **13** on the trunnion of the flange holder **1**, apply adhesive (Loctite #262 or its equivalent) to four screws **14** and tighten them.

Tightening torque : 14.5 to 21.7 ft·lbf (20 to 30 N·m)

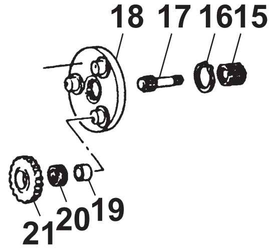
Note :
Before applying adhesive, remove oil and grease completely from the screws, and use hardening accelerator.

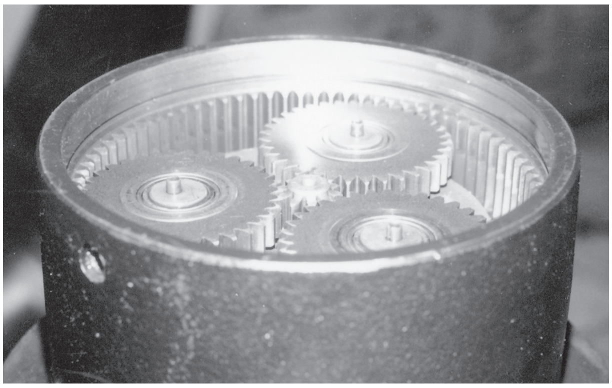
Tools :
- Torque wrench (2)
- Hexagon bit (7)



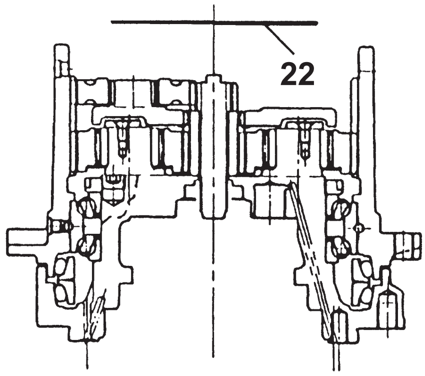
Procedure

(12) Install sun gear **15** fitted with external snap ring **16**, inner races **19**, holder **18**, planetary gears A **21**, cage & rollers **20**, and drive gear **17**.



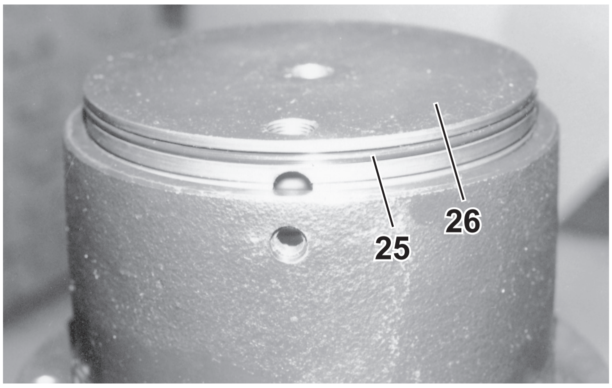


(13) Install thrust plate **22**.



(14) Apply grease to O-ring **25** and install it to cover **26**. Install the cover on housing **6** with the U-groove aligned with the tapped hole for plug **8** in housing **6**.

Tool :
• Plastic hammer (17)

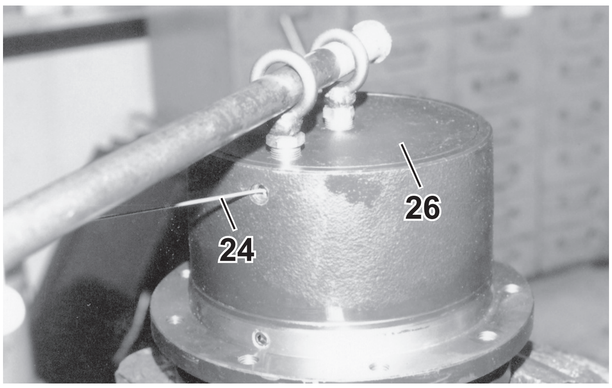


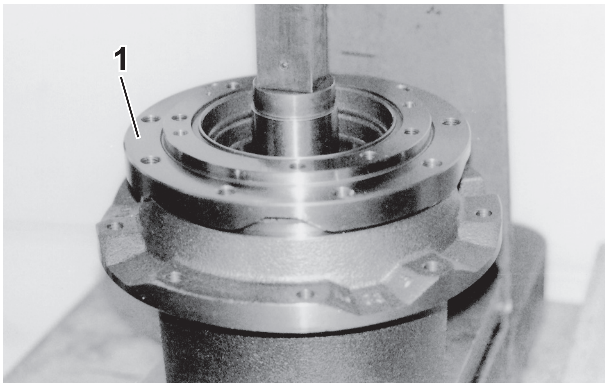
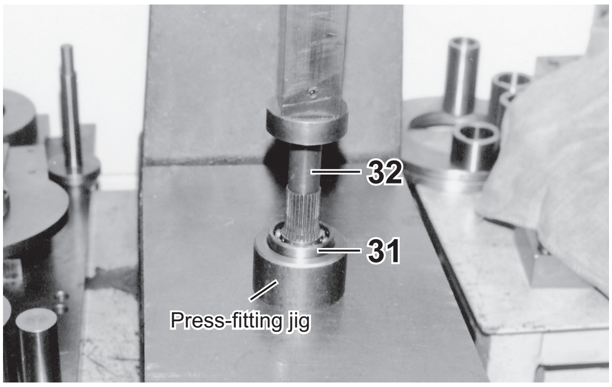
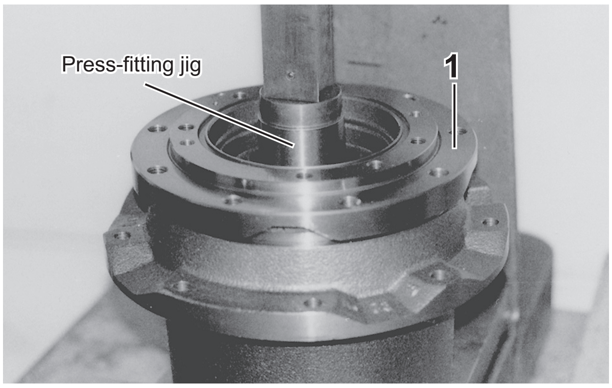
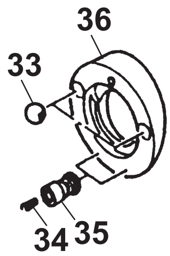
(15) Bend the end of wire **24** by about 0.24 in. (6 mm) at an angle of 90 degrees and insert it into the tapped hole in housing **6**. Turn cover **26** to draw in wire **24**.
Tools :
• Eye bolt (S-1)
• Round rod (S-15)

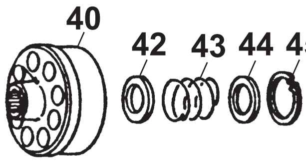
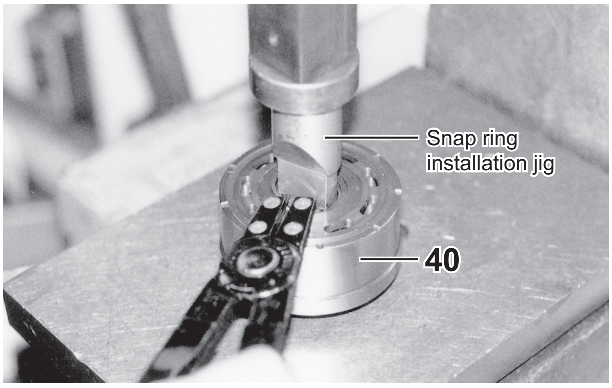
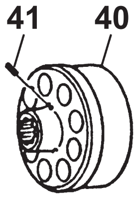
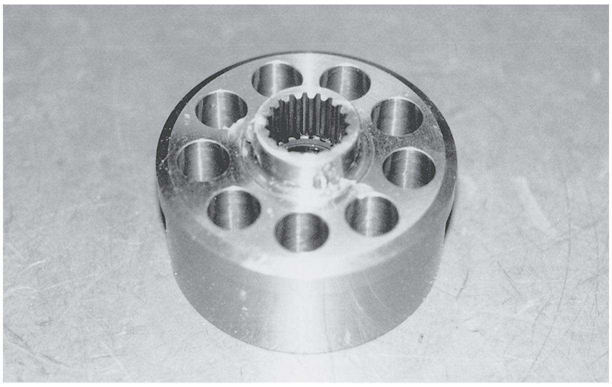
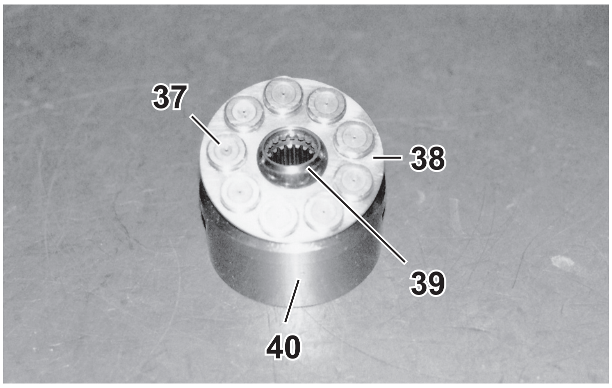
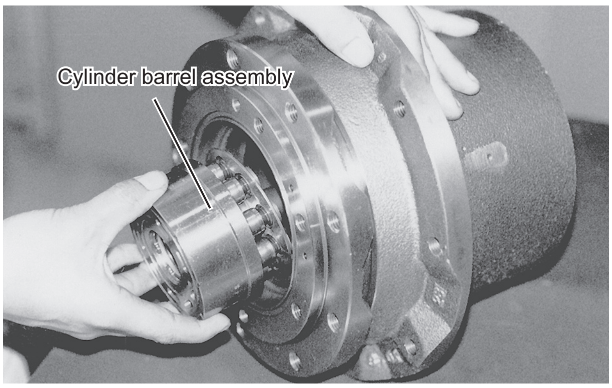
(16) Wind a seal tape around plug **8** and tighten it.

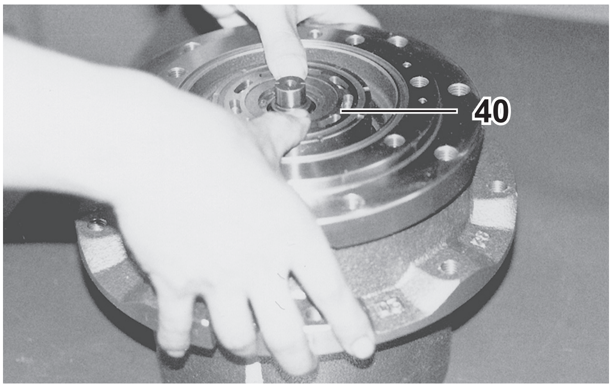
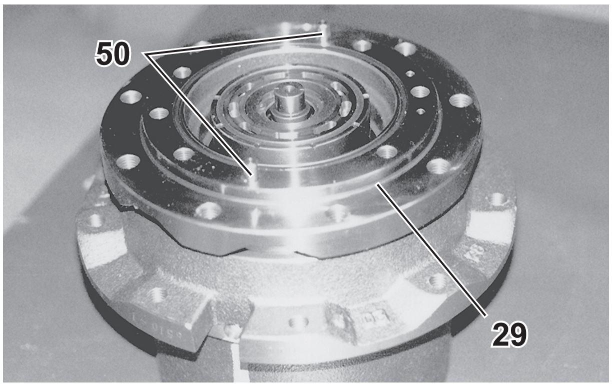
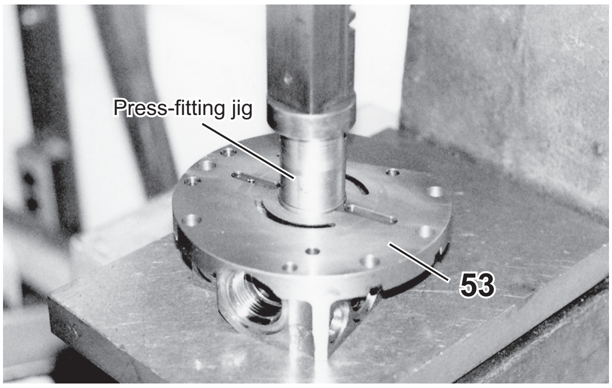
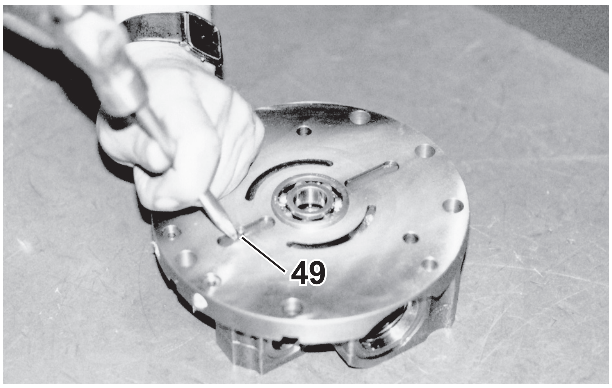
Tightening torque : 50.6 to 88.3 ft·lbf (7 to 9 N·m)

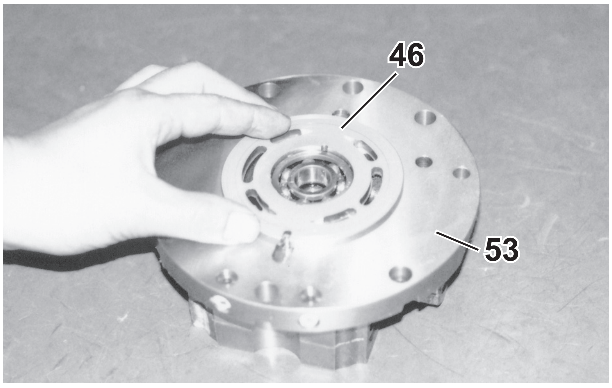
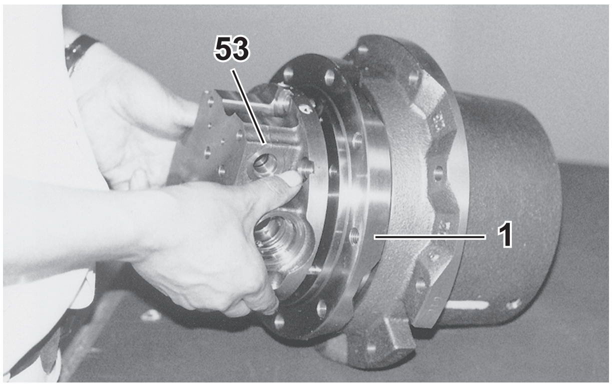
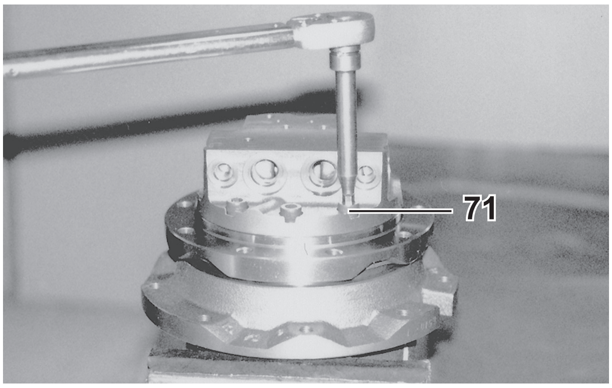
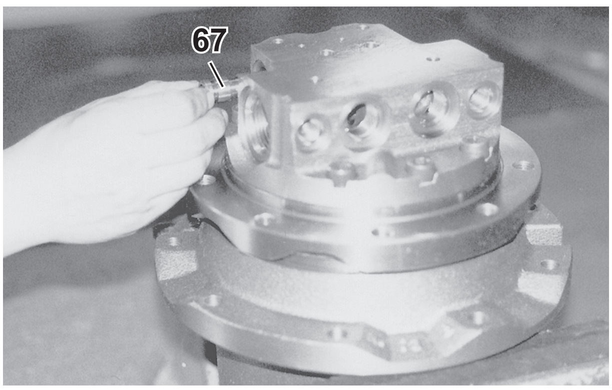
Tools :
• Torque wrench (1)
• Hexagon bit (7)



Procedure	
(17) Press-fit oil seal **30** into flange holder **1**. **Tool :** • Oil seal press-fitting jig (S-8)	
(18) Press-fit ball bearing **31** into shaft **32**. **Tool :** • Ball bearing press-fitting jig (S-9)	
(19) Press-fit the shaft assembly into flange holder **1**. **Tool :** • Shaft assembly press-fitting jig (S-10)	
(20) Install steel balls **33**, springs **34**, piston assemblies **35** and swash plate **36** into flange holder **1**. ***Note :*** *Apply hydraulic oil to the sliding surface of the swash plate before installation.* 	

Procedure	
(21) Install collar **42**, spring **43**, washer **44** and internal snap ring **45** into cylinder barrel **40**. **Tools :** • Snap ring pliers (19) • Snap ring installation jig (S-11) 	
(22) Apply grease to pins **41** and install them into the three holes in cylinder barrel **40**. 	
(23) Install retainer holder **39**, retainer plate **38** and piston assemblies **37**. ***Note :*** *Apply hydraulic oil to the **9** bores in the cylinder barrel **40**.*	
(24) Place the motor on its side and install the cylinder barrel assembly with the shaft's **32** spline used as a guide.	

Procedure	
(25) Press cylinder barrel **40** by hand to check that spring **43** force works normally. (26) Apply hydraulic oil to the sliding area of the cylinder barrel.	
(27) Install O-ring **29** and pins **50** into flange holder **1**. ***Note :*** *Apply a small amount of grease to the O-ring.*	
(28) Press-fit ball bearing **47** into base plate **53**. **Tool :** • Ball bearing press-fitting jig (S-12)	
(29) Install pin **49** and caulk it at two places. **Tools :** • Hammer (16) • Punch (20)	

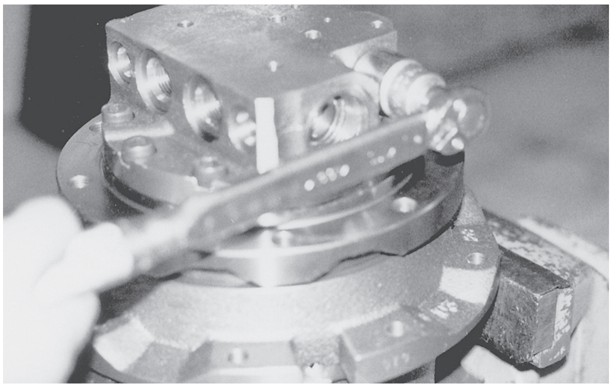
Procedure	
(30) Apply grease to the rear of valve plate **46** and install it onto base plate **53**. (31) Install O-rings **48** onto base plate **53**. ***Note :*** *Apply a small amount of grease to O-rings **48** before installation.*	
(32) Install base plate **53** onto flange holder **1**.	
(33) Tighten six hexagon socket head bolts **71**. Tightening torque : 89.7 to 99.8 ft·lbf (122 to 135 N·m) **Tools :** • Torque wrench (3) • Hexagon bit (9)	
(34) Install spool **67** and spring **68**. ***Notes :*** • *Install the spool **67** straight while turning it.* • *Apply hydraulic oil to the spool **67** before installation.*	

Procedure

(35) Install plugs **70** and **57** fitted with O-rings **69**.

Tightening torque : 36.2 to 43.4 ft·lbf (49 to 59 N·m)

Tools :
- Torque wrench (3)
- Hexagon bit (9)
- Socket (12)

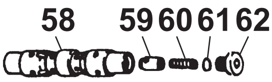


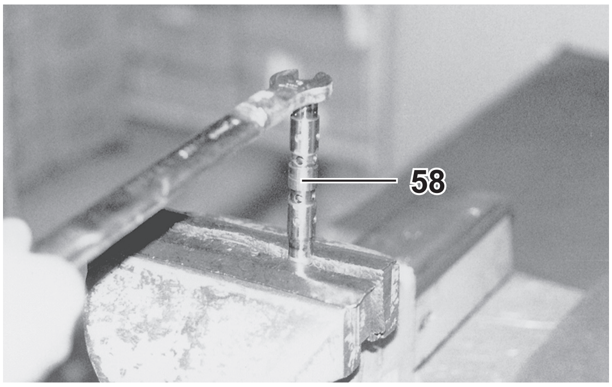
(36) Install check valve **59**, spring **60**, and plug **62** fitted with O-ring **61** to plunger **58**. Tighten the plug.

Tightening torque : 21.7 to 36.2 ft·lbf (29.4 to 49.0 N·m)

Note :
*Apply a small amount of grease to the O-ring **61**.*

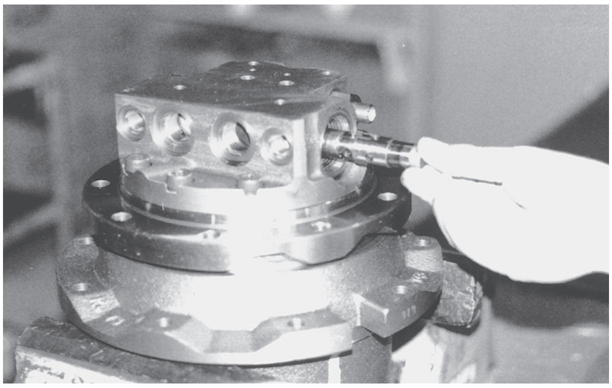
Tools :
- Torque wrench (5)
- Wrench (14)



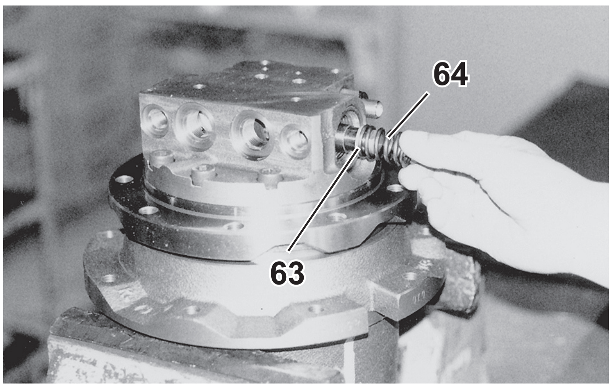


(37) Install the plunger assembly to base plate **53**.

Notes :
- *Apply hydraulic oil to the plunger assembly before installation.*
- *Install the plunger assembly straight while turning it.*



(38) Install spring seat **63** and spring **64**.



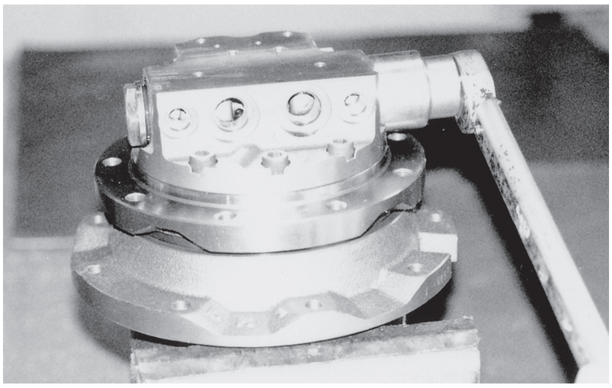
Procedure

(39) Tighten caps **66** fitted with O-ring **65** each.

Note :
*Apply a small amount of grease to the O-rings **65**.*

Tightening torque : 173.6 to 180.8 ft·lbf (235.4 to 45.2 N·m)

Tools :
- Torque wrench (4)
- Socket (13)

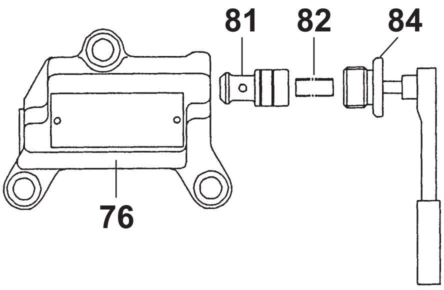


(40) Install check valve **81** and spring **82** into valve body **76**.

(41) Tighten plug **84**.

Tightening torque : 36.2 to 43.4 ft·lbf (49 to 59 N·m)

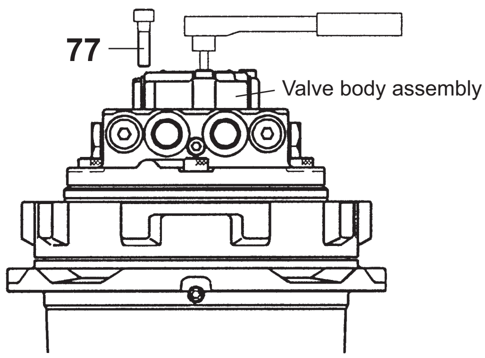
Tools :
- Torque wrench (3)
- Hexagon bit (9)



(42) Install O-rings **80** onto valve body **76**, and fasten the valve body assembly to base plate **53** with three hexagon socket head bolts **77**.

Tightening torque : 25.3 to 28.9 ft·lbf (34 to 39 N·m)

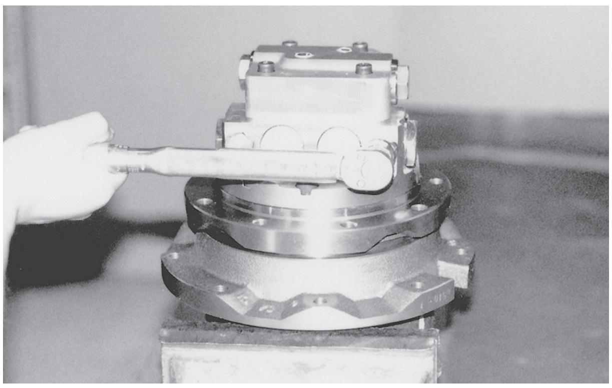
Tools :
- Torque wrench (2)
- Hexagon bit (8)

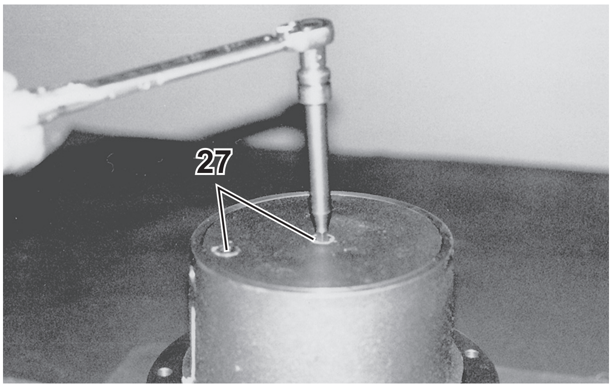
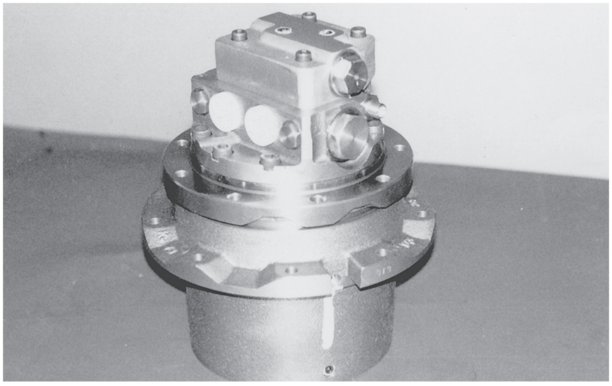


(43) Tighten plug **52** fitted with O-ring **51**.

Tightening torque : 27.5 to 30.4 ft·lbf (37 to 41 N·m)

Tools :
- Torque wrench (2)
- Socket (11)



Procedure	
(44) Put gear oil [approx. 0.95 Qts. (0.96)] from the tapped hole for plug **27**. (45) Tighten plugs **27** with O-rings **23**. Tightening torque : 15.9 to 17.4 ft･lbf (22 to 23.5 N･m) **Tools :** • Torque wrench (2) • Hexagon bit (8)	
(46) This completes the reassembly.	

6. Service Standards

Clean the removed parts, dry them with compressed air and repair or replace them, if necessary, according to the following service standards :

No.	Parts	Inspection item	Standard value (recommended value for replacement	Measure
1	Floating seal **2**	Sliding surface	No excessive flaws, wear or seizure	Replace.
2	Angular bearing **3**	Moving surface	o excessive flaws, wear or flaking in ball or race	Replace.
3	Housing **6**	Gear tooth surface	No excessive flaws, wear or flaking on tooth surface (More than 10% pitting in the engaged area of a tooth surface)	Replace.
4	Planetary gears B **12** and A **21**	Gear tooth surface. Rolling contact surface of cage & roller	Same as No.3. No excessive flaws, wear or flaking on the rolling contact surface	Replace.
5	Needle bearing **20** Cage & roller **11**	Cage & roller (needle bearing) surface	No excessive flaws, wear or flaking	Replace.
6	Thrust washer **9**	Sliding surface	No excessive flaws, wear or seizure	Replace.
7	Thrust plates **13** and **22**	Sliding surface	No excessive flaws, wear or seizure	Replace.
8	Sun gear **15**	Gear tooth surface	Same as No.3	Replace.
9	Inner races **10** and **19**	Cage & roller (needle bearing) surface	No excessive flaws, wear or flaking	Replace.
10	Drive gear **17**	Gear tooth surface	Same as No.3	Replace.
11	Holder **18**	Sliding surface against planetary gear B	No excessive flaws, or wear	Replace planetary gear B and holder together
12	O-rings **23, 25, 29, 48, 51, 56, 61, 65, 69, 73, 80,** and **83**	Surface condition and hardness	No flaws or distortion. Not hardened	Rubber seal members deteriorate with the lapse of time. Replacement with new seals is recommended every time they are reassembled.
13	Shaft **32**	Oil seal surface	No flaws or excessive wear	Replace.
14	Ball bearings **31** and **47**	Moving surface	Same as No.2	Replace.
15	Oil seal **30**	Lip surface and hardness	No flaws, distortion or excessive wear. Not hardened	Replace.
16	Swash plate **36**	Sliding surface against piston assembly Surface roughness	No excessive flaws 0.00079 in. over [0.02 mm], wear or seizure 0.4 Ra (0.8 Ra)	When sliding surface has roughened, repair it by lapping (#1000). Replace it if the damage is beyond repair.

No.	Parts	Inspection item	Standard value (recommended value for replacement	Measure
17	Cylinder barrel **40**	Clearance between it and piston assembly. Sliding surface against valve plate. Surface roughness	0.02 mm (0.04 mm) 0.00079 in. (0.02 mm) [0.00157 in. (0.04 mm)] No excessive flaws (over 0.02 mm), wear or seizure. 0.4 Ra (0.8 Ra)	Replace cylinder barrel and piston assembly together. When sliding surface has roughened, repair it by lapping (#1000). If the damage is beyond repair, replace the cylinder barrel and piston assembly together.
18	Springs **34, 43, 60, 64, 68** and **82**	Breakage or distortion		Replace.
19	Piston assembly **37**	Clearance between it and cylinder barrel. Sliding surface against swash plate and surface roughness. Play between pistons and shoes	Same as No.17 Same as No.16 0.00591 in. [0.15 mm] 0.01575 in. [0. 4 mm])	Same as No.17 Same as No.16 Replace.
20	Piston assembly **35**	Clearance between it and flange holder. Sliding surface against swash plate and surface roughness.	Same as No.17 Same as No.16	Same as No.17 Same as No.16
21	Valve plate **46**	Sliding surface against cylinder barrel and surface roughness. Thickness : 5 mm	Same as No.17 0.189 in. [4.8 mm]	Same as No.17 Replace.
22	Base plate **53**	Sliding surface against plunger. Sliding surface against spool.	No excessive flaws, wear or seizure. No excessive flaws, wear or seizure.	Replace base plate and plunger together. Replace base plate and spool together.
23	Plunger **58**	Sliding surface against base plate. Sliding surface against check valve.	No excessive flaws, wear or seizure. No excessive flaws, wear or seizure.	Replace base plate and plunger together. Replace plunger and check valve together.
24	Check valve **59**	Sliding surface against plunger. Seat surface against plunger.	No excessive flaws, wear or seizure. The plunger is seated completely.	Replace plunger and check valve together. Replace plunger and check valve together.
25	Spool **67**	Sliding surface against base plate.	No excessive flaws, wear or seizure.	Replace base plate and spool together.
26	Valve body **76**	Sliding surface against check valve.	No excessive flaws, wear or seizure.	Replace check valve and valve body together.
		Seat surface against check valve.	The check valve is seated completely.	
27	Check valve **81**	Sliding surface against valve body.	No excessive flaws, wear or seizure.	Replace check valve and valve body together.
		Seat surface against valve body.	The valve body is seated completely.	

7. Troubleshooting

1) Motor

Trouble	Cause	Measure
1. Motor does not rotate.	1) Malfunction of equipment other than motor, counter balance valve and reduction gear.	Check whether the specified volume of hydraulic oil is fed to the motor suction side. Then, check and repair each part.
	2) Escape of pressure oil due to excessive wear of motor's sliding parts.	Replace any excessively worn parts. Repair any flaws or burrs on the surfaces, clean all the parts and reassemble them.
	3) Malfunction due to breakage of motor's sliding parts. (In this case, motor makes an abnormal sound).	Disassemble the motor and replace any broken parts. Clean all the parts and reassemble them.
	4) Relief valve operates due to too much load applied to motor.	Check the load and regulate it to the value corresponding to the set relief pressure.
2. Motor speed is low.	1) Specified volume of oil is not being supplied to motor due to failure of hydraulic pump, system relief valve, etc.	Check whether the specified volume of hydraulic oil is fed to the motor suction side. Then, check and repair each part.
	2) Specified speed is not obtained due to drop of motor's displacement.	After disassembling the motor, check them for excessive wear of the sliding parts. Repair or replace any worn parts.
3. Large fluctuation in motor revolutions	1) A large volume of high pressure oil leaks and flows out from drain port due to wear of motor's parts, causing a large drop and fluctuation in motor revolutions. The fluctuation is also caused by worn bearing.	After disassembling the motor, check the parts and replace any worn parts. Clean all the parts and reassemble them.
4. Oil leak	1) Breakage of oil seals or O-rings.	Replace any broken oil seals and O-rings. Take care not to damage the lip of the oil seal. Apply a small amount of grease to O-rings before assembly.

2) Counter Balance Valve

Trouble	Cause	Measure
1. Motor does not turn or motor speed is low.	1) Plunger is not moved. (1) No pilot pressure oil supplied. (2) Foreign substances caught between plunger and base plate. (3) Clogged orifice.	 Check the piping for breakage. Remove all the foreign substances, repair any damaged area, clean and reassemble the parts. If the damage is serious and oil leak is bad, replace the part. Clean the part with cleaning oil and reinstall it.
2. Motor does not stop or is slow to stop.	1) Plunger does not return. (1) Foreign substances caught between plunger and base plate. (2) Broken spring. (3) Spring is not installed. (4) Clogged orifice.	 Remove all the foreign substances, repair any damaged area, clean and reassemble the parts. If the damage is serious and oil leak is bad, replace the part. Replace the spring. Then, remove all the foreign substances, repair any damaged area, clean and reassemble the parts. Install a spring in the correct position. Clean the part with cleaning oil and reinstall it.
3. Fluctuation in motor revolutions.	1) Plunger does not move smoothly. (1) Foreign substances caught inside. (2) Clogged orifice.	 Remove all the foreign substances and repair any damaged area. Then, clean the parts and reassemble them. If the damage is serious and oil leak is bad, replace the part. Clean the part and reinstall it.
4. Large shock on stopping traveling.	1) Plunger is quick to return. (1) Spring seat is not installed.	 Install a spring seat in the correct position.
5. Abnormal sound.	1) Plunger does not return. (1) Foreign substances caught inside. (2) Broken spring. (3) Clogged orifice.	 Remove al the foreign substances, repair any damaged area, clean the parts and reassemble them. If the damage is serious and oil leak is bad, replace the part. Replace the spring. Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them. Clean the part with cleaning oil and reassemble it.

3) Anti-Cavitation Valve

Trouble	Cause	Measure
1. Motor does not turn or motor speed is low.	1) Seat of check valve is defective. (1) Foreign substances caught inside. (2) Broken spring.	Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them. If the damages is serious and oil leak is bad, replace the part. Replace the spring. Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them.
2. Large cavitation sound on traveling.	1) Sticking of check valve (1) Foreign substances caught between check valve and valve body.	Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them. If the damage is serious and oil leak is bad, replace the part.

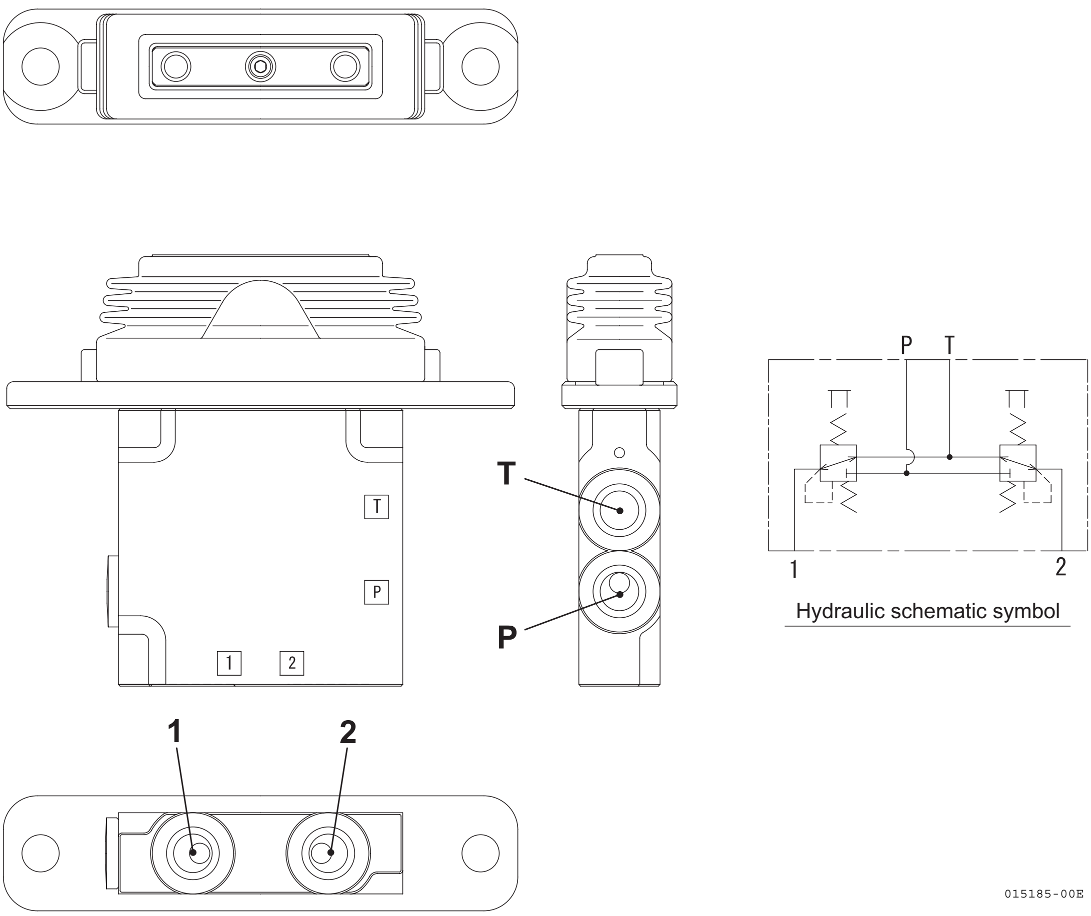
4) 2-Speed Switching Mechanism

Trouble	Cause	Measure
1. Deviation in travel	1) Spool does not move. (1) Foreign substances caught between spool and valve body.	Remove all the foreign substances and repair any damaged area. Clean the parts and reassemble them. If the damage is serious and oil leak is bad, replace the part.
	(2) Spring is not installed.	Install a spring in the correct position.
	(3) Broken spring.	Replace the spring. Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them.
	2) Oil leak due to excessive wear of high speed control piston.	Replace the high speed control piston. Remove all the foreign substances, clean the part and reinstall it.
	3) High speed control piston is not installed.	Install a high speed control piston in the correct position.
	4) Excessive wear of steel ball.	Replace the steel ball. Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them.
2. Does not travel in fast speed	1) Plunger does not move due to foreign substances caught between plunger and body.	Remove all the foreign substances and repair any damaged area. Clean the parts and reassemble them. If the damage is serious and oil leak is bad, replace the part.
	2) Oil leak due to excessive wear of two speed control piston.	Replace the two speed control piston. Remove all the foreign substances, clean the part and reinstall it.
	3) Two speed control piston is not installed.	Install a two speed control piston in the correct position.
	4) Clogged orifice in oil passage of two speed piston chamber.	Cleaning the orifice, then reinstall it.
	5) Plunger installed in the wrong direction.	Check the direction of the plunger and install it in the correct direction.
3. Does not travel in low speed	1) Spring is not installed.	Install a spring in the correct position.
	2) Broken spring.	Replace the spring. Remove all the foreign substances, repair any damaged area, clean the parts and reassemble them.
	3) Plunger installed in the wrong direction.	Check the direction of the plunger and install it in the correct direction.

6-6 Blade Control Pilot Valve

1. Outline

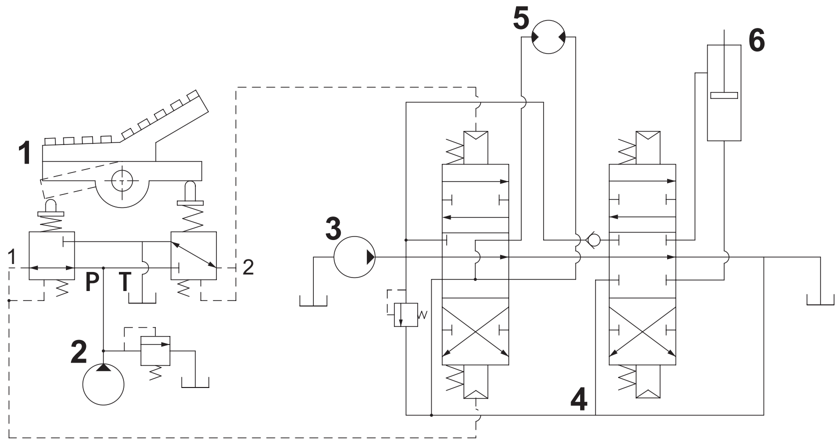
This valve is a remote control valve with a pressure reducing system. It consists of two pressure-reducing valves to regulate the secondary side pressure and control system for the valves. The secondary side pressure is controlled by the blade lever movement and it is proportional to the lever stroke.



Primary side pressure	Maximum 1000 PSI (6.9 MPa)
Secondary side pressure	0 to 420 PSI <Maximum control pressure> (0 to 2.9 MPa)
Back pressure limit	42 PSI (0.29 MPa)
Rated oil flow	2.64 GPM (10 L/m)

2. Operation Theory

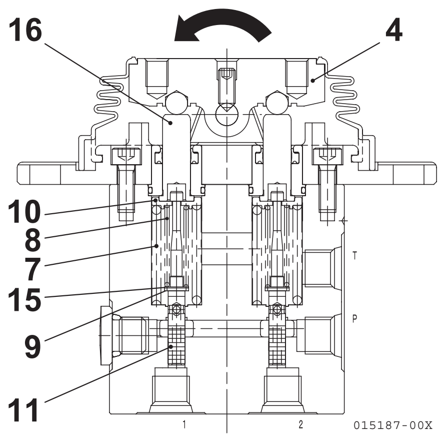
Hydraulic schematic example of a typical use of the valve is shown below to explain the operation theory.



1 Control pilot valve
2 Pilot oil pump
3 Main pump
4 Main control valve
5 Hydraulic motor
6 Hydraulic cylinder

Hydraulic circuit schematic

015186-00E



1) Control Lever in Neutral

Spool **11** is pushed up by spring **7** via spring seat **10** and kept in the neutral position shown to the right. Accordingly, spool **11** connects the secondary side ports 1 and 2 to the return circuit port T only so that the secondary side pressure is the same as that of the return circuit port T.

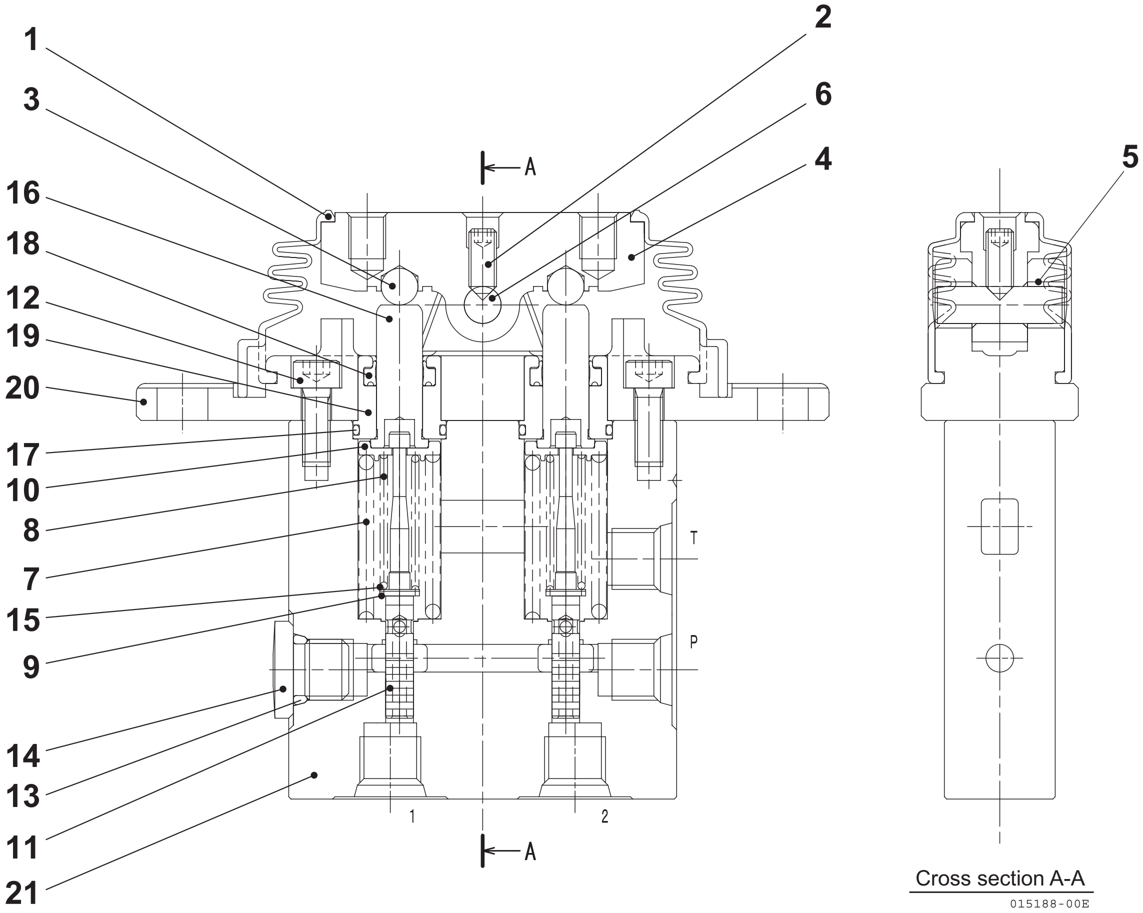
2) Control Lever Operated

When the control lever is operated to move cam **4** in the direction of an arrow, push rod **16** of the port 1 side is pushed down and spool **11** is moved downward via spring seat **10**, spring **8**, shim **15** and washer **9**. The port P connects to the port 1 and oil discharged by the pilot oil pump flows to the port 1 to develop pressure in the circuit.

When the lever is moved to raise the oil pressure in the port 1 circuit till the designed force of spring **8**, the pressure spool **11** receives and the spring force balance, consequently keep the pressure in the port 1 circuit constant.

Spool of the port 2 side holds its neutral condition and pilot oil from main control valve returns to reservoir through the return circuit port T.

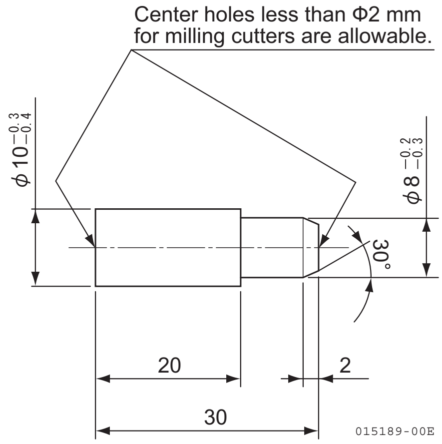
3. Cross Section Drawing and Component Parts



No	Description	Q'ty	No	Description	Q'ty
1	Rubber boot	1	12	Allen head cap screw	2
2	Allen head screw	1	13	O-ring	1
3	Steel ball	2	14	Plug	1
4	Cam	1	15	Shim	2
5	Bushing	2	16	Push rod	2
6	Cam shaft	1	17	O-ring	2
7	Spring (Return)	2	18	Gasket	2
8	Spring (Secondary side pressure regulating)	2	19	Plug	2
9	Washer	2	20	Cover	1
10	Spring seat	2	21	Casing	1
11	Spool	2			

4. Special Tool

Jig to remove bushing



5. Disassembly and Reassembly

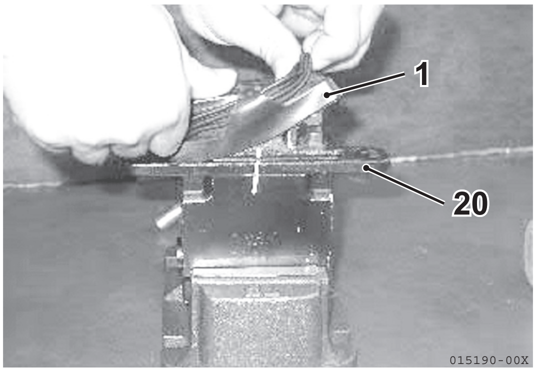
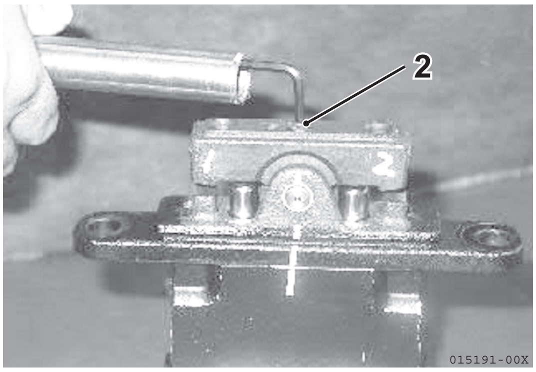
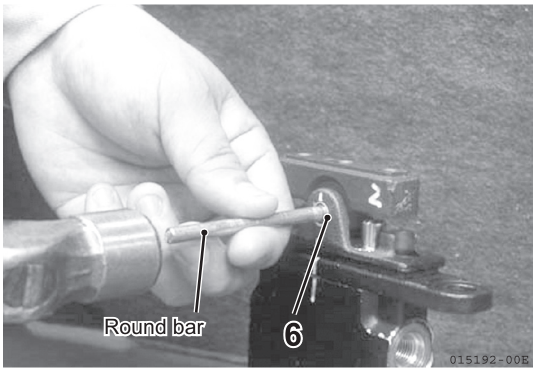
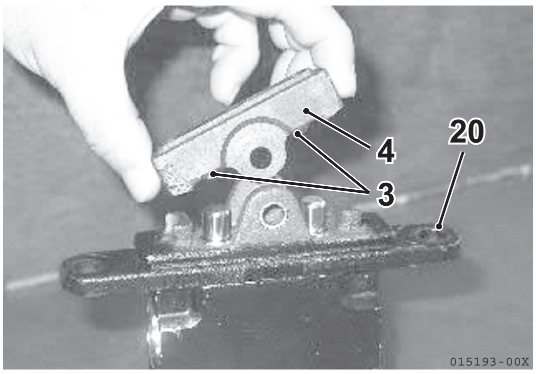
1) Precautions

(1) Since the parts of this equipment are generally precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean place that is free from dust.
(2) Prepare clean tools and treated oil.
(3) First, clean the external surface of the removed valve body.
(4) Before beginning disassembly, review the drawings of the internal structure and prepare the required parts according to the purpose and extent of the disassembly.
(5) In principle, replace the removed O-rings with new ones.
(6) Handling of O-rings
[1] Lubricate the O-rings and the O-ring fitting seats with clean grease or hydraulic oil.
[2] The O-rings may not be damaged in handing or distorted by heat
[3] Do not extend any O-rings with such great force as to permanently deform them.
[4] O-ring should be installed to the plug with a jig.

2) Tools

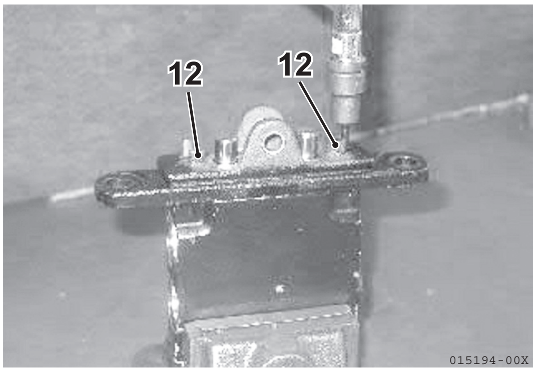
Tool	Q'ty	Size	Remarks
Allen key	1	6	
Hammer	1	-	
Bushing removing jig	1	-	Refer to 4. Special Tool
Screwdriver	1	-	
Others	• Kerosene • Grease • Vapor phase corrosion inhibitor • Locktite 241 • Round bar (O.D.:7 mm or less)		

3) Disassembly

Procedure	
(1) Plug each port and clean the valve by kerosene. (2) Fix the valve on a vise with using buffing plates. (3) Pull up rubber boot **1** to remove it from cover **20**.	
(4) Loosen allen head screw **2**. ***Note :*** *Much torque is required to loosen it because screw lock agent is applied on its thread.*	
(5) Punch out cam shaft **6** by using a round bar and hammer.	
(6) Remove cam **4**. ***Note :*** • *Cam **4** and steel ball **3** are inseparable.* • *Put marks on cam **4** and cover **20** to reassemble them as they were.*	

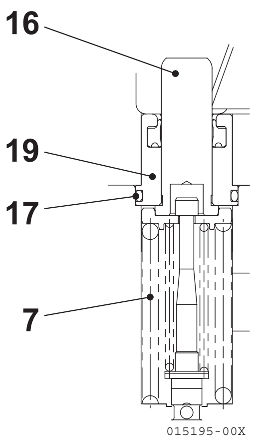
Procedure

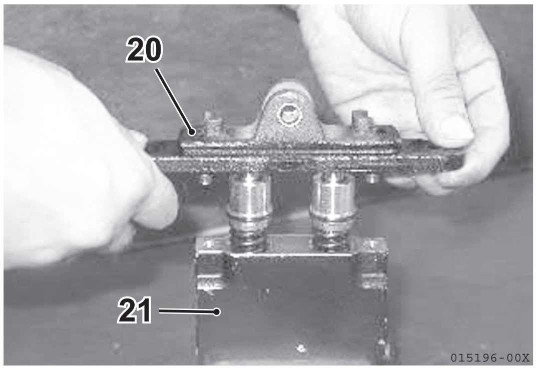
(7) Remove two allen head cap screws **12**.



(8) Remove cover **20**.

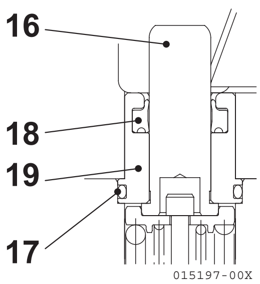
Note :
- *Put marks on casing **21** and cover **20** to reassemble them as they were.*
- *When removing, take care of push rod **16** and plug **19** for popping out by spring **7** (plug **19** may remain in casing **21** but it must be temporary due to friction of O-ring **17**).*

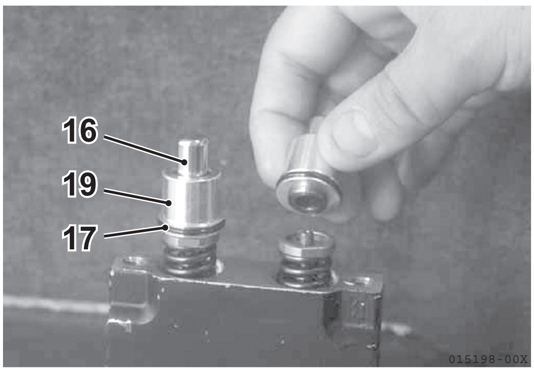


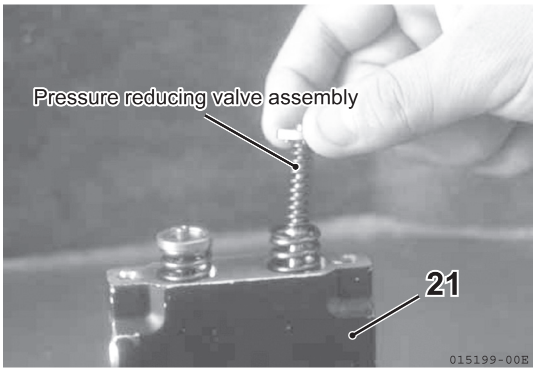
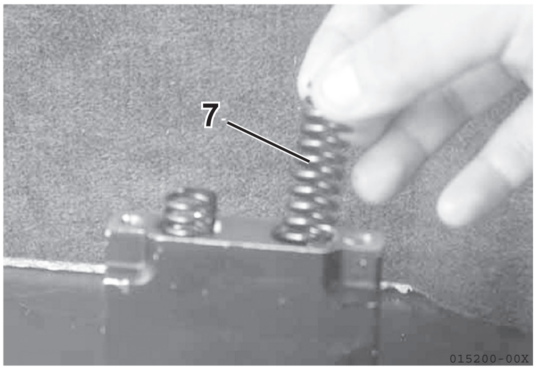
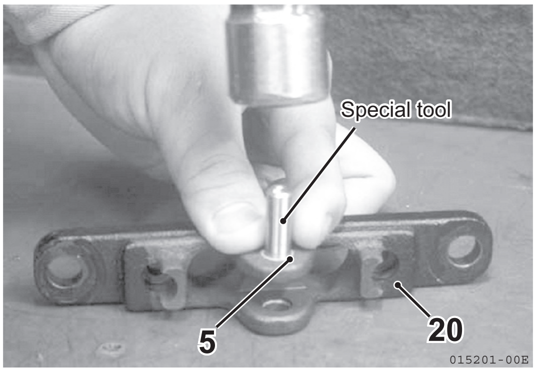
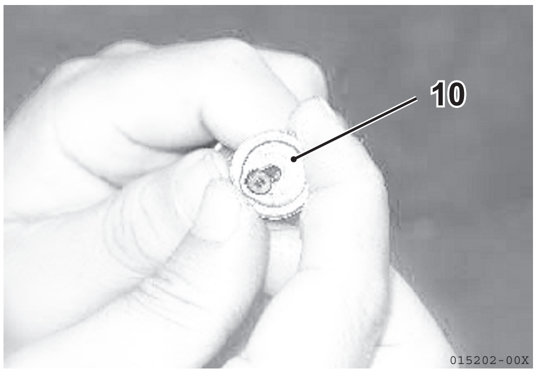


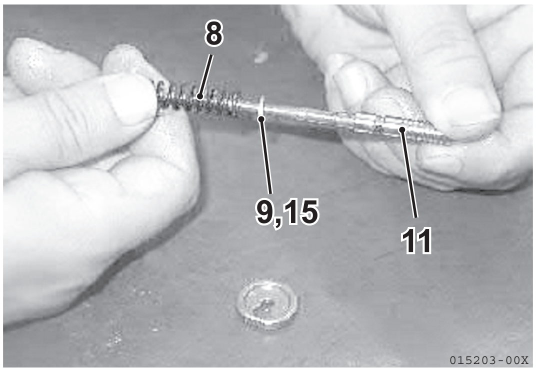
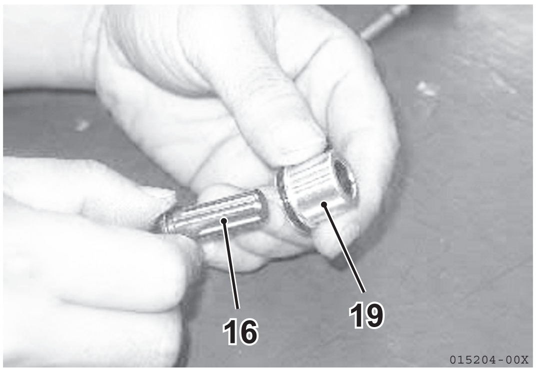
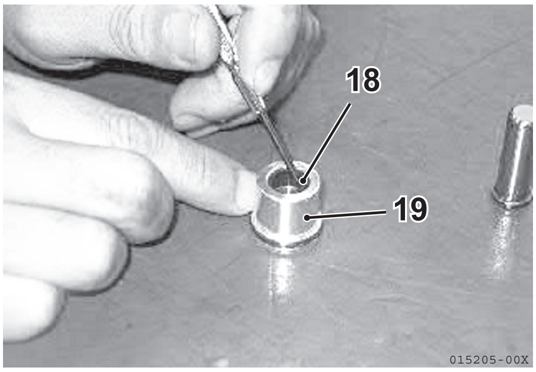
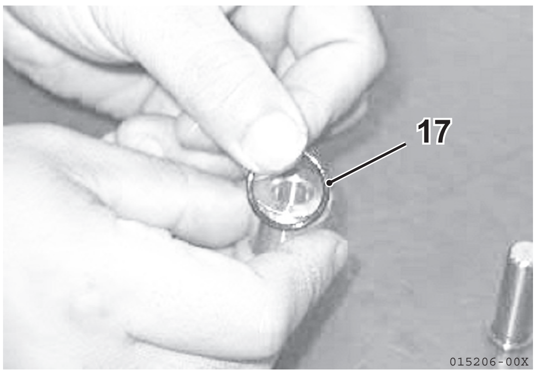
(9) Remove plug **19** with push rod **16**, gasket **18** and O-ring **17**.

Note :
*Put marks on plug **19** and casing **21** to reassemble them as they were.*

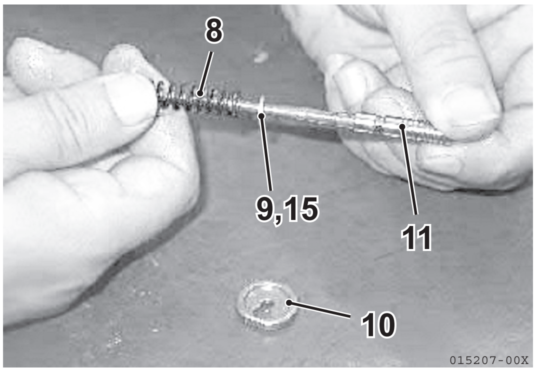
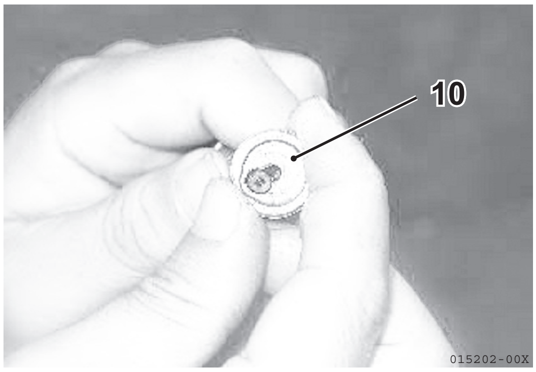
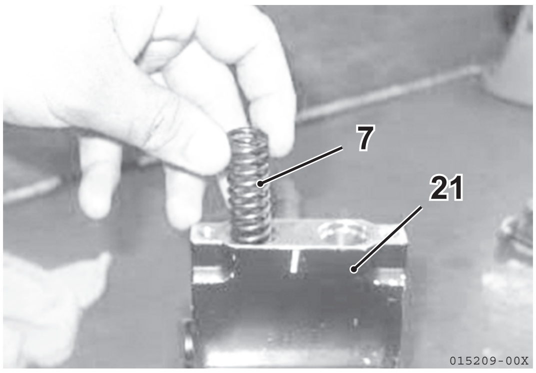


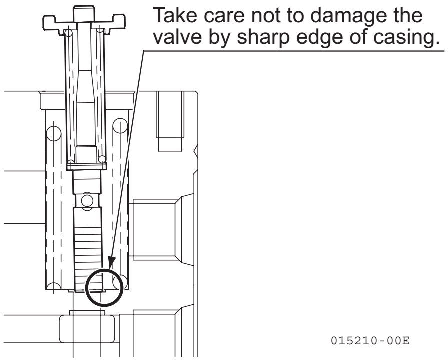
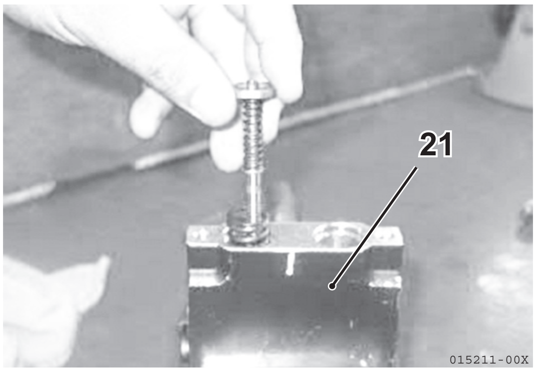


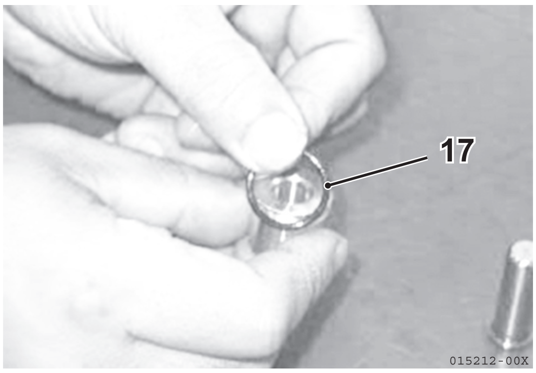
Procedure	
(10) Remove pressure reducing valve assembly and spring **7** from casing **21**. ***Note :*** *Do not mix up two assemblies to reinstall them as they were.*	 
(11) Put cover **20** on a flat surface and lightly strike bushing **5** by using a special tool and hammer to remove it.	
(12) If disassembling of pressure reducing valve assembly is required, press spring seat **10** to bow spring **8**, laterally displace spring seat **10** and remove it from spool **11** through larger opening of it. ***Note :*** • *Be careful not to damage spool surface.* • *Do not press down spring seat **10** more than 4 mm.* • *Always keep pressure reducing valve as assembly.*	

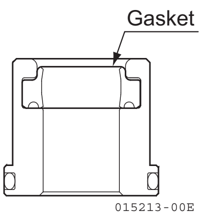
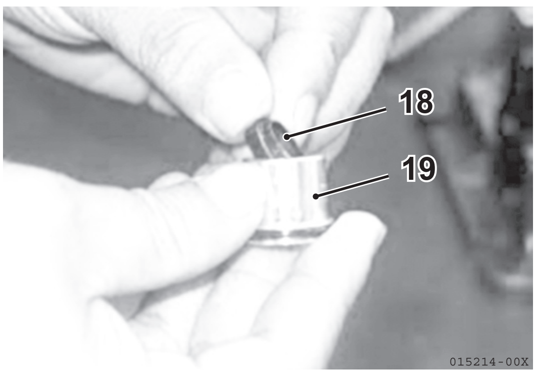
Procedure	
(13) Separate spool **11**, spring **8**, shim **15** and washer **9**. ***Note :*** • *Always keep pressure reducing valve as assembly.* • *Washer **9** is used for presetting of spring **8**. Its thickness differs assembly by assembly and some may have no washer **9**.*	
(14) Remove push rod **16** from plug **19**.	
(15) Remove gasket **18** from plug **19**. ***Note :*** • *Use appropriate tool to remove gasket **18**.* • *Take care not to damage inner surface of plug **19**.*	
(16) Remove O-ring **17** from plug **19**.	

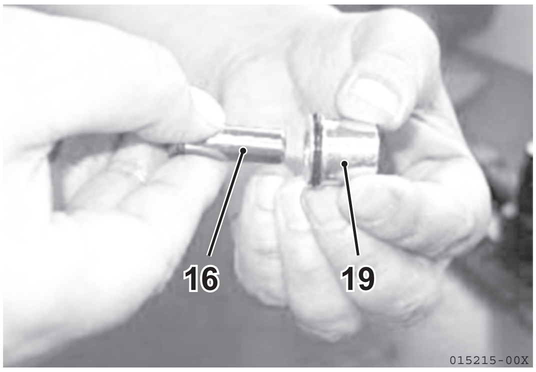
4) Reassembly

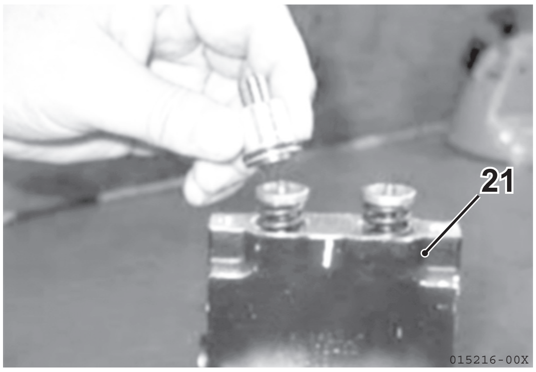
Procedure	
(1) Install washer **9**, shim **15** and spring **8** on spool **11** in order. ***Note :*** *Washer **9** is used for presetting of spring **8**. Its thickness differs assembly by assembly and some may have no washer **9**.*	
(2) Install spring seat on spool **11** through larger opening of it, press spring seat to bow spring and laterally displace spring seat to fix it on spool **11**. ***Note :*** • *Be careful not to damage spool surface.* • *Do not press down spring seat **10** more than 4 mm.*	
(3) Fix casing **21** on a vise with using buffing plates and install spring **7** on casing **21**. ***Note :*** *Reinstall the part to the original position before disassembling.*	

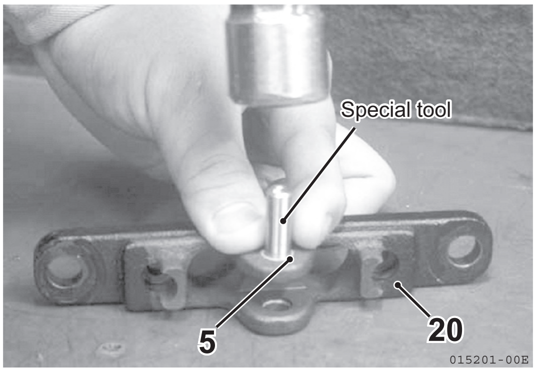
Procedure	
(4) Install pressure reducing valve sub-assembled at the steps (1) and (2) in casing **21**. ***Note :*** • *Reinstall the part to the original position before disassembling.* • *When installing pressure reducing valve, be careful not to excessively press the bottom of spool **11** to sharp edge of casing **21**.*  	

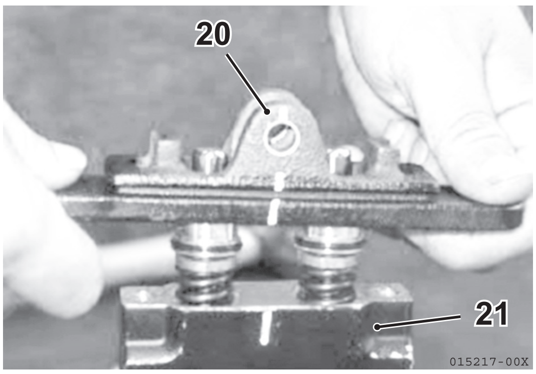
(5) Install O-ring **17** on plug **19**.	

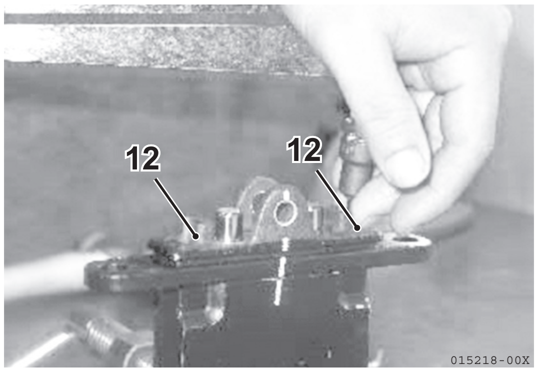
(6) Install gasket **18** on plug **19**. ***Note :*** • *Take care of installation direction of gasket **18**.* • *Coat grease on gasket **18** before installing.*  	

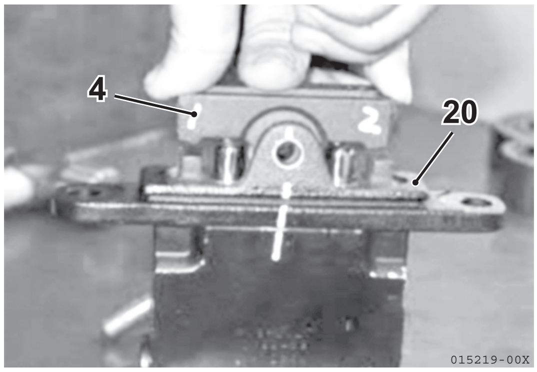
Procedure	
(7) Install push rod **16** on plug **19**. ***Note :*** • *Coat hydraulic oil on push rod **16** before installing.* • *Do not strongly press push rod **16** or lip of gasket **18** may be damaged.*	

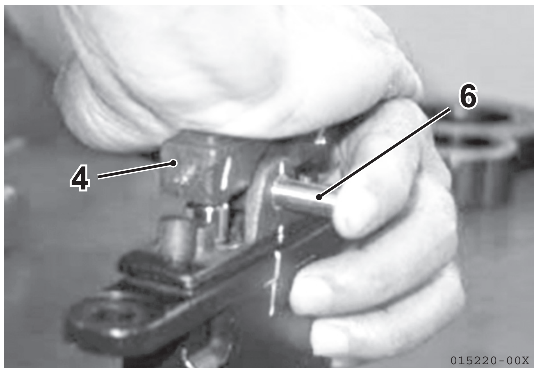
(8) Install push rod sub-assembled at the steps (5), (6) and (7) in casing **21**.	

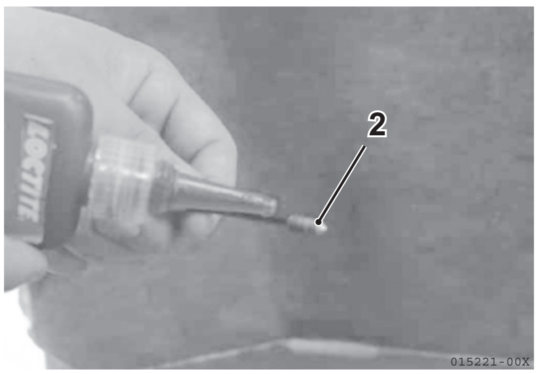
(9) Put cover **20** on a flat surface and lightly strike bushing **5** by using a special tool and hammer to fit it. ***Note :*** *Be careful for the end of bushing **5** not to project from the inside of cover **20**.*	

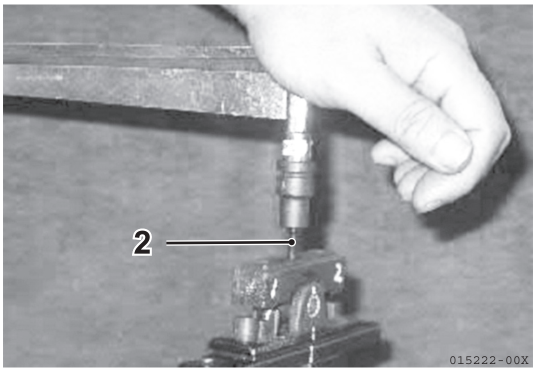
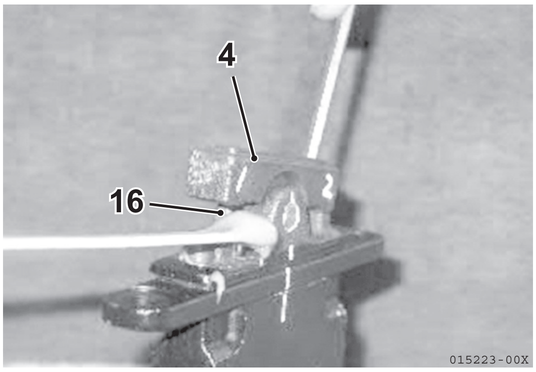
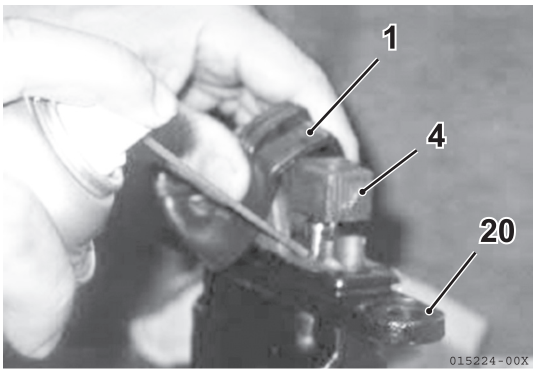
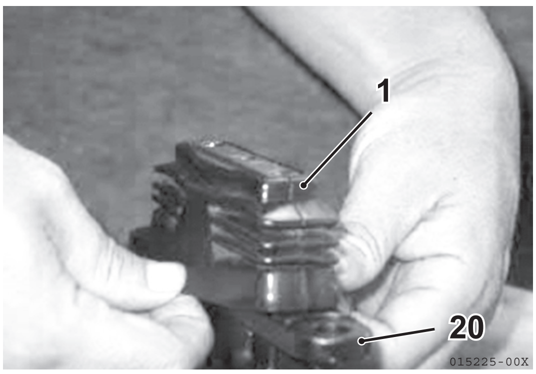
(10) Put cover **20** on casing **21**. ***Note :*** *Reinstall the part to the original position before disassembling.*	

Procedure	
(11) Tighten two allen head cap screws **12** to 6.42 to 6.56 ft•lb (8.7 to 8.9 N•m).	

(12) Install cam **4** on cover **20**. ***Note :*** *Reinstall the part to the original position before disassembling.*	

(13) Install cam shaft **6** with pressing cam **4** down. ***Note :*** *Coat grease on cam shaft **6** before installing it.*	

(14) Apply Loctite 241 or equivalent of it on allen head screw **2**.	

Procedure	
(15) Tighten allen head screw **2** to 4.4 to 5.8 ft•lb (5.9 to 7.9 N•m).	
(16) Move cam **4** to coat grease on the top of push rod **16**. ***Note :*** *Use soft spatula or something so as for surfaces of push rod **16** and plug **14** not to damage.*	
(17) Put rubber boot **1** over cam **4** and then fit its bottom end into a groove of cover **20**. ***Note :*** • *Spray anti-rusting oil on all parts in rubber boot **1** before installing it.* • *Securely fit rubber boot **1** into a groove of cover **20**, or its dust and waterproof performances go down.*	

5) Servicing Instruction

All parts disassembled should be rinsed by cleaning oil. According to the criteria below, repair or replace with a new one as required.

Note :

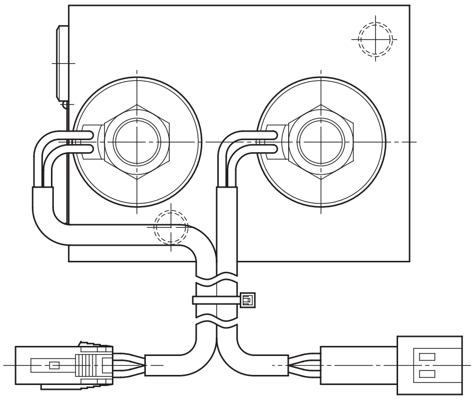
- *It is preferable that seals like a gasket and O-ring are to be replaced with new ones every time once removed but can be reused unless it has damage.*
- *Single service parts supply of spool **11** or casing **21** is disapproved because both parts fitting is controlled at the factory.*

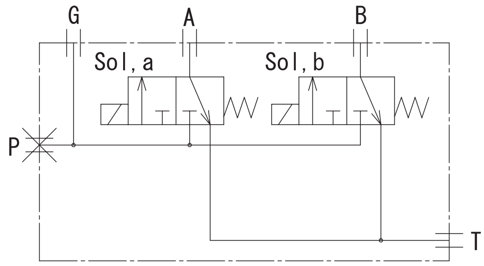
No.	Symptoms	Criteria	Corrections
1	Low secondary side pressure	• Low primary side pressure • Spring **8** broken or weakened • Excessive clearance between spool **11** and casing **21** • Too much play in control lever movement	• Obtain proper primary side pressure • Replace spring **8** • Replace complete assembly • Replace lever
2	Unstable secondary side pressure	• Sticky friction part • Return line pressure fluctuation • Air in the circuit	• Repair • Direct return to reservoir • Purge air
3	High secondary side pressure	• High return line pressure • Sticky friction part	• Direct return to reservoir • Repair

6-7 Solenoid Valve for P.T.O. Operation

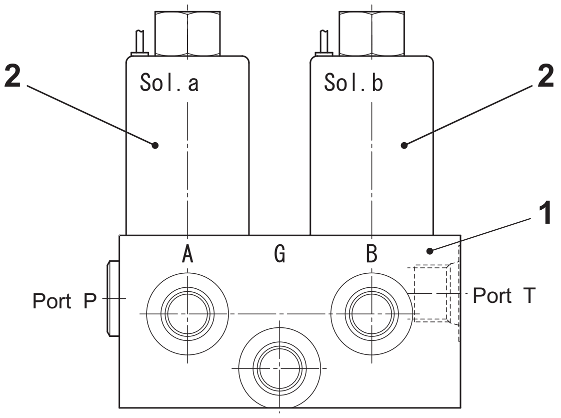
1. Outline

This valve consists of body **1** and two solenoid valves **2**.





Symbol



No	Description
1	Body
2	Solenoid valve

015226-00E

2. Operation Theory

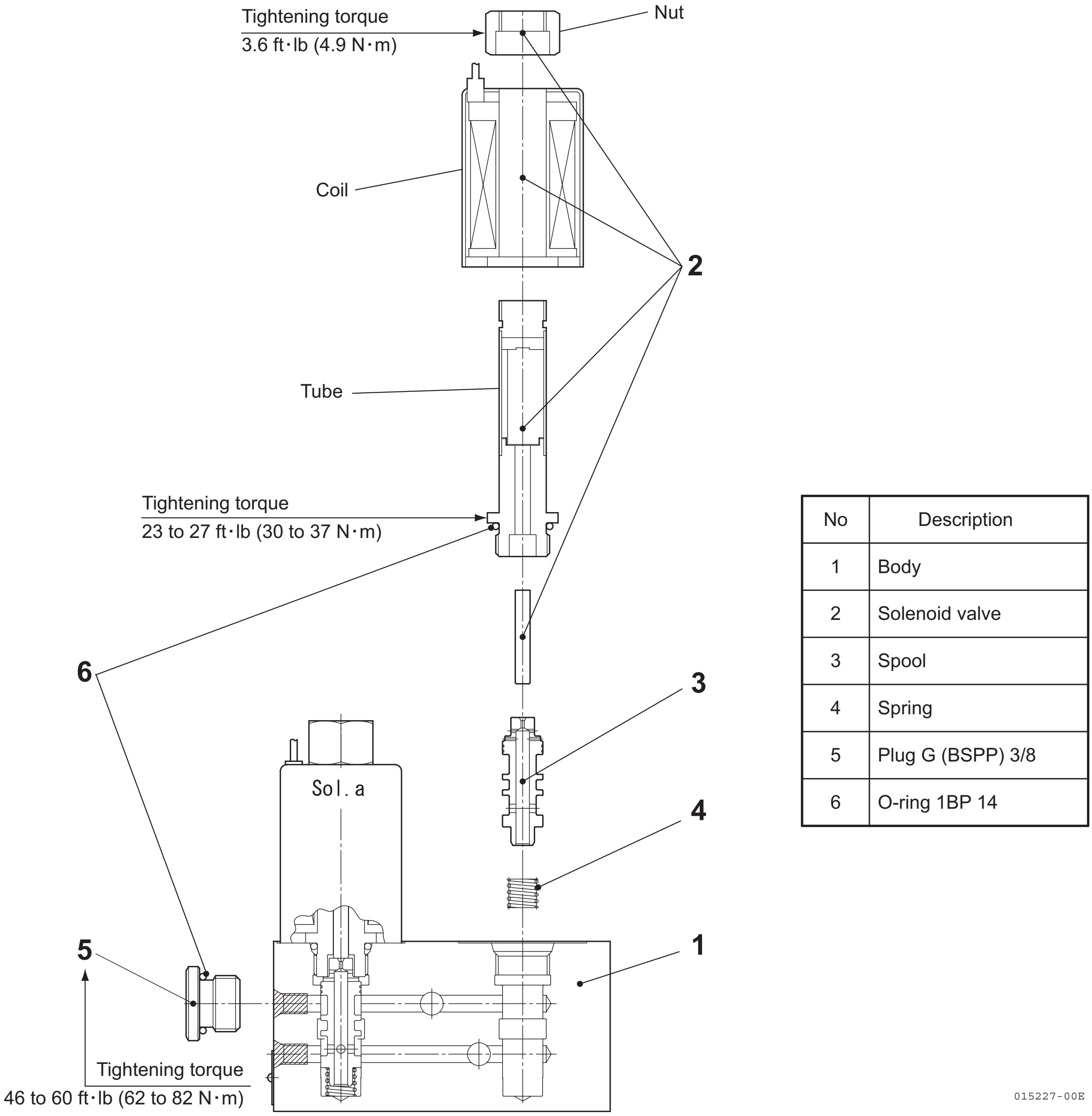
The oil discharged from pump P4 flows to port G but it is blocked when solenoids are not exited. Ports A and B connect to port T so the circuits are led to the reservoir.

When the solenoids are exited, oil passage is open and oil from port G flows to port A or port B.

3. Disassembly and Reassembly

1) Precautions

(1) Take care not to damage O-rings and inner parts when disassembling and storing.
(2) Damaged O-rings and inner parts must be replaced with new ones.
(3) Take care of direction of parts installing and of reinstalling all removed parts.
(4) Reassemble all parts in reverse order of disassembling and take care for dust or foreign materials.

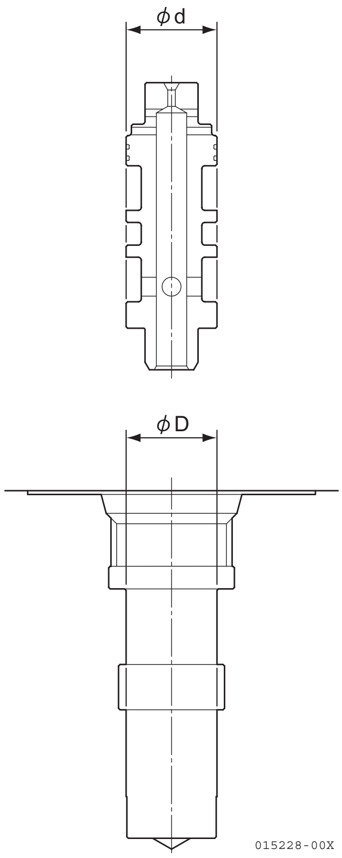


No	Description
1	Body
2	Solenoid valve
3	Spool
4	Spring
5	Plug G (BSPP) 3/8
6	O-ring 1BP 14

2) Disassembly/Reassembly of Solenoid Valve

(1) Loosen nut to remove coil. (Wrench: Hex 19 mm)
(2) Loosen tube to remove it. (Wrench: Hex 21 mm)
(3) Remove spool **3** and spring **4**.
(4) Reassemble all parts in reverse order. Take care not to damage Hex part of tube.

4. Servicing Instruction

Solenoid valve	Measure the clearance between body **1** and spool **3**. Clearance=ØD-Ød Standard clearance : 0.03 mm or less
	

Symptom	Possible causes	Corrections
Spool malfunction	Sticked by dust or foreign material	Clean spool and replace hydraulic oil
	Parts damage, excessive wear	Replace valve
Solenoid malfunction	Bad terminal connection	Connect terminal
	Coil damaged	Replace solenoid
	Lead wire disconnected	
Oil leak to outside	Screws or nuts loosened	Retighten to specified torque
	O-ring damaged	Replace O-ring

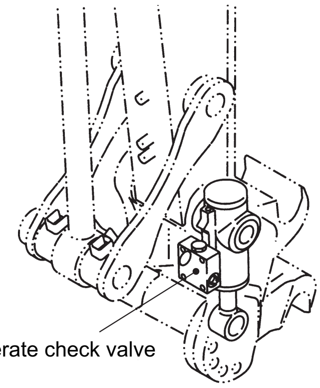
6-8 Pilot Check Valve (For Quick Coupler Circuit)

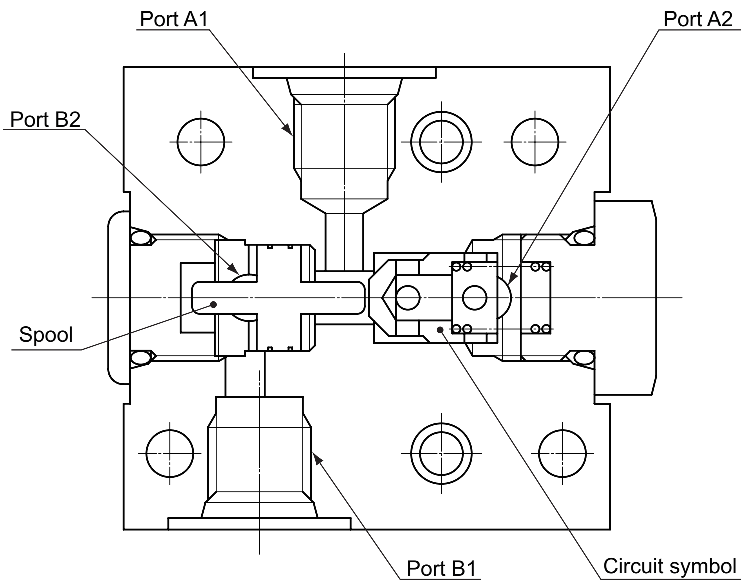
1. Outline

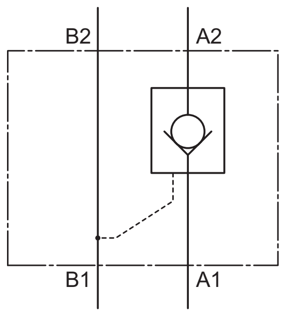
The pilot check valve provides the oil flow in the hydraulic circuit with directionality.
This is opened at the specified pressure (cracking pressure) in one direction and completely blocks the oil flow in the reverse direction. It, however, has the pilot function which enables oil flow in the reverse direction on certain condition.

2. Theory of Operation

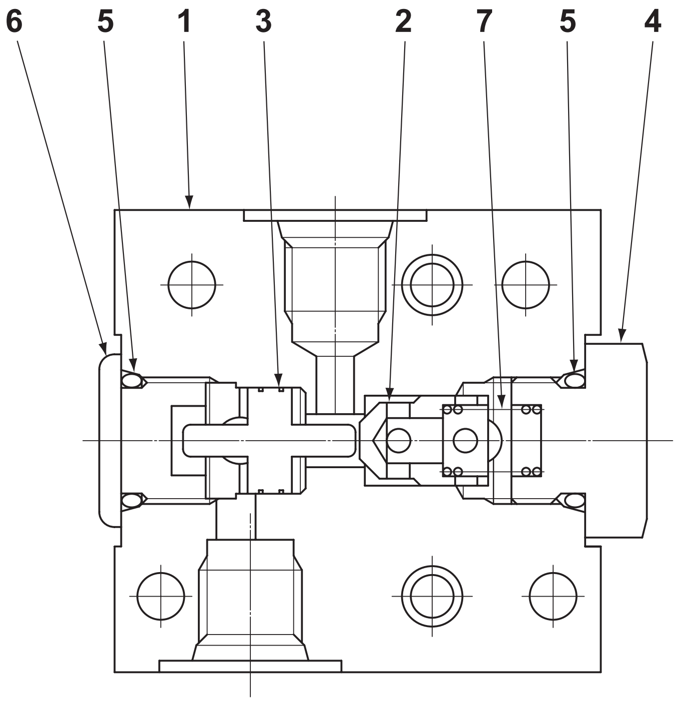
The oil provided from the port A1 is blocked by the poppet. When the pressure exceeds the specified pressure (cracking pressure), the poppet opens and the oil flows into the port A2.
The oil provided to the port A2 cannot flow out because the poppet is pressed on the valve body seat.
When the pressure (pilot pressure) in the ports B1and B2 rises, the spool presses and opens the poppet. This allows oil to flow from the port A2 to the port A1.







3. Exploded View and Component Parts



No.	Part	Q'ty.
1	Valve body	1
2	Poppet	1
3	Spool	1
4	Plug	1
5	O-ring	2
6	Plug	1
7	Spring	1

4. Disassembly and Reassembly

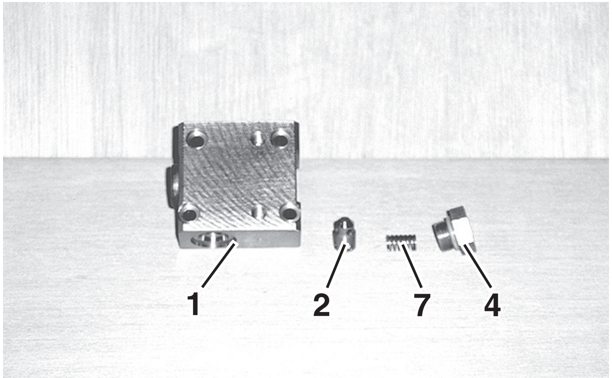
1) Precaution for Disassembly and Reassembly

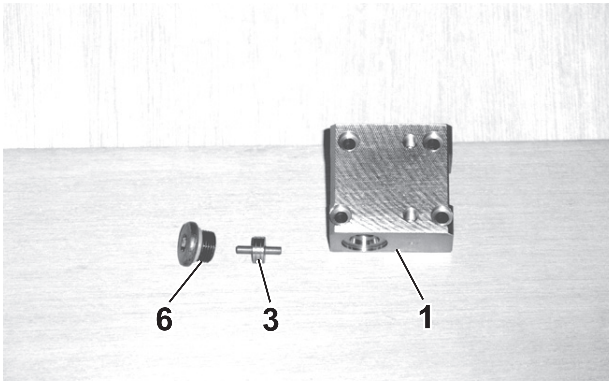
(1) Since the parts of this equipment are generally precision-made for tight clearances, be sure to perform disassembly and reassembly in a clean place that is free from dust.
(2) Prepare clean tools and treated oil.
(3) First, clean the external surface of the removed valve body.
(4) Before beginning disassembly, review the drawings of the internal structure and prepare the required parts according to the purpose and extent of the disassembly.
(5) In principle, replace the removed O-rings with new ones.
(6) Handling of O-rings
[1] Lubricate the O-rings and the O-ring fitting seats with clean grease or hydraulic oil.
[2] The O-rings may not be damaged in handing or distorted by heat
[3] Do not extend any O-rings with such great force as to permanently deform them.
[4] O-ring should be installed to the plug with a jig.

2) Tools for Disassembly and Reassembly

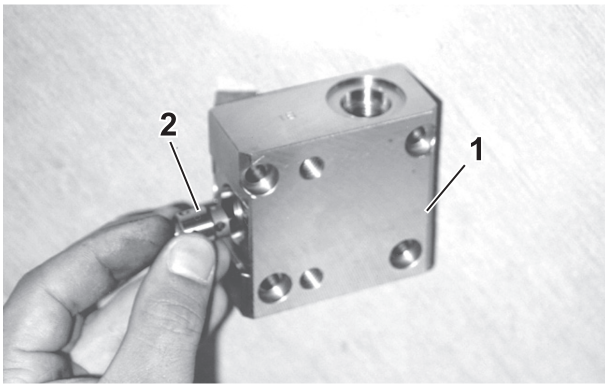
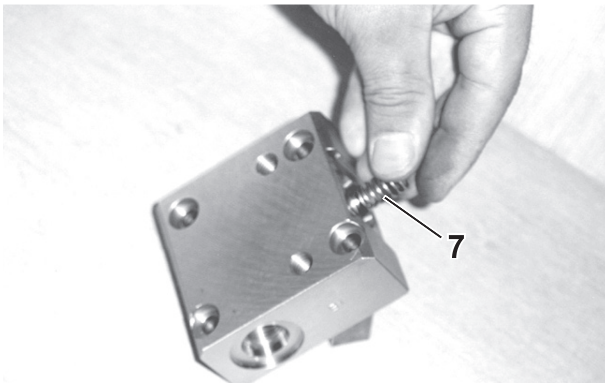
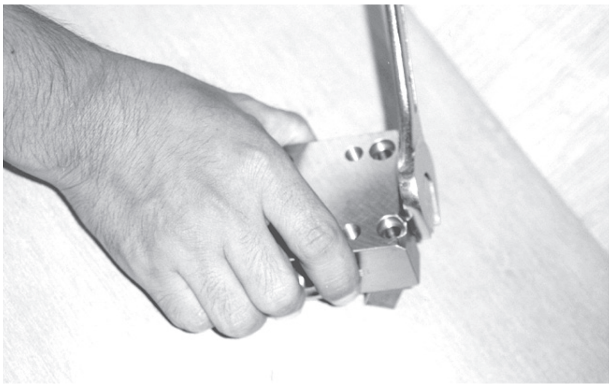
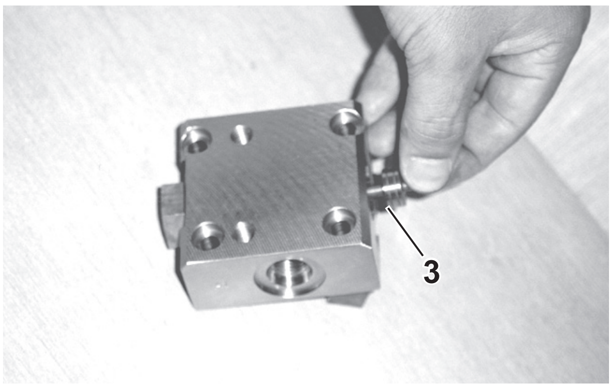
Tool	Nominal Size
Wench (mm)	22
Hexagon socket screw key (mm)	8

3) Disassembly

Procedure	
1. Check valve section Remove the hexagon plug **4** from the valve body **1** to remove the spring **7** and the poppet **2**. **Tool :** • Wrench (22)	

2. Pilot section Remove the hexagon socket head plug **6** from the valve body **1** to remove the spool **3**. **Tool :** • Hexagon socket screw key (8)	

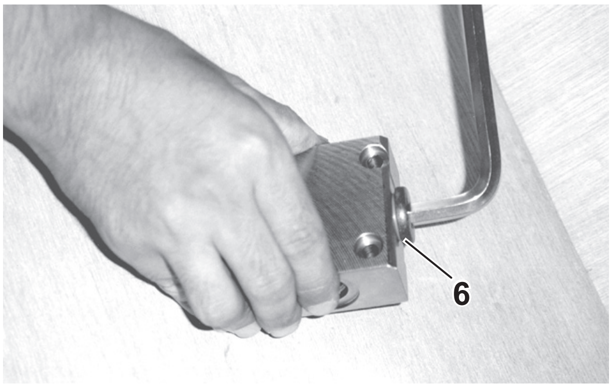
4) Reassembly

Procedure	
1. Installing poppet Install the poppet **2** into the valve body **1**. ***Notes :*** • *No foreign substances adhering* • *Lubricate the external surface of the poppet with lube oil.*	
2. Installing spring Install the spring **7** into the poppet **2**. ***Note :*** *No dirt adhesion.*	
3. Installing hexagon plug Screw the hexagon plug **4** in the valve body **1**. **Tool :** • Wrench (22) ***Notes :*** • *No foreign substances adhering* • *Make sure that the poppet **2** and the spring **7** have been installed.* Tightening torque : 51.0 ft·lbf. (69.0 N·m)	
4. Installing spool Install the spool **3** into the valve body **1**. ***Notes :*** • *No foreign substances adhering* • *Lubricate the external surface of the poppet with lube oil.*	

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>5. Installing hexagon socket head plug
Install the hexagon socket head plug 6 into the valve body 1.

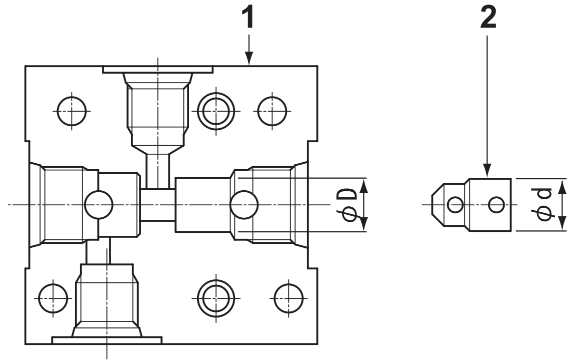
Tool :
• Hexagon socket screw key (8)

Notes :
• No foreign substances adhering
• Make sure that the spool 3 has been installed.

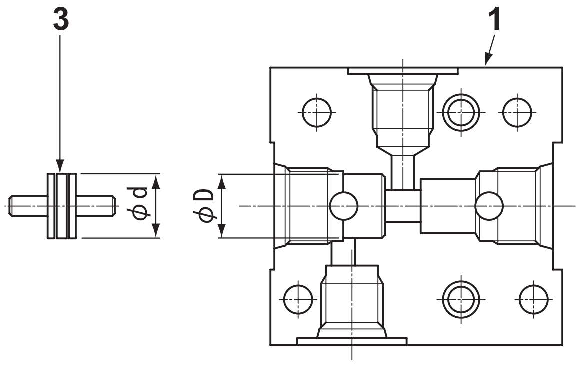
Tightening torque : 51.0 ft･lbf. (69.0 N･m)</td><td>
</td></tr>
</table>

5) Service Standard

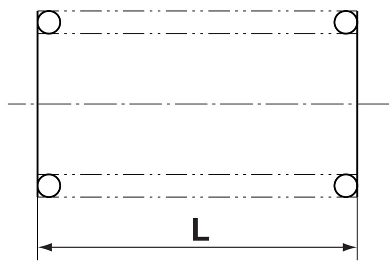
<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(1) Check valve
Measure the clearance between body 1 and poppet 2.
Clearance = ØD-Ød
Standard : max 0.00189 in. (0.048 mm)</td><td>



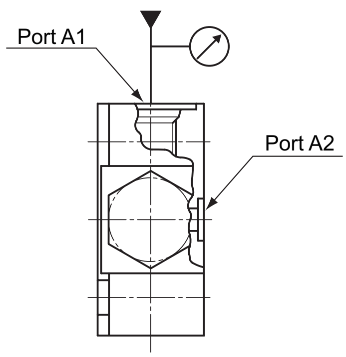
</td></tr>
<tr><td>(2) Pilot section
Measure the clearance between body 1 and spool 3.
Clearance = ØD-Ød
Standard : max 0.00177 in. (0.045 mm)</td><td>



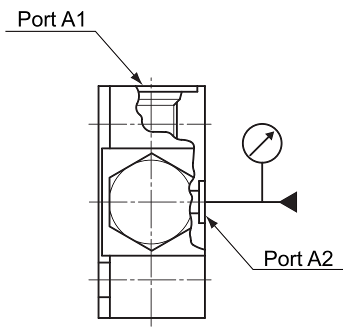
</td></tr>
<tr><td>(3) Spring
Measure the full length of spring 7.
Standard : 0.579 to 0.602 (14.7 to 15.3 mm)</td><td>

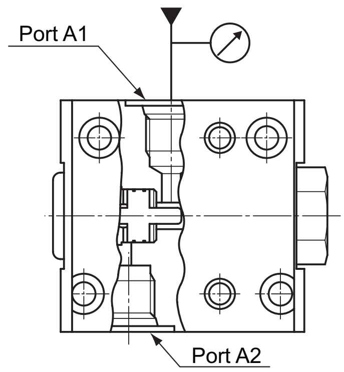


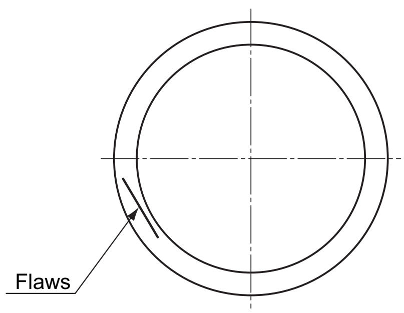
</td></tr>
<tr><td>(4) Checking cracking pressure
Apply pressure on the port A1.
Measure the pressure when poppet opens.
Standard value : 58.3 PSI (0.4 MPa)</td><td>



</td></tr>
</table>

Procedure	
(5) Checking leakage [1] Apply pressure on the port **A2** to measure the oil quantity flowing out of the port **A1**. Standard value : Less than 0.000132 GPM (0.0005 L/min) at 14.2 PSI (0.1 MPa)	

[2] Apply pressure on the port **A1** to measure the oil quantity flowing out of the port **B1**. Standard vale : Less than 0.053 GPM (0.2 L/min) at 44.1 PSI (0.3 MPa)	

(6) O-ring Check the surface of O-ring **5** visually for flaws.	

6) Troubleshooting

Trouble	Cause	Measure
Malfunction of operate check valve	[1] Flaws in seat portion [2] Dust caught in seat portion [3] Permanent set of spring	[1] Replace poppet [2] Disassemble and clean, and replace hydraulic oil. [3] Replace spring
External leakage	[1] Damaged O-ring [2] Damaged surface of installation area	[1] Replace O-ring [2] Replace valve body

CHAPTER 7

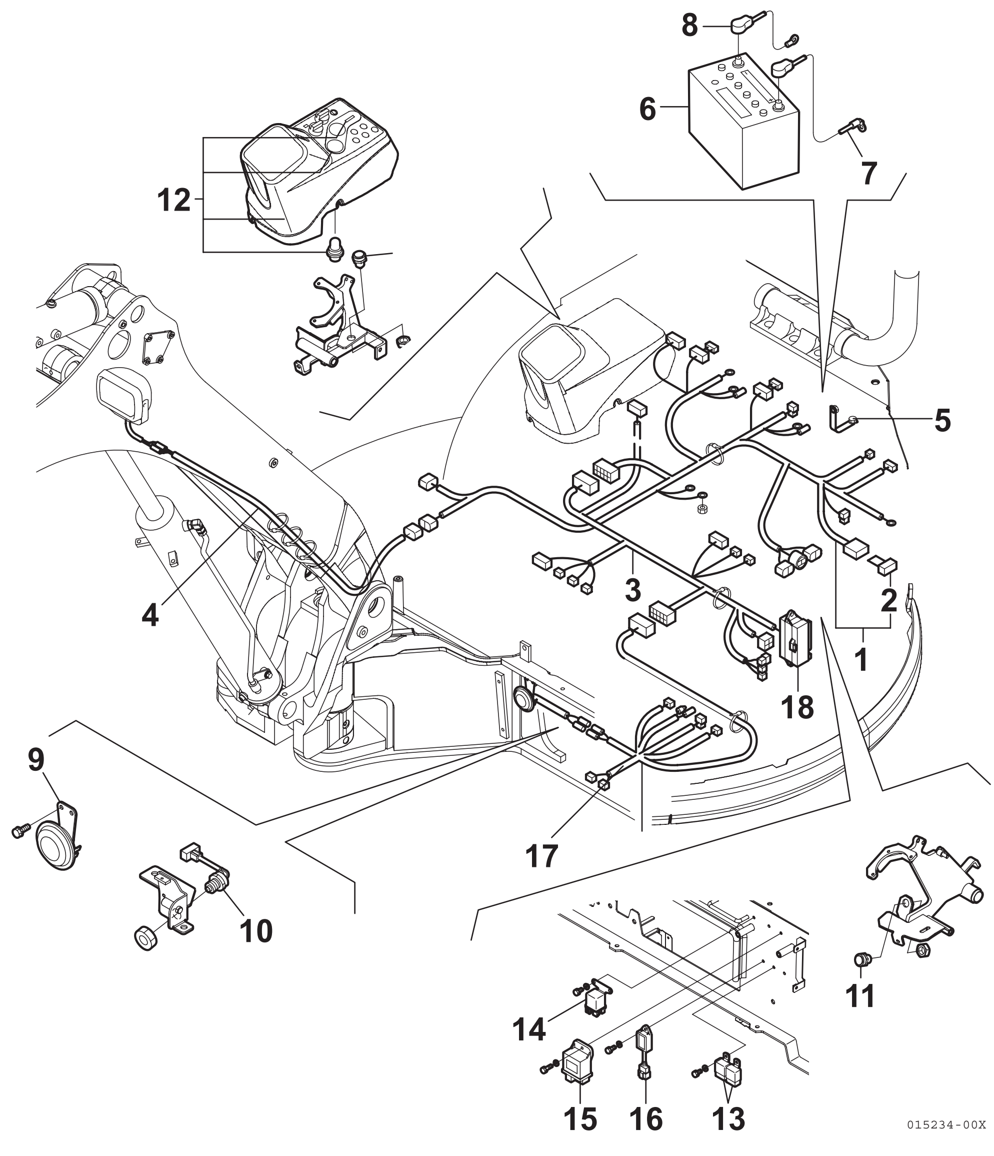
ADJUSTMENT AND REPAIR

7. Adjustment and Repair

7-1 Electric Equipment of Machine

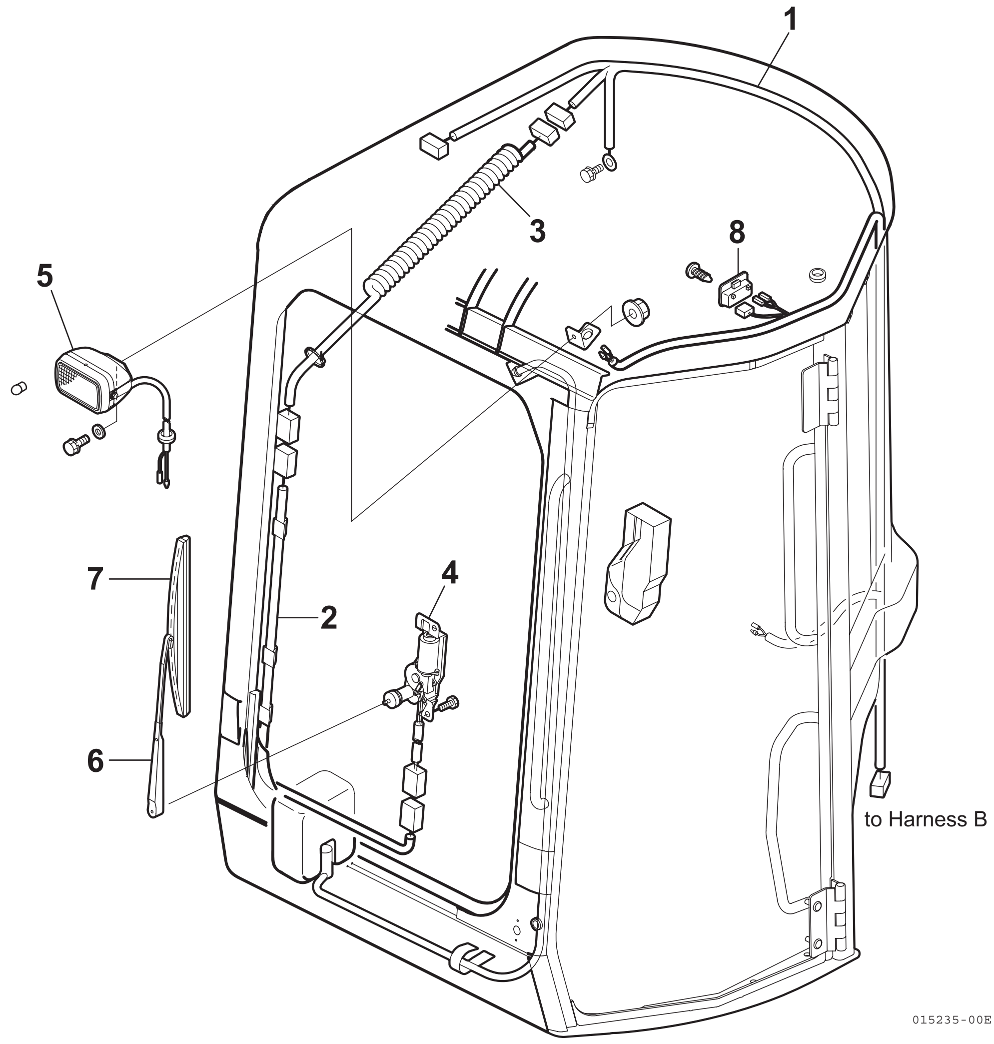
7-1-1 Parts Layout of Electrical Equipment

1) Electric Wiring



No.	Part	No.	Part	No.	Part
1	Harness A	7	Battery cable (positive)	13	Safety relay (SN2206)
2	Slow blow fuse	8	Battery cable (negative)	14	Glow relay
3	Harness B	9	Horn	15	Safety relay
4	Harness (for boom light)	10	Starter switch	16	Timer (1 sec.)
5	Engine earth cord	11	Starter switch	17	Harness C
6	Battery	12	Indicator box	18	Fuse box

Cabin

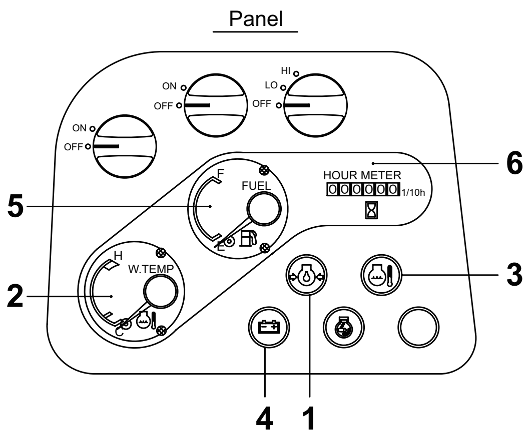


No.	Part	No.	Part
1	Harness A (CAB)	6	Wiper arm
2	Harness B (CAB)	7	Wiper blade
3	Curl cord	8	Room lamp
4	Wiper motor		
5	Headlight		

7-1-2 Monitor and Alarm Systems

For safer machine operation, the operator needs to have a clear understanding of the machine's condition. However, it is difficult for the operator to keep an eye on every aspect of the machine he/she operating.
Therefore, gauges and alarms are installed to warn the operator of any trouble of the machine at the early stage.
Note :
The monitors do not give a full assurance of the machine's condition. The indications shown on them should be used as a guide for daily check and periodic maintenance according to the operation and maintenance manual.

1) Part Name



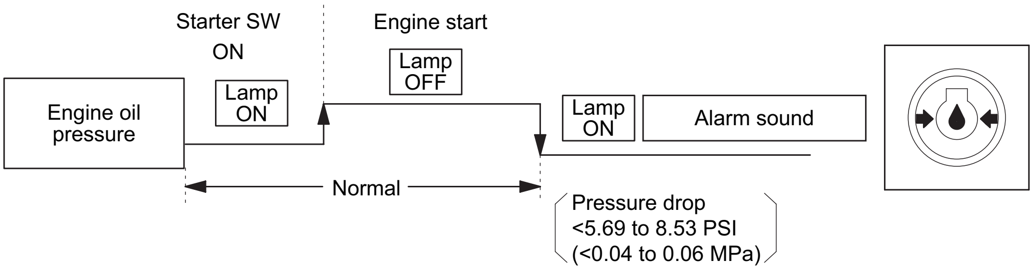
1 Engine oil alarm lamp
2 Water temp. meter
3 Water temp. alarm lamp
4 Battery charge alarm lamp
5 Fuel gauge
6 Hour meter

2) Function of Alarm Sensor

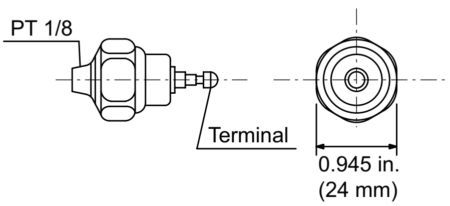
- All the lamps should go on for a few seconds when the starter switch is turned on.
- All the lamps should go off when the engine is running.
- The engine oil pressure and battery charge alarm lamps should go on when the engine is stopped.
- The buzzer should sound when a lamp goes on while the engine is running.

3) Alarm Sensor Operation

(1) Lube oil pressure drop monitoring (engine oil pressure switch)
When the engine oil pressure falls, the lamp goes on and the buzzer sounds.



The switch monitors the lube oil pressure drop of the engine and causes the engine oil pressure alarm lamp to go on and the alarm buzzer to sound.
Working pressure : 5.69 to 8.53 PSI (0.04 to 0.06 MPa)
Installation position : Engine block



When the alarm buzzer sounds, check the following items.

[1] Degeneration of engine oil

[2] Clogging of oil filter element

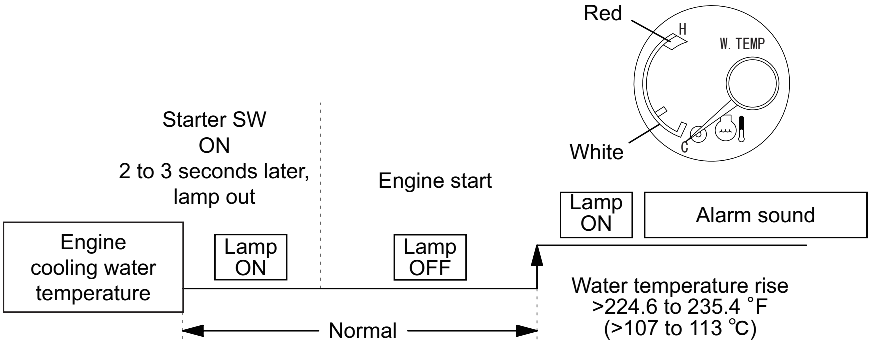
[3] Malfunction of engine oil pressure switch
Refer to Section "4. Engine" for the checking procedure of the engine oil pressure switch.

[4] Malfunction of pressure control valve

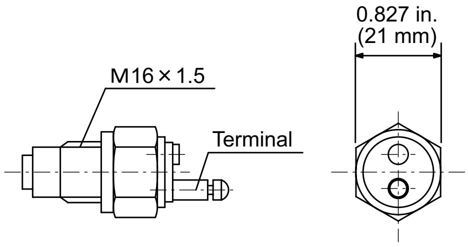
[5] Wear or breakage of engine oil pressure pump

(2) Overheating sensor (water temperature switch)

The water temp. meter indicates the engine cooling water temperature.
The pointer should be within the white range while the engine is running.
If the pointer goes up to the red range, the engine is overheating.



Turned on : Cooling water temp. : 224.6 to 235.4°F (107 to 113°C)
Turned off : Cooling water temp. : 212°F (100°C) or less
Installation position : Cooling water pump on engine

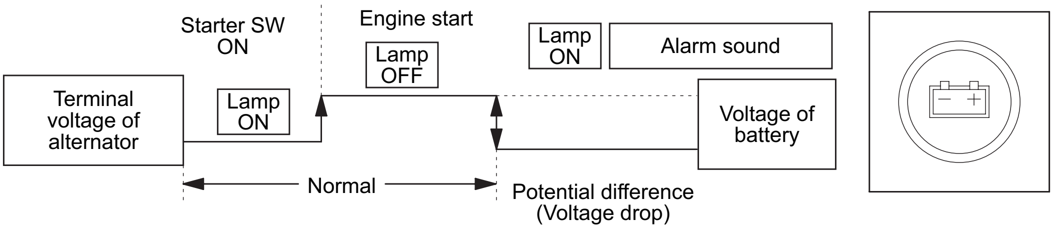


When the alarm buzzer sounds, check the following items.

[1] Refer to Section "4. Engine" and "10. Troubleshooting".

(3) Battery charge

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



When the alarm buzzer sounds, check the following items.

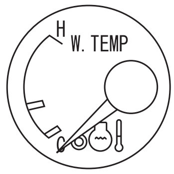
[1] Degeneration or malfunction of battery.

[2] Refer to Section "7-1-4 Circuit Description of Engine Start and Stop, and Battery Charging".

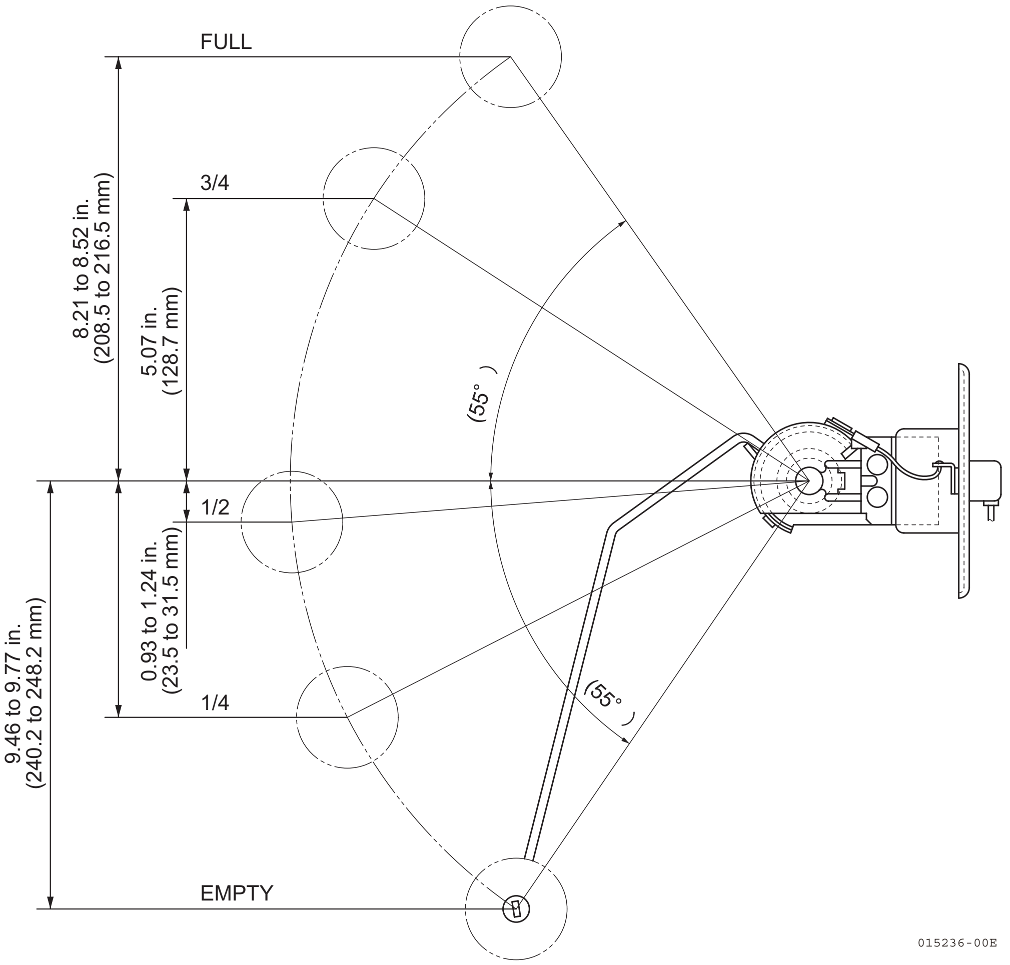
(4) Fuel gauge

When the starter switch is turned on, the fuel gauge starts to work to indicate the oil level in the fuel tank.

- It is normal for the fuel gauge to take some time to indicate the correct level after the starter switch is turned on.
- The remaining oil level indication can change depending on the inclination of the machine body.



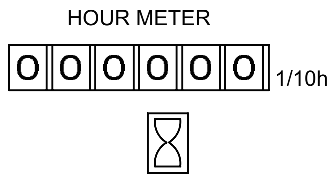
Fuel gauge unit



Float position	Resistance (Ω)
FULL	9.5 to 11.0
1/2	29 to 35
EMPTY	82 to 92

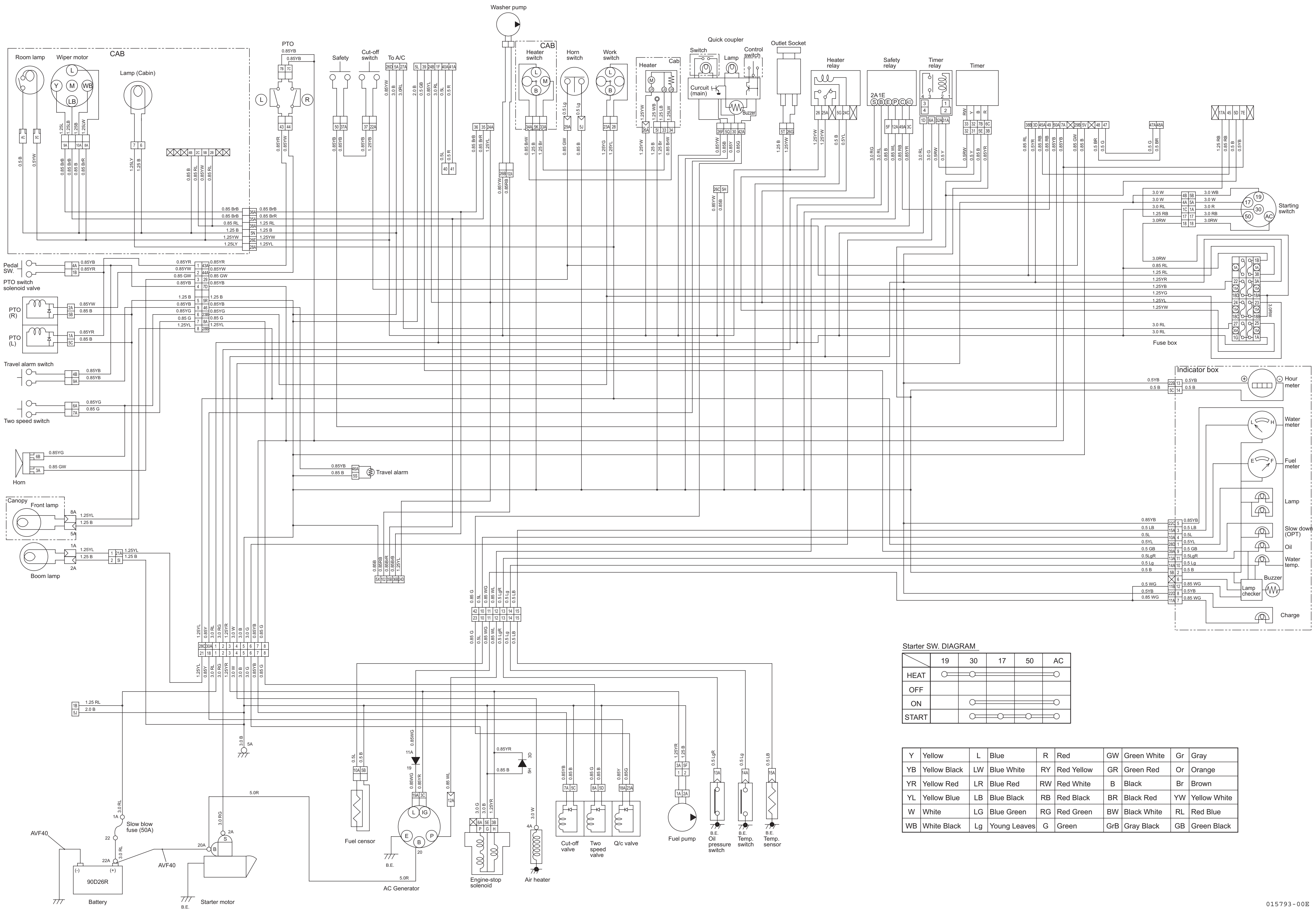
(5) Hour meter

When the starter switch is turned on, the hour meter starts to work.



7-1-3 Wiring Diagram

1) Standard Specifications



Starter SW. DIAGRAM

	19	30	17	50	AC
HEAT	○	○			○
OFF					
ON		○			○
START		○	○	○	○

Y	Yellow	L	Blue	R	Red	GW	Green White	Gr	Gray
YB	Yellow Black	LW	Blue White	RY	Red Yellow	GR	Green Red	Or	Orange
YR	Yellow Red	LR	Blue Red	RW	Red White	B	Black	Br	Brown
YL	Yellow Blue	LB	Blue Black	RB	Red Black	BR	Black Red	YW	Yellow White
W	White	LG	Blue Green	RG	Red Green	BW	Black White	RL	Red Blue
WB	White Black	Lg	Young Leaves	G	Green	GrB	Gray Black	GB	Green Black

7-1-4 Circuit Description of Engine Start and Stop, and Battery Charging

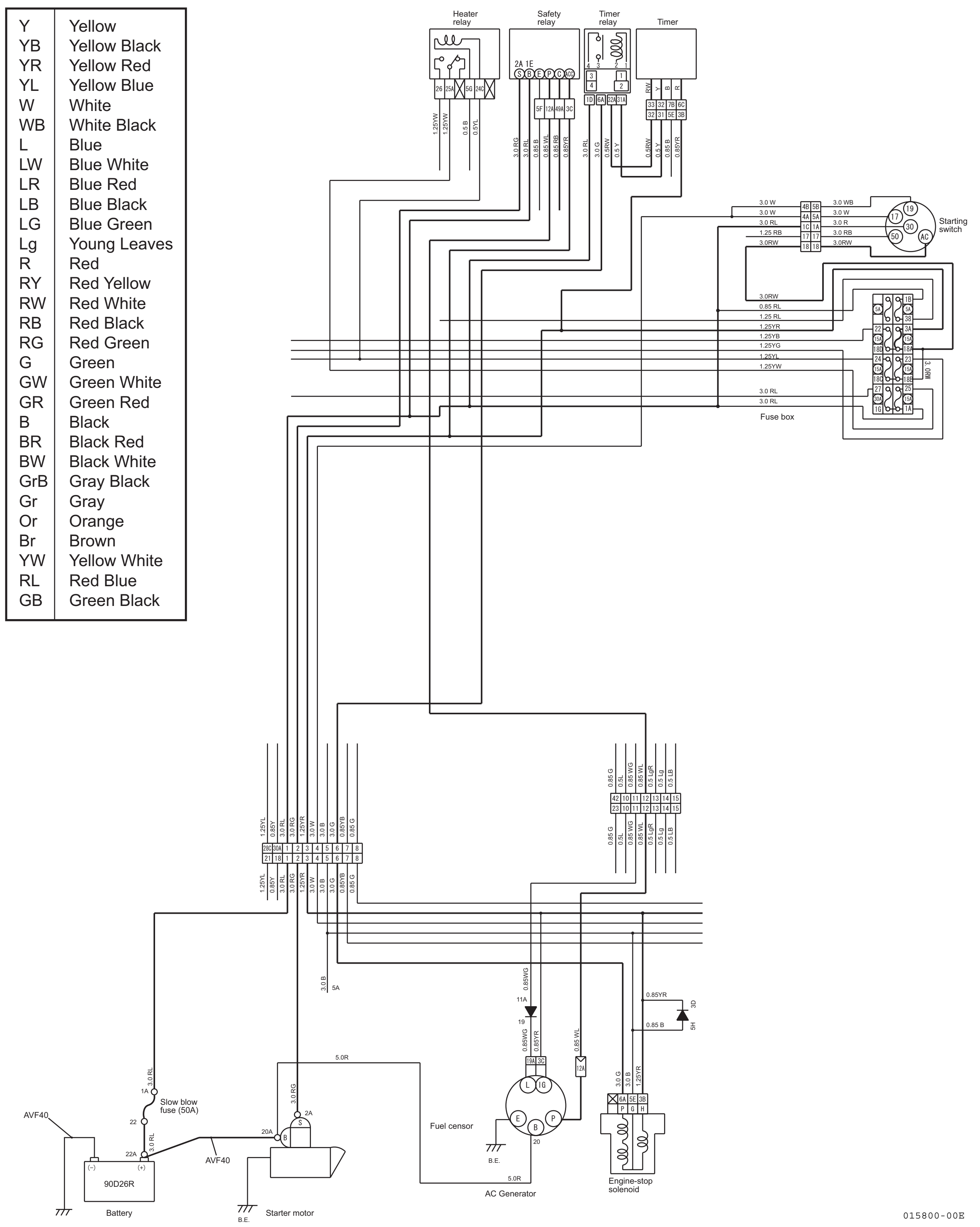
1. Start Engine

Turn on the starter switch.	The starter switch **30** is always supplied with electric current from the battery. (Battery -Slow blow fuse-Starter switch **30**)
↓	
The timer is supplied with electric current.	Starter switch **30**, **AC**-Lead wire **RW**-Fuse **15** A-Lead wire **YR**-Timer **R**
↓	
The relay is supplied with electric current from the timer, and the **1** and **2** are connected.	Timer **RW**-Relay **2**, Relay **1**-Timer **Y**
↓	
The relay operates, and the **3** and **4** are connected.	The relay **4** is always supplied with electric current from the battery through the slow blow fuse.
↓	
The engine stop solenoid **P** (pull) is supplied with electric current from the relay **3** to press the engine control lever.	The engine stop solenoid **H** (hold) is supplied with electric current when the starter switch is turned on.
↓	
The engine stop solenoid **P** is stopped being supplied with electric current. ↓	In about one second after the starter switch is turned on, the timer operates to stop electric current from flowing to the engine stop solenoid **P**. However, the engine stop solenoid **H** is still supplied with electric current when the starter switch is on, so that the control lever stays pushed.
Turn the starter switch to "START" position. ↓	The starter motor **B** is always supplied with electric current from the battery. The slow blow fuse lead wire **RL** and the safety relay **B** are supplied with electric current from the battery when the starter switch is turned to "START" position.
The electric current is supplied from the starter switch **50** to the safety relay, and from safety relay **S** to the starter motor **S** to rotate the starter motor.	The magnet switch of the starter motor operates to allow the pinion to jump out. At the same time, the crankshaft of the engine rotates and the engine starts to run.
↓	
The safety relay operates.	When the engine speed reaches the rated speed, the alternator **P** and safety relay **P** are connected. Therefore, the alternator and safety relay are supplied with electric current. The signal from the alternator flows to the safety relay and cuts off the connection between the safety relay **S** and the starter motor **S**, which causes the pinion to be pulled back and the engine to be prevented from overrunning.

2. Stop Engine

Turn off the starter switch.	
↓	
The engine stop solenoid H is stopped being supplied with the electric current to pull back the control lever.	The control lever blocks a flow of fuel oil to stop the engine.

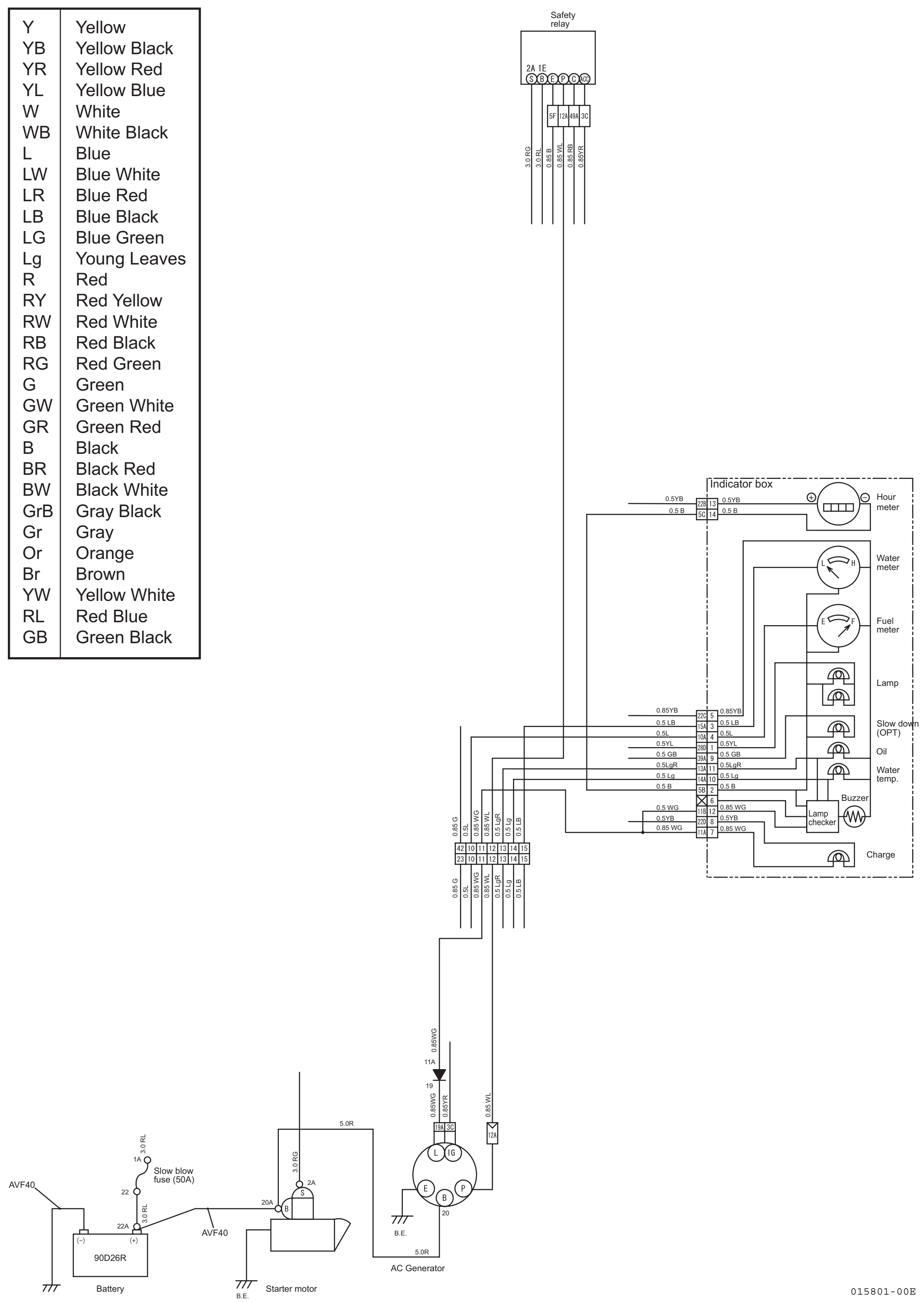
Y	Yellow
YB	Yellow Black
YR	Yellow Red
YL	Yellow Blue
W	White
WB	White Black
L	Blue
LW	Blue White
LR	Blue Red
LB	Blue Black
LG	Blue Green
Lg	Young Leaves
R	Red
RY	Red Yellow
RW	Red White
RB	Red Black
RG	Red Green
G	Green
GW	Green White
GR	Green Red
B	Black
BR	Black Red
BW	Black White
GrB	Gray Black
Gr	Gray
Or	Orange
Br	Brown
YW	Yellow White
RL	Red Blue
GB	Green Black



3. Charge Battery

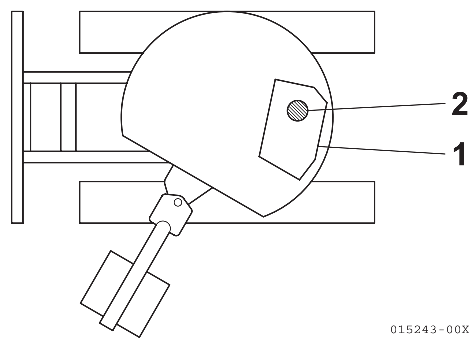
The electric current generated by the alternator flows to the battery to be charged.	The electric current flows from the alternator **B** to the battery through the starter motor **B** to charge the battery.
↓	
When the battery charge alarm lamp goes on, the battery charges poorly.	When the voltage generated by the alternator is low, the circuit in the alternator is turned on, and the electric current flows from the battery charge alarm lamp in the indicator box to the alternator to light the alarm lamp. (Indicator box→Lead wire **WG**→Alternator **L**)

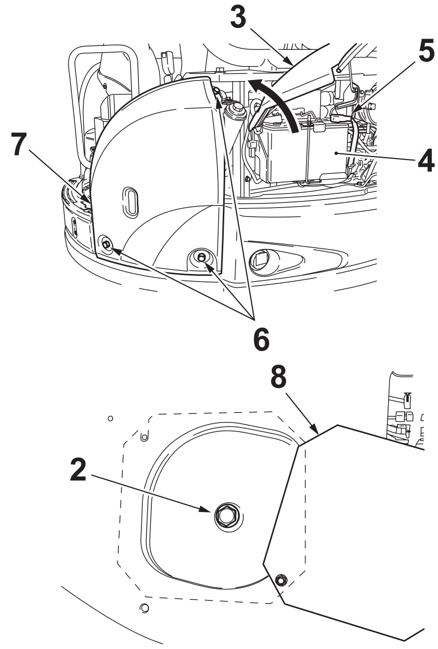
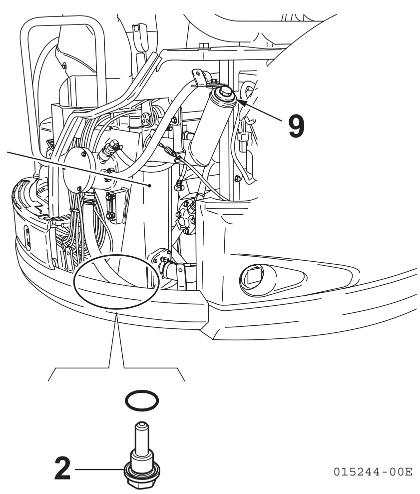
Y	Yellow
YB	Yellow Black
YR	Yellow Red
YL	Yellow Blue
W	White
WB	White Black
L	Blue
LW	Blue White
LR	Blue Red
LB	Blue Black
LG	Blue Green
Lg	Young Leaves
R	Red
RY	Red Yellow
RW	Red White
RB	Red Black
RG	Red Green
G	Green
GW	Green White
GR	Green Red
B	Black
BR	Black Red
BW	Black White
GrB	Gray Black
Gr	Gray
Or	Orange
Br	Brown
YW	Yellow White
RL	Red Blue
GB	Green Black



7-1-5 Removal and Reinstallation of Engine

1) Removal

Procedure	
(1) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.	

(2) Open the engine hood rear cover **3** and remove it. (3) Disconnect the battery negative cable **5** from the battery **4**. (4) Loosen three cap screws **6** to remove the side cover **7**. (5) Remove the bottom cover **8** and put an oil container under the drain plug **2** of the hydraulic oil reservoir. (6) Remove the drain plug **2** to drain hydraulic oil. **(Q'ty: 10 Gal(38L))** At this time, loosening or removing the filler cap **9** make oil draining easier.	 Viewed from under the machine body 

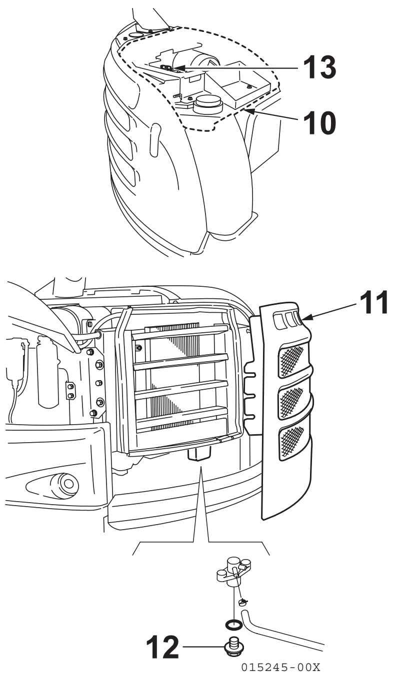
<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(7) Open the bonnet B 10.

(8) Open the bonnet R 11.

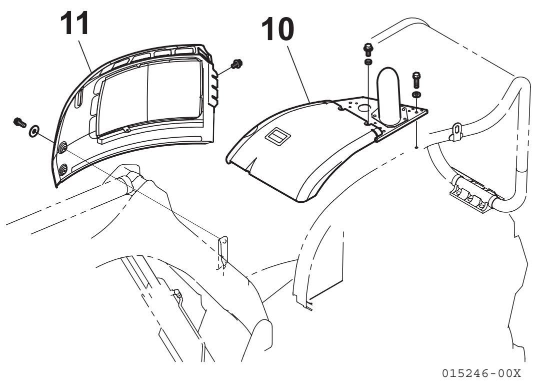
(9) Prepare a container for coolant draining.

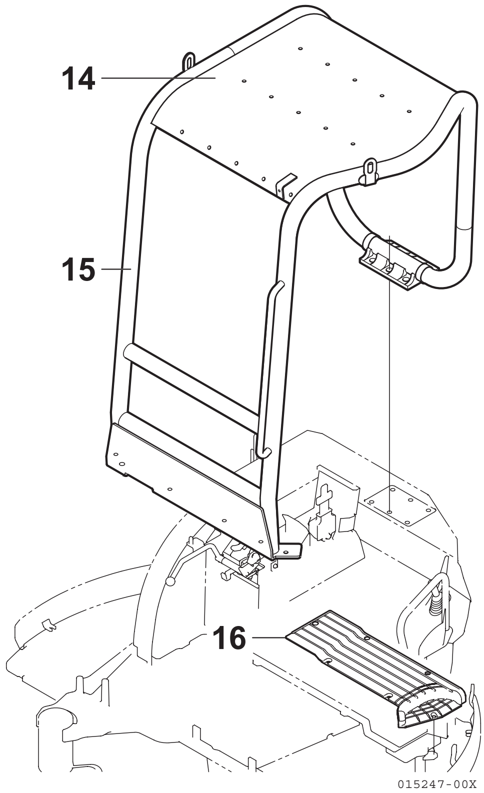
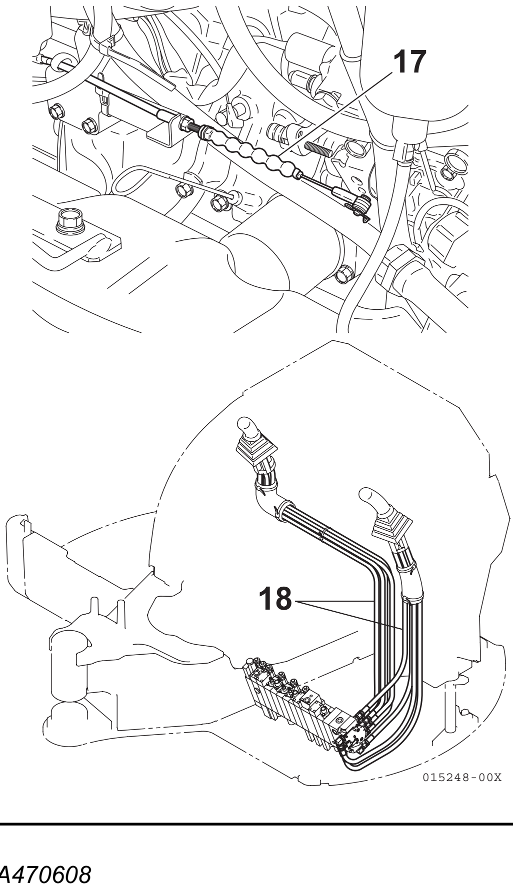
(10) Remove the drain plug 12 to drain coolant.

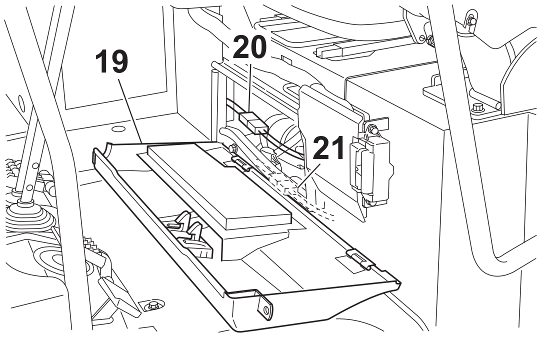
(Q'ty: 1.8 Gal((6.7L))

At this time, loosening or removing the radiator cap 13 make oil draining smoother.</td><td>
</td></tr>
</table>

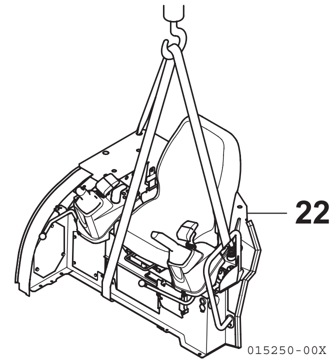
<table>
<tr><td>(11) Remove the bonnet B 10.

(12) Remove the bonnet R 11.</td><td>
</td></tr>
</table>

Procedure	
(13) Remove the canopy roof **14** and the canopy pole **15**. (14) Remove the floor step **16**.	
(15) Disconnect the engine speed control cable from the engine. (16) Disconnect the pilot oil hoses **18** from the control valve. ***Note :*** • *Mark each hose to reinstall on the original position.* • *Plug each hose end and fittings on the control valve against dust*	

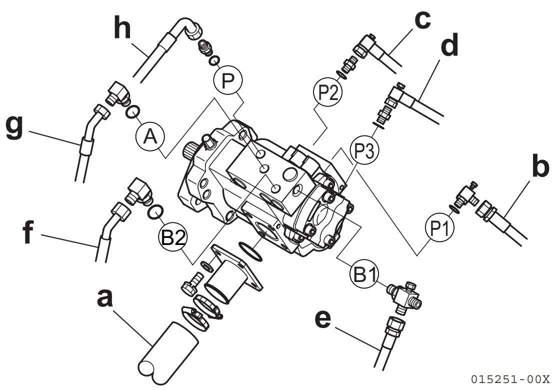
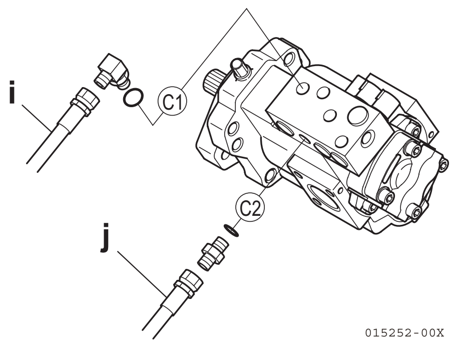
<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(17) Open the front cover 19 of the seat mount to disconnect two wiring couplers 20 and 21.</td><td>
015249-00X</td></tr>
</table>

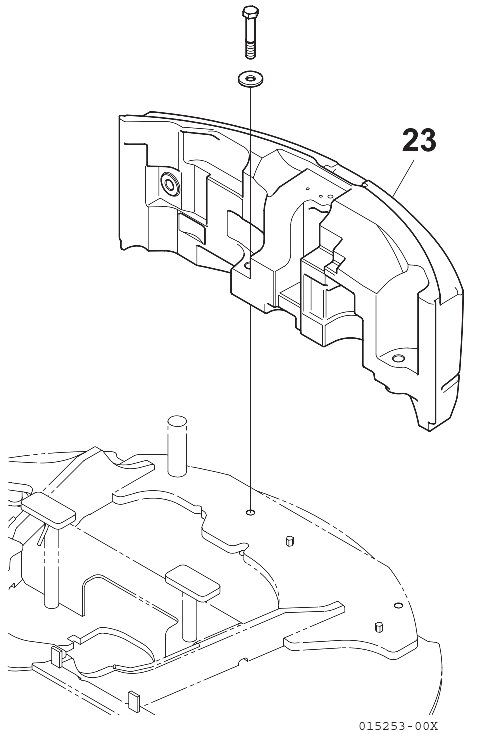
<table>
<tr><td>(18) Remove the seat mount 22.

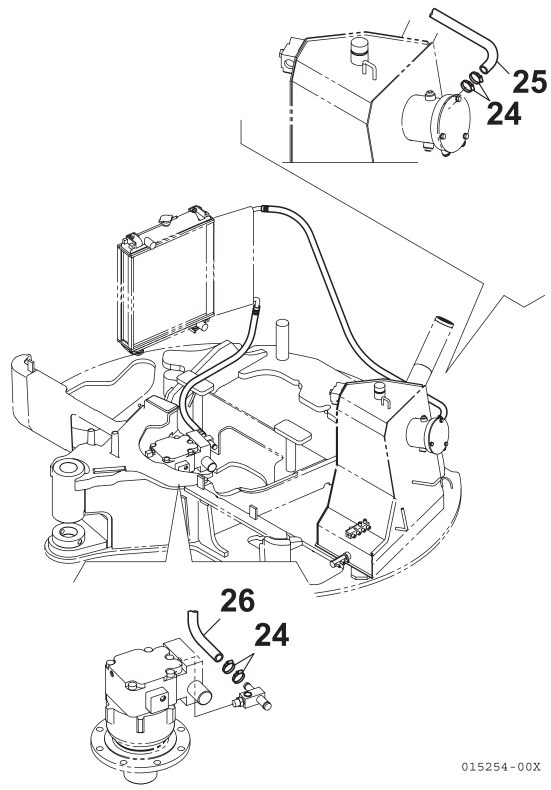
Note :
Use sling belt, hook and hoist with enough strength and capacity to lift it up.</td><td>
015250-00X</td></tr>
</table>

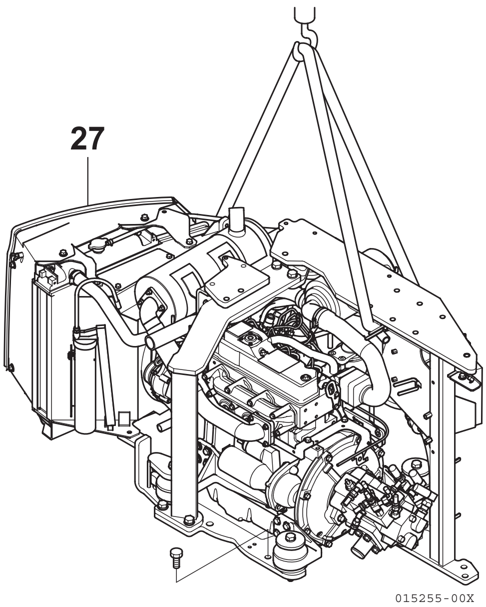
<table>
<tr><td>(19) Disconnect hydraulic hoses from the hydraulic pump.

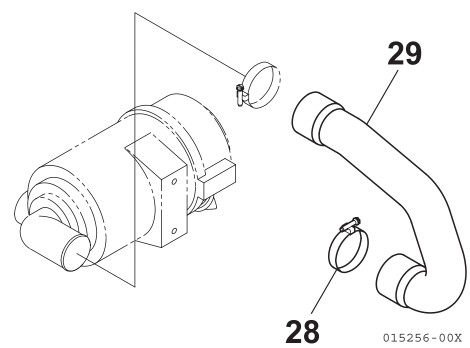
a. Suction
b. P1
c. P2
d. P3
e. B1
f. B2
g. A
h. P(P4)
i. C1
j. C2

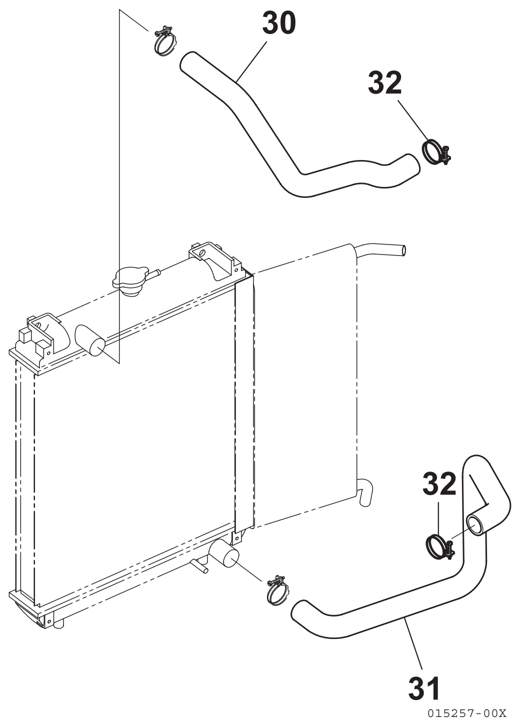
Note :
• Mark each hose to reinstall on the original position.
• Plug each hose end and fittings on the control valve against dust.</td><td>
015251-00X

015252-00X</td></tr>
</table>

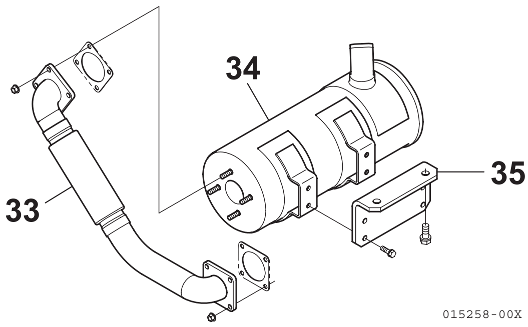
Procedure	
(20) Remove the rear weight **23**.	

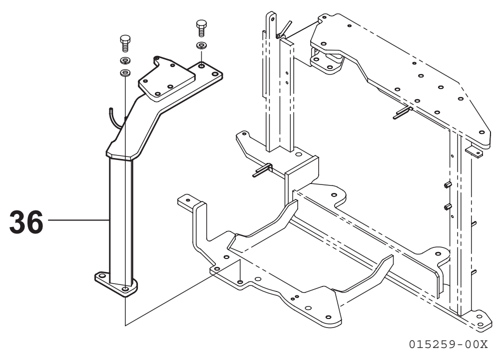
(21) Loosen two hose clips **24** to disconnect the hose (oil cooler - reservoir) from the reservoir. (22) Loosen two hose clips **24** to disconnect the hose (oil cooler - swing motor) from the swing motor.	

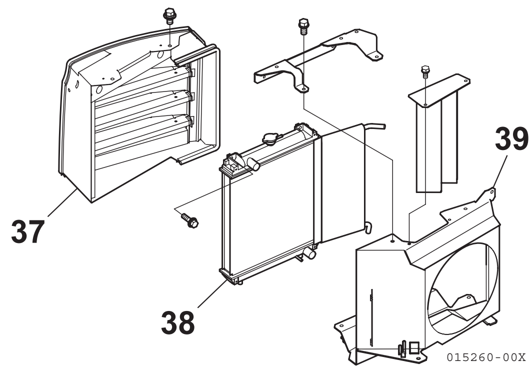
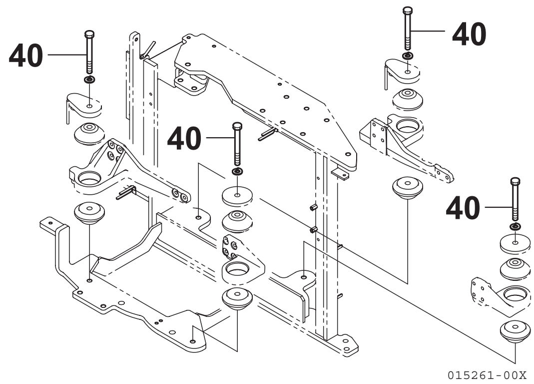
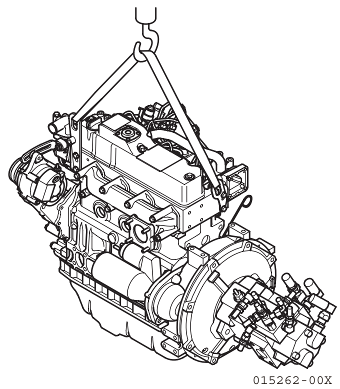
Procedure	
(23) Remove five cap screws to remove the engine sub-assembly **27**. ***Note :*** *Use sling belt, hook and hoist with enough strength and capacity to lift it up.*	

(24) Loosen the hose clip 70 **28** to disconnect the air intake hose A **29** from the air intake manifold.	

Procedure	
(25) Loosen the two hose clips **32** to disconnect the upper hose **30** and the lower hose **31** from the engine.	

(26) Loosen four nuts to remove exhaust gas tube **33** from the engine. (27) Loosen four cap screws to remove exhaust gas silencer **34** from the engine. (28) Loosen two cap screws to remove the silencer bracket **35**.	

(29) Remove the silencer bracket **36** from the engine mount.	

Procedure	
(30) Remove the duct **37**, radiator **38** and shroud **39**.	
(31) Loosen four cap screws **40** to remove the vibroisolating rubbers.	
(32) Remove the engine by lifting. ***Note :*** *Always keep balance of the engine when lifting it.*	

2) Reinstallation

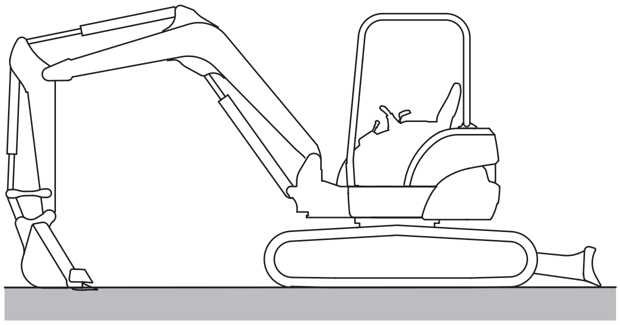
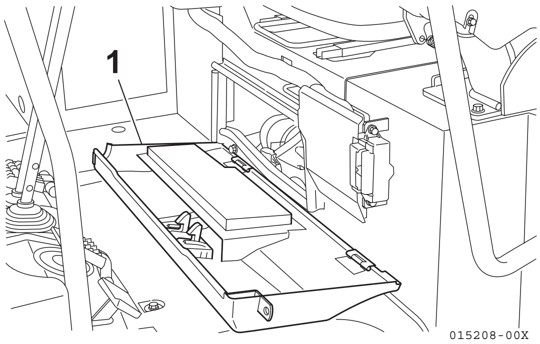
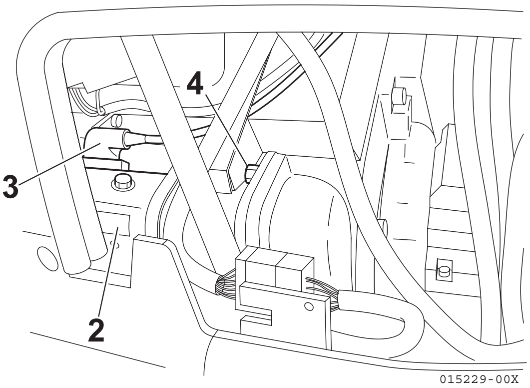
Reinstall the engine in the reverse order of the removal procedure.

Adhesive and tightening torque

No.	Parts	Size	Adhesive	Tightening torque
1	Engine mount vibroisolating rubber	M16 (10.9T)	Apply Three Bond or its equivalent	151.9 to 173.6 ft·lbf (205.8 to 235.2 N·m)
2	Engine mount F, R	M10 (10.9T)	Apply Three Bond or its equivalent	47.0 to 54.2 ft·lbf (6.5 to 7.5 N·m)
3	Air cleaner	M8	-	14.5 to 16.6 ft·lbf (19.6 to 22.6 N·m)
4	Air cleaner intake hose	Hose clip 70	-	1.8 to 2.5 ft·lbf (2.5 to 3.4 N·m)
5	Air cleaner intake hose (intake side)	Hose clip 70	-	0.9 to 1.1 ft·lbf (1.2 to 1.5 N·m)
6	CW hose	Hose clip 41	-	1.8 to 2.5 ft·lbf (2.5 to 3.4 N·m)
7	CW hose	Hose clip 48	-	1.8 to 2.5 ft·lbf (2.5 to 3.4 N·m)
8	Fuel gauge unit	M5	-	0.9 to 1.1 ft·lbf (1.18 to 1.47 N·m)
9	Fuel gauge hose	Hose band 14	-	0.7 to 1.1 ft·lbf (0.98 to 1.47 N·m)
10	Fuel tank	M14	Apply Three Bond or its equivalent	86.8 to 108.5 ft·lbf (118 to 147 N·m)
11	Battery holding rod	M24	-	2.2 ft·lbf (2.94 N·m) [Lock nut : 0.9 to 1.2 ft•lbf (12.7 to 16.7 N•m)]
12	Heater hose	Hose clip 22	-	1.6 to 1.8 ft·lbf (2.16 to 2.45 N·m)
13	Drain plug 14	M14	-	43.4 ft·lbf (59 N·m)
14	Drain plug	M24	-	79.6 ft·lbf (107.9 N·m)
15	Bracket (muffler	M16 (10.9T)	Apply Three Bond or its equivalent	123.0 to 151.9 ft·lbf (166.7 to 206.0 N·m)
16	Counter weight	M24	Apply Three Bond or its equivalent	354.4 to 441.2 ft·lbf (480.7 to 598.4 N·m)
17	Canopy roof	M16 (10.9T)	Apply Three Bond or its equivalent	57.9 to 72.3 ft·lbf (78.4 to 98.0 N·m)
18	Canopy (TOPS	M16 (10.9T)	Apply Three Bond or its equivalent	123.0 to 151.9 ft·lbf (166.7 to 206.0 N·m)

7-1-6 Removal and Reassembly of Starter Motor

1) Removal

Procedure	
(1) Lower the bucket on the ground, and stop the engine.	
(2) Open the front cover **1**.	
(3) Remove the wire harness **3** connected with the starter motor **2**. (4) Remove the installation bolt **4** for the starter motor to remove the starter motor.	

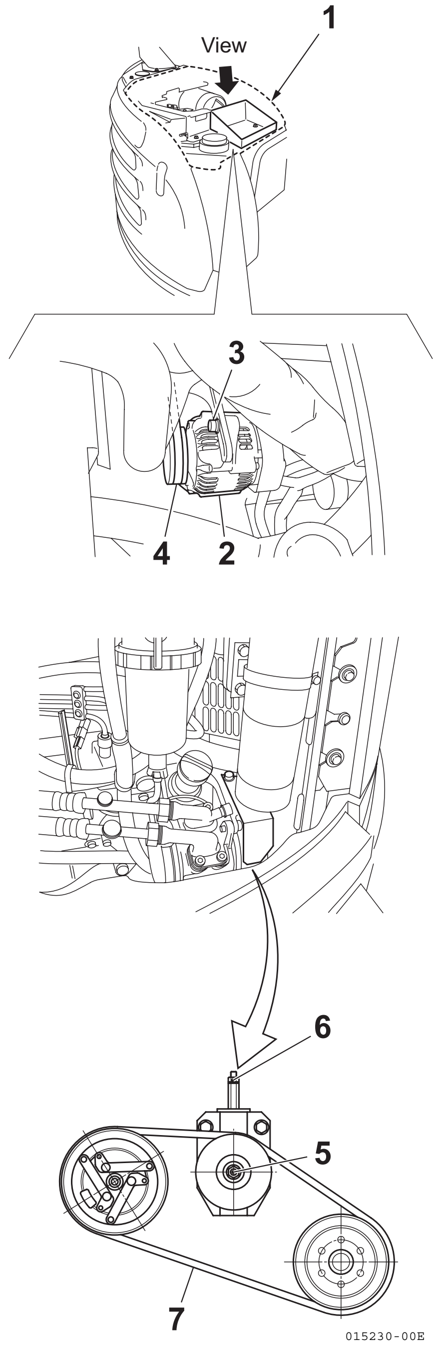
2) Reinstallation

Install the starter motor in the reverse order of the removal procedure.

Starter motor installation bolt (M12)	
Tightening torque	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)

7-1-7 Removal and Reassembly of Drive Belts for Generator and Compressor

1) Removal

Procedure	
(1) Open the bonnet B**1**. (2) Loosen the hold bolts **3** of the generator **2** to loosen tension of the belt **4**. (3) For the machine with the air conditioner, open the engine hood rear cover, loosen the cap screw **5** and adjuster screw **6**, to loosen tension of the belt **7**. (4) Remove the belts **4**, **7**.	

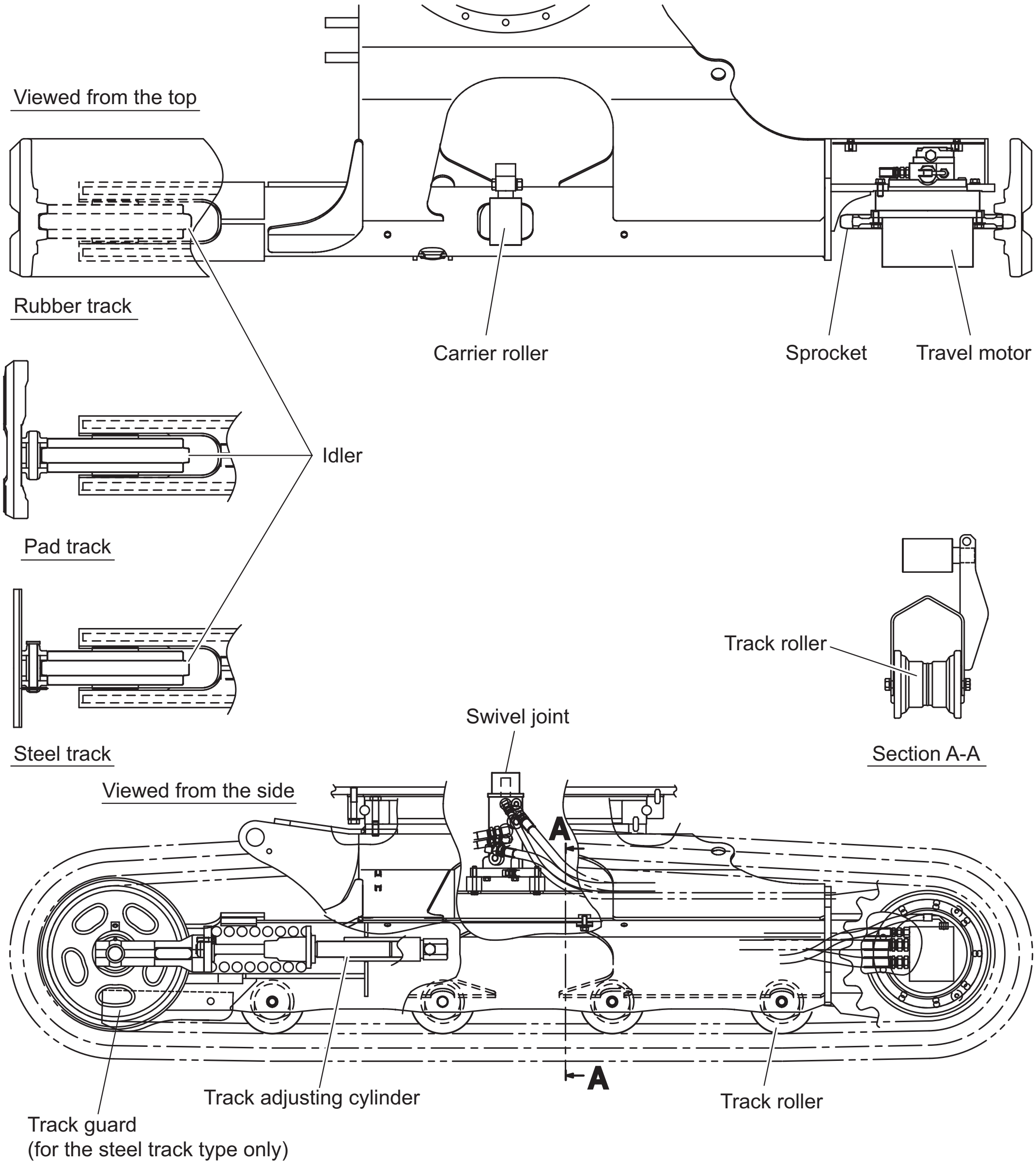
2) Reinstallation

Install the starter motor in the reverse order of the removal procedure.

7-2 Undercarriage

7-2-1 Outline

The undercarriage consists of travel motors, a track frame, carrier rollers, front idlers, tracks (steel or rubber) and other parts.
The hydraulic oil fed through the control valve and the swivel joint from the hydraulic pump causes the travel motor to rotate, so that the power is transmitted to the track via the sprocket.
The machine travels forward or reverses by operating the travel levers.



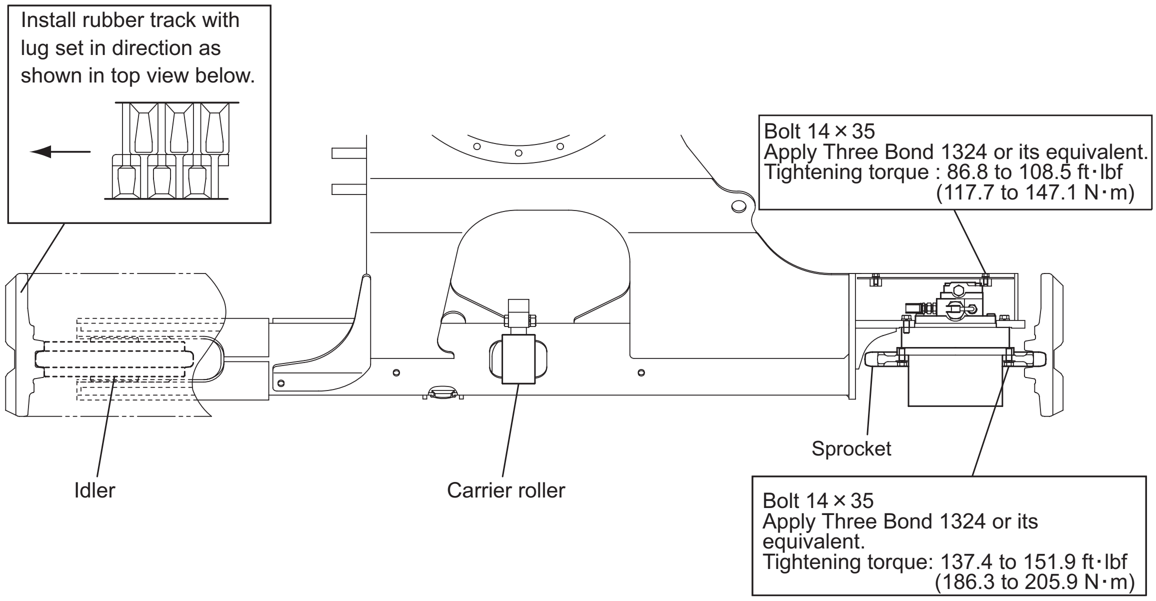
7-2-2 Main Parts

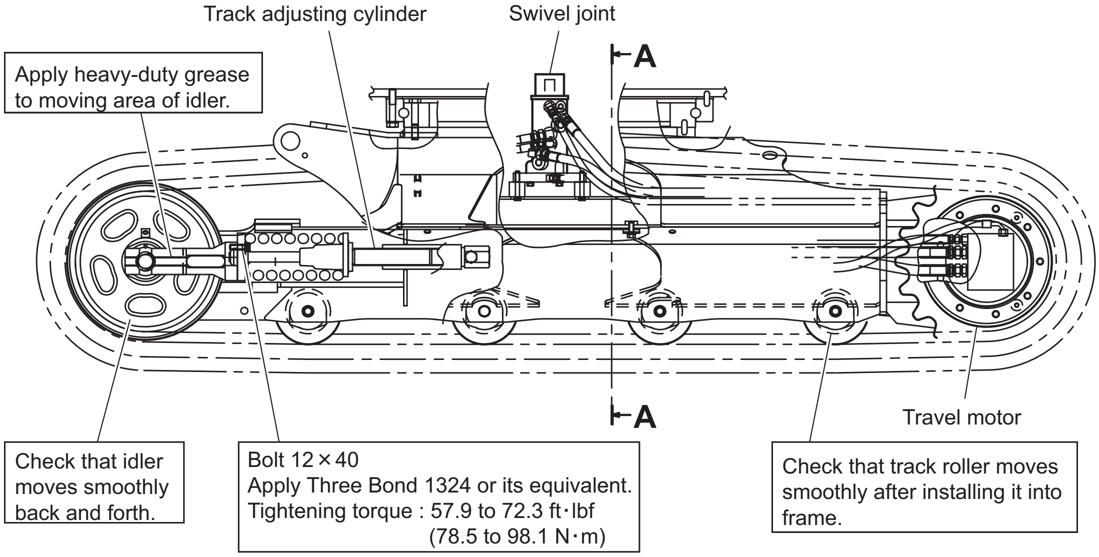
The maximum compatibility is introduced between the steel and rubber track type models. For the compatibility of the main parts, see the right table.

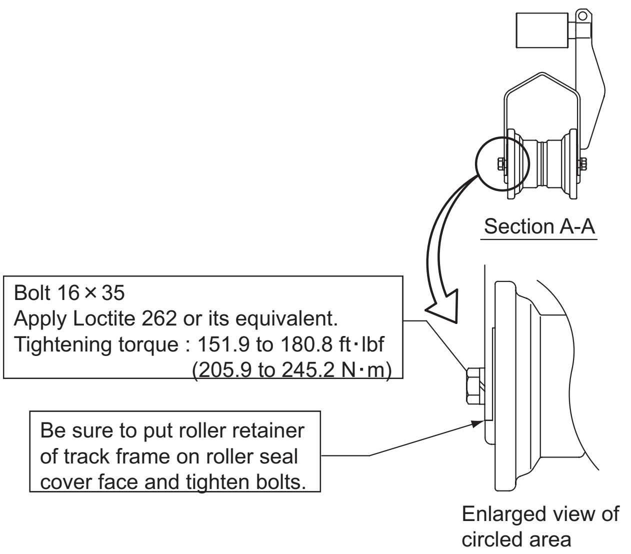
Compatibility of main pars

Type / Part	Steel track	Rubber track
Travel motor	○	○
Sprocket	○	○
Idler assembly	○	○
Track roller	○	○
Carrier roller	×(exclusive)	×(exclusive)
Track guard	×(exclusive)	—

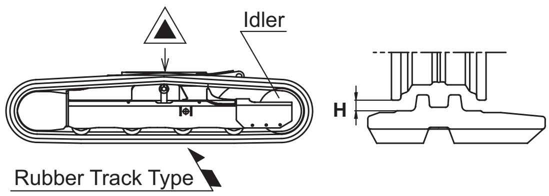
7-2-3 Points of Reassembly (Rubber Track)





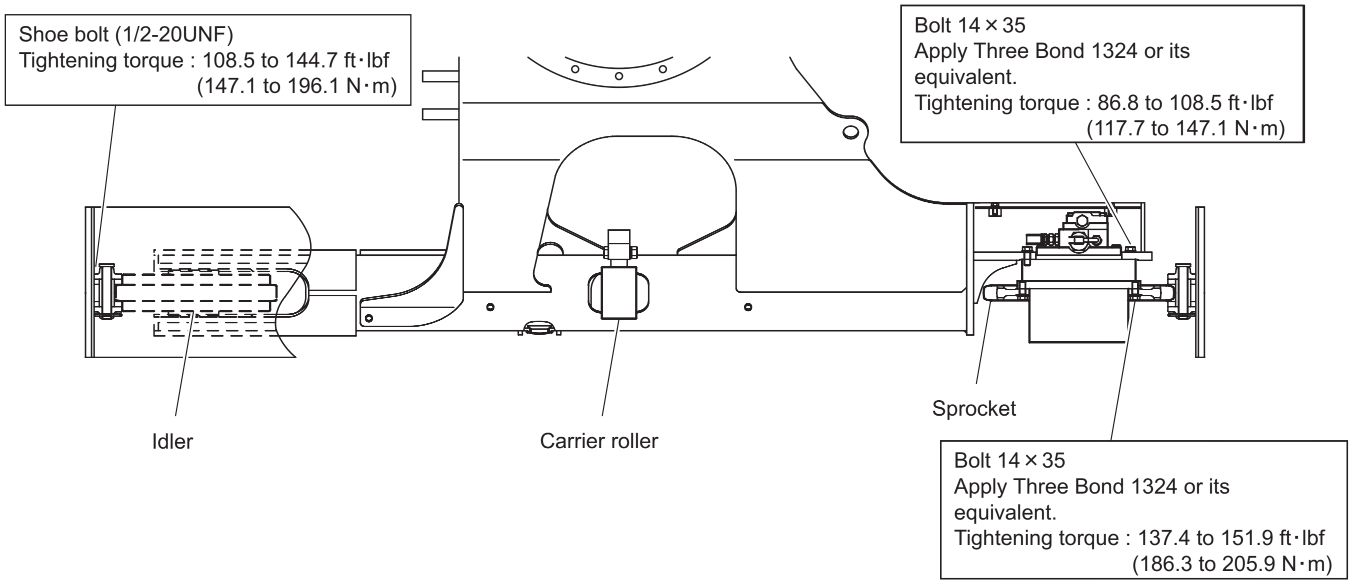


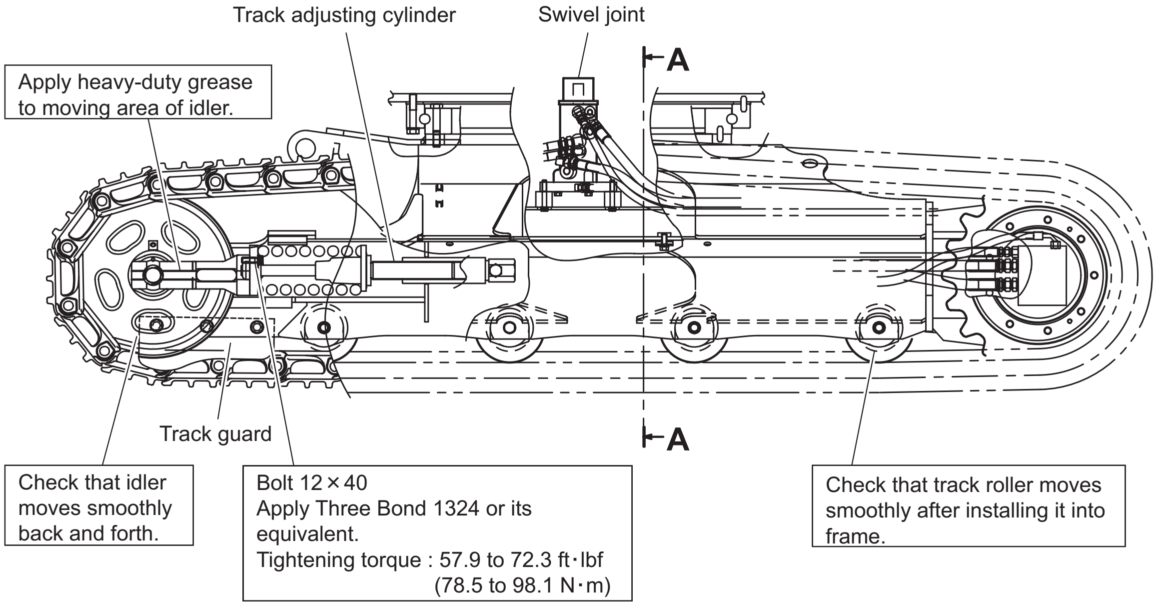
Track Tension Adjustment :

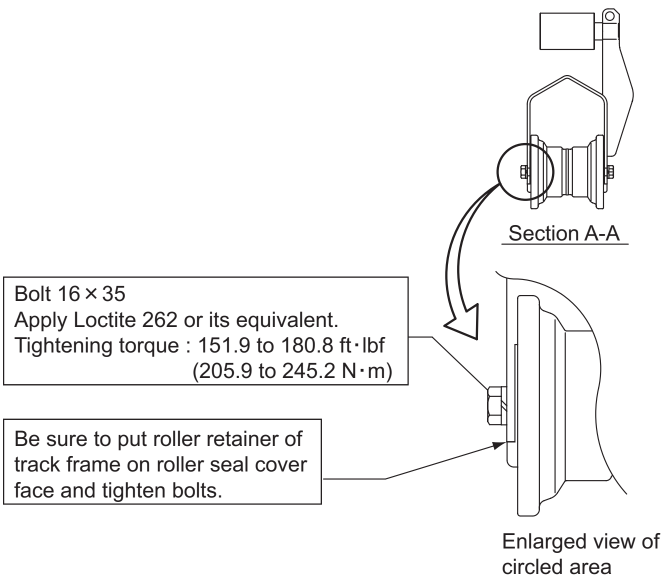


1. Raise the track on one side using the boom.
2. Bring the mark ▲ on the inside surface of the rubber track to the upper center of the carrier roller.
3. Adjust the track tension so that the clearance H between the outside rolling surface of the second track roller from the idler and the track tread, as shown in the figure, is within the range from 0.31 to 0.51 in. (8 to 13 mm).
4. After rotating the track several times, check that the clearance H should be within the range from 0.31 to 0.51 in. (8 to 13 mm).
5. If not, readjust the track tension following the above steps 1 to 3. Then check the clearance H again, following the step 4.

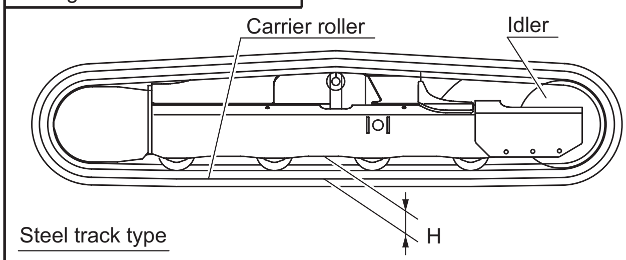
7-2-4 Points of Reassembly (Steel Track)







Enlarged view of circled area



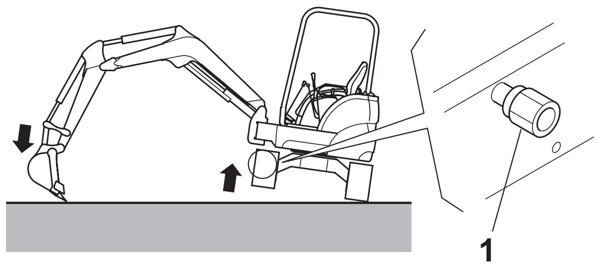
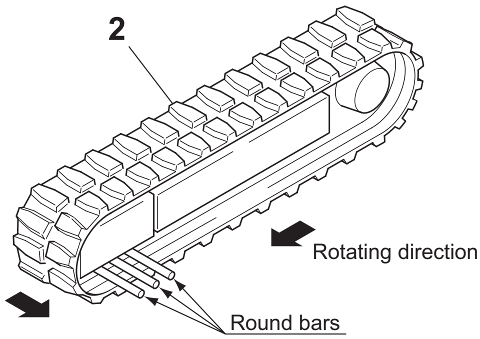
1. Raise the track on one side using the boom.
2. Adjust the track tension so that the clearance H between the lower center of the track frame and the upper surface of the shoe plate is within the range from 4.13 to 4.53 in. (105 to 115 mm).

7-2-5 Removal and Reinstallation of Track

1) Removal of Rubber Track

Put safety blocks, which are strong enough to support the machine, under the machine while working with the machine body raised.

Do not loosen the nipple valve more than one turn since it might jump out due to the inside high-pressure grease.

Procedure	
(1) Turn the implement 90 degrees to the right or the left and lower it to the ground to raise the track on one side. (2) Loosen the nipple valve **1** to loosen the track tension. ***Note :*** *If the grease does not come out smoothly from the nipple valve, put down the machine on the ground and move it forward and backward.*	
(3) Insert round bars between the rubber track **2** and the track frame, and turn the sprocket in the reverse direction. Slide the rubber track off when it is separated from the idler by the round bars.	

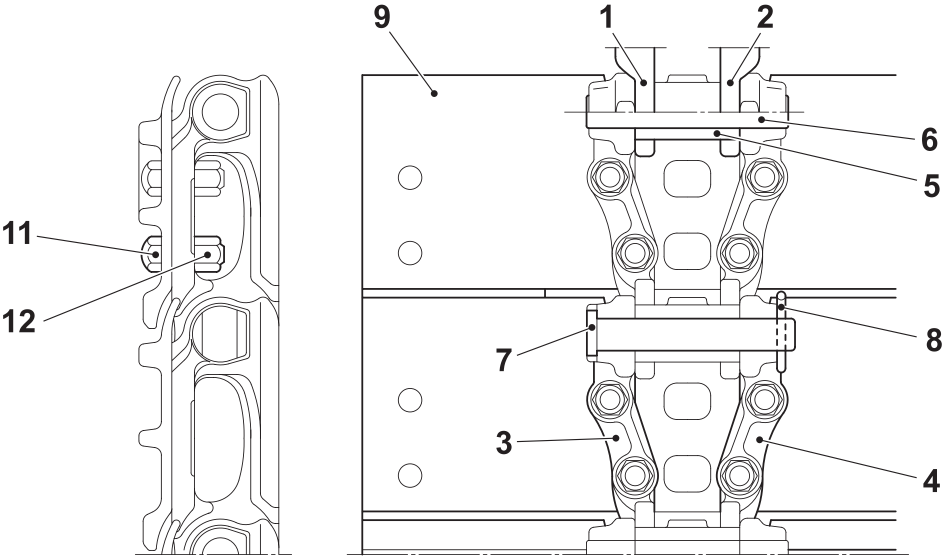
2) Reinstallation of Rubber Track

Reinstall the rubber track in the reverse order of the removal procedure.

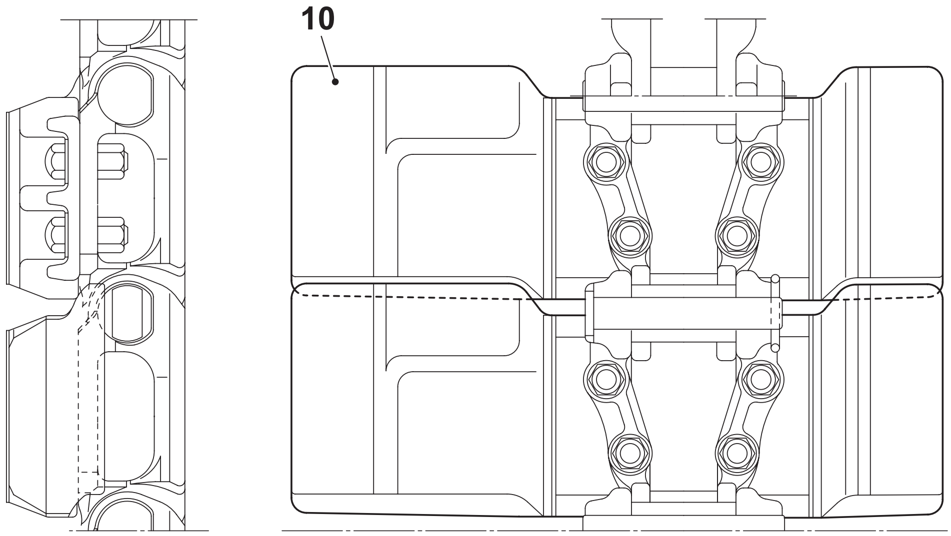
7-2-6 Removal and Reinstallation of Steel Track

1) Structural Drawings

(1) Track shoe



(2) Pad track

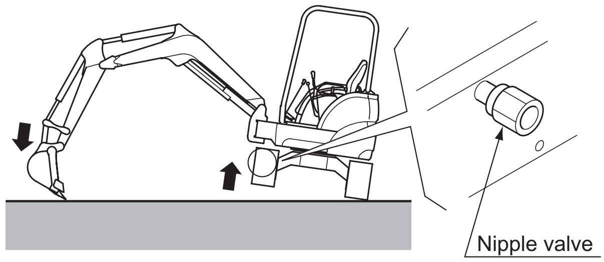
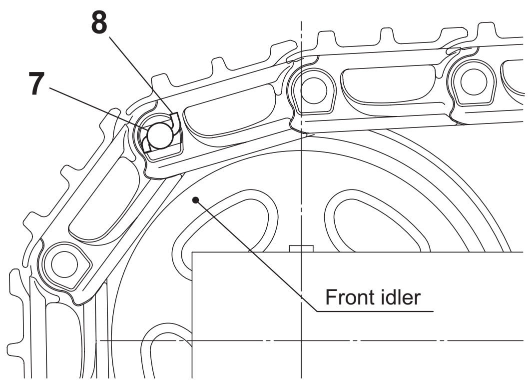
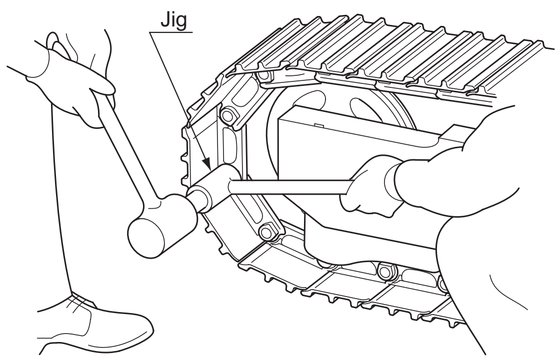


No.	Part	Q'ty	No.	Part	Q'ty
1	Track link R	39×2	7	Master pin	1×2
2	Track link L	39×2	8	Cotter pin	1×2
3	Master link R	1×2	9	Track shoe L350	40×2
4	Master link L	1×2	10	Pad track L400	40×2
5	Track bush	40×2	11	Shoe bolt	160×2
6	Track pin	39×2	12	Shoe nut	160×2

2) Removal of Steel Track

⚠ **Put safety blocks, which are strong enough to support the machine, under the machine while working with the machine body raised.**

⚠ **Do not loosen the nipple valve more than one turn since it might jump out due to the inside high-pressure grease.**

Procedure	
(1) Turn the implement 90 degrees to the right or the left and lower it to the ground to raise the track on one side. (2) Loosen the nipple valve to loosen the track tension. ***Note :*** *If the grease does not come out smoothly from the nipple valve, put down the machine on the ground and move it forward and backward.*	
(3) Turn the track shoe until the master pin **7** comes to the front idler side and remove the cotter pin **8**.	
(4) Pull out the master pin **7**. ***Notes:*** • *Put down the machine on the ground to remove the master pin.* • *When using a hammer to remove the master pin, take care not to give a permanent set on the top of the master pin.* [Reference] : Use a jig as illustrated in figure A.	 Fig. A (For reference)

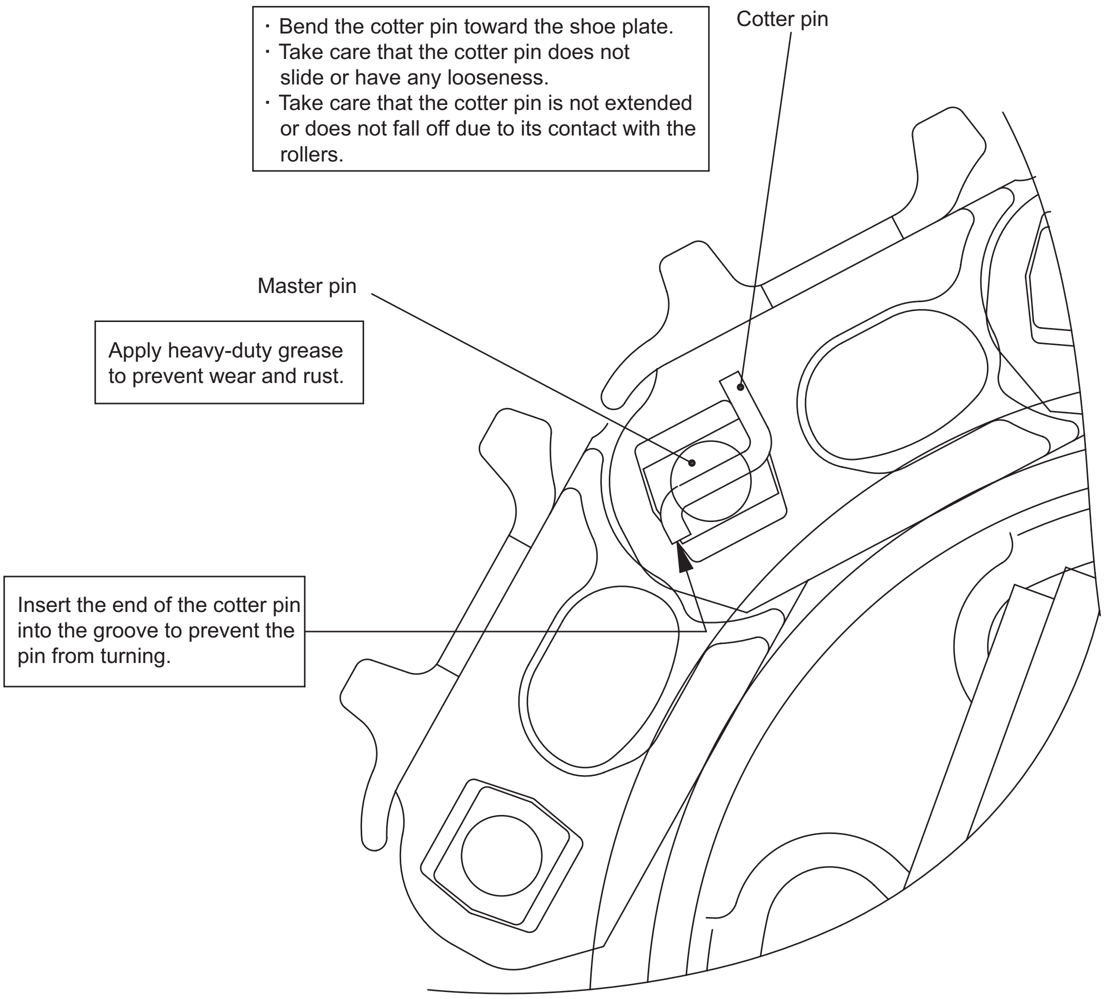
3) Reinstallation of Steel Track

Reinstall the steel track in the reverse order of the removal procedure.

Note :

*For how to bend the cotter pin **8**, refer to the description on the following page.*

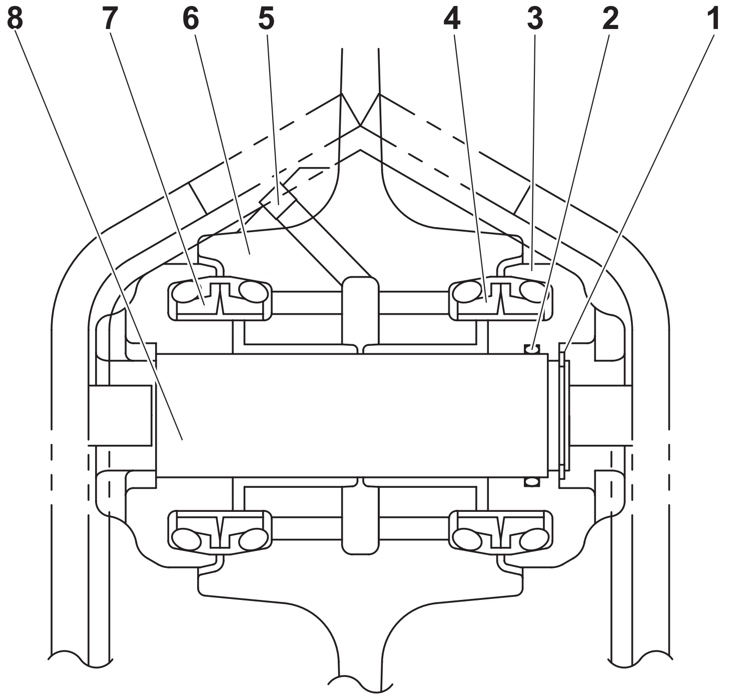
- How to bend cotter pins (For steel track)



Shoe bolt (1/2 - 20 UNF)
Tightening torque : 108.4 to 144.6 ft·lbf
(147 to 196 N·m)

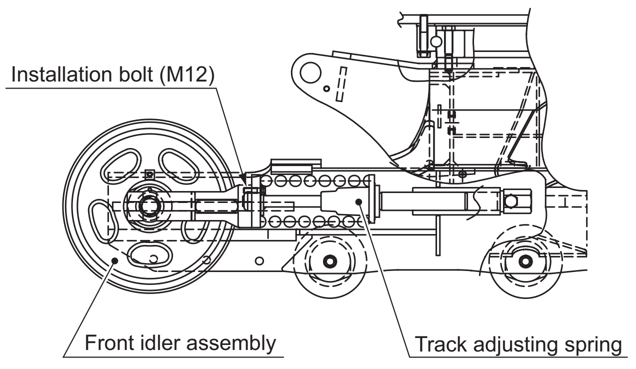
7-2-7 Disassembly and Reassembly of Front Idler

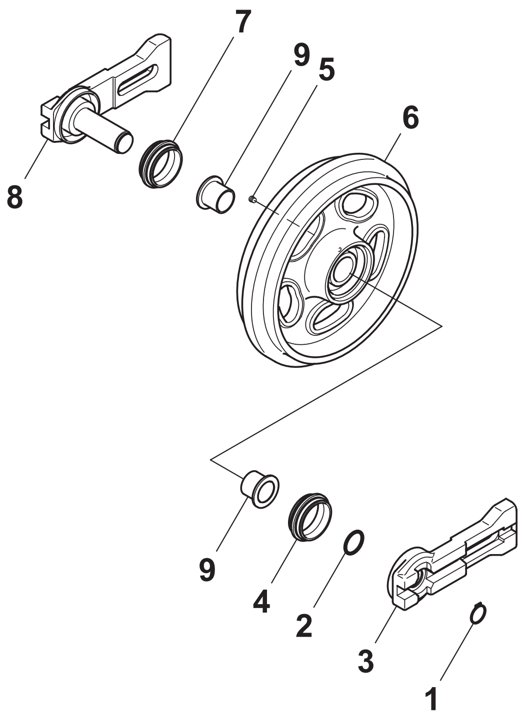
1) Structural Drawing and Component Part



No.	Part	Q'ty	No.	Part	Q'ty
1	External snap ring C (35)	1	6	Idler	1
2	O-ring 1A G40	1	7	Floating seal	1
3	Idler seal cover B	1	8	Shaft (with seal cover)	1
4	Floating seal	1	9	Bush	2
5	Screw plug PT 1/8	1			

2) Disassembly

Procedure	
(1) Remove the front idler assembly from the track frame. (2) Remove the track adjusting spring. Installation bolt (M12) for track adjusting spring Adhesive Apply Three Bond 1324 or its equivalent. Tightening torque : 57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)	

Procedure	
(3) Remove the thread plug PT1/8 **5** to drain engine oil. Type : Engine oil SAE 30 Q'ty : 0.074 Qts. (0.07 L) (4) Remove the external snap ring C **11** from the shaft **8** and remove the idler seal cover B **3**. ***Note :*** *Remove the snap ring C **1** while pressing the outer face of the idler **6** with a press or the like, and it can be removed easily.* (5) Pull the shaft (with the seal cover) **8** out of the idler **6** and remove the floating seals **4** and **7**. ***Notes :*** • *Since the shaft **8** is press-fitted into the seal cover, they cannot be disassembled.* • *Measure the bore of bush **9**. If the measured value is within the allowable wear limit, do not remove the bush.*	

3) Reassembly

Reassemble the front idler in the reverse order of the disassembly procedure.

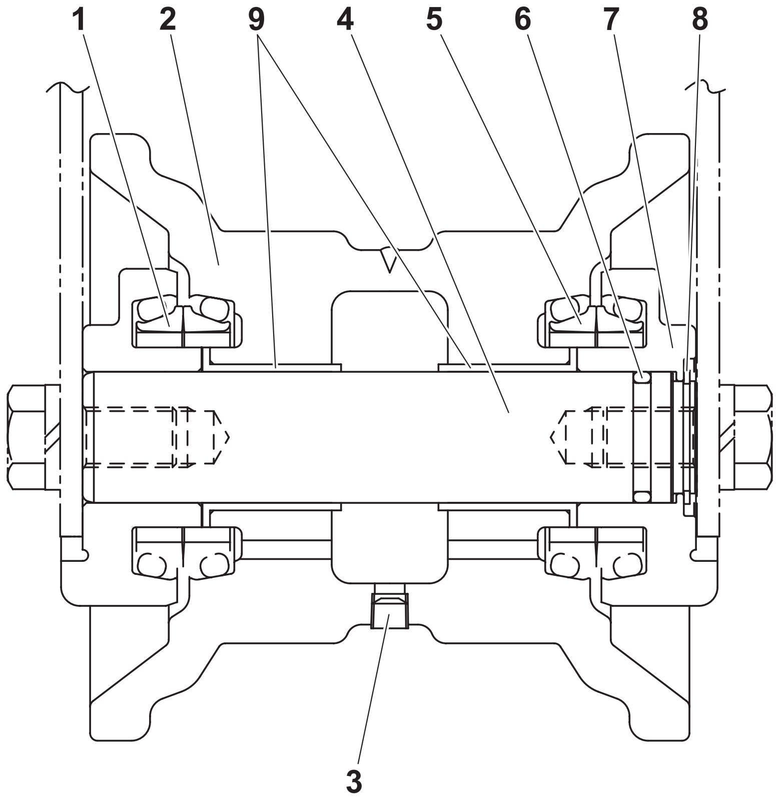
Notes:

- *Replace the O-ring and the floating seals with new ones.*
- *For the procedure for installing the floating seals, refer to Section "7-2-9 Installation of Floating Seal".*

Thread plug PT 1/8	
Tightening torque	6.5 to 7.2 ft·lbf (8.8 to 9.8 N·m)

7-2-8 Disassembly and Reassembly of Track Roller

1) Structural Drawing and Component Part

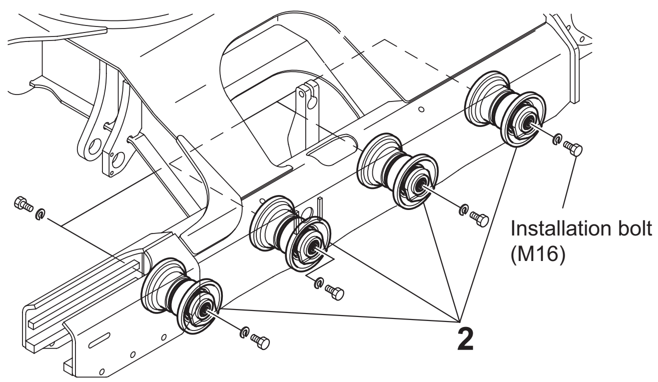


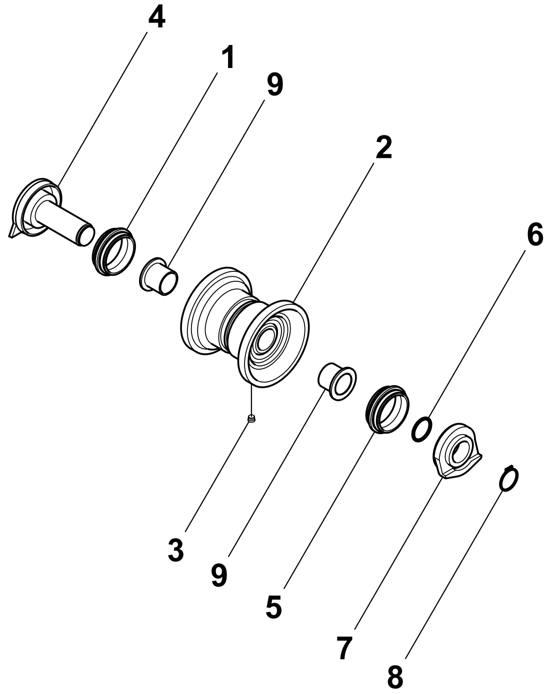
No.	Part	Q'ty	No.	Part	Q'ty
1	Floating seal	1	6	O-ring 1B P29	1
2	Roller	1	7	Seal cover B	1
3	Plug PT1/8	1	8	External snap ring C (30)	1
4	Shaft (with seal cover)	1	9	Bush	2
5	Floating seal	1			

2) Disassembly

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(1) Remove the track roller assembly 2 from the track frame.
Installation bolt (M16)

Adhesive
Apply Three Bond 1324 or its equivalent.

Tightening torque : 152 to 181 ft･lbf
(206 to 245 N･m)</td><td>
</td></tr>
</table>

Procedure	
(2) Remove the plug PT 1/8 **3** to drain engine oil. Type : Engine oil SAE 30 Q'ty : 0.12 Qts. (0.11 L) (3) Remove the snap ring C **8** from the track roller **2**. ***Note :*** *Remove the snap ring C while pressing the outer face of the roller with a press or the like, and it can be removed easily.* (4) Remove the seal cover B **7** and the floating seal **5** from the roller **2**. (5) Pull out the shaft (with the seal cover) **4** and remove the floating seal **1**. ***Notes:*** • *Since the shaft is press-fitted into the seal cover, they cannot be disassembled.* • *Measure the bore of the bush* **9***. If the measured value is within the allowable wear limit, do not remove the bush.*	

3) Reassembly

Reassemble the track roller in the reverse order of the disassembly procedure.

Notes :

- *Replace the O-ring and the floating seals with new ones.*
- *For the procedure for installing the floating seals, refer to Section "7-2-9 Installation of Floating Seal".*

Plug PT 1/8
Apply loctite 572 or its equivalent
Tightening torque : 6.5 to 7.2 ft·lbf (8.8 to 9.8 N·m)

7-2-9 Installation of Floating Seal

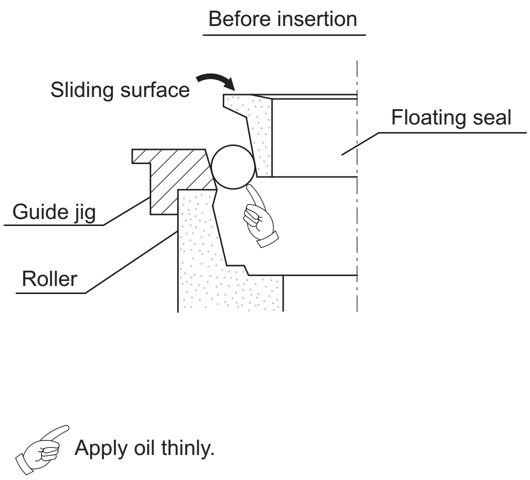
1) Inspection for Damage

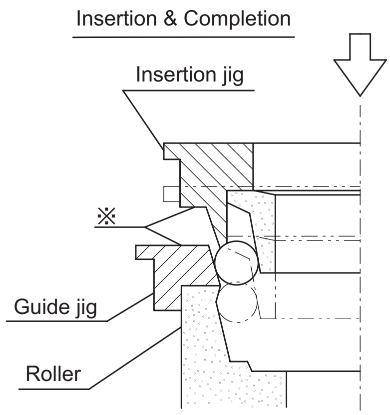
(1) Check for flaws or breakages on the sliding surface of the floating seal.
(2) Check for flaws, breakages or distortion on the O-ring.
(3) Check for fins or burrs on the collar and roller bush.

Note :
The fins or burrs will cause damage to the O-ring. Remove any fin or burr with sand paper or the like.

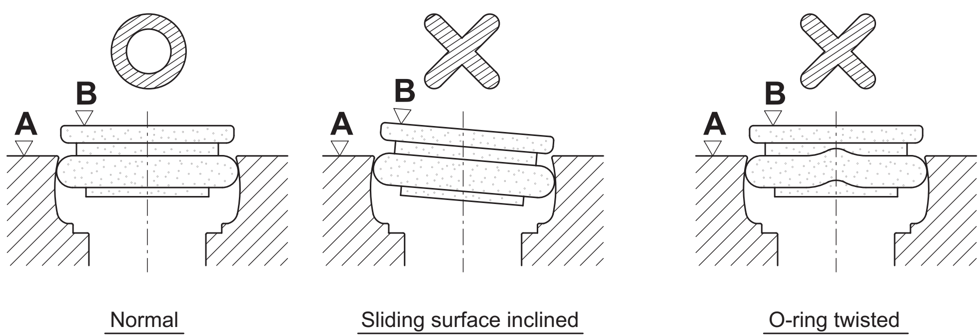
2) Use of Jigs

(1) Clean the collar, roller, roller bush, etc. with oil or compressed air.
(2) Do not use a waste cloth to wipe the sliding surface of the floating seal. Use a paper cleaner instead.
(3) Installation using jigs :





(4) Check that there is no inclination of the sliding surface and no distortion in the O-ring.



(5) Clean the sliding surface completely and apply oil thinly.
(6) Assemble the roller assembly. Avoid placing heavy stress on the sliding surface.

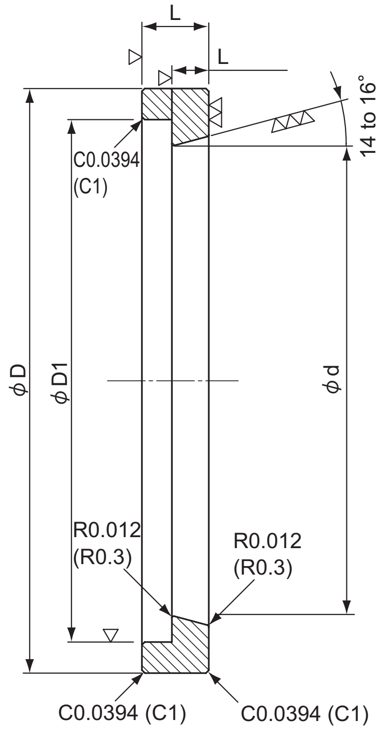
3) Inspection After Installation

(1) After putting oil into the roller, seal it. Then, turn the roller manually 2 to 3 times to from an oil film on the sliding surface.
(2) Turn the roller manually to check that the torque is not excessively high.
(3) Check that there is no oil leak.

7-2-10 Drawings of Jigs

Floating seal insertion jig (Guide jig)

Material : S45C (Equivalent to SAE 1045)

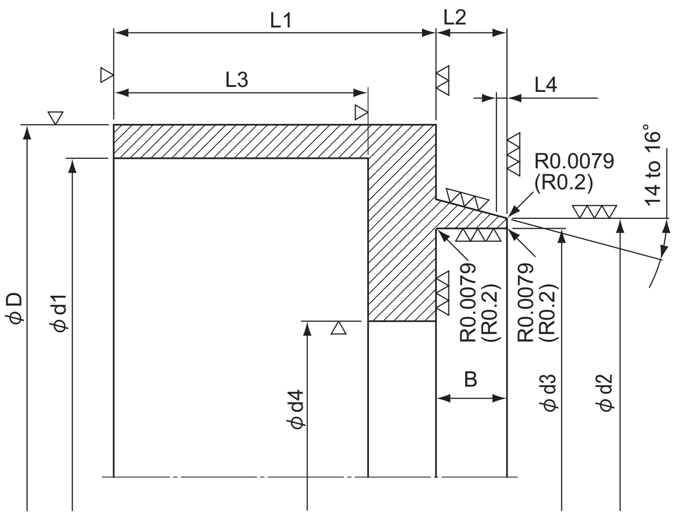


Unit : in. (mm)

Jig	A-015	A-016
ϕD	4.53 (115)	4.33 (110)
ϕD1	3.96 (100.5)	3.62 (92)
ϕd	3.50 to 3.51 (88.9 to 89.1)	3.29 to 3.3 (83.5 to 83.7)
L	0.47 (12)	0.47 (12)
1	0.26 to 0.29 (6.7 to 7.3)	0.26 tp 0.29 (6.7 to 7.3)
Used for	Idler	Track roller

Floating seal insertion jig (Thrusting jig)

Material : S45C (Equivalent to SAE 1045)

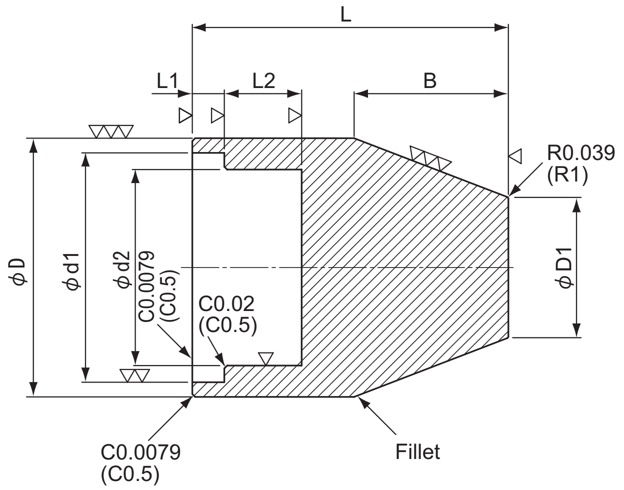


Unit : in. (mm)

Jig	A-017	A-018
ϕD	4.53 (115)	4.33 (110)
ϕd1	3.74 (95)	3.54 (90)
ϕd2	3.48 to 3.49 (88.4 to 88.6)	3.28 to 3.29 (83.3 to 83.5)
ϕd3	3.40 to 3.41 (86.4 to 86.6)	3.185 to 3.193 (80.9 to 81.1)
ϕd4	1.97 (50)	1.97 (50)
L1	1.97 (50)	1.97 (50)
L2	0.33 to 0.35 (8.5 to 8.9)	0.30 to 0.31 (7.6 to 8.0)
L3	1.57 (40)	1.57 (40)
L4	0.055 to 0.063 (1.4 to 1.6)	0.02 to 0.03 (0.6 to 0.8)
B	0.3 to 0.32 (7.9 to 8.1)	0.378 to 0.386 (9.6 to 9.8)
Used for	Idler	Track roller

O-ring insertion jig

Material : S45C (Equivalent to SAE 1045)

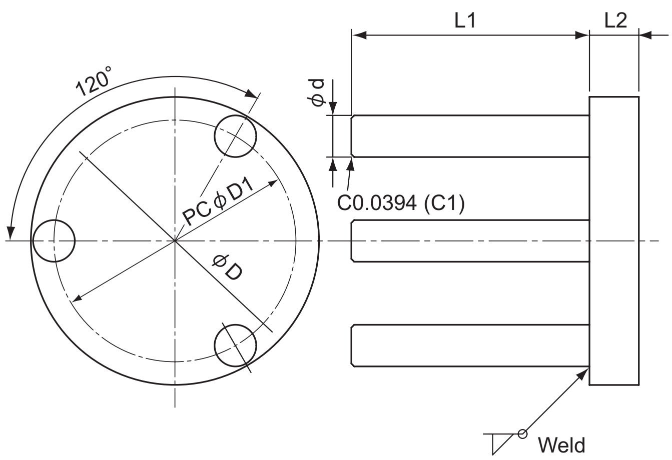


Unit : in. (mm)

Jig	A-012
ϕD	1.61 to 1.63 (41 to 41.5)
ϕD1	1.30 (33)
ϕd1	1.58 to 1.59 (40.2 to 40.3)
ϕd2	1.4 (35.5)
L	1.77 (45)
B	0.87 (22)
L1	0.18 (4.5)
L2	0.47 (12)
Used for	Idler

Seal cover holding jig

Material : S25C (Equivalent to SAE 1025)

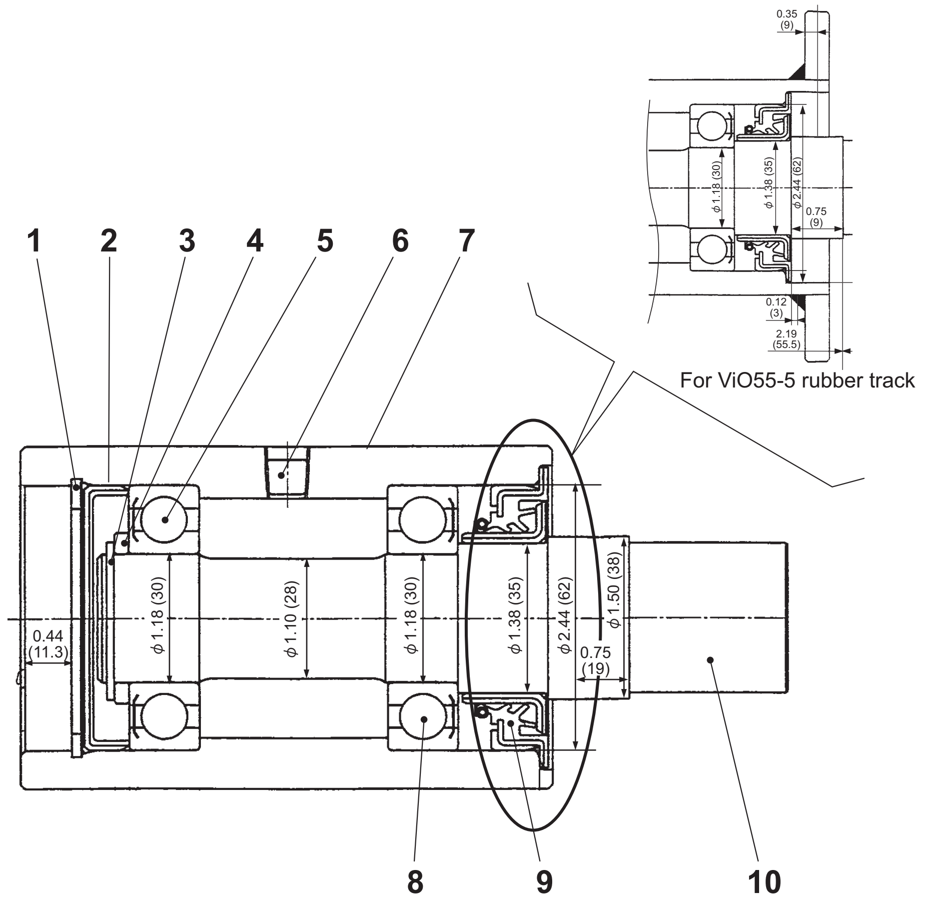


Unit : in. (mm)

Jig	A-014
ϕD	3.54 (90)
PCϕD1	2.95 (75)
ϕd	0.47 (12)
L1	2.95 (75)
L2	0.59 (15)
Used for	Idler and track roller

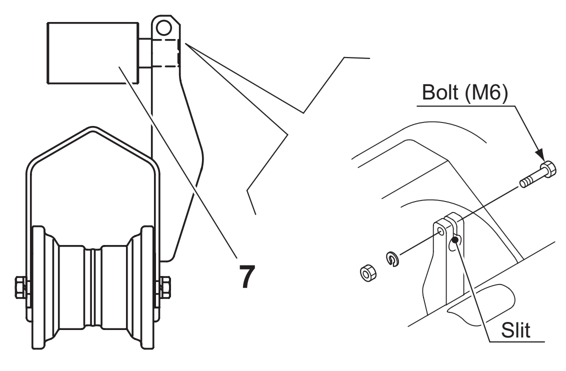
7-2-11 Disassembly and Reassembly of Carrier Roller

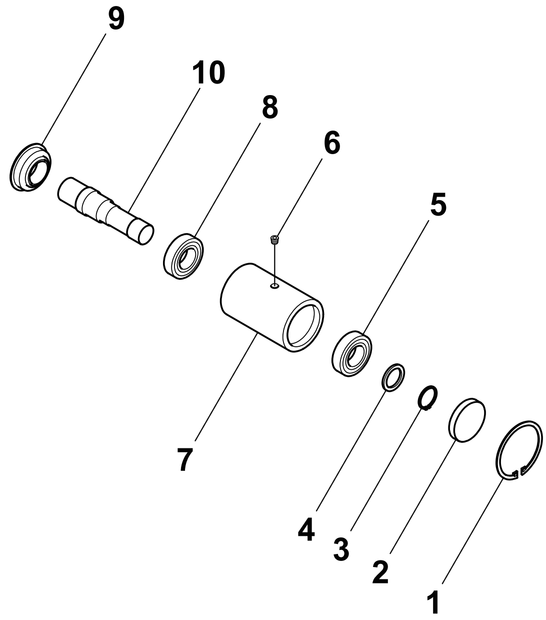
1) Structural Drawings and Component Part



No.	Part	Q'ty	No.	Part	Q'ty
1	External snap ring C (62)	1	6	Plug R1/8	1
2	Cap	1	7	Roller	1
3	External snap ring C (30)	1	8	Bearing 6206Z	1
4	Washer	1	9	Seal	2
5	Bearing 6206Z	1	10	Shaft	1

2) Disassembly

Procedure	
(1) Loosen the tightening bolt for the carrier roller assembly **7** to remove the roller from the track frame. ***Note :*** *Put a wedge into the slit in the bracket to remove the roller smoothly.*	

Procedure	
(2) Remove the snap ring C **1** and the cap **2**. (3) Remove the snap ring C **3** and the washer **4**. Then, pull out the shaft **10** with a press. (4) Remove the seal **9** and the bearings **5** and **8**. (5) Remove the plug R 1/8 **6**.	

3) Reassembly

Reassemble the carrier roller in the reverse order of the disassembly procedure.

Notes :

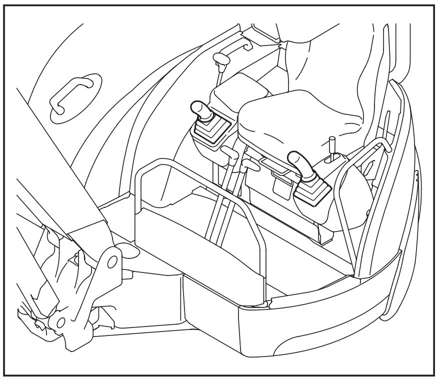
- *Replace the cap and the seal with new ones.*
- *Supply inside of the roller with ALBANIA EP-2 or its equivalent.*

Plug R 1/8
Apply loctite 242 or its equivalent
Quantity of grease : 0.06 Qts. (0.057 L)

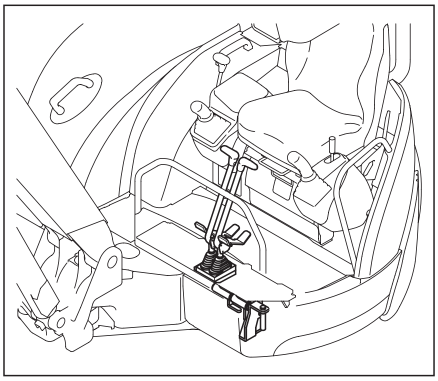
7-3 Controls

7-3-1 Control Train

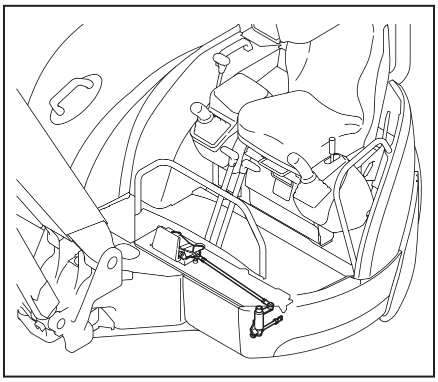
1) Control Lever (R)
Control Lever (L)



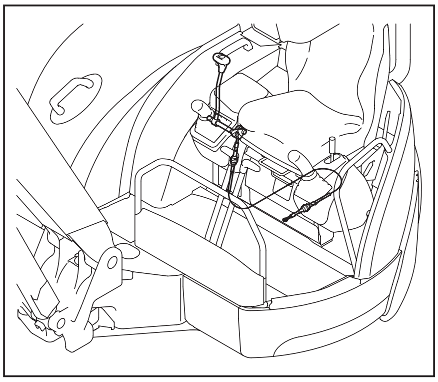
2) Travel Levers



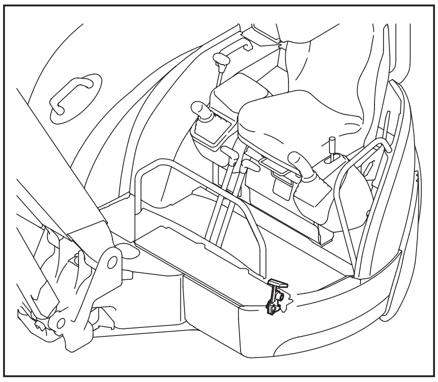
3) Boom Swing Pedal



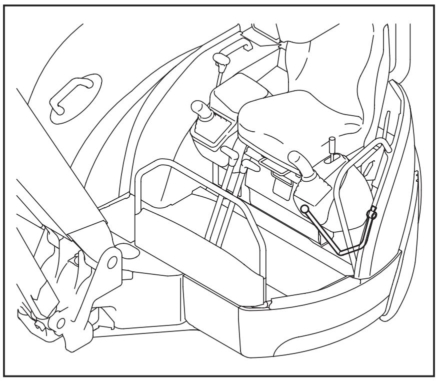
4) Blade Lever



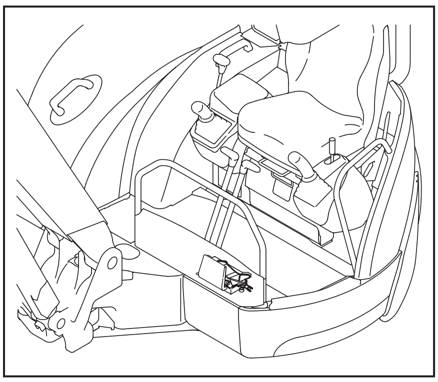
5) High-Speed Pedal



6) Lock Lever



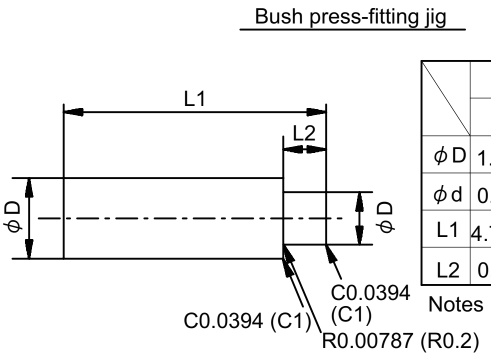
7) P.T.O.



7-3-2 Mechanical Control Linkage

1) Points of Assembly

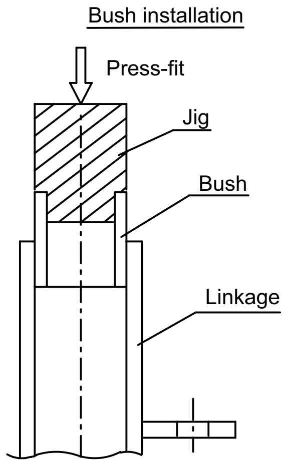
(1) Use a jig to install the bush into the linkage.



Unit : in (mm)

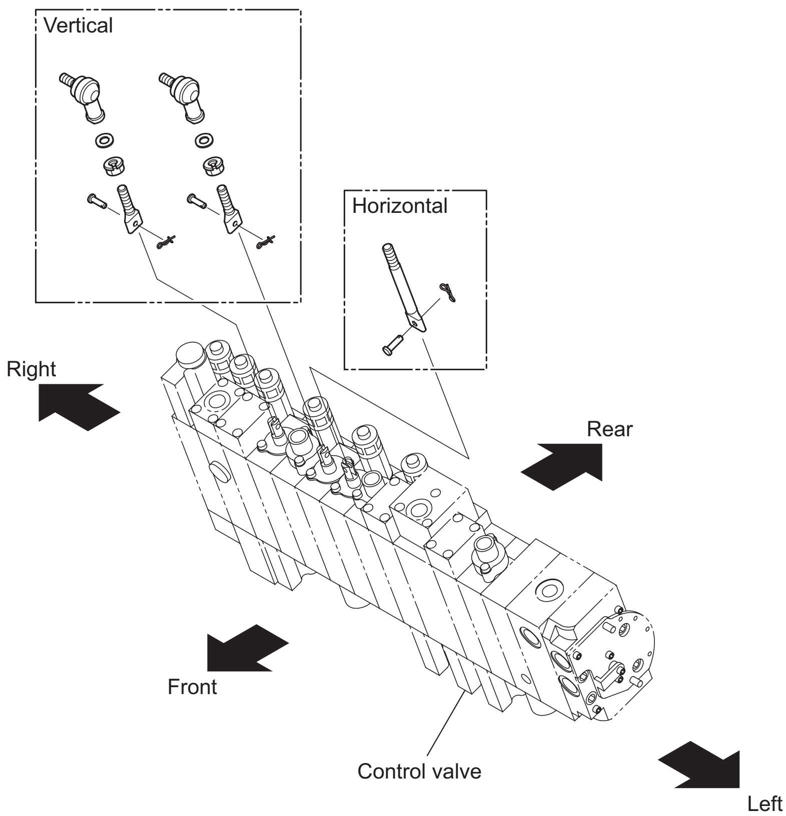
	Jig No. F-001	Jig No. F-002
φD	1.18 (30)	←
φd	0.55 (14)	0.79 (20)
L1	4.72 (120)	←
L2	0.55 (14)	←

Notes : F-001 : Boom swing linkage
P.T.O. pedal
Lever stand R
Bracket for high-speed travel
F-002 : Others

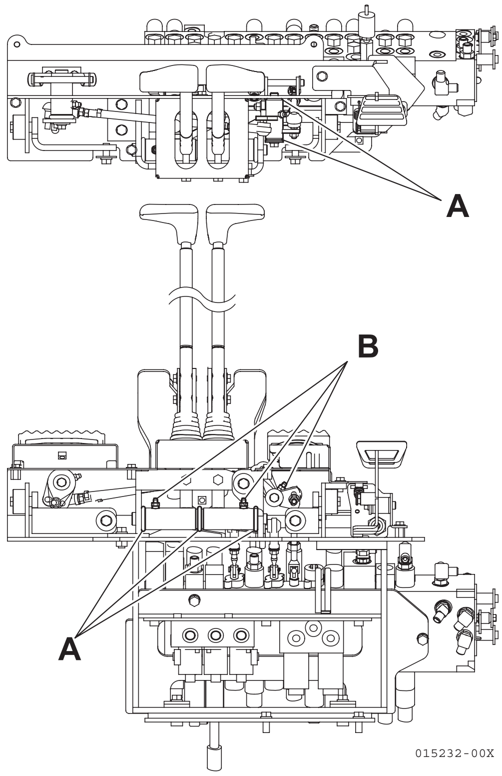


(2) Set the crevices of the control valve spools as shown below.

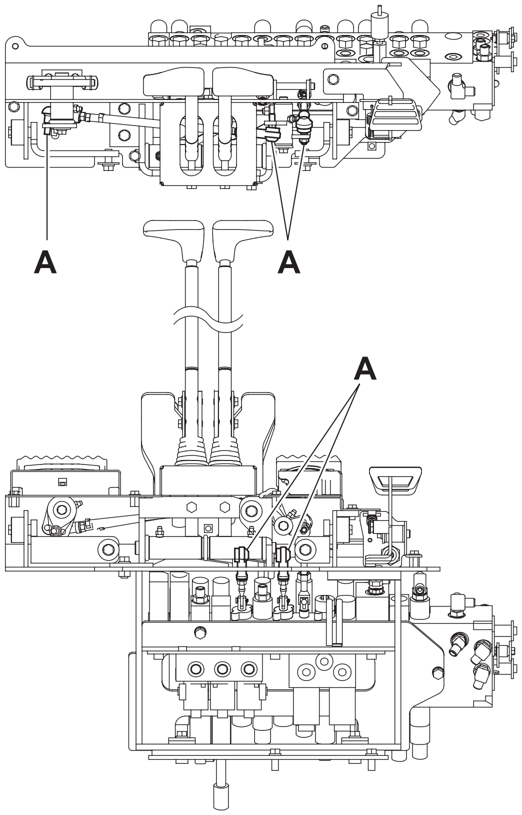
- Travel sections : Vertical
- Boom swing section : Horizontal

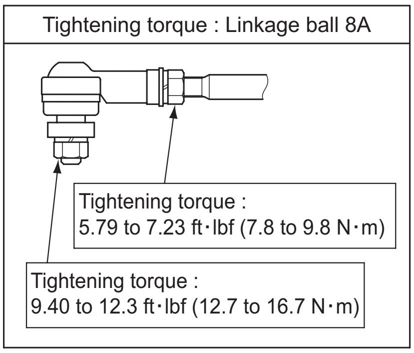


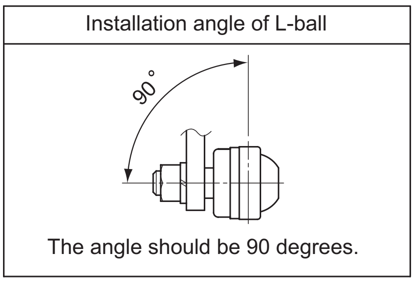
(3) Apply grease to the linkages, and take care not to damage O-rings **A** when installing the linkages.
(4) Supply grease to the nipples **B** after installation.



2) Torque Specs for Rod Joints







7-3-3 Adjustment of Travel Levers

1) Position of Travel Lever Grips

(1) The difference in side level between the right and left lever grips : Within 0.12 in. (3 mm)

(2) Adjustment

[1] Difference in side level

- Loosen the nut **1** of the L-ball and rotate the rod **2** to adjust the positions of the lever grips to 7.99 in. (203 mm) from the frame front end.
- After adjusting the difference in side level between the both levers to within 0.12 in. (3 mm), tighten the nut **1**.

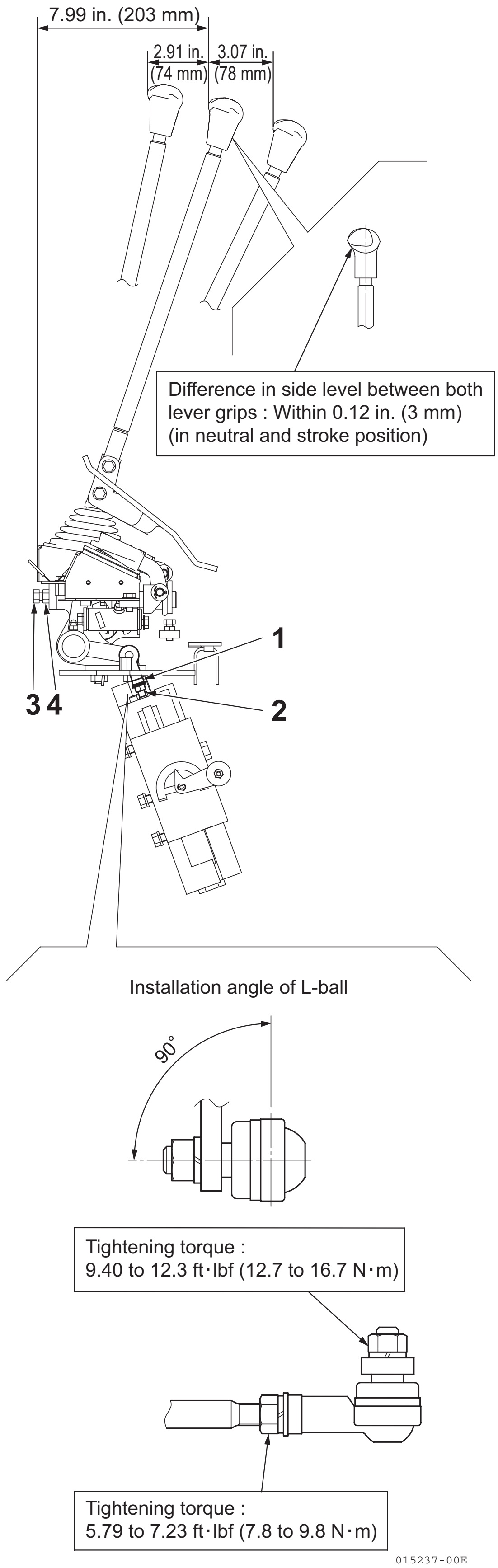
2) Adjustment of Stopper Bolts (Forward and Reverse Travel)

(1) Loosen the lock nuts **4** of the stopper bolts **3**.

(2) Screw in stopper bolts **3** until they have no contact with travel lever.

(3) Move the travel lever to its stroke ends, and loosen stopper bolts **3** until they contact with the travel lever.

(4) Move the travel lever to the neutral position, loosen the stopper bolts **3** half a turn further and tighten lock nuts **4** to fix them.



7-3-4 Adjustment of Boom Swing Pedal

1) Setting Pedal Level

(1) Loosen the nut **2** of L-ball **1**.

(2) Adjust the boom swing pedal with rod **3** so that the pedal is level.

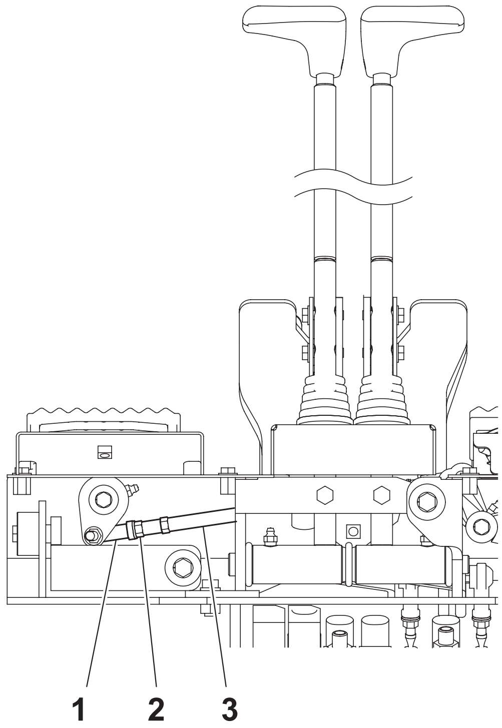
(3) Tighten the nut **2** of L-ball **1**.

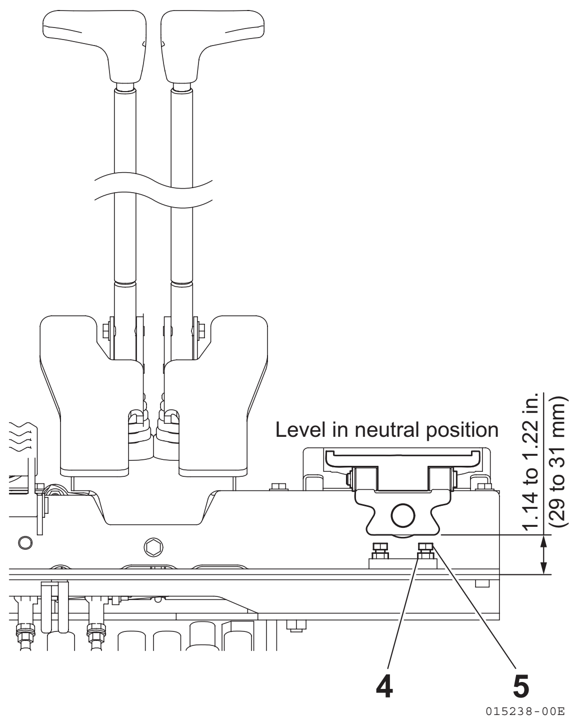
2) Adjustment of Stopper Bolts (Right and Left Boom Swing)

(1) Loosen the lock nuts **4** and screw in the stopper bolts **5** until they have no contact with boom swing pedal.

(2) Move the boom swing pedal to its stroke ends, and loosen the stopper bolts **5** until their heads contact with the pedal.

(3) Loosen the stopper bolts **5** one more turn and tighten the lock nuts **4** to fix them.



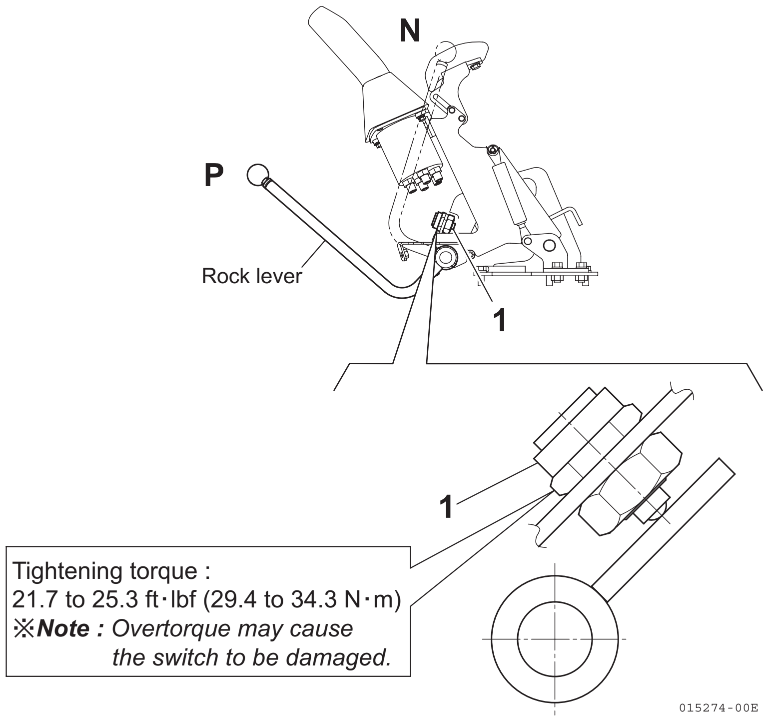


7-3-5 Adjustment of Lock Lever

1) Operation of Lock Lever

(1) The operating force for moving the lock lever from **P** to **N** should be less than 13.23 lbs. (6 kg).

(2) The lock lever switch **1** should not allow the implements to operate when the lock lever is in **N** position.



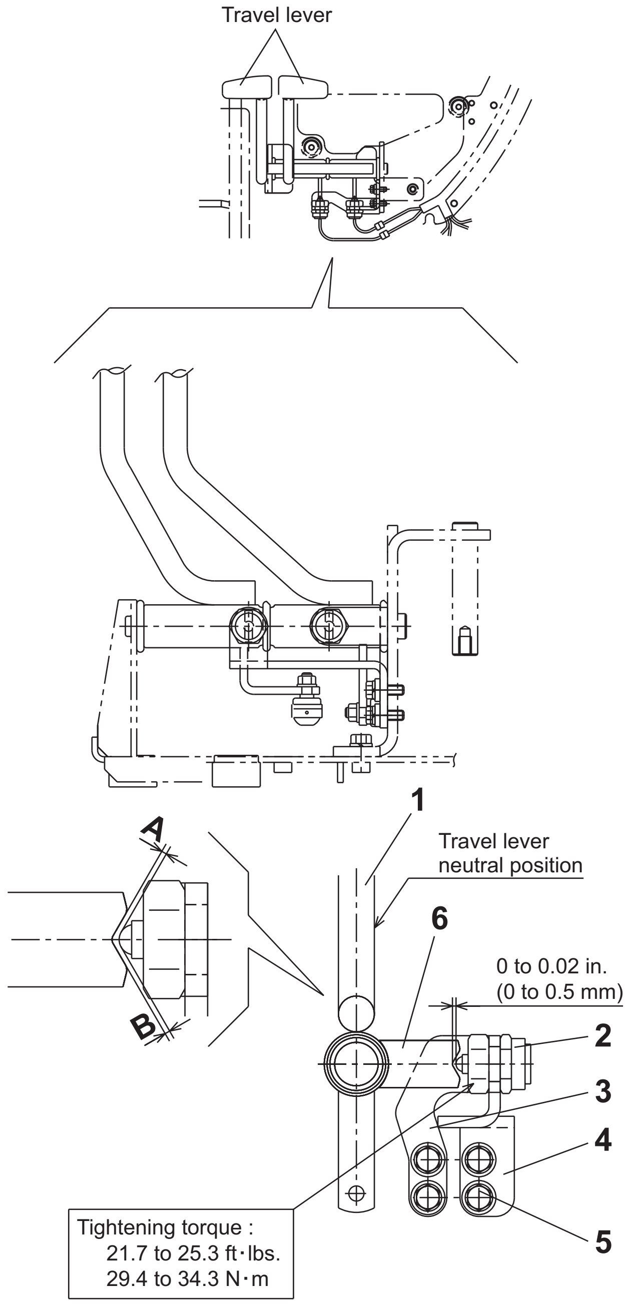
Lock lever switch operation

Lever position	Switch condition	Switch circuit	Cut-off valve operation	Implement operation
P	Pushed	ON	Operate	Operate
N	Normal	OFF	Stop	Can not operate

7-3-6 Adjustment Procedure of Travel Alarm Switch

(1) Set the travel lever **1** to the neutral position.
(2) Loosen bolt **5** (4 pcs.) of bracket **3**, **4** of travel alarm switch **2**.
(3) Adjust the distance between the travel lever arm **6** and the travel alarm switch **2** to 0.02 in. (0.5 mm) or less.

Note :
Make the clearances A and B equal.



7-3-7 Adjustment Procedure of P.T.O. Pedal

1. Adjustment of P.T.O. pedal in neutral position

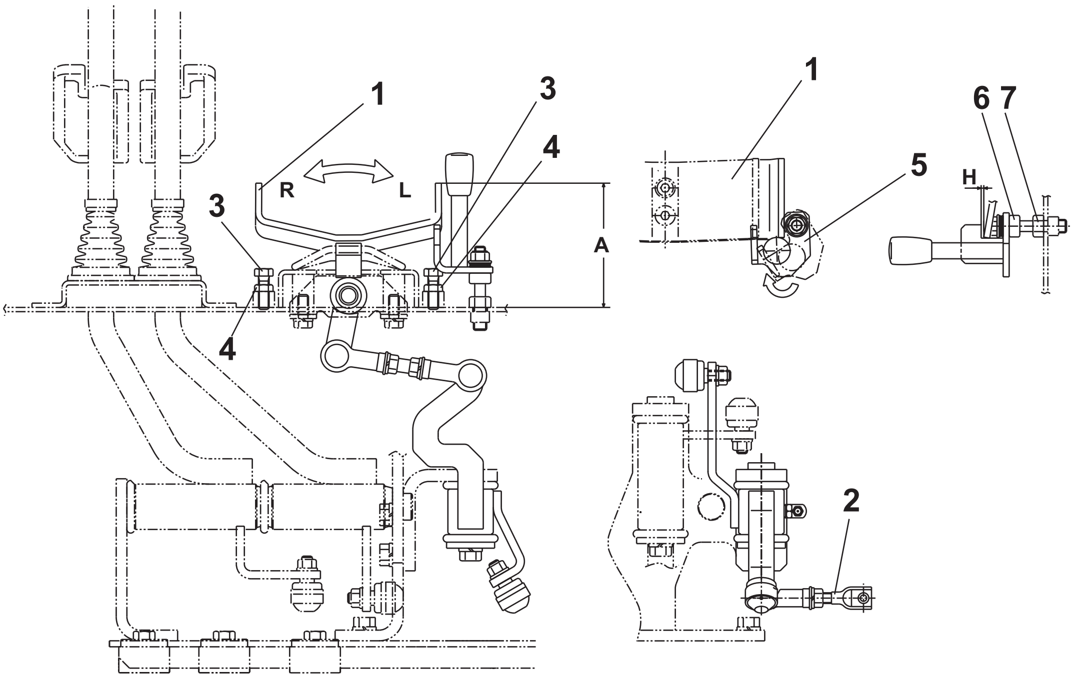
(1) Adjust the distance A to 3.63 to 3.70 in. (92 to 94 mm) with the rod 2.

2. Adjustment of P.T.O. pedal

(1) Tighten the stopper bolt **3** so that it does not contact with the P.T.O. pedal 1 when moving the P.T.O. pedal to its stroke end.
(2) Move the P.T.O. pedal **1** on the right side to its stroke end.
(3) Loosen the stopper bolt **3** until the bolt head contacts with the P.T.O. pedal **1** at its full stroke.
(4) Loosen the stopper bolt **4** half more turn and tighten the lock nut **4**.
(5) Adjust the left side by the same way as the right side.

7-3-8 Adjustment Procedure of P.T.O. Pedal Lock

Adjust the P.T.O. pedal lock after adjusting the P.T.O. pedal.
(1) Loosen the lock nut **7**.
(2) Move the P.T.O. pedal **1** on the left side until the P.T.O. pedal 1 contacts with the stopper bolt **3**.
(3) Move the P.T.O. pedal lock to the lock position.
(4) Adjust the distance H to 0.079 in. (2 mm) or less with the bolt **6**.
(5) Tighten the lock nut **7**.



7-3-9 Adjustment of Accelerator Lever

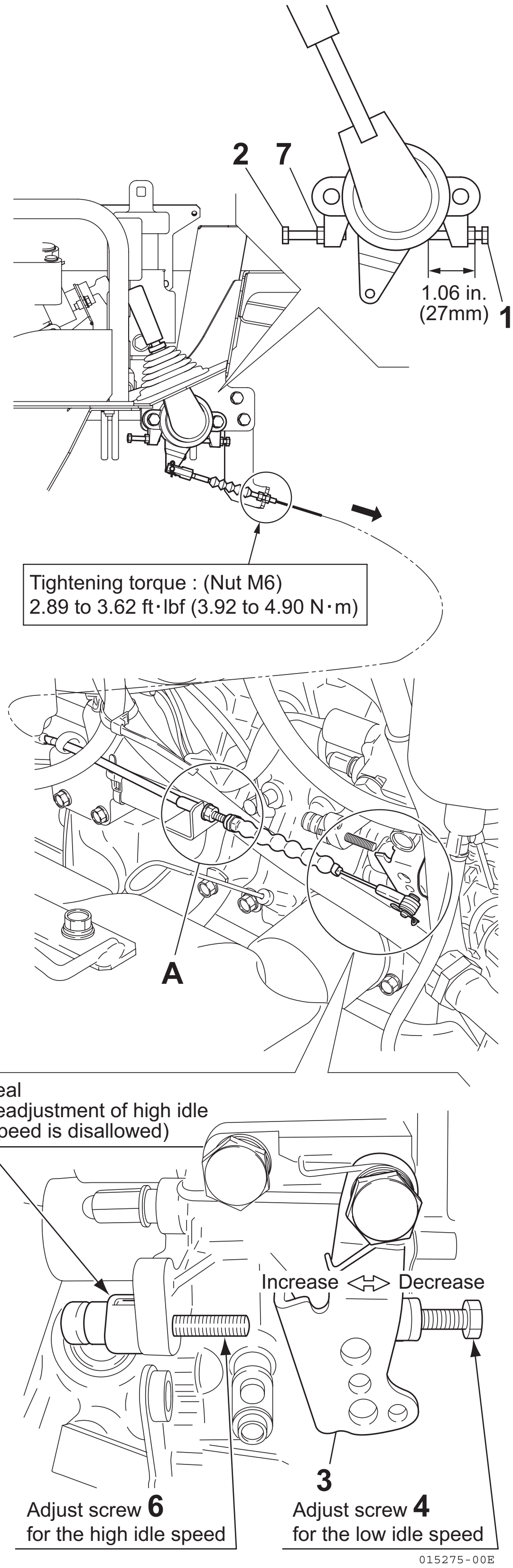
1) Adjustment of Idle Speed

(1) Adjust the length of the stopper bolt **1** to 1.06 in. (27 mm), as shown in the drawing. Loosen the stopper bolt **2** and keep it loosened.

(2) Move the accelerator lever forward to its stroke end (the minimum idling speed position).

(3) Adjust the accelerator cable **5** in the part **A** so that the regulator handle **3** on the engine side contacts with the adjusting bolt **4** for the minimum idling speed.

(4) Check if the minimum idling speed is 1125 to 1175 rpm. If not, make readjustment with the accelerator cable **5** in the part **A** or the adjusting bolt **4**.



2) Adjustment of High Idle Speed

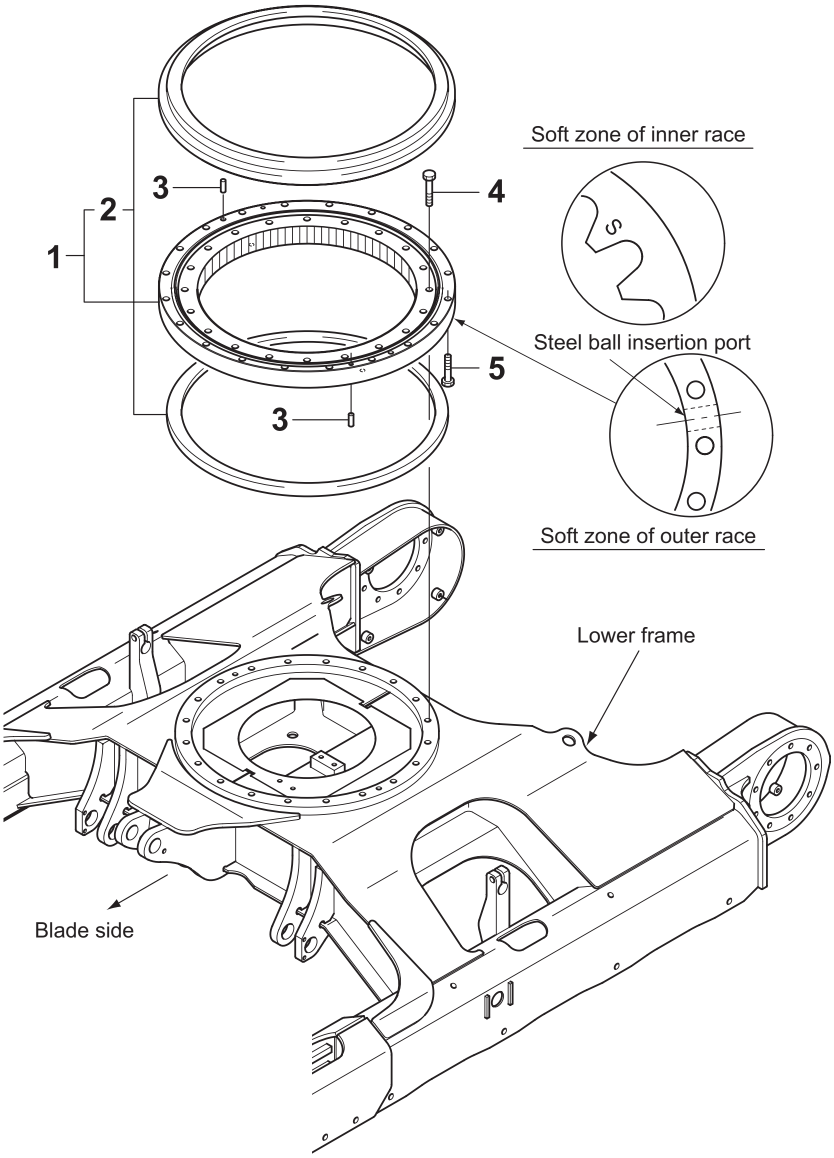
(1) Move the accelerator lever back to its stroke end until the regulator handle **3** on the engine side contacts with the adjusting bolt **6** for the maximum idling speed.

(2) While keeping this condition, tighten the stopper bolt **2** until it contacts with the lever link and then, tighten the lock nut **7**.

Note :

- *Check that the maximum idling speed is 2565 to 2615 rpm.*
- *The adjust screw **6** is set under seal so that the high idle speed cannot be readjusted.*

7-4 Swing Bearing



1) Structure

The swing bearing is a single row ball bearing and the internal gear is induction hardened.

The steel balls roll on the smooth surfaces of the inner and outer races.

A soft zone is made at the starting point of the hardening on the race, on which the steel balls roll, and the "S" mark is indicated on the upper surface of the inner race. In order to decrease the load on this soft zone, place the "S" mark on the right side of the lower frame, as shown in the right figure.

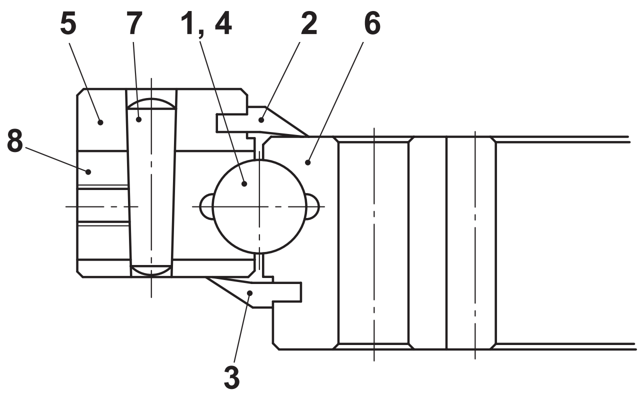
The outer race also has a soft zone at the steel ball insertion port. Install this port on the right side of the lower frame, as shown in the right figure.

2) Part

No.	Part
1	Swing bearing
2	Seal kit
3	Dowel pin 13×36
4	Bolt M16×90
5	Bolt M16×80

3) Details of Swing Bearing

No.	Part	Q'ty
1	Steel ball	77
2	Seal A	1
3	Seal B	1
4	Support	77
5	Outer race	1
6	Inner race	1
7	Taper pin	1
8	Plug	1



4) Inspection

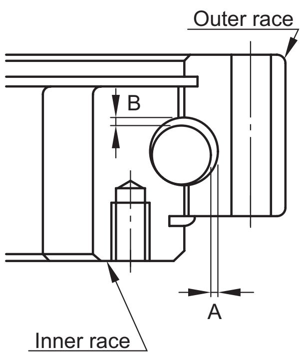
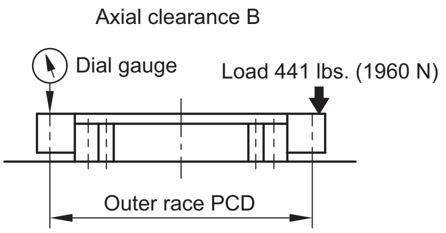
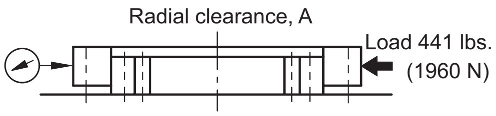
(1) Check the gear tooth surfaces for the nicks, flaws, cracks, wear and breakage. Replace if the damage is excessive.

(2) Check for abnormal sound. Clean, grease or replace if necessary.

(3) Check for the play in the inner and outer races and rotation fluctuation. Refer to the service standards for repair or replacement.

(4) Check for the grease leak from the swing bearing seal. Replace if the leakage is excessive.

5) Service Standards

			Standard	Wear limit
			0.002 to 0.0098 in. (0.05 to 0.25 mm)	0.022 in. (0.55 mm)
			0.002 to 0.012 in. (0.05 to 0.30 mm)	0.024 in. (0.6 mm)
Steel ball dia.			Ø1.0 in. (Ø25.4 mm)	—
Tightening torque	Turning frame×outer race Lower frame×inner race	M16×80 M16×90	195.3 to 224.2 ft·lbf (264.8 to 304.0 N·m)	Apply Loctite 262 or its equivalent.

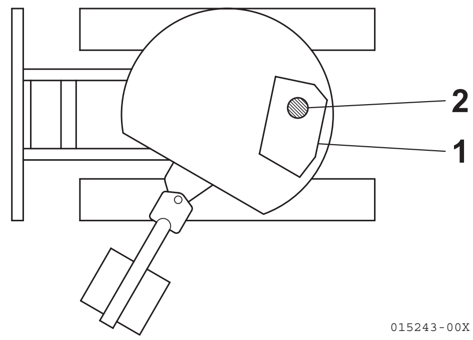
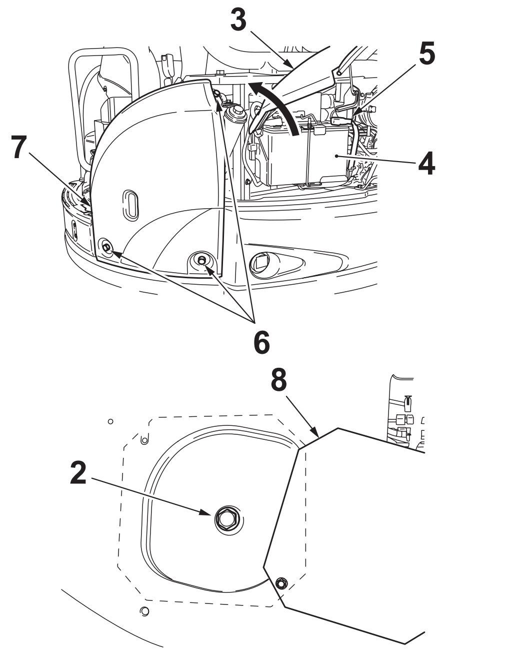
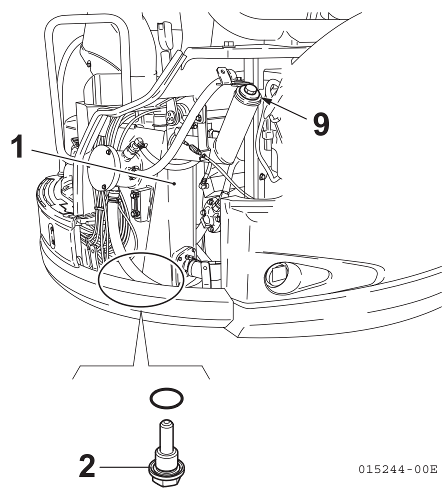
Note :

Supply multi-purpose grease to the swing bearing.

7-5 Hydraulic Equipment

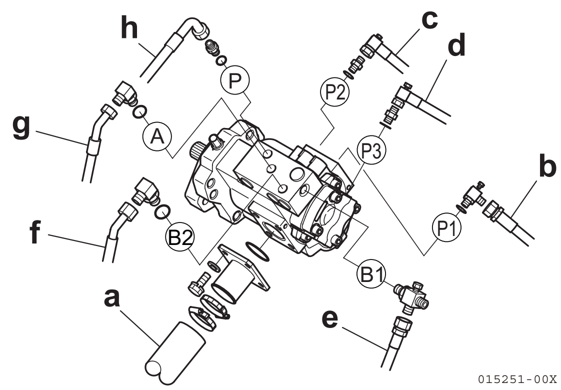
7-5-1 Removal and Reinstallation of Hydraulic Pump

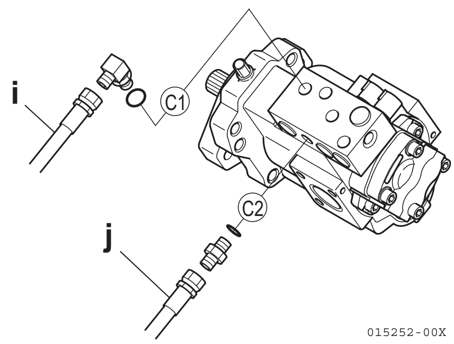
1) Removal

Procedure	
(1) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.	
(2) Open the engine hood rear cover **3** and remove it. (3) Disconnect the battery negative cable **5** from the battery **4**. (4) Loosen three cap screws **6** to remove the side cover **7**. (5) Remove the bottom cover **8** and put an oil container under the drain plug **2** of the hydraulic oil reservoir. (6) Remove the drain plug **2** to drain hydraulic oil. **(Q'ty: 10 Gal(38L))** At this time, loosening or removing the filler cap **9** make oil draining easier.	 Viewed from under the machine body 

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(7) Disconnect hydraulic hoses from the hydraulic pump.

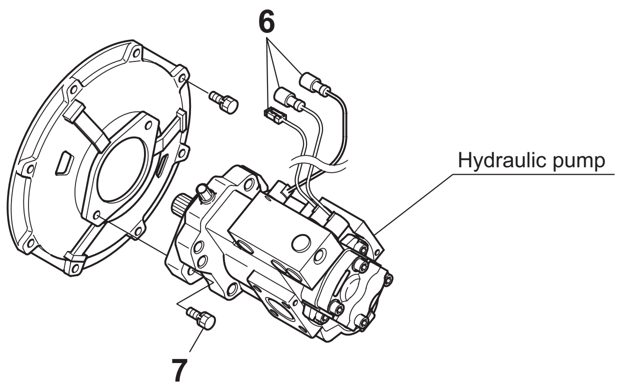
a. Suction
b. P1
c. P2
d. P3
e. B1
f. B2
g. A
h. P(P4)
i. C1
j. C2

Note :
• Mark each hose to reinstall on the original position.
• Plug each hose end and fittings on the control valve against dust.</td><td>


</td></tr>
</table>

<table>
<tr><td>(8) Remove the couplers 6 of the wires for the cut-off valve, the high-speed travel and the quick coupler.

(9) Remove the installation bolts 7 from the flywheel cover to remove the hydraulic pump.

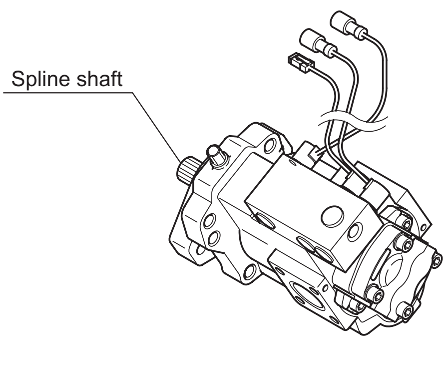
Note :
Put rope onto the hydraulic pump to remove it using a lifting device.</td><td>
</td></tr>
</table>

2) Reinstallation

Reinstall the hydraulic pump in the reverse order of the removal procedure.

Notes :

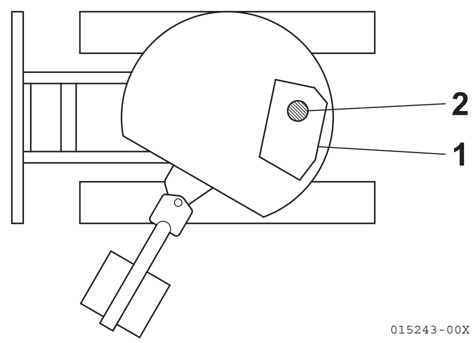
- *Apply heavy-duty grease to the spline shaft of the hydraulic pump.*
- *After reinstalling the hydraulic pump, be sure to release the air from the hydraulic pump.*
  Refer to Section "1-10 Air Release of Hydraulic Equipment".

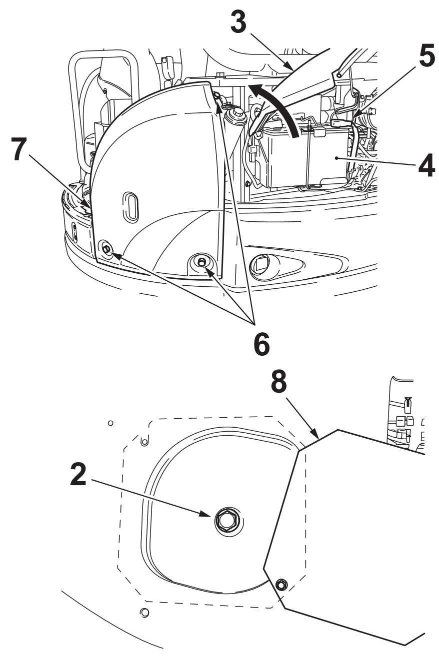
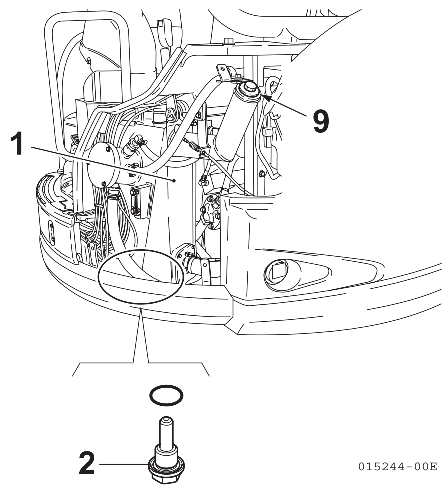


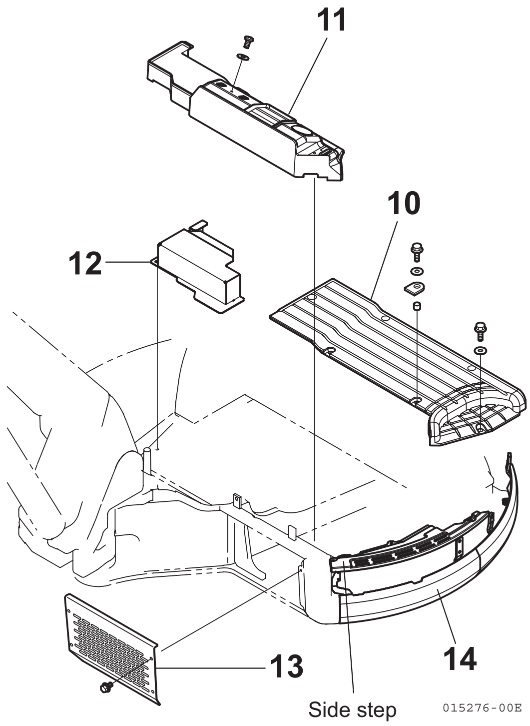
Hydraulic pump installation bolt M12	
Tightening torque	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)

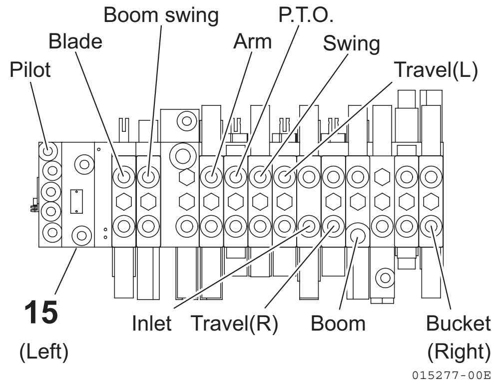
7-5-2 Removal and Reinstallation of Control Valve

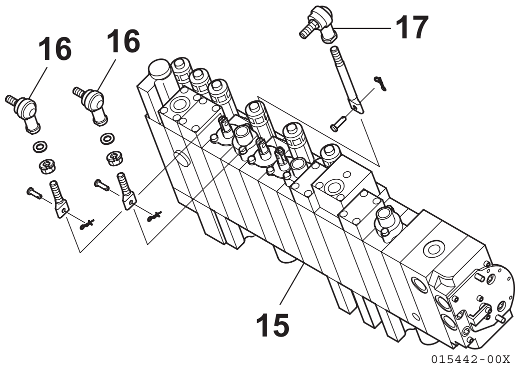
1) Removal

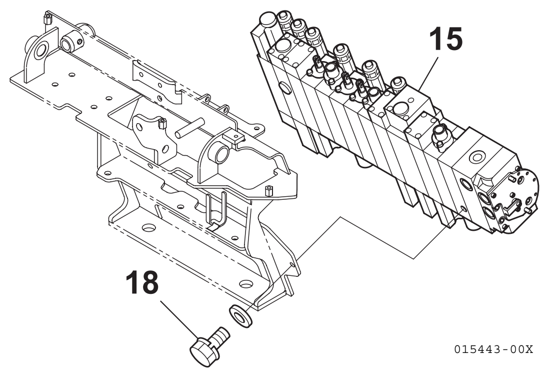
Procedure	
(1) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.	

(2) Open the engine hood rear cover **3** and remove it. (3) Disconnect the battery negative cable **5** from the battery **4**. (4) Loosen three cap screws **6** to remove the side cover **7**. (5) Remove the bottom cover **8** and put an oil container under the drain plug **2** of the hydraulic oil reservoir. (6) Remove the drain plug **2** to drain hydraulic oil. **(Q'ty: 10 Gal(38L))** At this time, loosening or removing the filler cap **9** make oil draining easier. Alternatively, a compression vacuum, which is installed to the breather hose of the hydraulic oil tank, can be used if a stable air pressure (air from a compressor) can be ensured.	 Viewed from under the machine body 

Procedure	
(7) Remove the step **10**, floor mat **11** and step B **12**. (8) Remove the cover F **13** and frame guard L **14** (and side step for canopy spec machine only).	

(9) Remove the hydraulic hoses from the control valve **15** in order from left to right. ***Notes :*** • *Mark the removed hoses not to reinstall them in the wrong positions.* • *Protect the hose and connector not to adhere dust.* (10) Disconnect the wire harness couplers from the seat mount.	

(11) Remove the L-balls **16** and **17** connecting to the travel R and L, and the boom swing section spools of the control valve **15**.	

Procedure	
(12) Remove three cap screws (M10) **18** to remove the control valve **15**.	

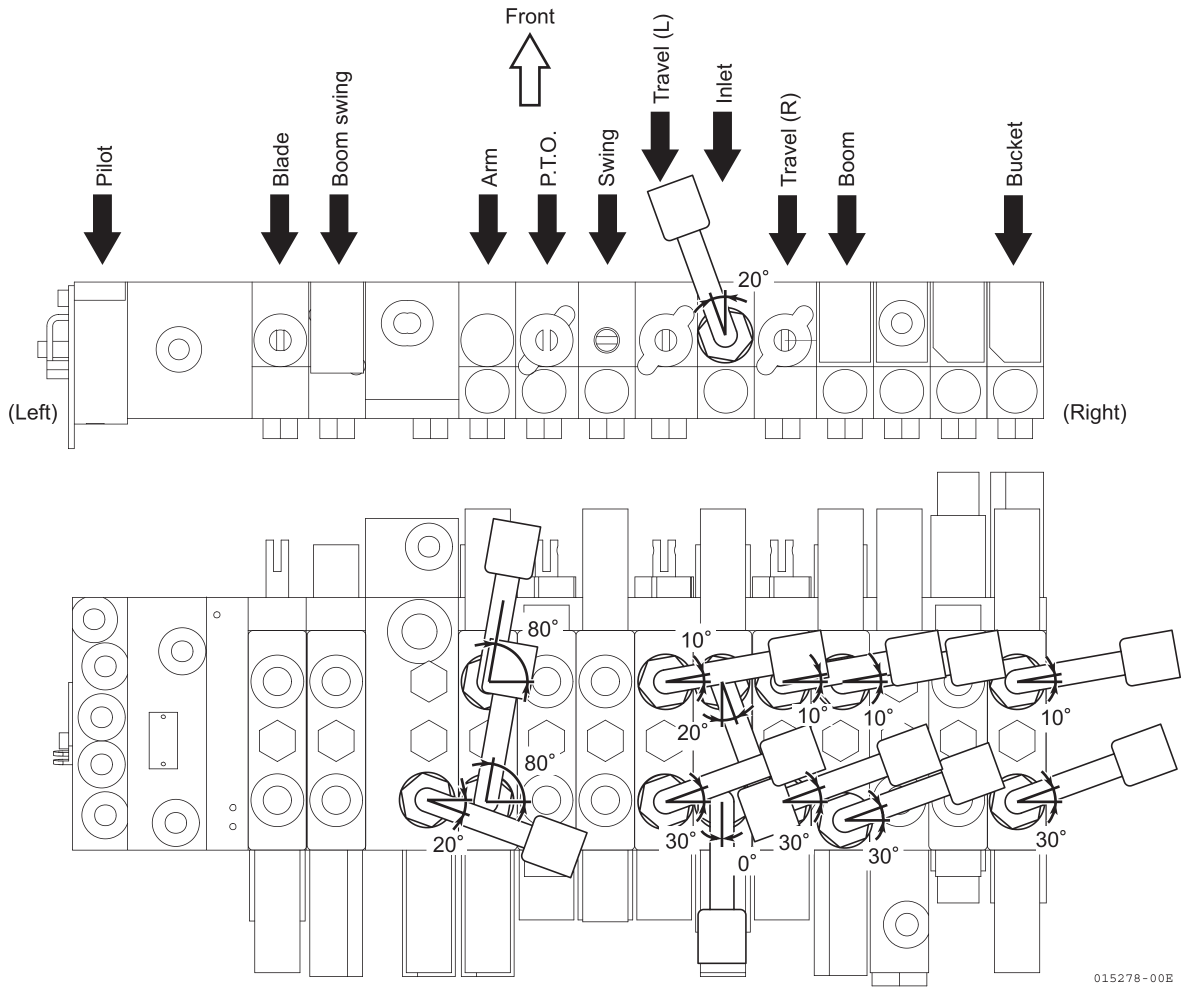
2) Reinstallation

Reinstall the control valve in the reverse order of the removal procedure.

Notes :

- *Install the hoses out of contact with any other hoses.*
- *After reinstallation, raise the hydraulic oil temperature to 122 to 140 °F (50 to 60 °C) and apply load to all the sections to check for oil leak.*

Connector and joint setting angle

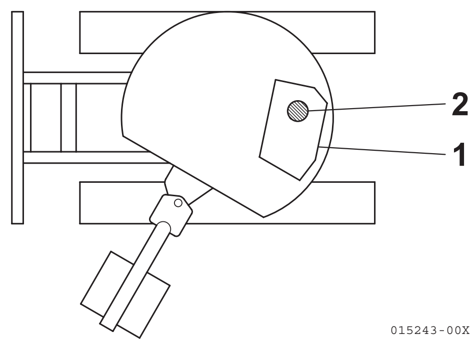


7-5-3 Removal and Reinstallation of Swing Motor

1) Removal

Procedure

(1) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.



(2) Open the engine hood rear cover **3** and remove it.

(3) Disconnect the battery negative cable **5** from the battery **4**.

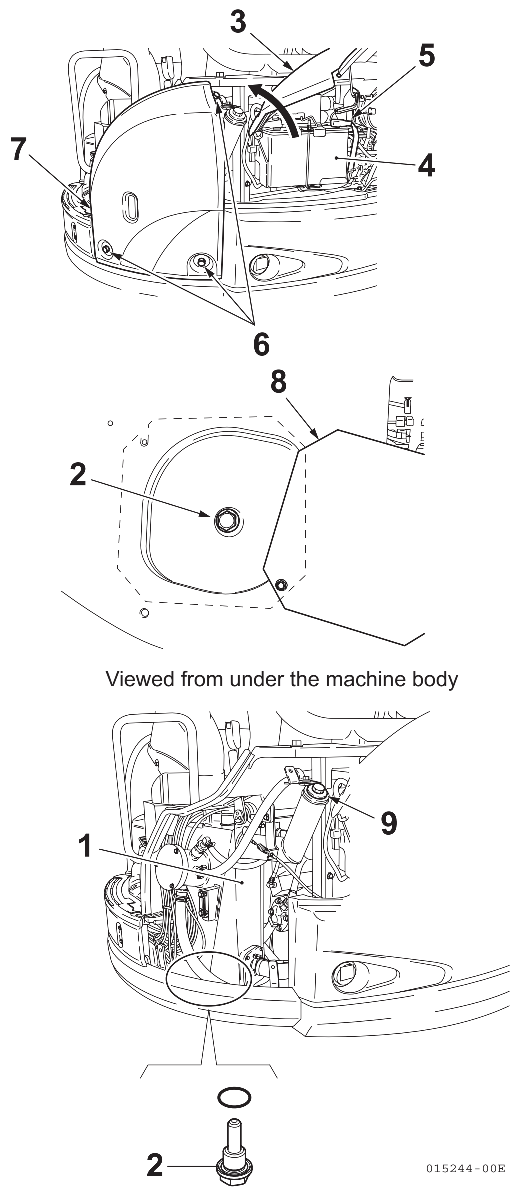
(4) Loosen three cap screws **6** to remove the side cover **7**.

(5) Remove the bottom cover **8** and put an oil container under the drain plug **2** of the hydraulic oil reservoir.

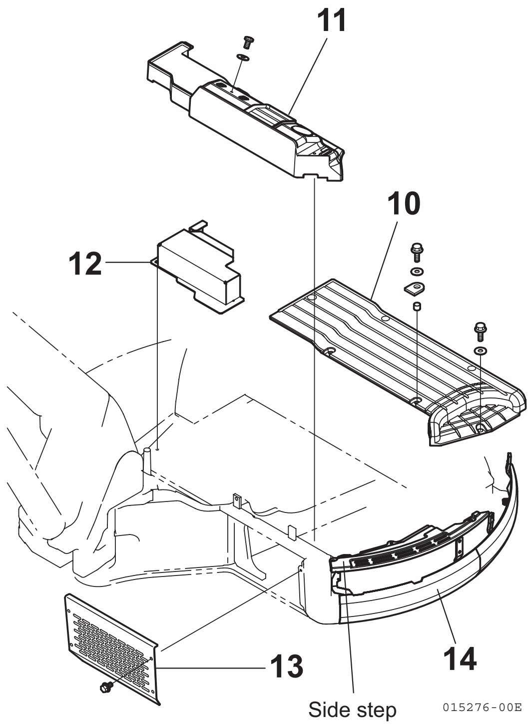
(6) Remove the drain plug **2** to drain hydraulic oil.

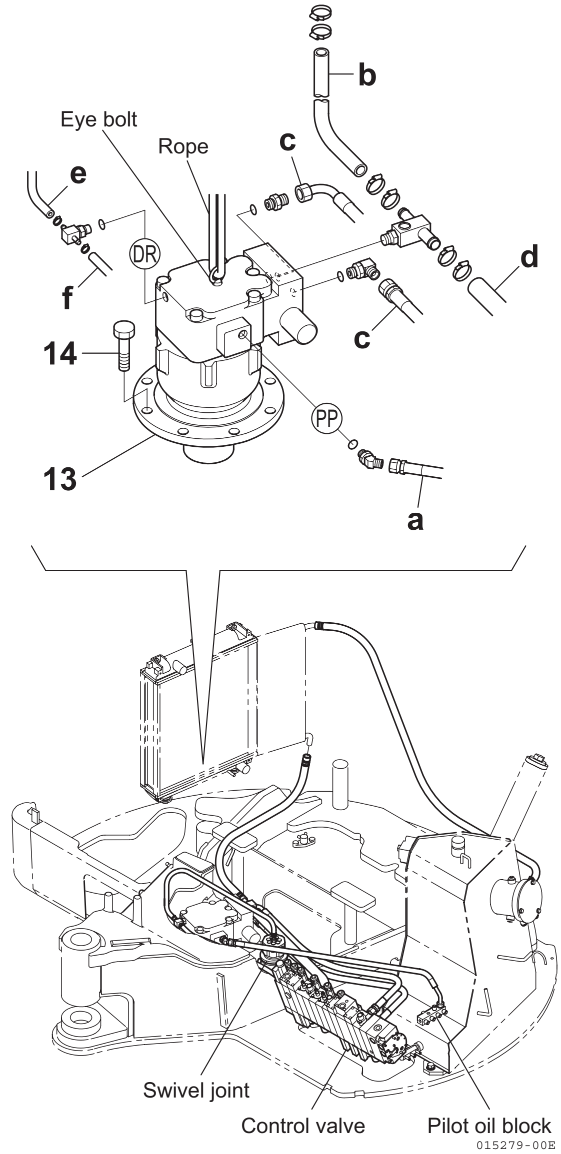
(Q'ty: 10 Gal(38L))

At this time, loosening or removing the filler cap **9** make oil draining easier.
Alternatively, a compression vacuum, which is installed to the breather hose of the hydraulic oil tank, can be used if a stable air pressure (air from a compressor) can be ensured.



Viewed from under the machine body

Procedure	
(7) Remove the step **10**, floor mat **11** and step B **12**.	

Procedure	
(8) Disconnect the hydraulic hoses from the swing motor **13**. **a : Hose (to pilot oil block)** **b : Drain hose (to oil cooler)** **c : Hose (from control valve)** **d : Drain hose (from control valve)** **e : Drain hose (to swivel joint)** **f : Hose (from control valve)** (9) Loosen the cap screws **14** to remove the swing motor **13**. ***Note :*** *Install an eye bolt (M8) to the swing motor and put rope through the eye bolt to remove the motor using a lifting device.*	

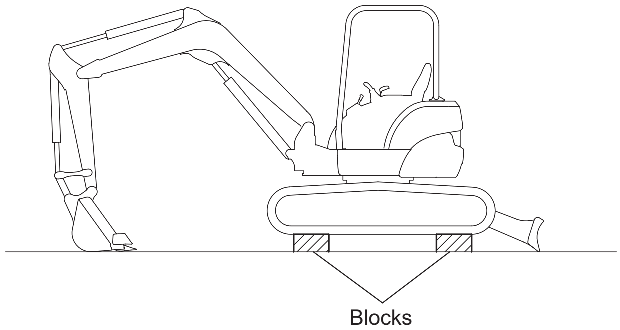
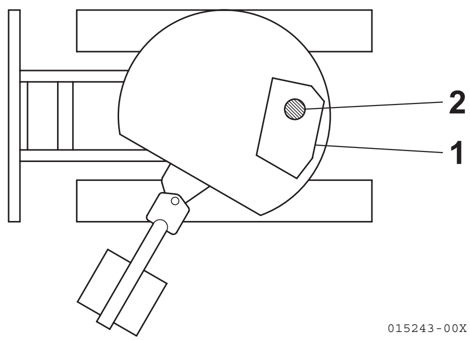
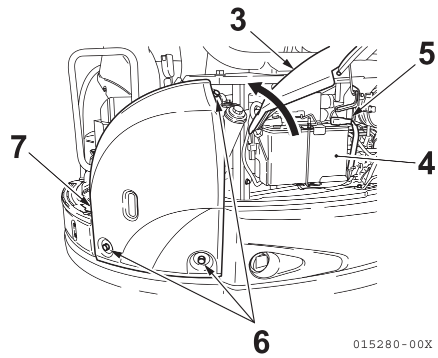
2) Reinstallation

Reinstall the swing motor in the reverse order of the removal procedure.

Swing motor installation bolt M16	
Adhesive	Apply loctite 262 or its equivalent
Tightening torque	191.7 to 217.0 ft·lbf (259.9 to 294.2 N·m)

7-5-4 Removal and Reinstallation of Swivel Joint

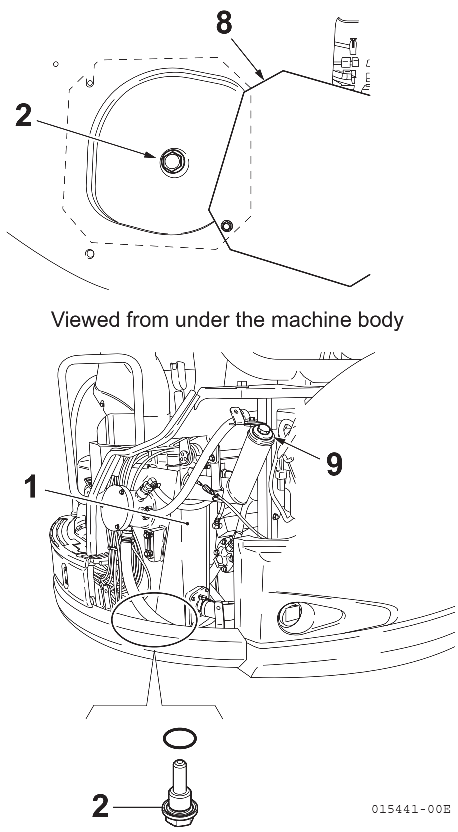
1) Removal

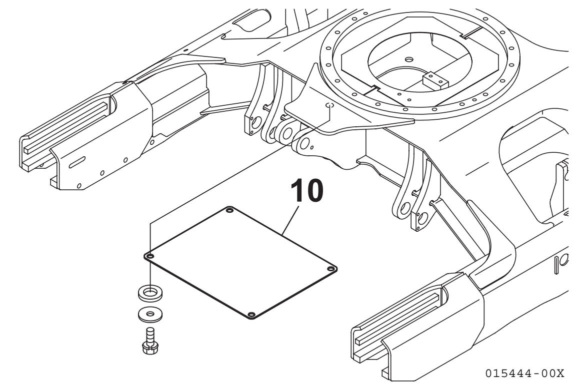
Procedure	
(1) Operate the implements and the blade to raise the machine. (2) After raising the machine, put blocks under the machine. ***Note :*** *To prevent the machine from dropping, be sure to put blocks.*	
(3) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.	
(4) Open the engine hood rear cover **3** and remove it. (5) Disconnect the battery negative cable **5** from the battery **4**. (6) Loosen three cap screws **6** to remove the side cover **7**.	

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>(7) Remove the bottom cover 8 and put an oil container under the drain plug 2 of the hydraulic oil reservoir.

(8) Remove the drain plug 2 to drain hydraulic oil.

(Q'ty: 10 Gal(38L))

At this time, loosening or removing the filler cap 9 make oil draining easier.</td><td>
</td></tr>
</table>

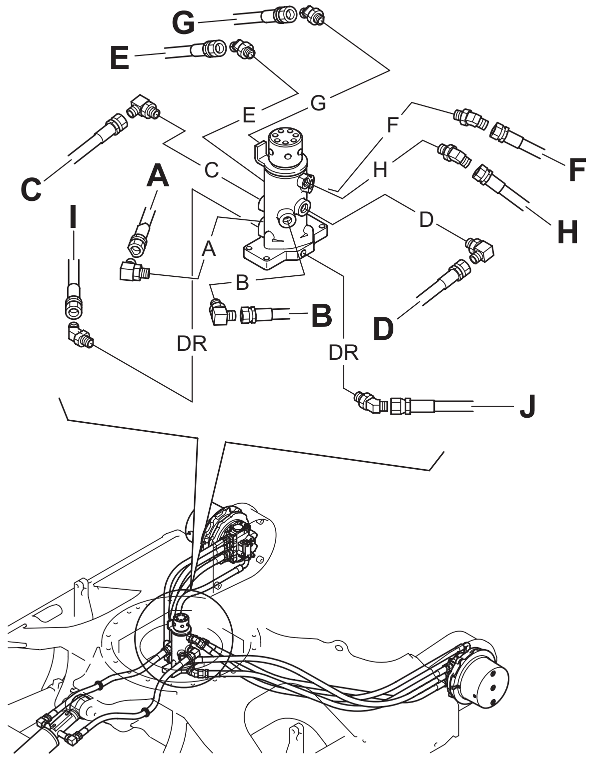
<table>
<tr><td>(9) Remove the bottom cover 10.</td><td>
</td></tr>
</table>

Procedure	

(10) Remove the hydraulic hoses on the lower frame side from the swivel joint.

G : High-speed pilot (R)
E : Travel motor (R)
I : Drain (R)
C : Blade cylinder (Rod end)
A : Travel motor (R)
H : High-speed pilot (L)
B : Travel motor (L)
J : Drain (L)
D : Blade cylinder (Bottom end)
F : Travel motor (L)

Notes :
- *Remove the hydraulic hoses in order of the positions on the swivel joint from the lowest.*
- *Mark the removed hoses to identify their respective positions for reinstallation.*

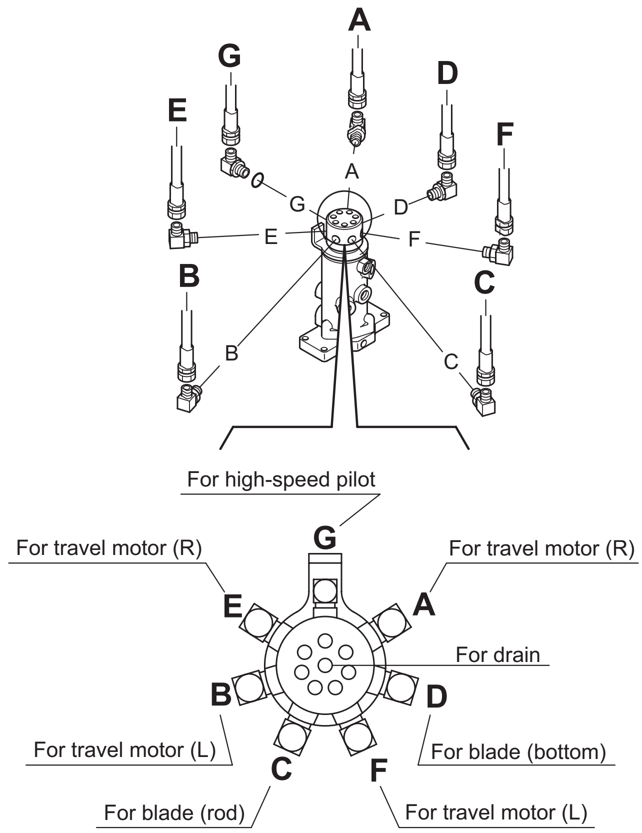


(11) Remove the hydraulic hoses on the turning frame side from the swivel joint.

G : High-speed pilot
A : Travel motor (R)
I : Blade (Bottom end)
F : Travel motor (R)
C : Blade (Rod end)
B : Travel motor (L)
E : Travel motor (R)
I and J : Drain

(12) Remove the swivel joint by lifting it up.

Note :
Mark the lower frame and the swivel joint to reinstall the swivel joint in the correct direction.



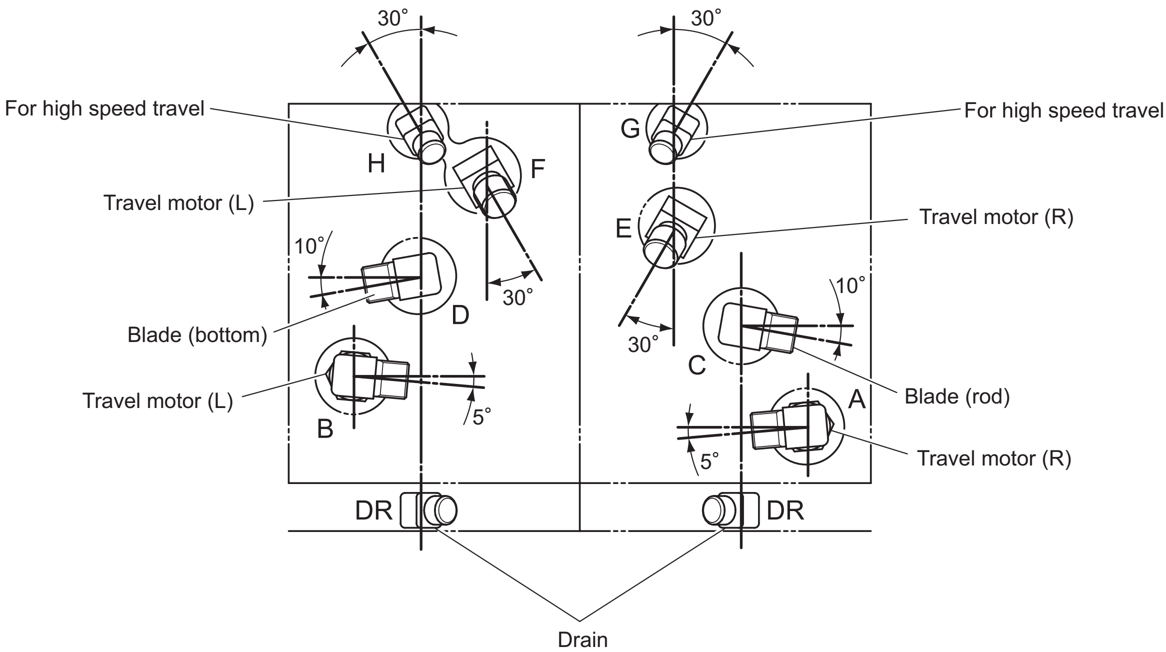
2) Reinstallation

Reinstall the swivel joint in the reverse order of the removal procedure.

Swivel joint installation bolt M10	
Adhesive	Apply Three Bond 1324 or its equivalent
Tightening torque	32.6 to 43.4 ft·lbf (44.1 to 58.8 N·m)

Installation angle of connectors (exploded view)

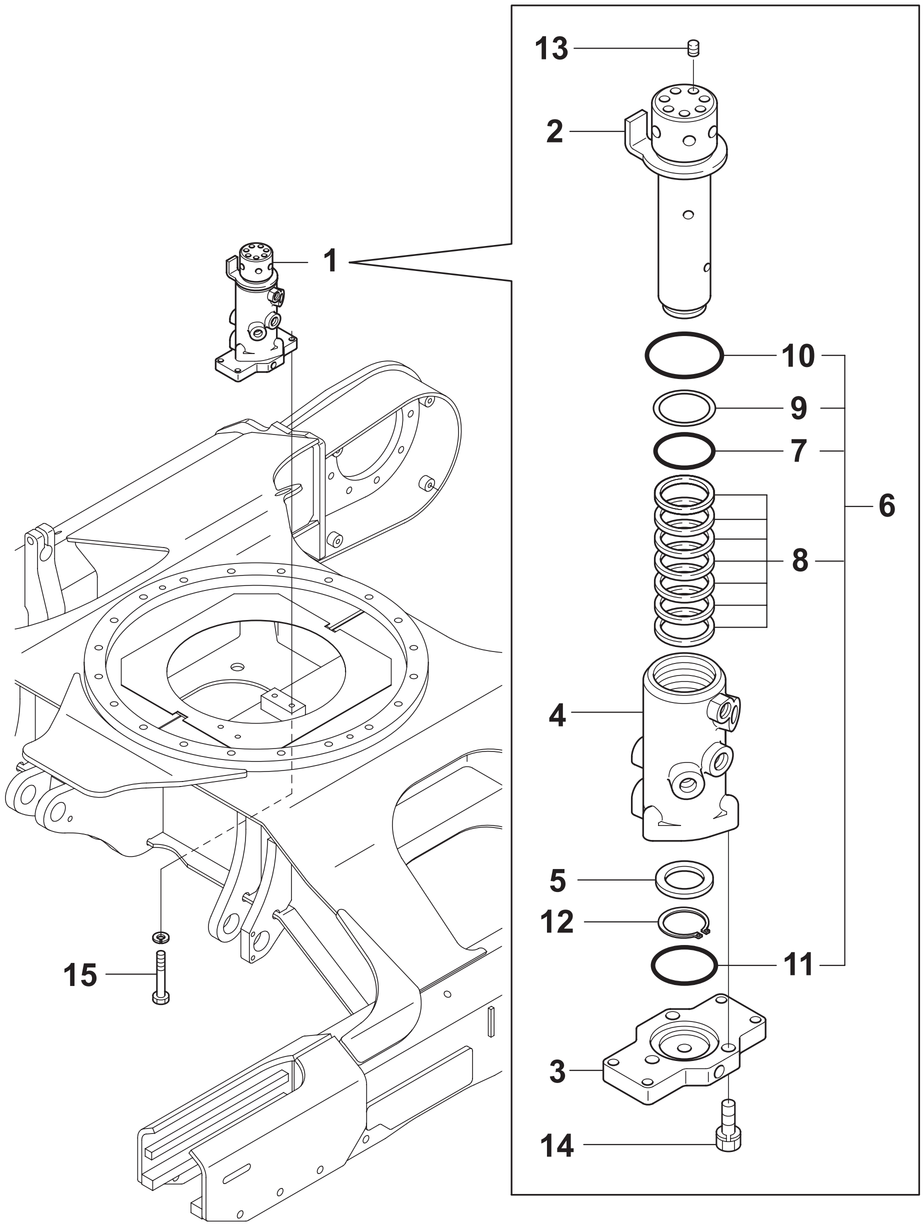
(1) Swivel joint hub side



7-5-5 Disassembly and Reassembly of Swivel Joint

1) Swivel Joint

The swivel joint is used to prevent the hydraulic piping from twisting when the upperstructure swings. The swivel joint consists of the shaft, hub and seal kit. The shaft and hub have holes and grooves, and the oil supplied from the port of the shaft, passing through the hub groove, is fed to the actuators of the undercarriage.

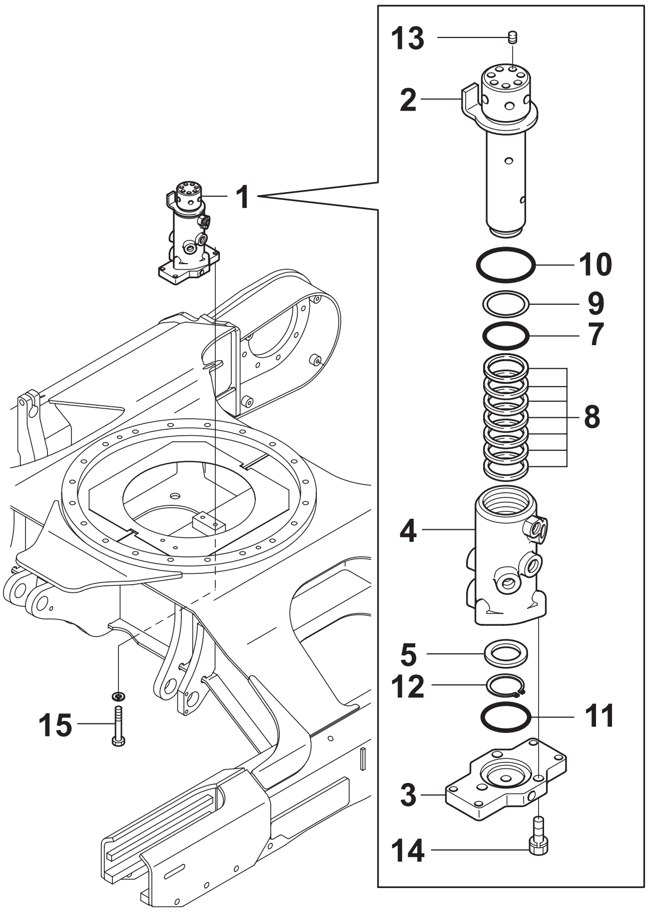


No.	Part	Q'ty	No.	Part	Q'ty
1	Swivel joint assembly	1	8	Seal (O-ring 55.76×5.7)	7
2	Swivel shaft	1	9	Back-up ring	1
3	Swivel flange (with spring washer 10×40)	4	10	O-ring 1A P 75.0	1
			11	O-ring 1A G 70.0	1
4	Swivel hub	1	12	External snap ring	1
5	Swivel spacer	1	13	Screw plug PT 1/4	7
6	Seal kit	1	14	Bolt M 10	3
7	O-ring 55.76×5.7	1	15	Bolt M 10	4

2) Disassembly and Reassembly of Swivel Joint

• Disassembly

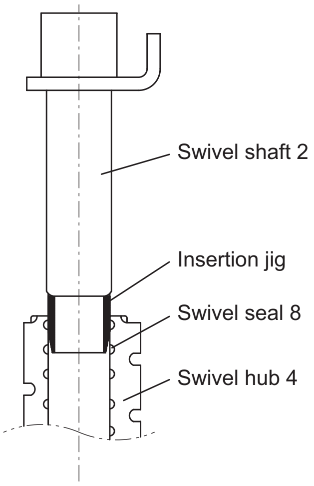
(1) Remove the bolts **14**.
(2) Remove the swivel flange **5** and the O-ring **11**.
(3) Remove the external snap ring C **12** and the swivel spacer **5** from the swivel shaft **2**.
(4) Pull the swivel shaft **2** out of the swivel hub **4** and remove O-ring **10**.
(5) Remove the swivel seals **8**, O-ring **7** and back-up ring **9** from the swivel hub **4**.



• Reassembly

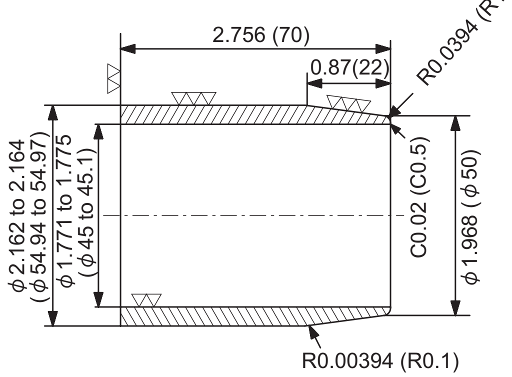
(1) Install swivel seals **8,** O-ring **7** and back-up ring **9** into swivel hub **4**.
(2) Apply multi-purpose grease to the inner surface of swivel hub **4**.
(3) Install the O-ring **10** on the swivel shaft **2** and insert the shaft into the swivel hub **4** slowly.
• Use a jig E-004
• Apply multi-purpose grease to the outer surface of the shaft.
(4) Install the swivel spacer **5** and the external snap ring **12** to the swivel shaft **2**.
(5) Install the swivel flange **3** with O-ring **11**, on the swivel hub **4** in this order and tighten bolts **14**.

Insertion of shaft



Shaft insertion jig No.E-004

Unit : in. (mm)



Note : The ▽▽▽ areas must be hard chromium plated.

3) Cautions for Handling and Storing Seals

(1) O-rings are packed in the package that is suitable for storage.

(2) Do not leave the O-rings outside the package.

(3) For storing, put the O-rings in the packages and place them in a dark and cool place (in a parts box or cardboard box) under 104°F (40°C) to avoid direct sunlight. If the stored condition is proper, it can be stored for four or five years.

(4) Do not put anything on the O-rings, or they may be distorted.

4) How to Fit O-rings (For Inner Side)

• Fitting

(1) Use lithium soap group multi-purpose grease.

(2) For fitting a seal ring, make it heart-shaped as shown in the right figures and press one end of it into the groove. Then, fit the whole seal ring while pressing it with your finger (Figs. 1 and 2).

(3) When using jigs for fitting seal rings, use the jigs with round edges to avoid damaging the seal rings. (Fig. 3)

(4) If the seal ring is distorted after fitting, correct the distortion with the jig before assembly. (Fig. 4)

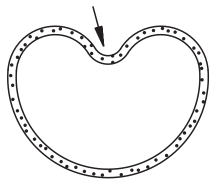


Fig. 1

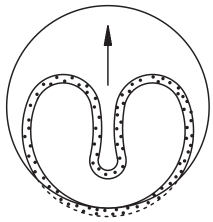


Fig. 2

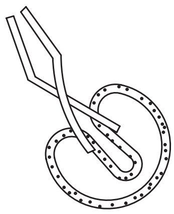


Fig. 3

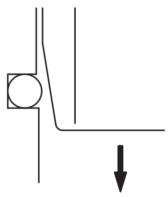


Fig. 4

5) Repair and Replacement of Parts

(1) Disassemble and reassemble at a place free from dust.

(2) Completely remove the contamination, foreign matter (sludge), etc. from the disassembled parts.

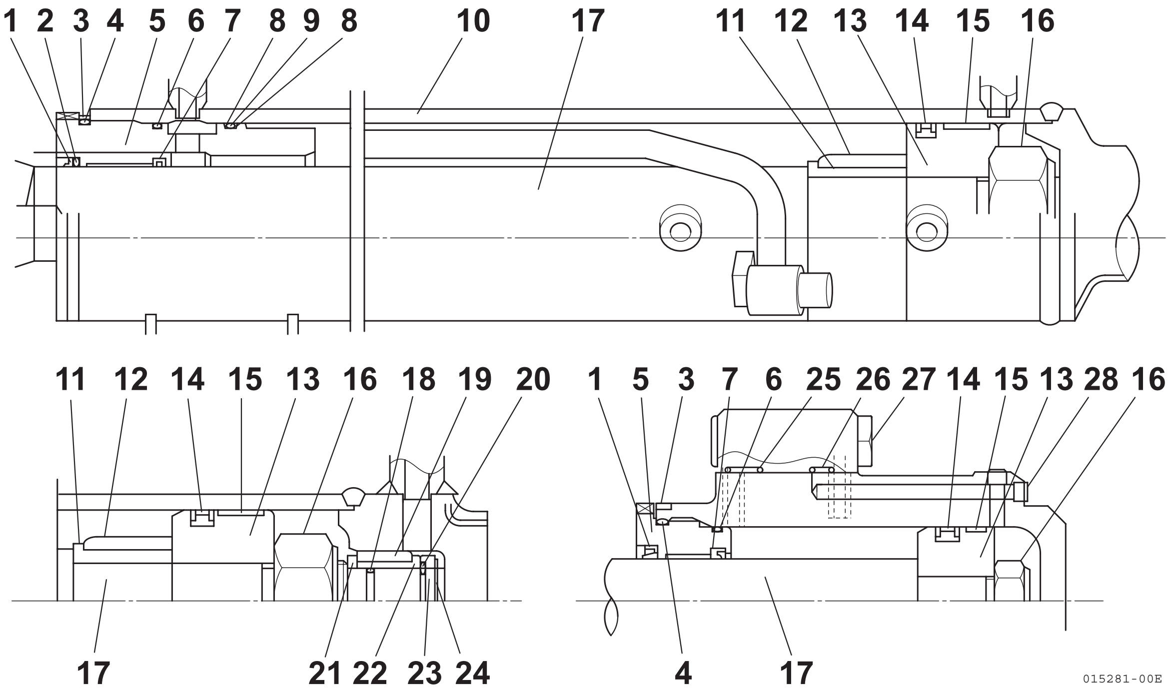
(3) Check for flaws or nicks on the seal surface of the shaft.
Repair or replace the part when necessary.

(4) Replace the shaft if it is worn.

(5) Replace all seals in reassembly.

7-5-6 Disassembly and Reassembly of Hydraulic Cylinders

1) Sectional View and Parts

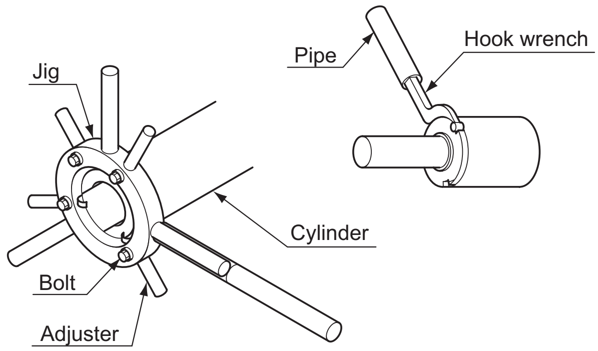


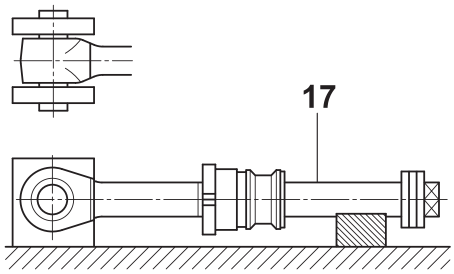
No.	Part	Boom	Arm	Bucket	Swing	Blade	Quick coupler
1	Spring ring	○	○	○	○	○	—
2	DKB seal	○	○	○	○	○	○
3	Lock washer	○	○	○	○	○	○
4	O-ring	○	○	○	○	○	○
5	Head	○	○	○	○	○	○
6	O-ring	○	○	—	—	—	—
7	ISI packing	○	○	○	○	○	○
8	Back-up ring	○	○	○	○	—	—
9	O-ring	○	○	○	○	○	○
10	Cylinder tube	○	○	○	○	○	○
11	Cushion collar	○	○	—	—	—	—
12	Cushion plunger	○	○	—	—	—	—
13	Piston	○	○	○	○	○	○
14	Piston seal	○	○	○	○	○	○
15	Wearing ring	○	○	○	○	○	○
16	U-nut	○	○	○	○	○	○
17	Rod	○	○	○	○	○	○
18	O-ring	—	○	—	—	—	—
19	Cushion plunger	—	○	—	—	—	—
20	Stopper	—	○	—	—	—	—
21	Spacer	—	○	—	—	—	—
22	Cushion collar	—	○	—	—	—	—
23	Cover (stopper)	—	○	—	—	—	—
24	External snap ring C		○	—	—	—	—
25	O-ring	—	—	—	—	—	○
26	O-ring	—	—	—	—	—	○
27	Operate check valve	—	—	—	—	—	○
28	Screw plug	—	—	—	—	—	○

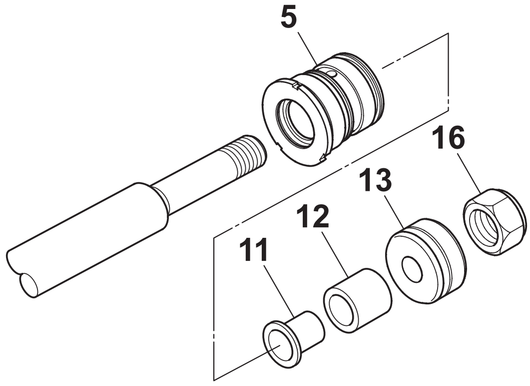
2) Cautions for Disassembly and Reassembly

(1) Parts are produced so accurately. Be careful not to damage any parts by dropping them or knocking them together.
(2) If there are any burrs on the surface of the seal installation part or the O-ring groove, remove them.
(3) Never use the lock washer removed once.
(4) Replace once removed seals and O-rings with new ones.
(5) Clean all the parts and dry them by air blow.

3) Disassembly

Procedure	
(1) Drain the oil from the hydraulic cylinder. (2) Hold the cylinder in the bottom end or the pin hole on the bottom side, and put the rod side of the cylinder on a block. (3) Raise the pawl of the lock washer **3** on the head 5 to loosen the head **5**. ***Note :*** *Use a hook wrench or a jig to loosen the head* ***5****.*	

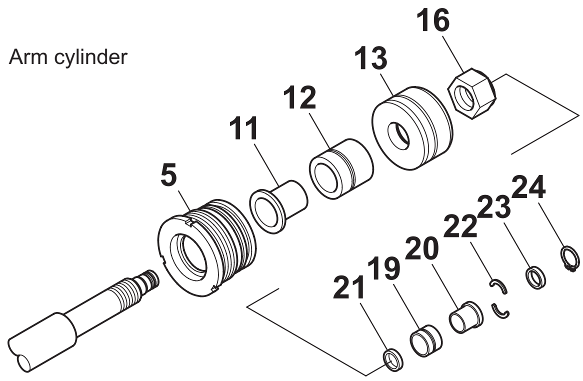
(4) Pull out the rod assembly **17** from the cylinder tube **10**, and then hold the cylinder rod assembly in the rod end or the pin hole on the rod side.	 Hold cylinder rod assembly.

(5) Disassembly of boom cylinder. Remove the U-nut **16**, and then the piston **13**, the cushion collar **11**, the cushion plunger **12** and the head **5** from the rod in order.	

Procedure

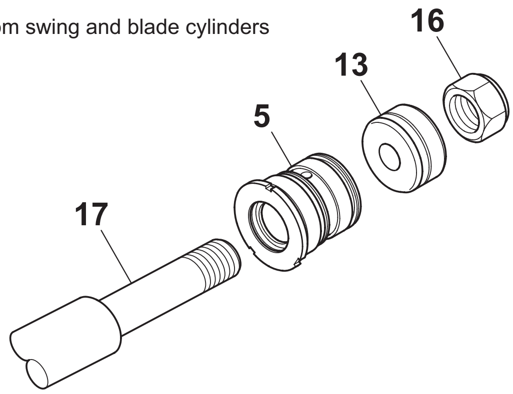
(6) Disassembly of arm cylinder.
- Remove the external snap ring C **24**, and then the cover **23** (for the stopper), the stopper **20**, the cushion plunger **19**, the cushion collar **22** and the spacer **21** in order.
- Remove the U-nut **16**, and then the piston **13** and the head **5**.

Arm cylinder



(7) Disassembly of bucket, boom swing and blade cylinders. Remove the U-nut **16**, and then the piston **13** and the head **5** in order.

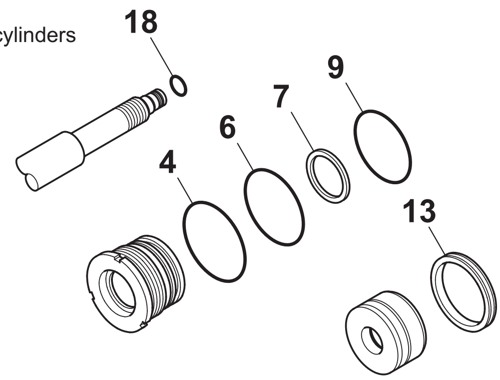
Bucket, boom swing and blade cylinders



(8) Remove the O-rings **4**, **6**, **9** and **18** and the DKB seal, the ISI packing **7** and the SPGW (or SPGTI) seal **14**.

Note :
Use a sharp tool to raise each O-ring or SPGW (or SPGTI) seal, and then insert a spatula to remove it.

For all cylinders

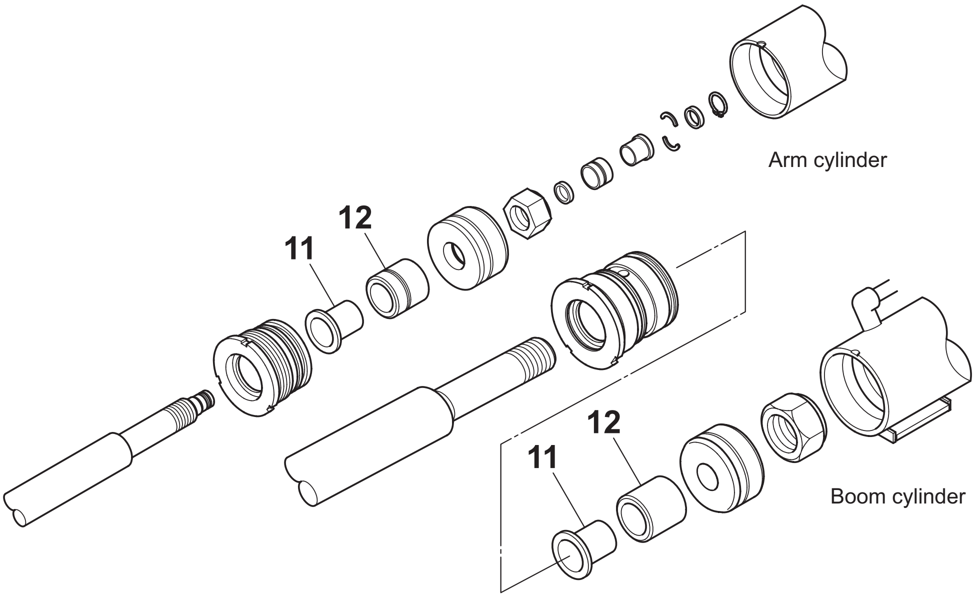


4) Reassembly

Reassemble the hydraulic cylinder in the reverse order of the disassembly procedure.

Notes :

- *Take care not to install the cushion collar **21** and the cushion plunger **12** in the wrong direction.*
- *Replace O-rings, packings and seals with new ones.*

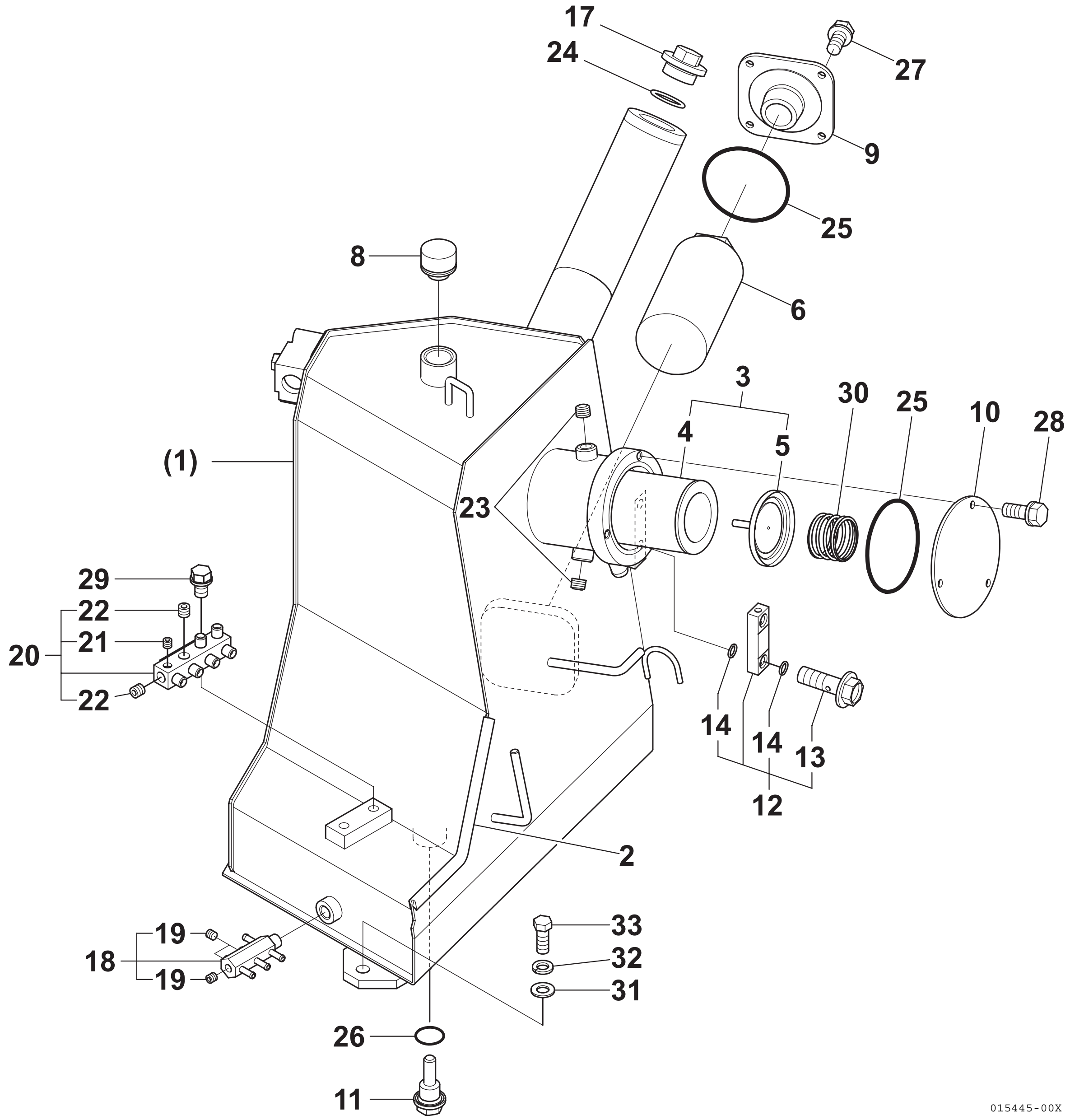


U-nut size and tightening torque

No.	Item	Size	Tightening torque	Adhesive
1	Boom	M39	1374.4 to 1446.7 ft·lbf (1863.3 to 1961.4 N·m)	Three Bond 1324 or its equivalent
2	Arm (ViO40-2)	M33	1012.7 to 1085.0 ft·lbf (1373.0 to 1471.1N·m)	Three Bond 1324 or its equivalent
3	Arm (ViO50-2)	M36	1048.9 to 1121.2 ft·lbf (1422.0 to 1520.1 N·m)	Three Bond 1324 or its equivalent
4	Bucket	M30	759.5 to 831.9 ft·lbf (1029.7 to 1127.8 N·m)	Three Bond 1324 or its equivalent
5	Boom swing	M33	1012.7 to 1085.0 ft·lbf (1373.0 to 1471.1 N·m)	Three Bond 1324 or its equivalent
6	Blade	M36	1048.9 to 1121.2 ft·lbf (1422.0 to 1520.1N·m)	Three Bond 1324 or its equivalent
7	Quick coupler	M20	217.0 to 253.2 ft·lbf (294.2 to 343.2 N·m)	Three Bond 1324 or its equivalent

7-5-7 Hydraulic Oil Tank

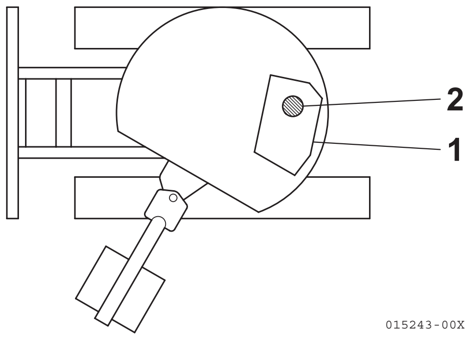
1. Structure

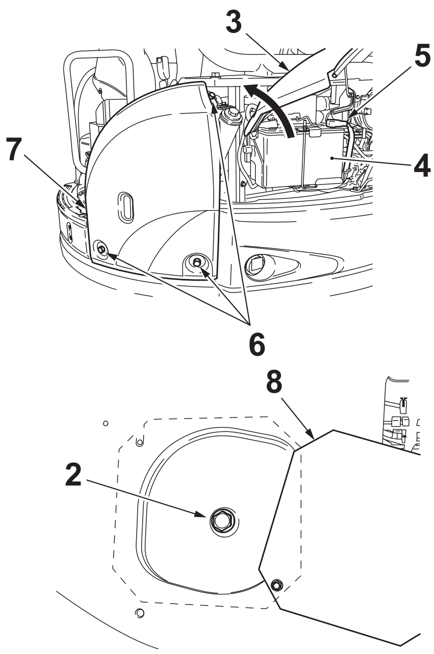
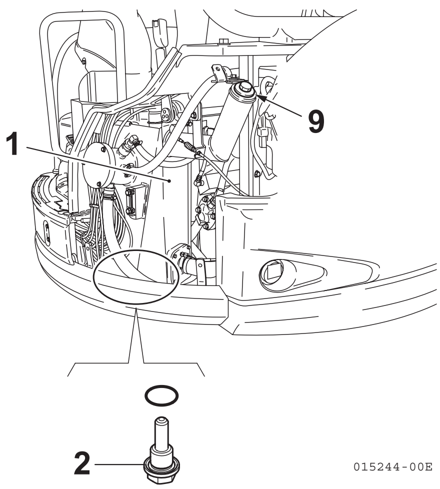


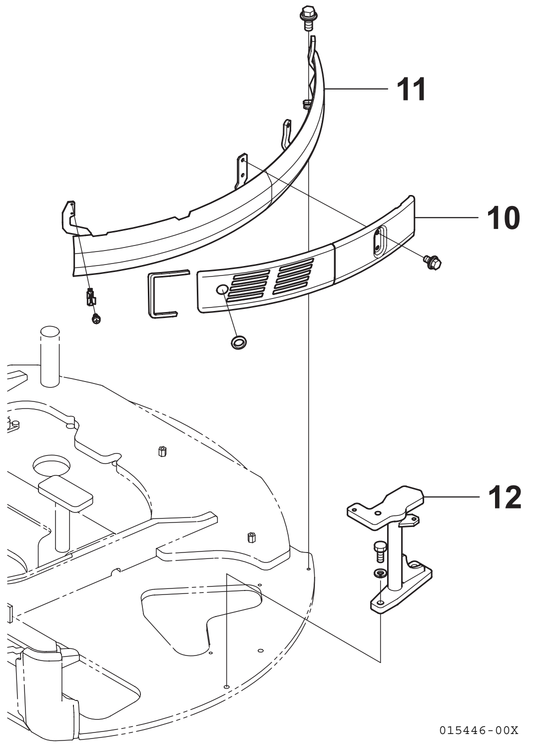
No.	Part	No.	Part	No.	Part
1	Reservoir Ass'y	12	Level gauge	24	O-ring 1A P38.0
2	Edge rubber	13	Level gauge screw	25	O-ring 1A G105.0
3	Return filter Ass'y	14	O-ring	26	O-ring 1A S30.0
4	Return filter	17	Filler cap	27	Cap screw M8×16
5	By-pass valve	18	Drain oil block	28	Cap screw M8×20
6	Suction filter	19	Plug BSPT 1/4	29	Cap screw M10×16
8	Cap	20	Pilot oil block	30	Spring
9	Suction flange	21	Plug BSPT 1/8	31	Washer
10	Cover plate	22	Plug BSPT 1/4	32	Spring washer
11	Drain plug (w/magnet)	23	Plug BSPT 3/8	33	Cap screw M14×35

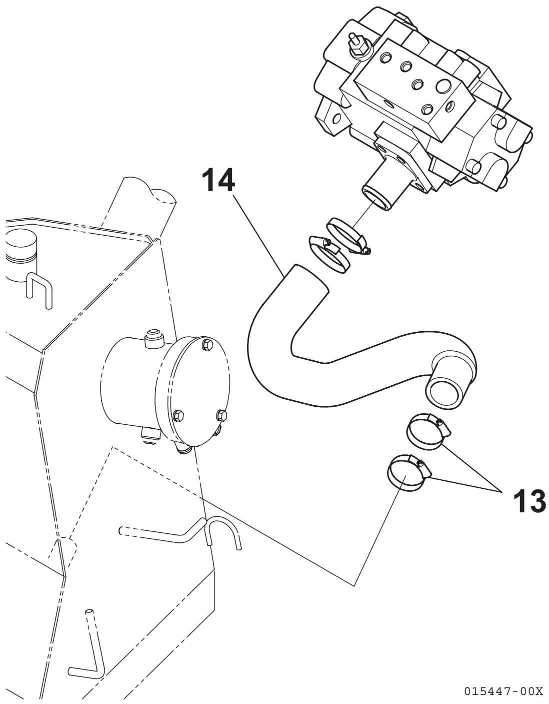
2. Removal and Reinstallation of Hydraulic Oil Tank

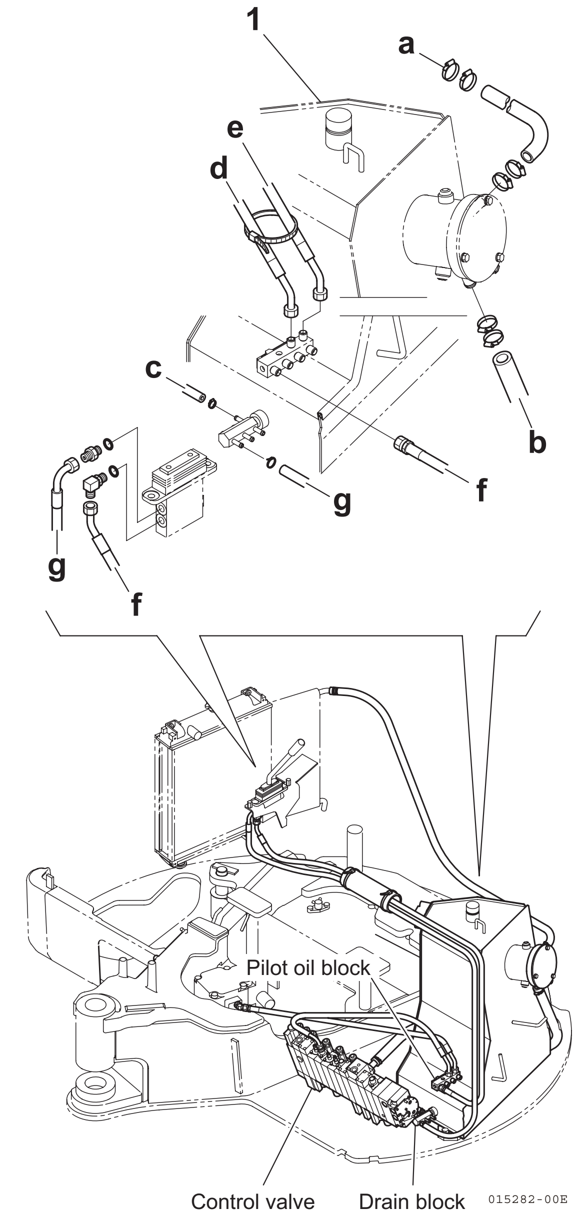
1) Removal

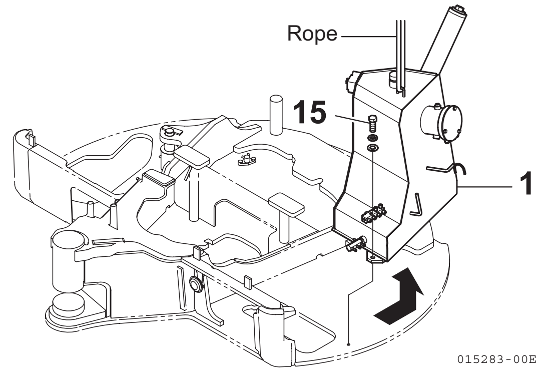
Procedure	
(1) Swing the upperstructure so that the drain plug **2** of hydraulic oil reservoir **1** can position in the middle of the tracks. Then lower the bucket to the ground and stop the engine.	

(2) Open the engine hood rear cover **3** and remove it. (3) Disconnect the battery negative cable **5** from the battery **4**. (4) Loosen three cap screws **6** to remove the side cover **7**. (5) Remove the bottom cover **8** and put an oil container under the drain plug **2** of the hydraulic oil reservoir. (6) Remove the drain plug **2** to drain hydraulic oil. **(Q'ty: 10 Gal(38L))** At this time, loosening or removing the filler cap **9** make oil draining easier.	 Viewed from under the machine body 

Procedure	
(7) Remove the side cover **10**, side protector L**11** and bracket **12**.	

(8) Loosen two hose clips **13** to disconnect the suction hose **14** at its reservoir end.	

Procedure	
(9) Disconnect the hydraulic oil hoses from the reservoir **1**. **a : Drain hose (reservoir to oil cooler)** **b : Hose (control valve to reservoir)** **c : Hose (control valve to drain block)** **d : Hose (control valve to pilot block)** **e : Hose (swing motor to pilot block)** **f : Hose (blade valve to pilot block)** **g : Hose (blade valve to drain block)**	

(10) Loosen three cap screws **15** to remove the reservoir. ***Note :*** *Move the reservoir rearward and put rope on it by using proper lifting tools. (Make sure shim positions and quantities.)*	

2) Reinstallation

(1) Reinstall the hydraulic oil tank in the reverse order of the removal procedure.

Notes :

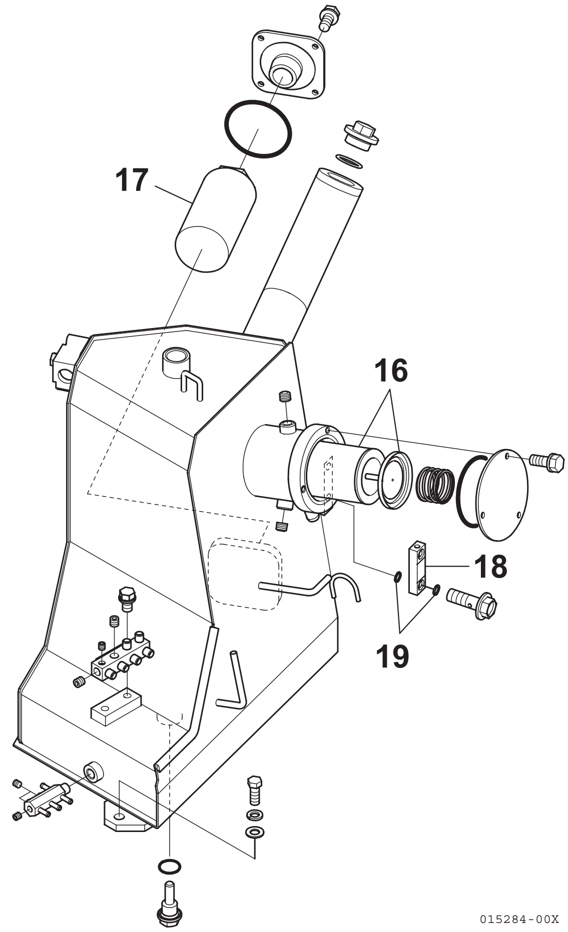
[1] Completely drain the oil from the hydraulic oil tank and wipe the impurities off the bottom of the tank.

*[2] Replace the return filter **16** with a new one.*

*[3] Clean the suction filter **17**. Replace it if the wire gauze is damaged.*

[4] Replace the oil when it reaches the replacement time or it has been deteriorated. If reusing the oil, maintain the oil quality so that it has no impurities.

*[5] Check the packing **19** of the oil level gauge **18** for oil leak, and replace any defective packing or other parts if necessary.*



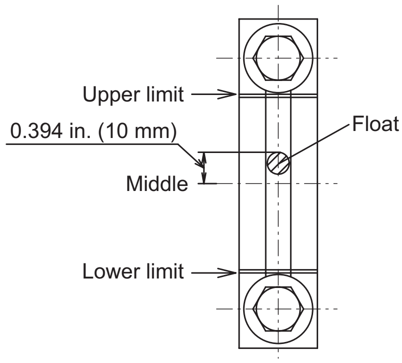
Hydraulic oil tank installation bolt M14	
Adhesive	Apply Three Bond 1324 or its equivalent
Tightening torque	86.8 to 108.5 ft·lbf (117.7 to 147.1 N·m)

3) Oil Level Check

(1) Place the machine on a firm and flat ground when checking the hydraulic oil level.

(2) Check the hydraulic oil level with the oil level gauge when the oil temperature is 32 to 86°F (0 to 30°C).

(3) The proper oil level is 0.394 in. (10 mm) above the middle of the oil level gauge. The hydraulic oil level increases or decreases depending on the hydraulic oil temperature due to its nature; therefore, check it when the oil is cooled.

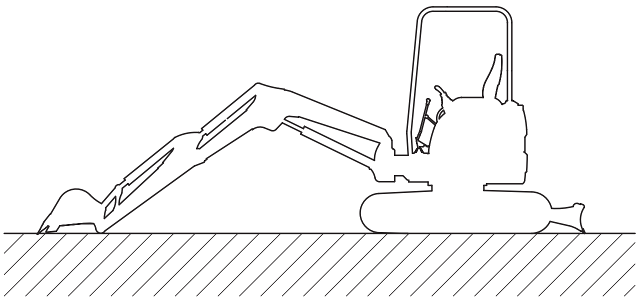


Oil level gauge

4) Machine Position in Oil Level Check

(1) Retract the bucket and arm cylinder rods completely to lower the bucket to the ground.

(2) Lower the blade to the ground.

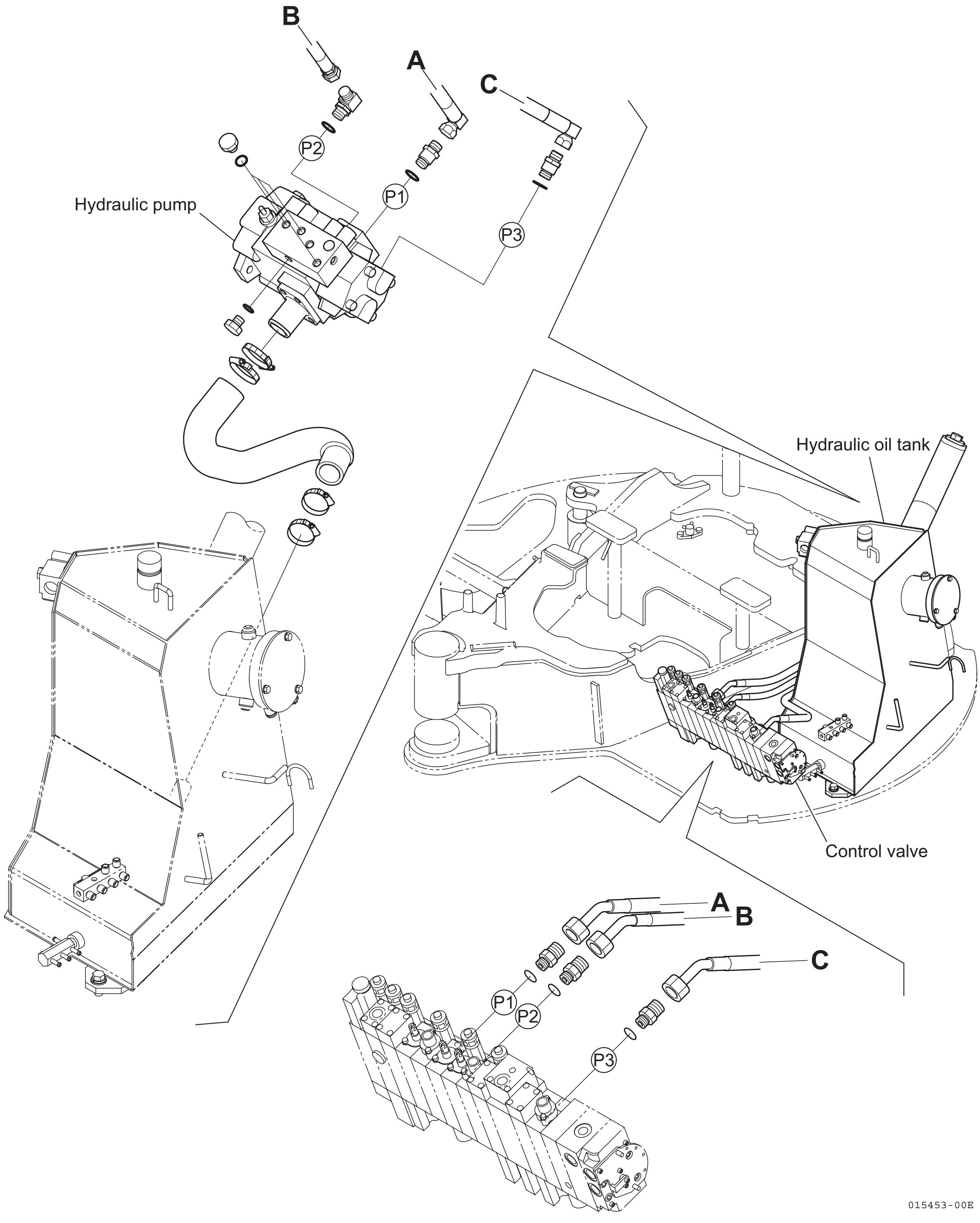


Machine position

7-5-8 Piping Layout

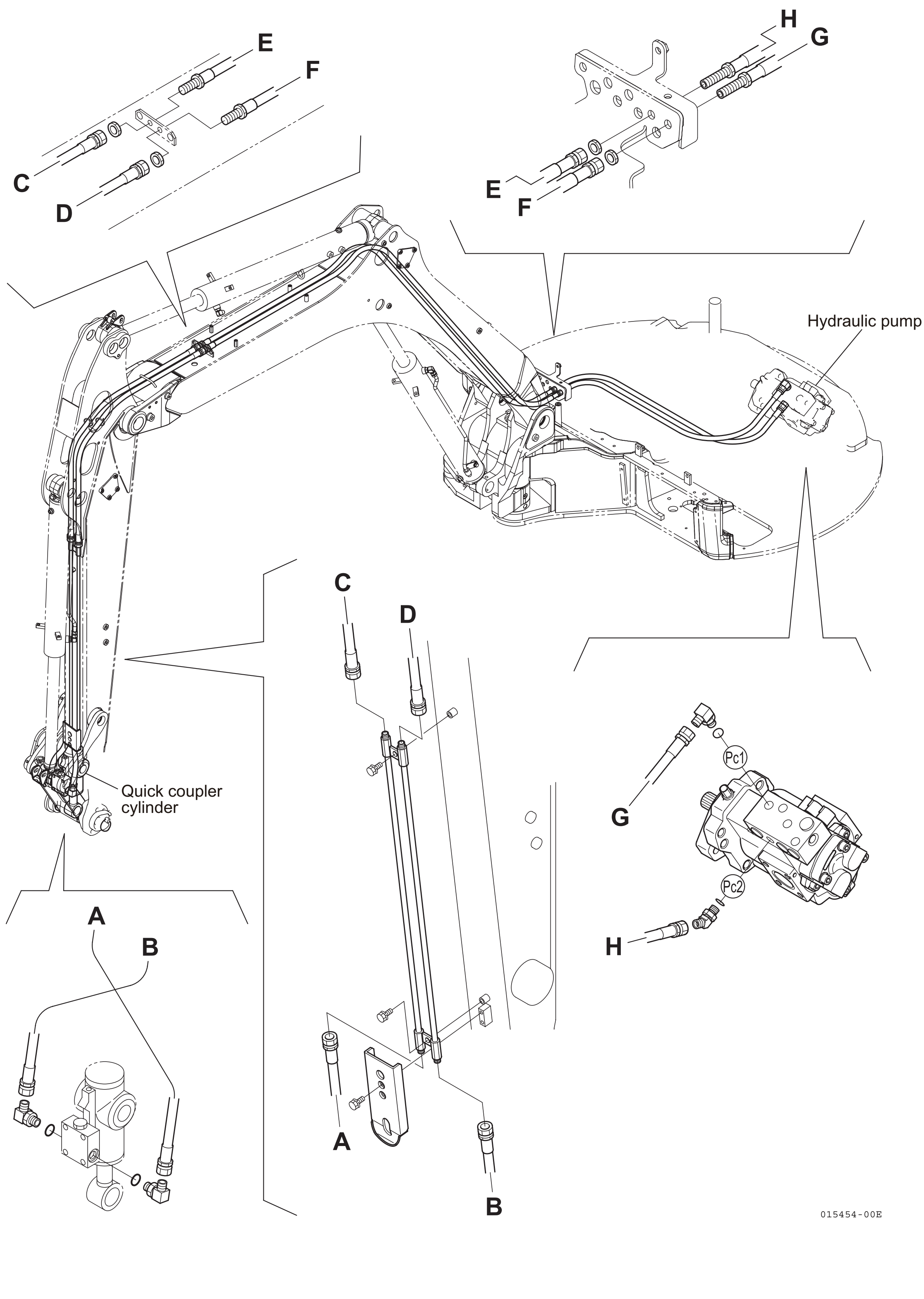
1) Upperstructure

(Hydraulic oil tank → Hydraulic pump → Control valve)



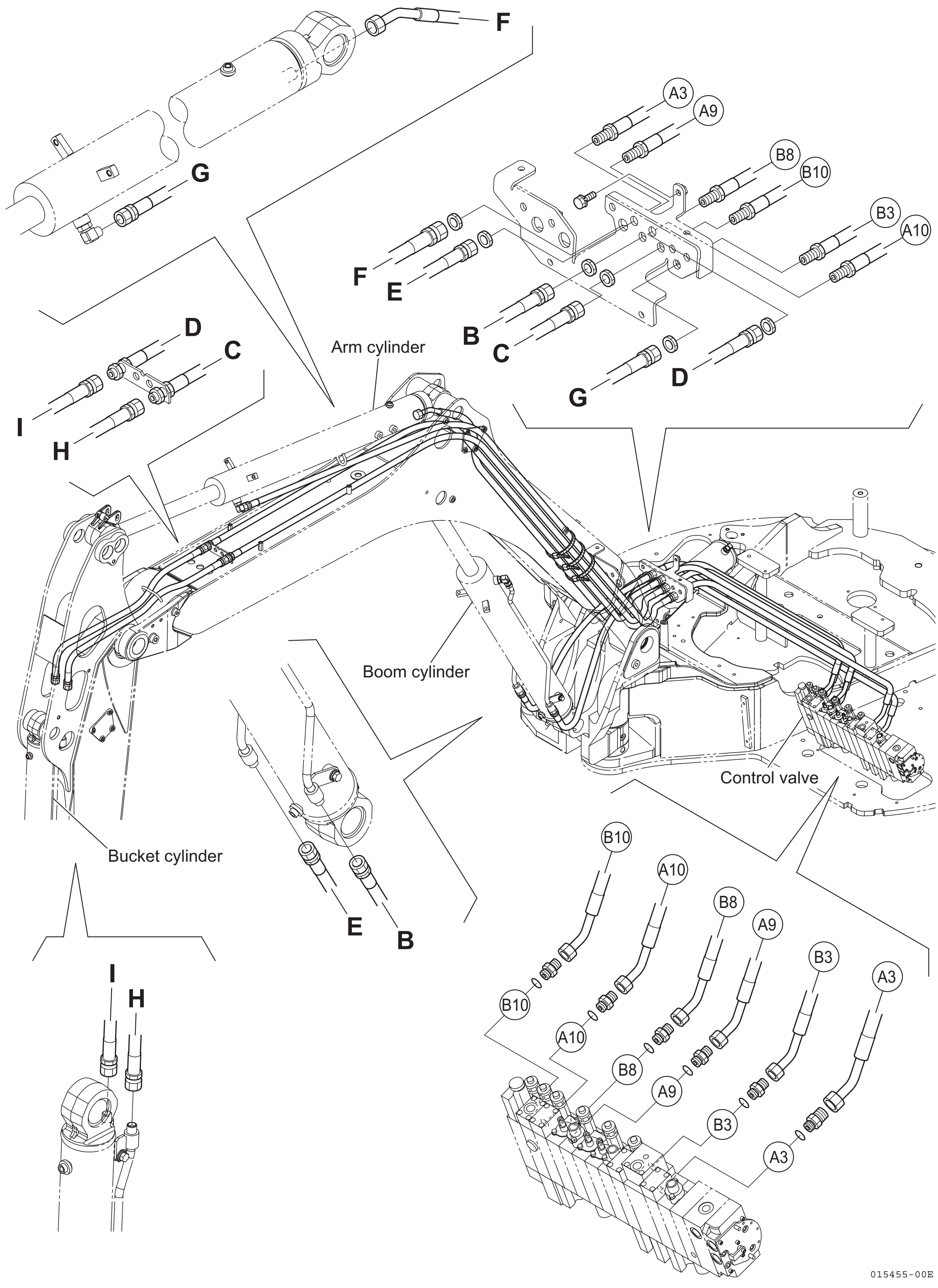
2) Upperstructure

(Hydraulic pump → Quick coupler)



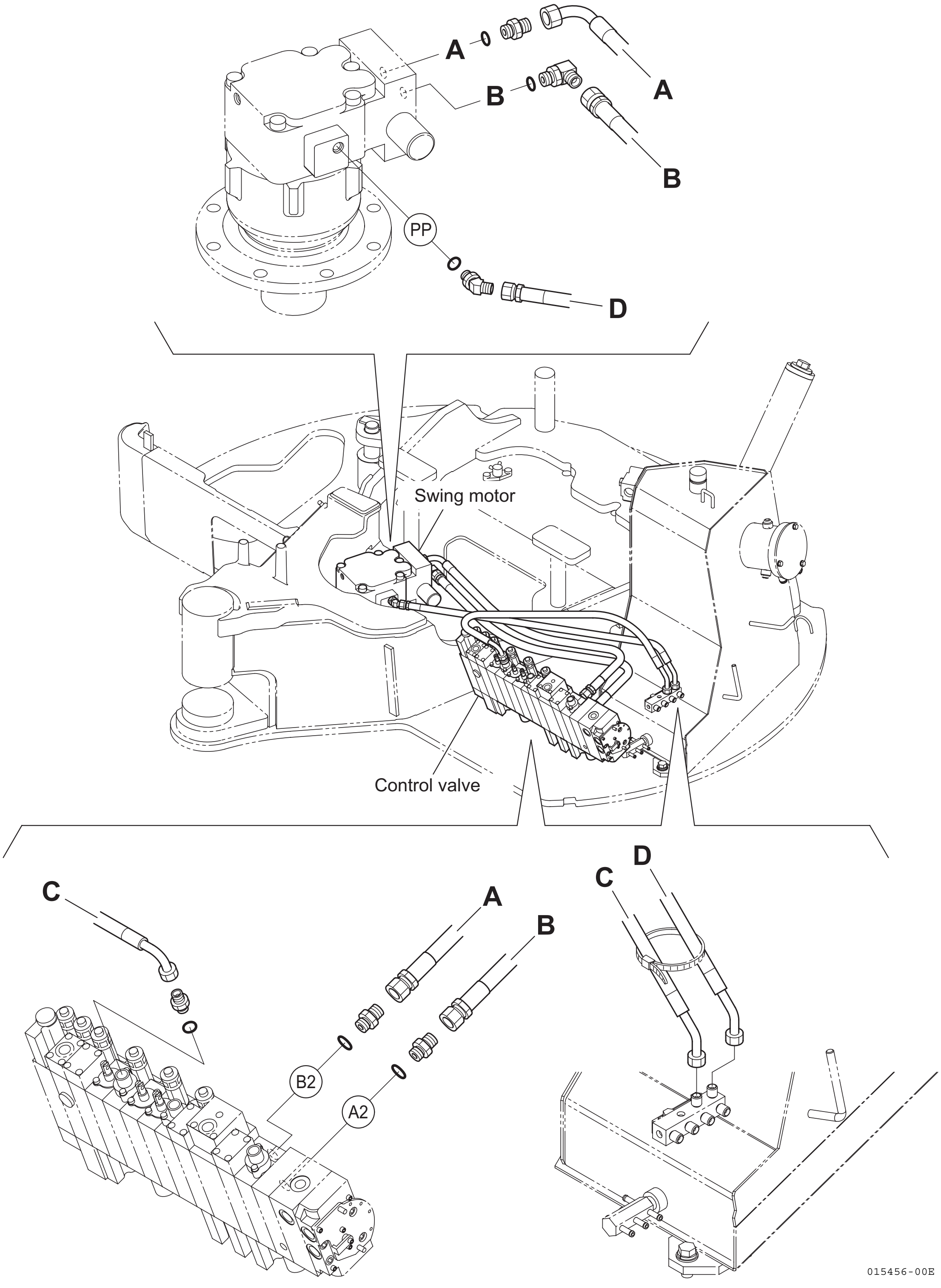
3) Upperstructure

(Control valve ←→ Implement cylinders)



4) Upperstructure

(Control valve ←→ Swing motor)

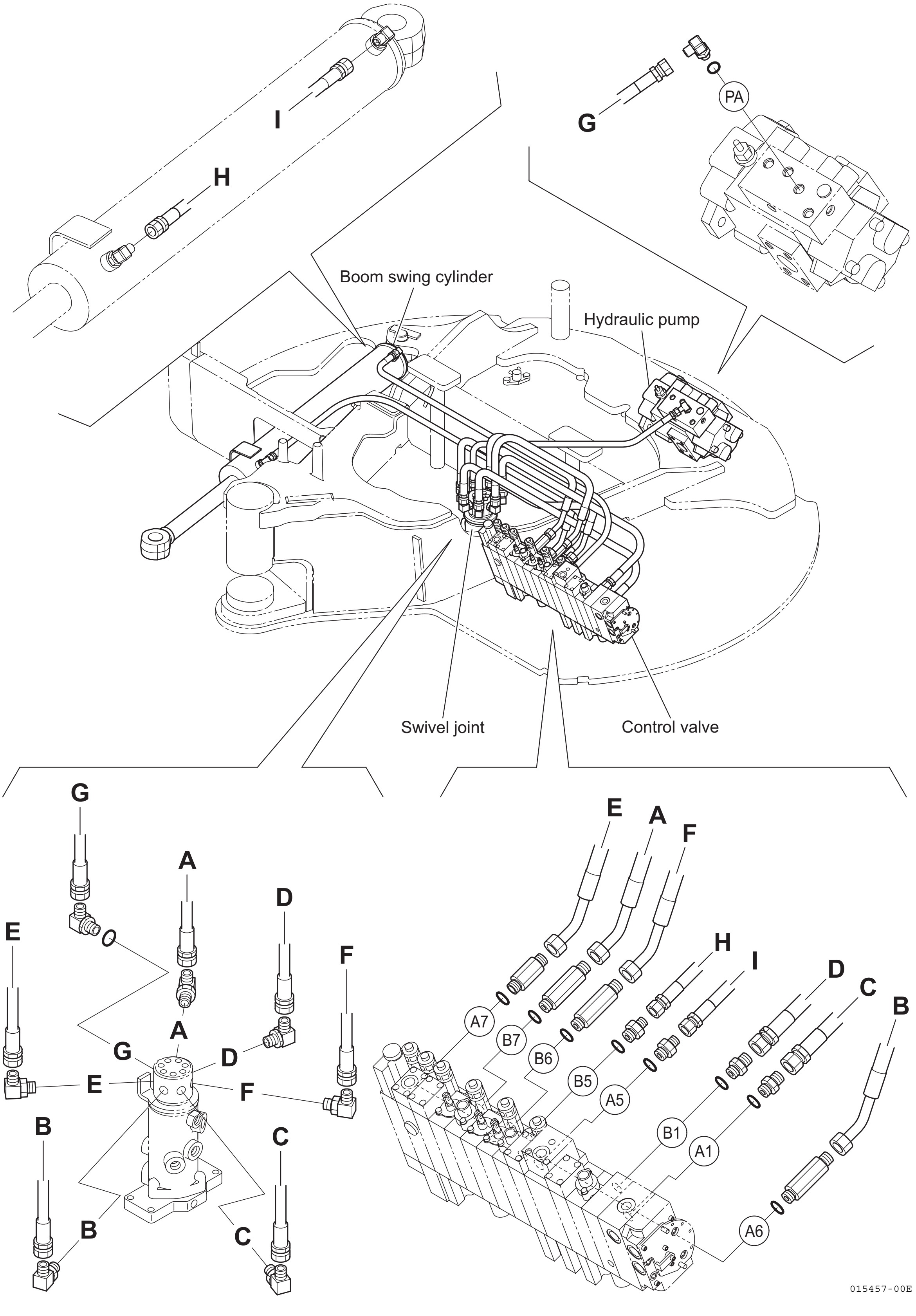


5) Upperstructure

(Control valve ←→ Swivel joint)

(Hydraulic pump → Swivel joint)

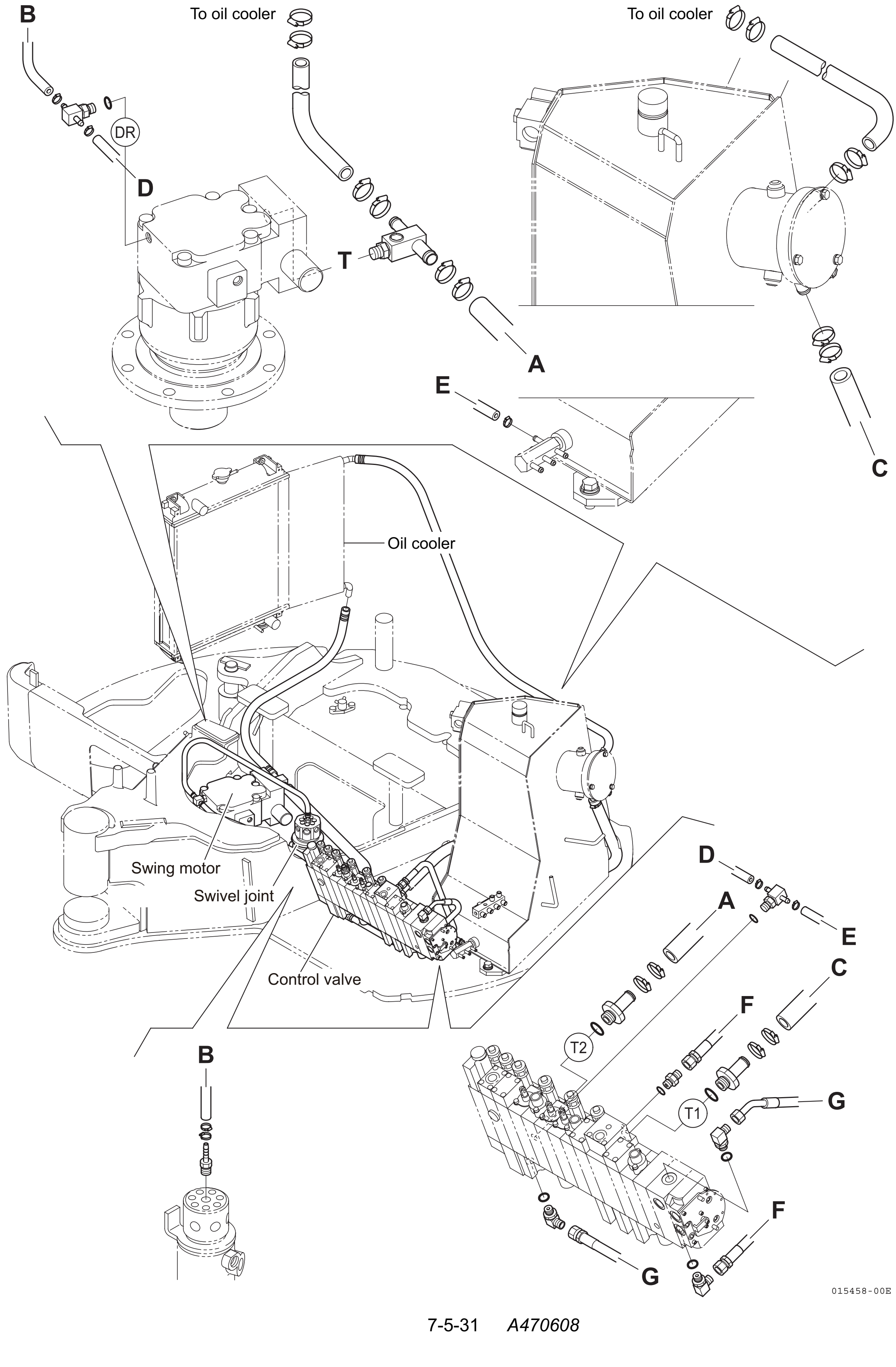
(Control valve ←→ Boom swing cylinder)



6) Upperstructure

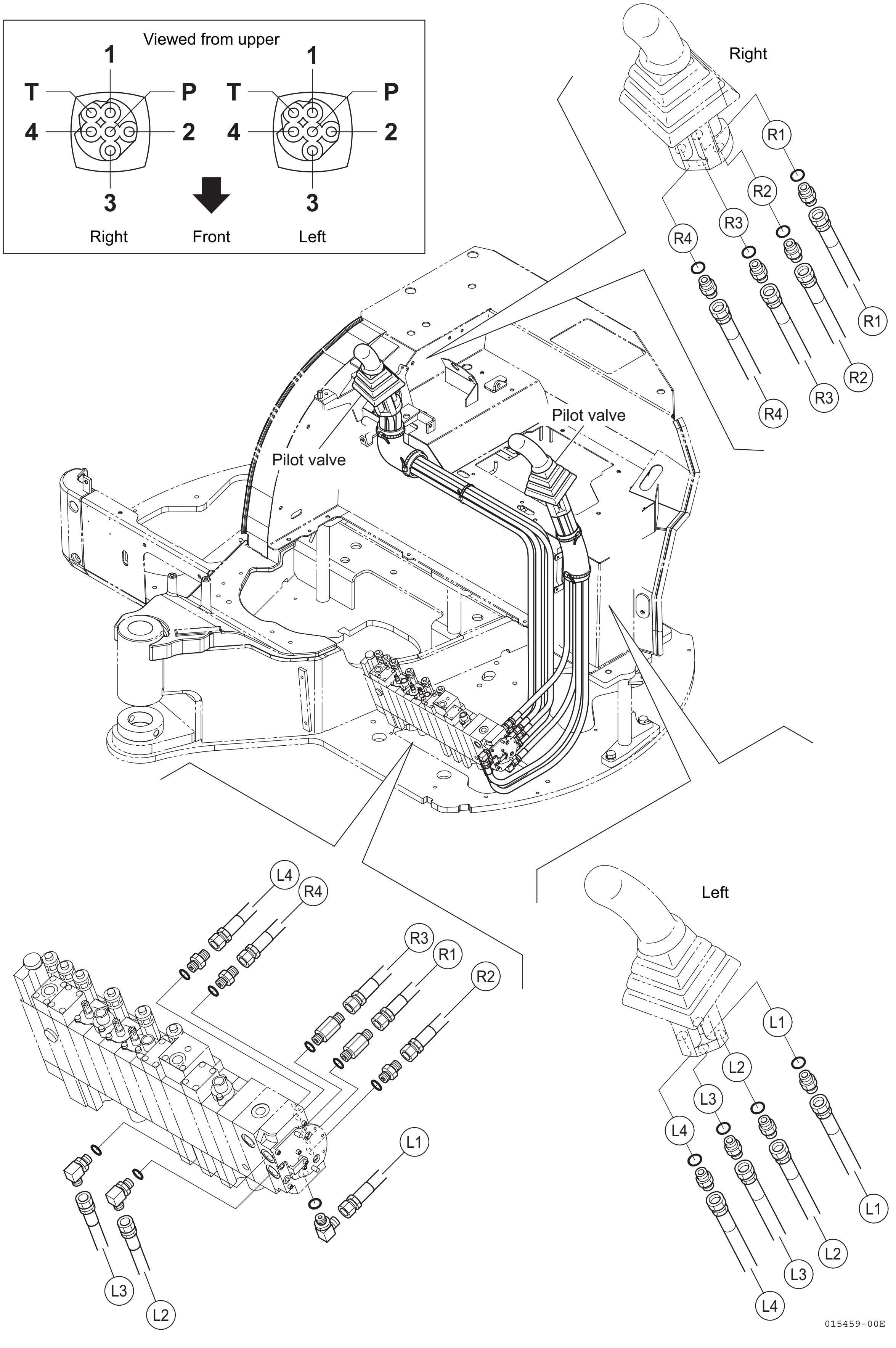
(Control valve → Hydraulic oil tank)

(Hydraulic pump → Swing motor → Control valve)



7) Pilot Control for Implements

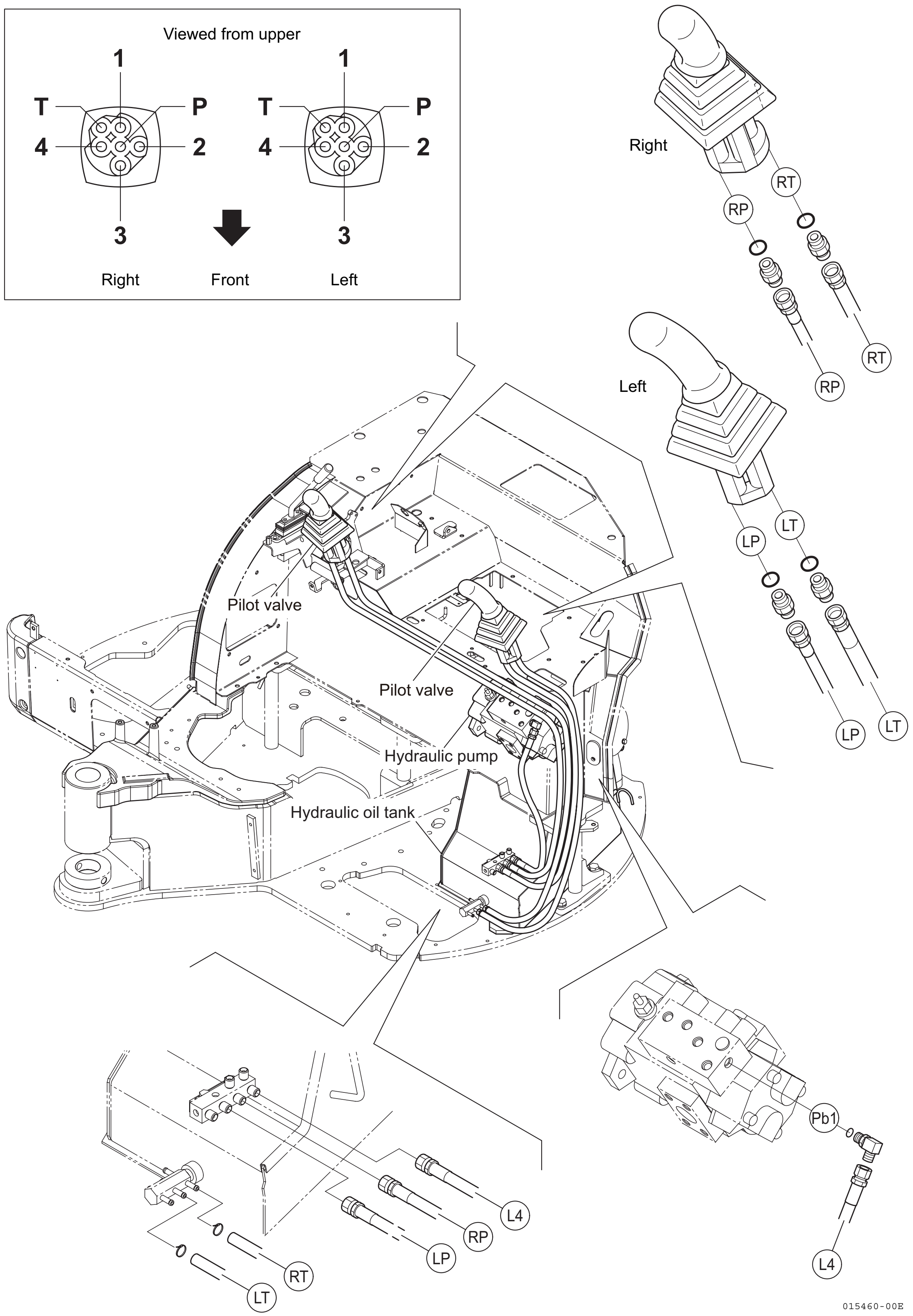
(Pilot valve → Control valve)



8) Pilot Control for Implements

(Pilot valve → Hydraulic oil tank)

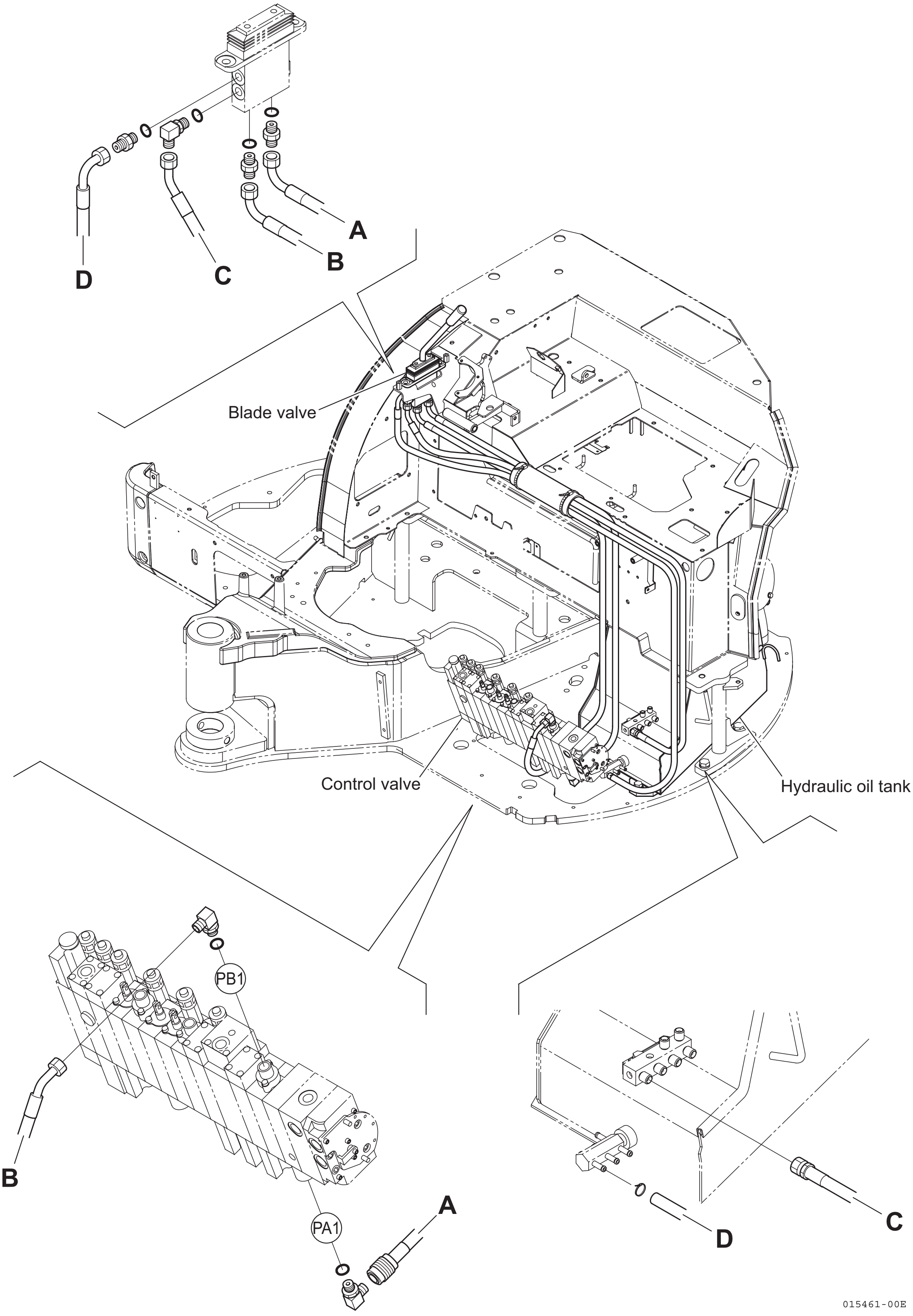
(Hydraulic pump → Pilot valve)



9) Undercarriage

(Control valve ←→ Blade valve)

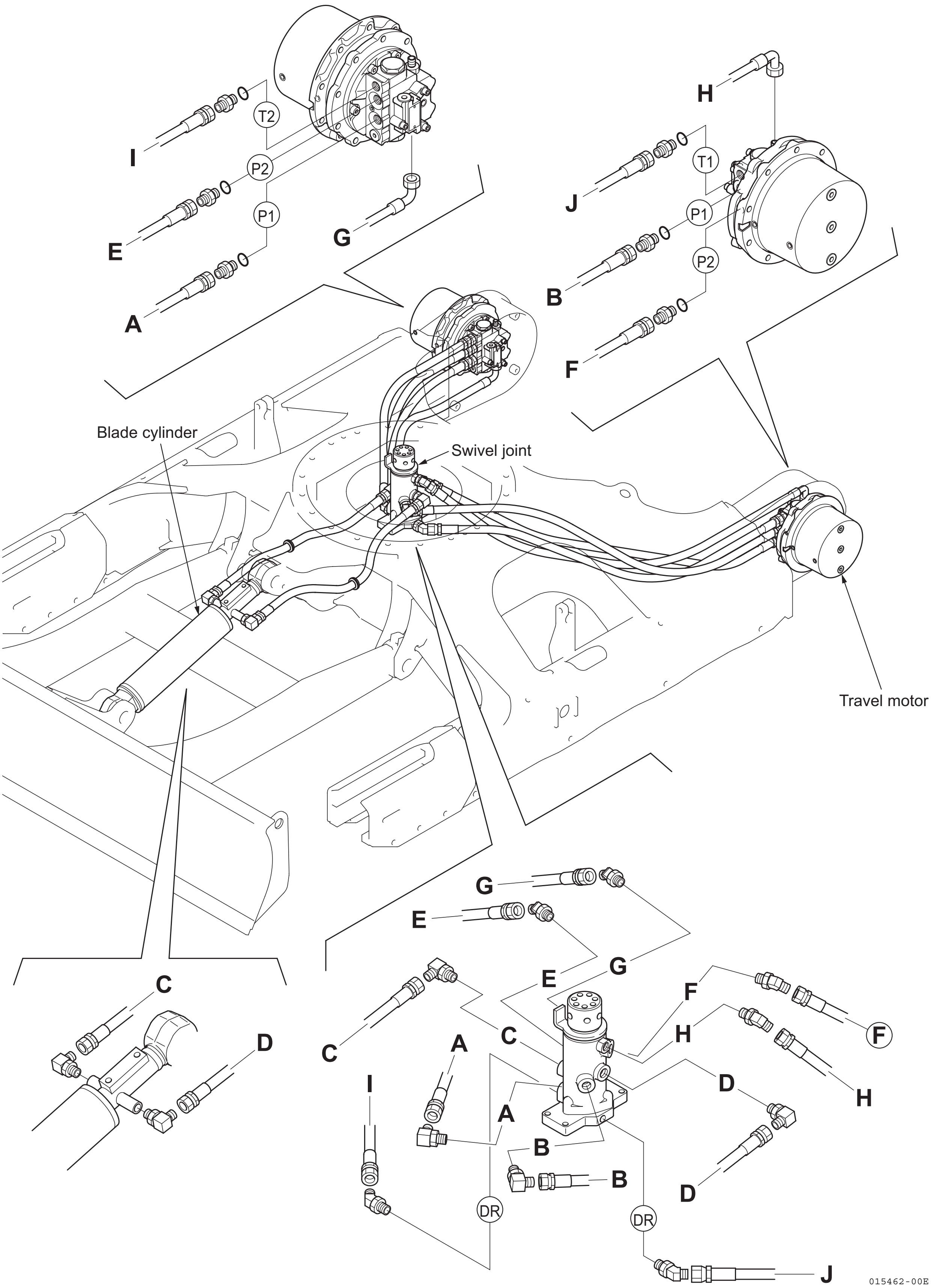
(Hydraulic oil tank ←→ Blade valve)



10) Undercarriage

(Swivel joint ←→ Travel motor)

(Swivel joint ←→ Blade cylinder)



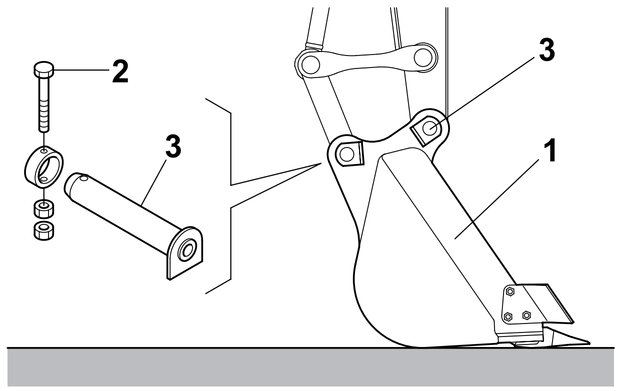
7-6 Work Implements

7-6-1 Removal and Reinstallation of Work Implements

Notes :

- *When removing the pin, check the number of shims installed and their positions.*
- *When removing the hose, put a plug into the hose connection port to keep the oil from flowing out.*
- *To prevent the oil from flowing out when removing the hose from each cylinder, connect a compressor vacuum to the breather hose to evacuate the hydraulic oil tank.*

1) Removal of Bucket

Procedure	
(1) Lower the bucket **1** to the ground with its back side down. (2) Remove the bolt **2** (M10) to remove the pin **3**. (3) Remove the bucket **1**.	

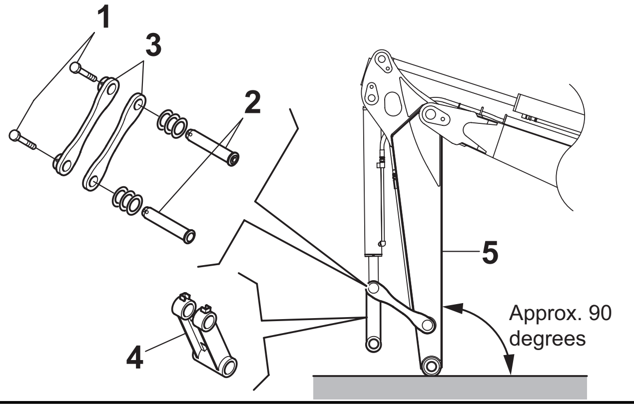
2) Removal of Arm

Procedure

(1) Remove the bucket.

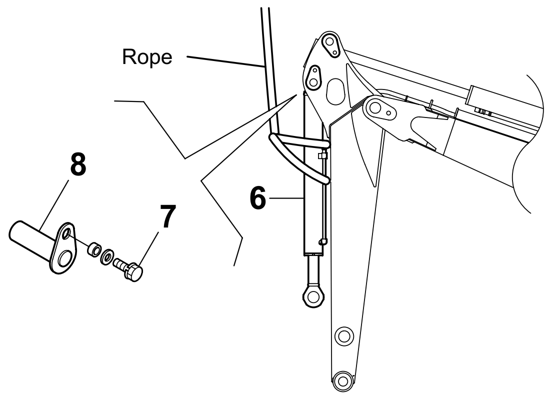
(2) Remove the bolt **1** (M10) and pull out the pin **2** to remove the bucket link **3** and the bucket arm **4**.

(3) Lightly place the top end of the arm **5** on the ground perpendicularly to the ground.



(4) Remove the hydraulic hose from the bucket cylinder **6**, and remove the bolt **7** (M10) to pull out the pin **8**. Then remove the bucket cylinder **6**.

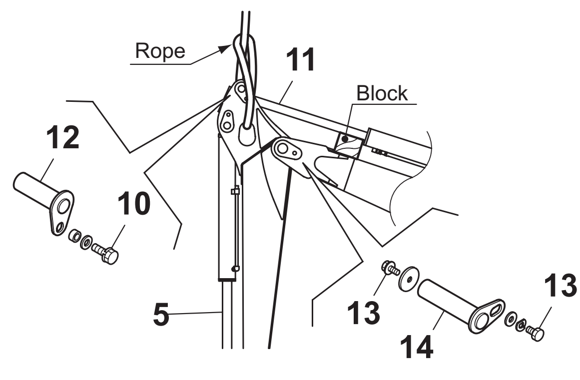
Note :
Put rope round the bucket cylinder to remove it using a lifting device.



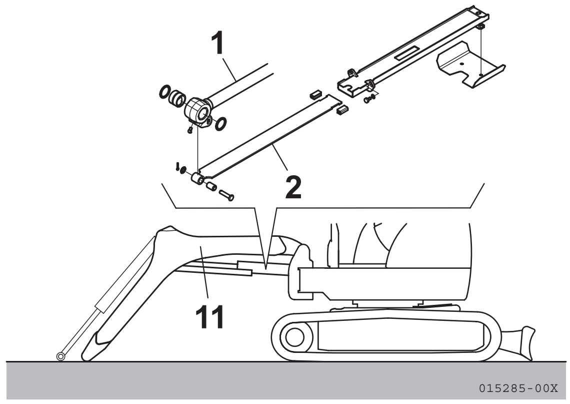
(5) After putting rope onto the arm **5**, remove the bolt **10** (M10) and pull out the pin **12** from the arm cylinder **11** on the rod side.

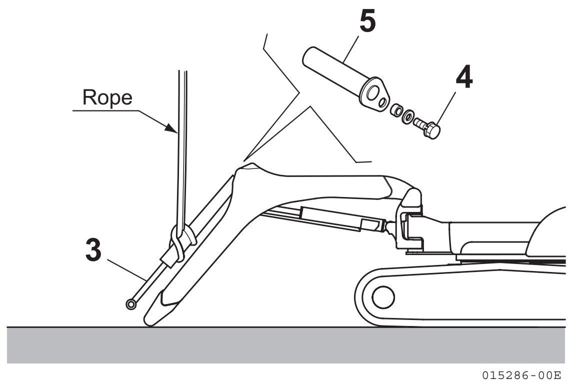
Note :
Put a block under the arm cylinder.

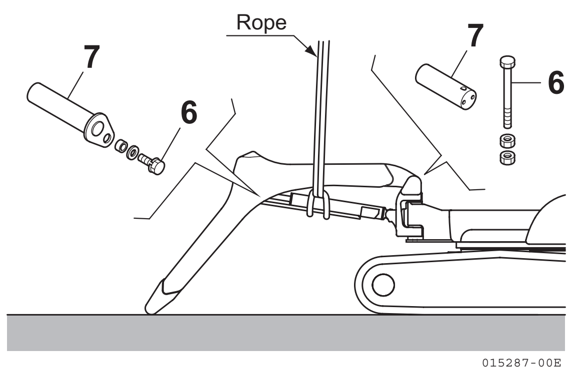
(6) Remove the bolts **13** (M12 and M14) to pull out the arm pin **14** and remove the arm **5**.

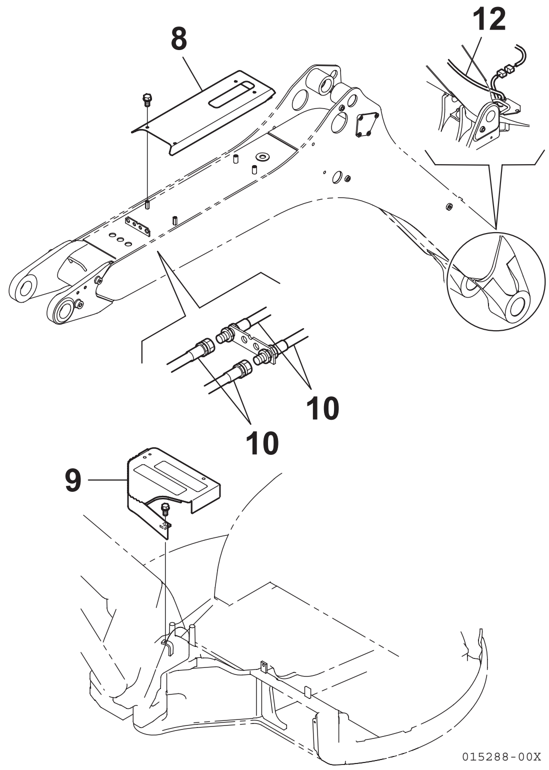


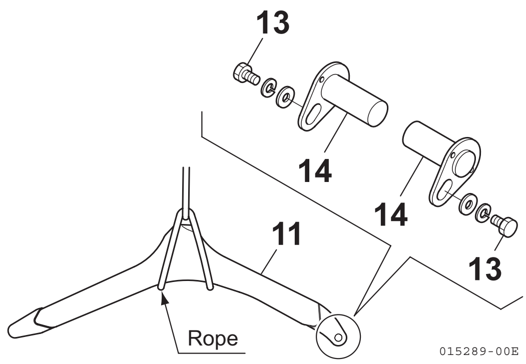
3) Removal of Boom

Procedure	
(1) After raising the boom **11** to the maximum, remove the slide cover **2** from the boom cylinder **1**. (2) Place the top end of the boom **11** on the ground. ***Note :*** *Install an expansion plug to the joint of the removed hydraulic hose and start the engine.*	

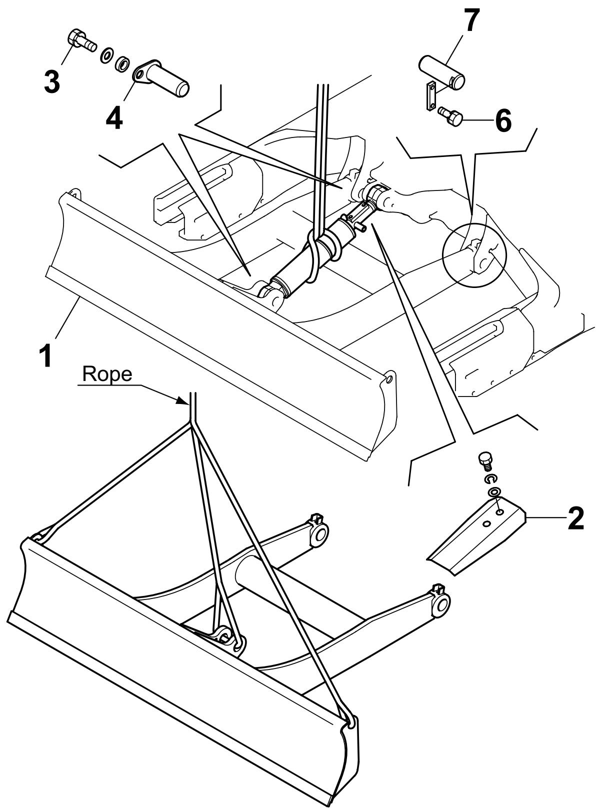
(3) After putting rope round the arm cylinder **3**, remove the hydraulic hose from the arm cylinder. (4) Remove the bolt **4** (M10) to pull out the pin **5**, and remove the arm cylinder **3**. ***Note :*** *Use a lifting device to remove the arm cylinder.*	

(5) After putting rope to the boom cylinder **1**, remove the hydraulic hose from the boom cylinder. (6) Remove the bolt **6** (M10) to pull out the pin **7**, and remove the boom cylinder **1**. ***Note :*** *Use a lifting device to remove the boom cylinder.*	

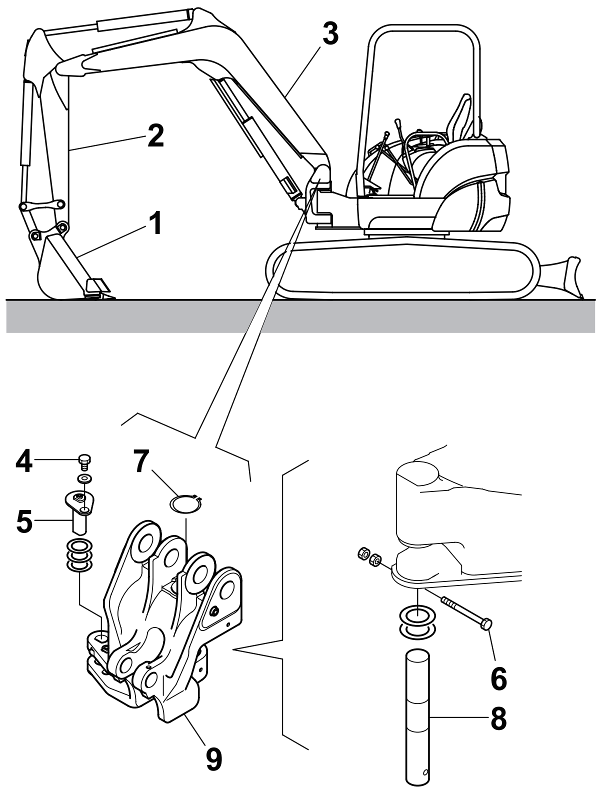
Procedure	
(7) Remove the cover **8** and step R **9** to separate the joint sections **10** of the hydraulic hoses to the bucket cylinder. (8) Disconnect the hoses from the frame. (9) Disconnect the boom light wiring at the connector section **12**.	

(10) After putting rope round the boom **11**, remove the bolt **13** (M10) to pull out the pins **14** and remove the boom **11**. ***Note :*** *Use a lifting device to remove the boom.*	

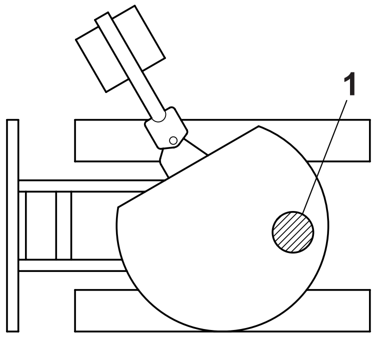
4) Removal of Blade

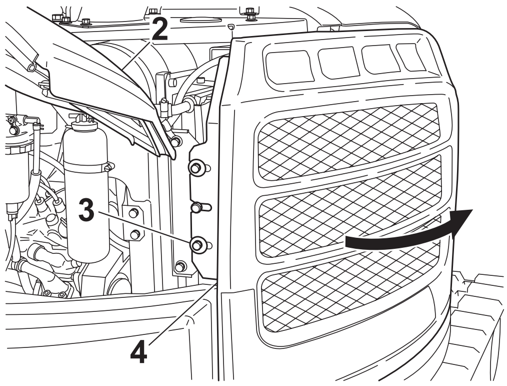
Procedure	
(1) Turn the implement to the blade side, lower the bucket and the blade **1** to the ground and stop the engine. (2) Remove the blade cover **2**, and then the hydraulic hose. (3) After putting rope round the blade cylinder **5**, remove the bolt **3** (M10) to pull out the pin 4 and remove the blade cylinder **5**. (4) After putting rope onto the blade **1**, remove the bolt **6** (M10) to pull out the pin **7** and remove the blade. ***Note :*** *Use a lifting device to remove the blade cylinder or the blade.*	

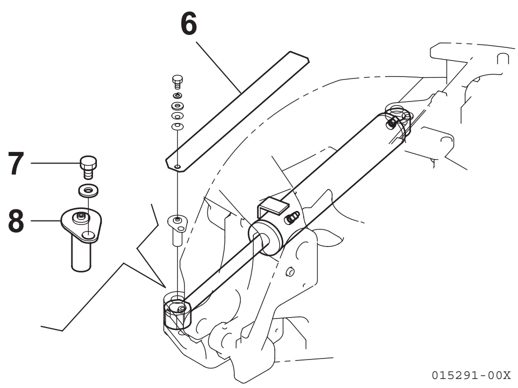
5) Removal of Boom Bracket

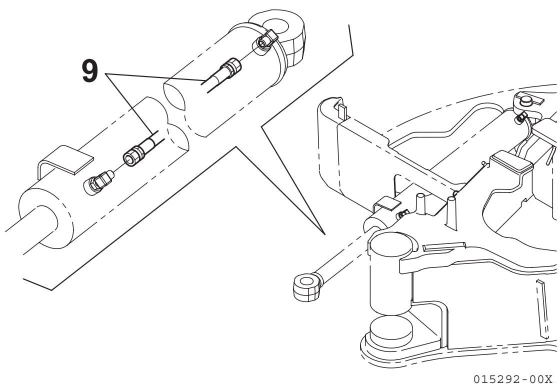
Procedure	
(1) Remove the bucket **1**. <Refer to Section "7-6-1 1) Removal of Bucket".> (2) Remove the arm **2**. <Refer to Section "7-6-1 2) Removal of Arm".> (3) Remove the boom **3**. <Refer to Section "7-6-1 3) Removal of Boom".> (4) Remove the bolt **4** (M10) to pull out the pin **5** for the boom swing cylinder. (5) Remove the bolt **6** (M14) and the snap ring C **7** to pull out the pin **8**, and then remove the boom bracket **9**. ***Note :*** *Put rope onto the boom bracket to remove it using a lifting device.*	

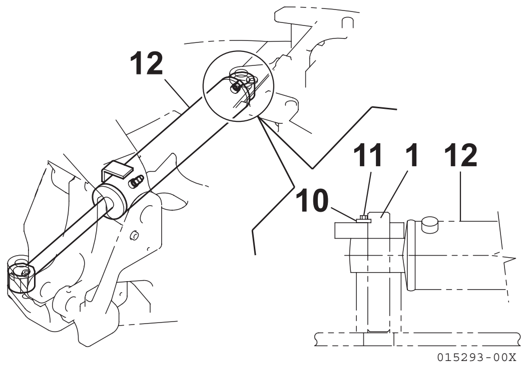
6) Removal of Boom Swing Cylinder

Procedure	
(1) Swing the upperstructure so that the engine comes opposite the blade. Then, lower the bucket to the ground and stop the engine. In this case, stop the upperstructure halfway between both tracks to pull out the pin **1** from the bottom side of the boom swing cylinder.	

(2) Open the engine hood rear cover **2** and loosen cap screws **3** to open the bonnet R **4**.	

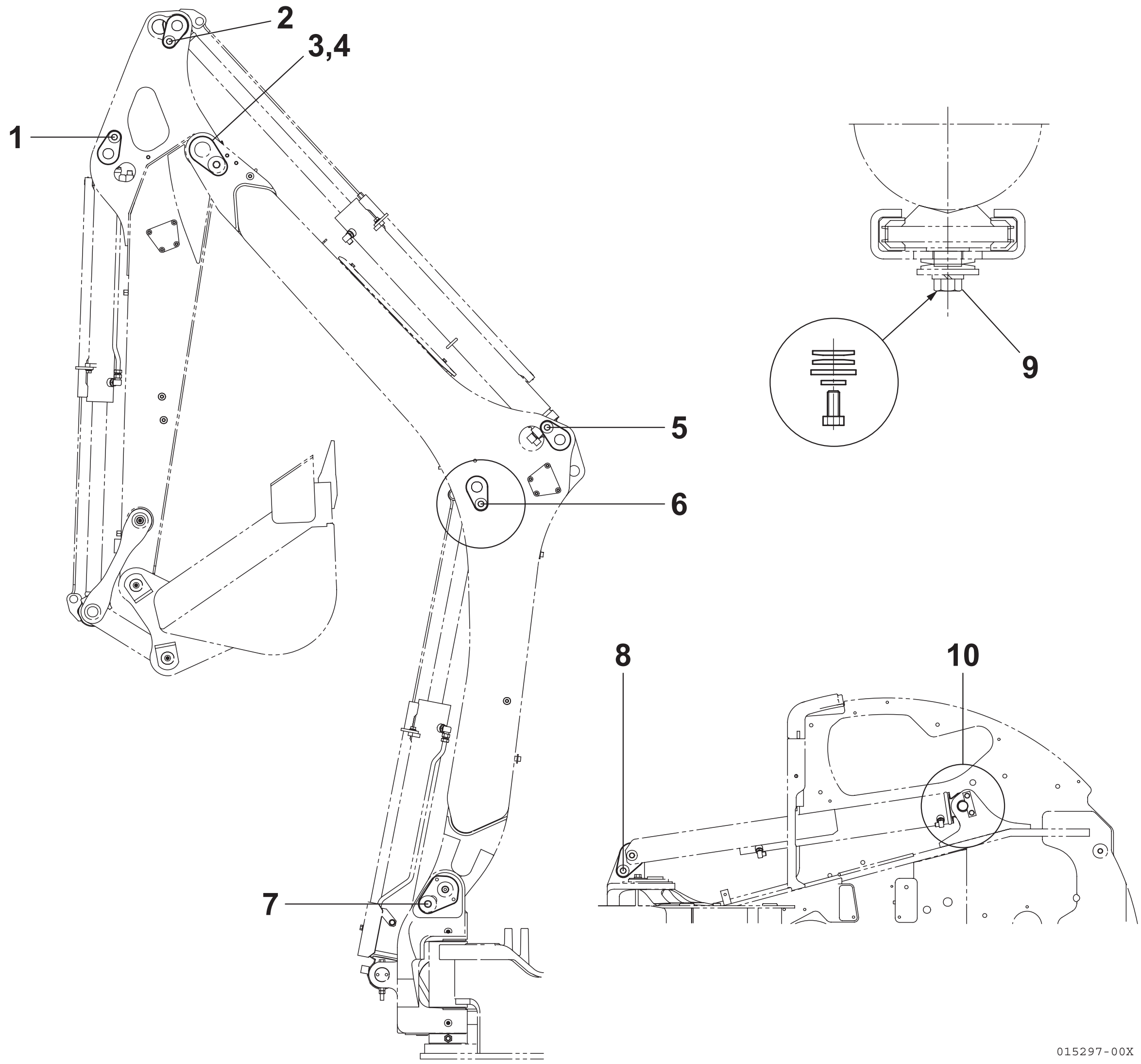
(3) Remove the boom swing cylinder cover **6**, and remove the bolt **7** (M10) to pull out the pin **8** on the rod side.	

(4) Disconnect the hydraulic hoses **9** from the boom swing cylinder.	

Procedure	
(5) Remove the lock plate **10** to pull out the pin **1**. ***Note :*** *Use the bolt **11** (M12) to pull out the pin **1**.* (6) Remove the boom swing cylinder **12**.	

7) Reinstallation

Reinstall the implement in the reverse order of the removal procedure.

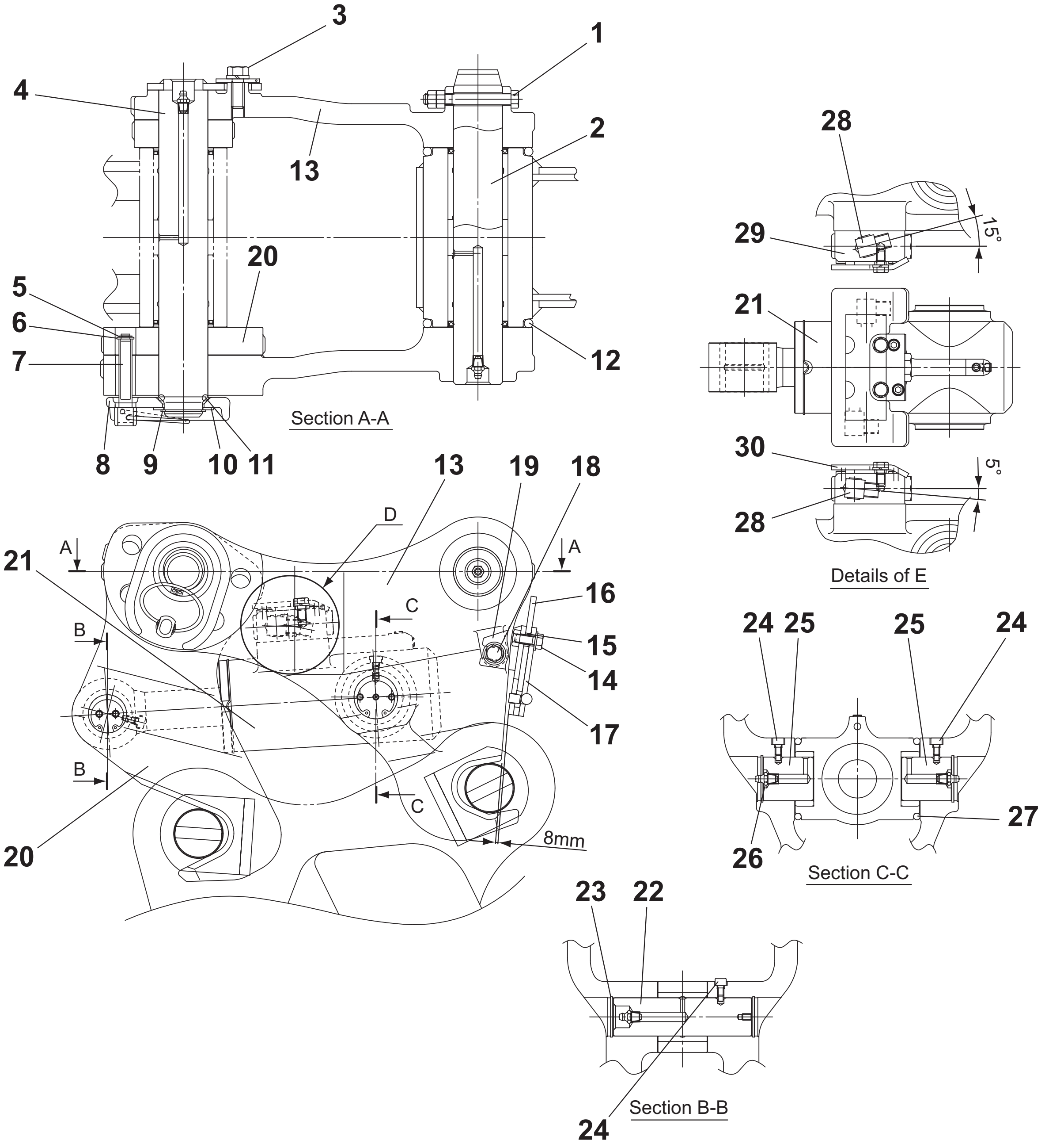


Tightening torque and Adhesive

No.	Size	Tightening torque	Adhesive
1	M12	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)	Apply Three Bond 1324 or its equivalent
2	M12		
3	M14	86.8 to 108.5 ft·lbf (117.7 to 147.1 N·m)	
4	M12	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)	
5	M12		
6	M12		
7	M14	86.8 to 108.5 ft·lbf (117.7 to 147.1 N·m)	
8	M12	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)	
9	M10	32.6 to 43.4 ft·lbf (44.1 to 58.8 N·m)	
10	M10		

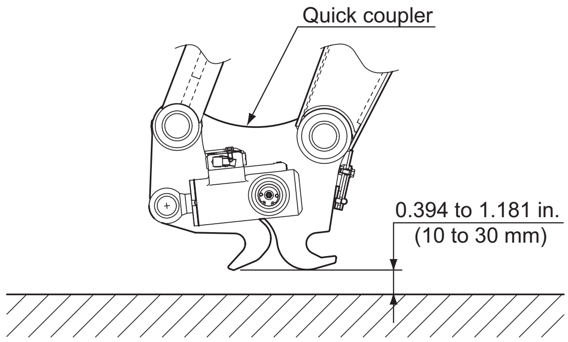
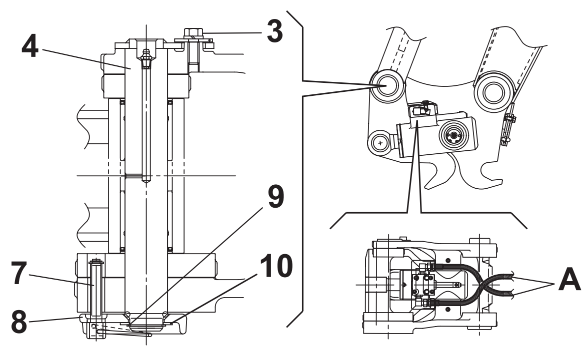
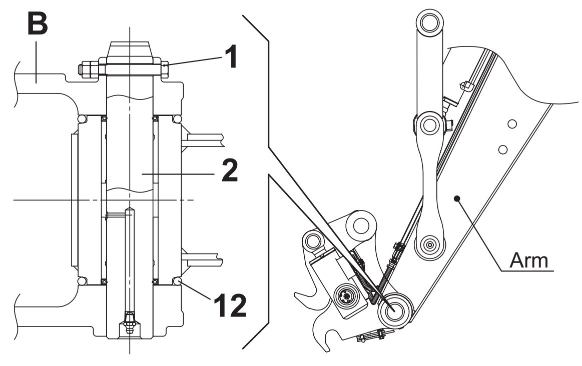
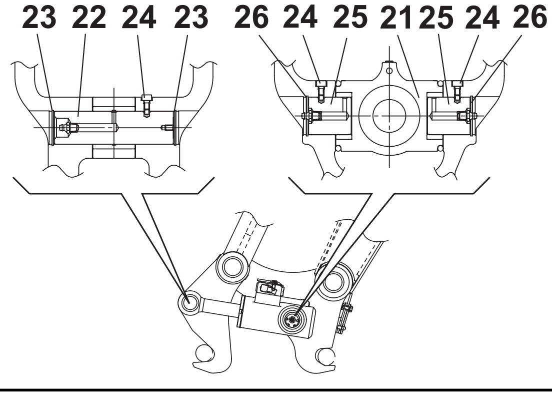
7-6-2 Quick Coupler

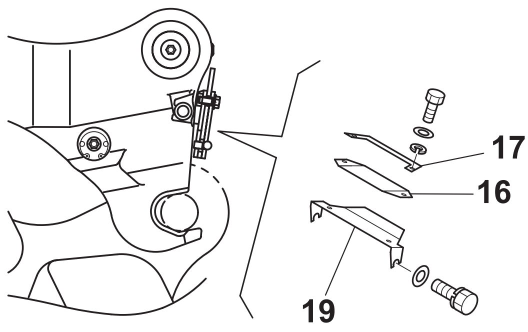
1) Structure



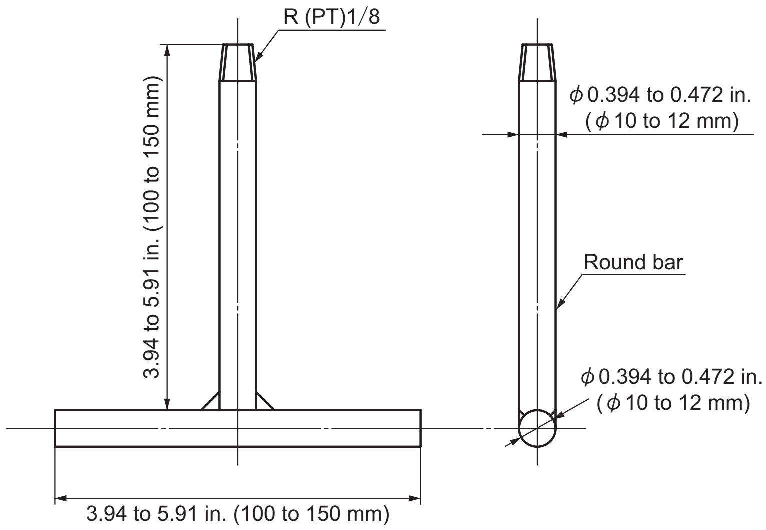
No.	Part	Q'ty	No.	Part	Q'ty	No.	Part	Q'ty
1	Bolt (M10×80)	1	11	O-ring (27.6×5.7)	1	21	Quick coupler cylinder	1
2	Pin (45×261)	1	12	O-ring 81-8	2	22	Pin (35×166)	2
3	Bolt (M12×30)	1	13	Bracket A	1	23	Internal snap ring C (35)	2
4	Pin (45×299)	1	14	Bolt (M8×20)	2	24	Hexagon socket head bolt	3
5	Snap ring E6	1	15	Collar (9×4)	2	25	Pin (40×45.5)	2
6	Plain washer 8	1	16	Plate (rubber)	1	26	Internal snap ring C (40)	2
7	Lock pin	1	17	Plate CMP	1	27	O-ring (61×6.0)	2
8	Lock plate	1	18	Bolt (M10×20)	2	28	Elbow PF1/4	2
9	External snap ring C (35)	1	19	Guard CMP	1	29	Operate check valve	1
10	Shim (35×2.3)	1	20	Bracket B	1	30	Cover	1

2) Disassembly

Procedure	
(1) Remove the attachment (the bucket etc.). (2) Lower the boom until the quick coupler reaches 0.394 to 1.181 in. (10 to 30 mm) above the ground.	
(3) Remove the snap ring C **9** and the shim **10**, and then remove the lock pin **7** and the lock plate **8**. (4) Remove the hydraulic hoses **A**. (5) Remove the bolt **3** (M12) and pull out the pin **4** to separate the quick coupler from the bucket link.	
(6) Remove the bolt **1** (M10) and pull out the pin **2** to remove the quick coupler and the O-ring **12** from the arm.	
(7) Remove the snap rings **23** and **26**, and the hexagon socket head bolts **24**, and then pull out the pins **22** and **25** to remove the quick coupler cylinder **21**. ***Note :*** *Use a jig to pull out the pin **25**. For the details of the jig, refer to Section "3) Pin Puller Jig" below.*	

Procedure	
(8) Remove the guard **19**, the rubber plate **16** and the plate **17**.	

3) Pin Puller Jig



4) Reassembly

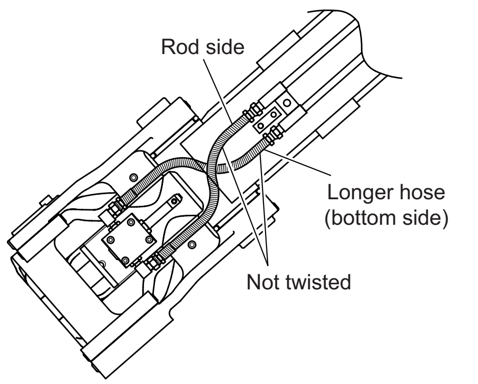
Reassemble the quick coupler in the reverse order of the disassembly procedure.

Notes :

- *Install the hydraulic hoses in the way the longer one with a red identification mark is under the other one.*
- *After installing the hydraulic hoses, operate the quick coupler to check whether the hydraulic hoses are not twisted or caught.*
- *Apply multipurpose grease to O-ring (27.6 × 5.7).*

Tightening torque

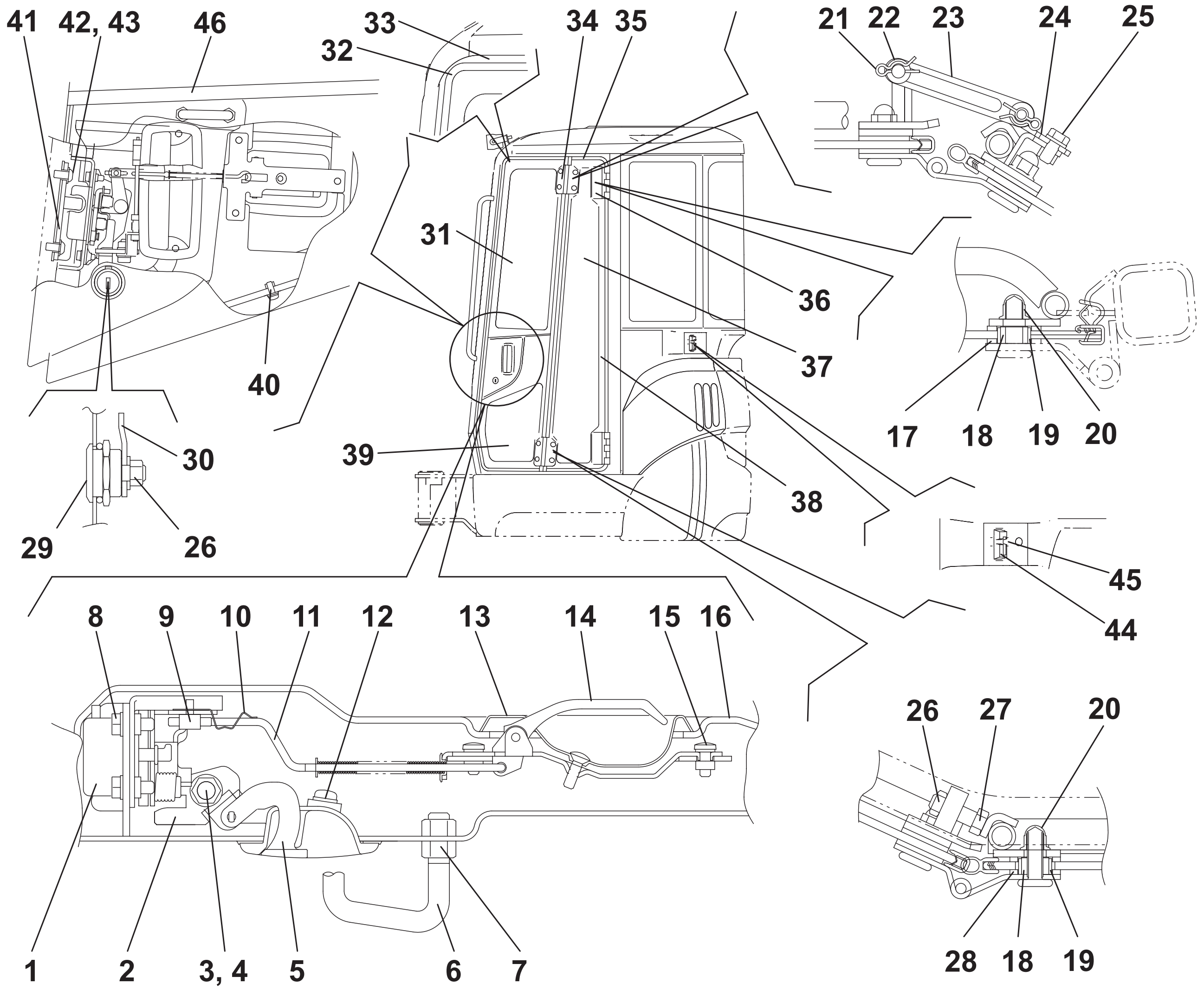
Bolt size	Tightening torque	Adhesive
M12	57.9 to 72.3 ft·lbf (78.5 to 98.1 N·m)	Three bond 1324 or its equivalent
Hexagon socket head bolt M8	7.23 to 8.68 ft·lbf (9.81 to 11.8 N·m)	↑



7-7 Cabin

7-7-1 Cabin

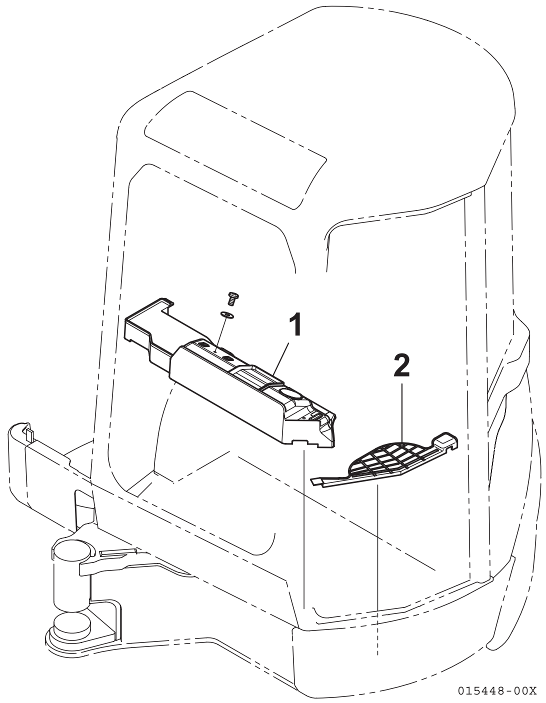
- Structure and component parts

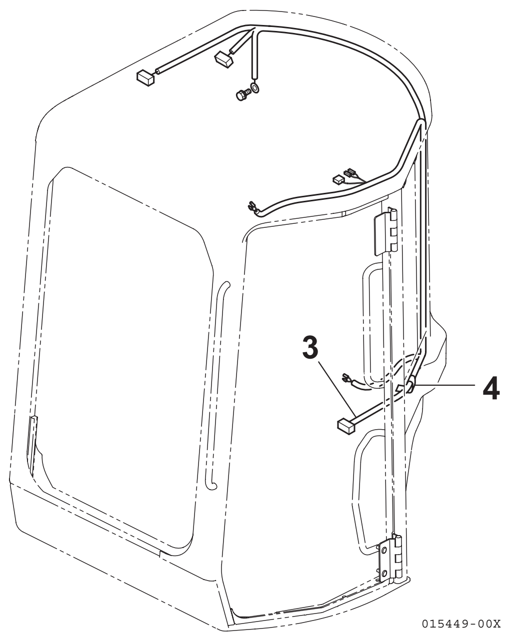


No.	Part	Q'ty	No.	Part	Q'ty	No.	Part	Q'ty
1	Lock CMP	1	17	Packing	4	33	Seal rubber A assembly	1
2	F lock release plate	1	18	Pipe	12	34	Hinge CMP (door)	2
3	Bolt 8×20	1	19	Tube	12	35	Seal rubber B assembly	1
4	Nut (with spring washer 8)	1	20	Cap nut 10	12	36	Hinge cover	2
5	Handle (outer)	1	21	Snap pin	2	37	Glass R (door)	1
6	Door hook	1	22	Polished washer 8	2	38	Frame CMP (door rear)	1
7	Nut (BC 10)	4	23	Stopper guide	1	39	Glass FL (door)	1
8	Bolt (with spring washer 6×10)	3	24	Plate CMP (stopper)	1	40	Pan headed screw	4
9	Pin	1	25	Flanged bolt (Black M8×16)	2	41	Striker CMP	1
10	Spring	1	26	Nut 10	2	42	HD washer 8.5×1.8	2
11	Rod (R handle CMP)	1	27	Bolt (10×30)	1	43	Button bolt	2
12	Pan headed screw	2	28	Packing	8	44	Catch	1
13	Cover	1	29	Cylinder CMP	1	45	Stopper rubber	1
14	Handle CMP	1	30	Lock plate	1	46	Trim	1
15	Bolt 6×16	3	31	Glass FU (door)	1			
16	Latch cover	1	32	Frame CMP (door F)	1			

1. Removal and Reinstallation of Cabin

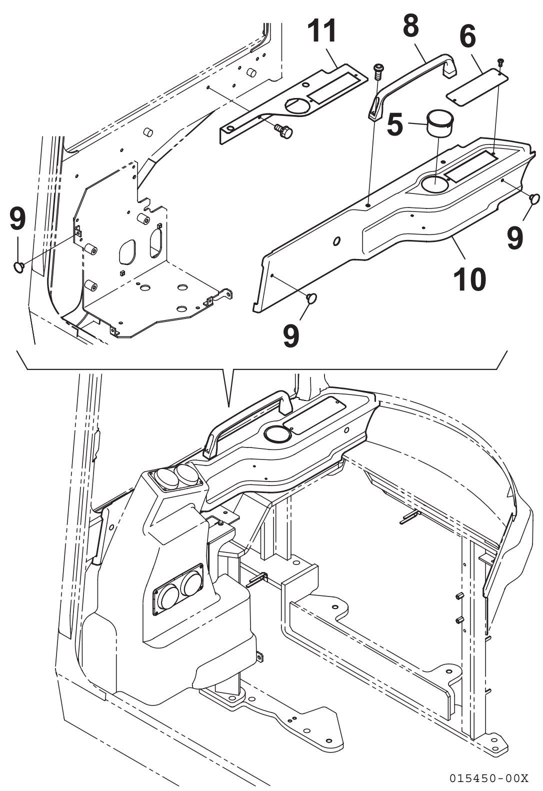
1) Removal

Procedure	
(1) Lower the bucket to the ground, and then stop the engine. (2) Remove the floor mats **1**, **2**.	

(3) Remove the coupler of the harness **3** (for the cabin), and then release the fixation of clamp **4**.	

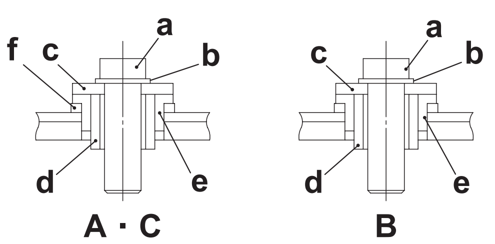
Procedure

(4) Remove side stay R (C) **11** and the clips **9** to remove the cover (S) **10** with cup holder **5**, cover plate **6**, grip **8** and ash tray.



(5) Remove five cabin holding cap screws **11**.

Note :
*Combinations of installation parts at **A**, **B** and **C** are different.*



	Part	A	B	C
a	Cap screw M16×55 (10.9T)	1	1	3
b	Spring washer 16	1	1	3
c	Washer 52×17×6	1	-	3
	Washer 60×17×6	-	1	-
d	Collar 20×30×26	1	1	3
e	Grommet 30×36×50	1	1	3
f	Washer 52×38×6	1	-	-

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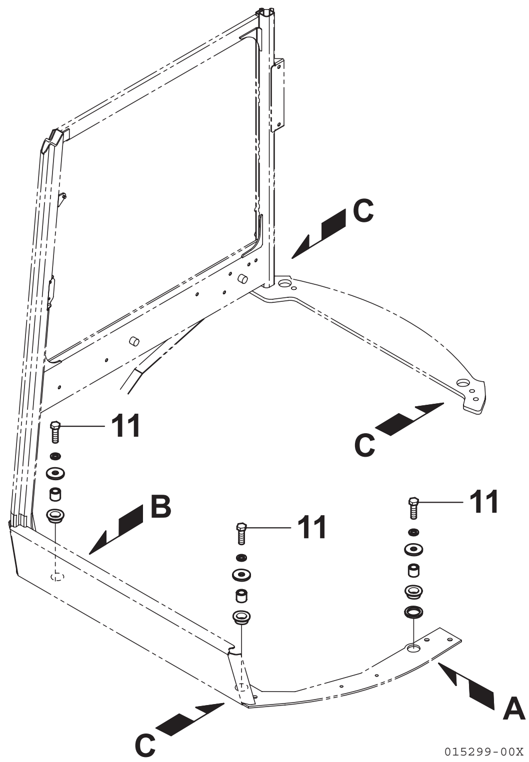
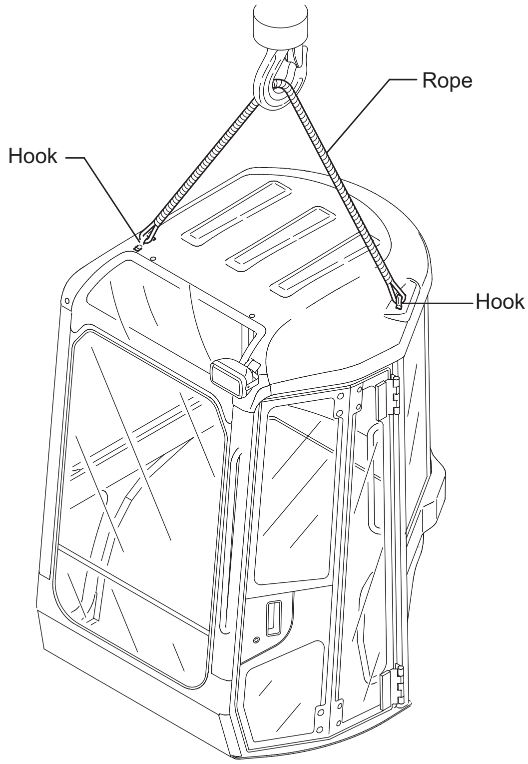


Procedure	
(6) Put rope to the hooks on the top of cabin to lift it. ***Notes :*** • *When lifting up the cabin, keep it horizontal.* • *Operate carefully not to interfere with any other objects.*	

2) Reinstallation

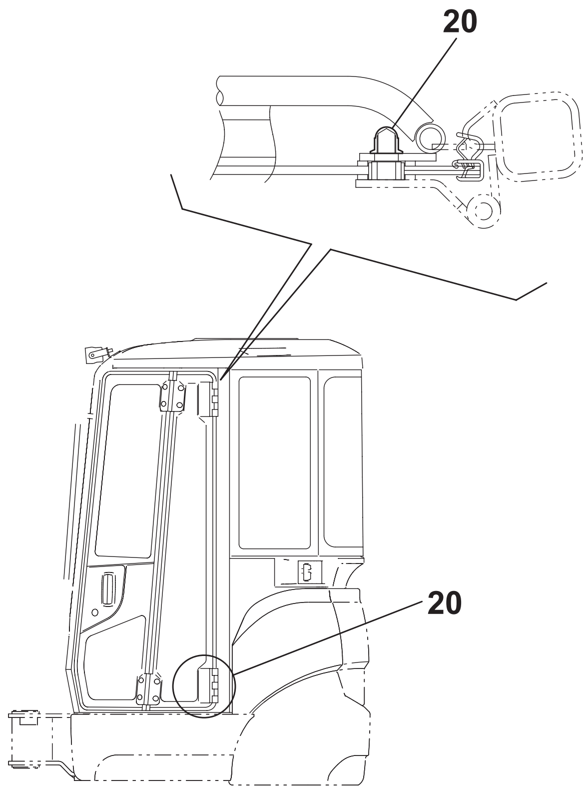
Reinstall the cabin in the reverse order of the removal procedure.

Tightening torque

Installation bolt for cabin (10.9T×M12)	
Adhesive	Apply Three Bond 1324 or its equivalent
125 to 150 ft·lbf (166.7 to 205 N·m)	

2. Removal and Reinstallation of Cabin Door

1) Removal

Procedure	
(1) Remove the cap nuts **20** to remove the cabin door.	

2) Reinstallation

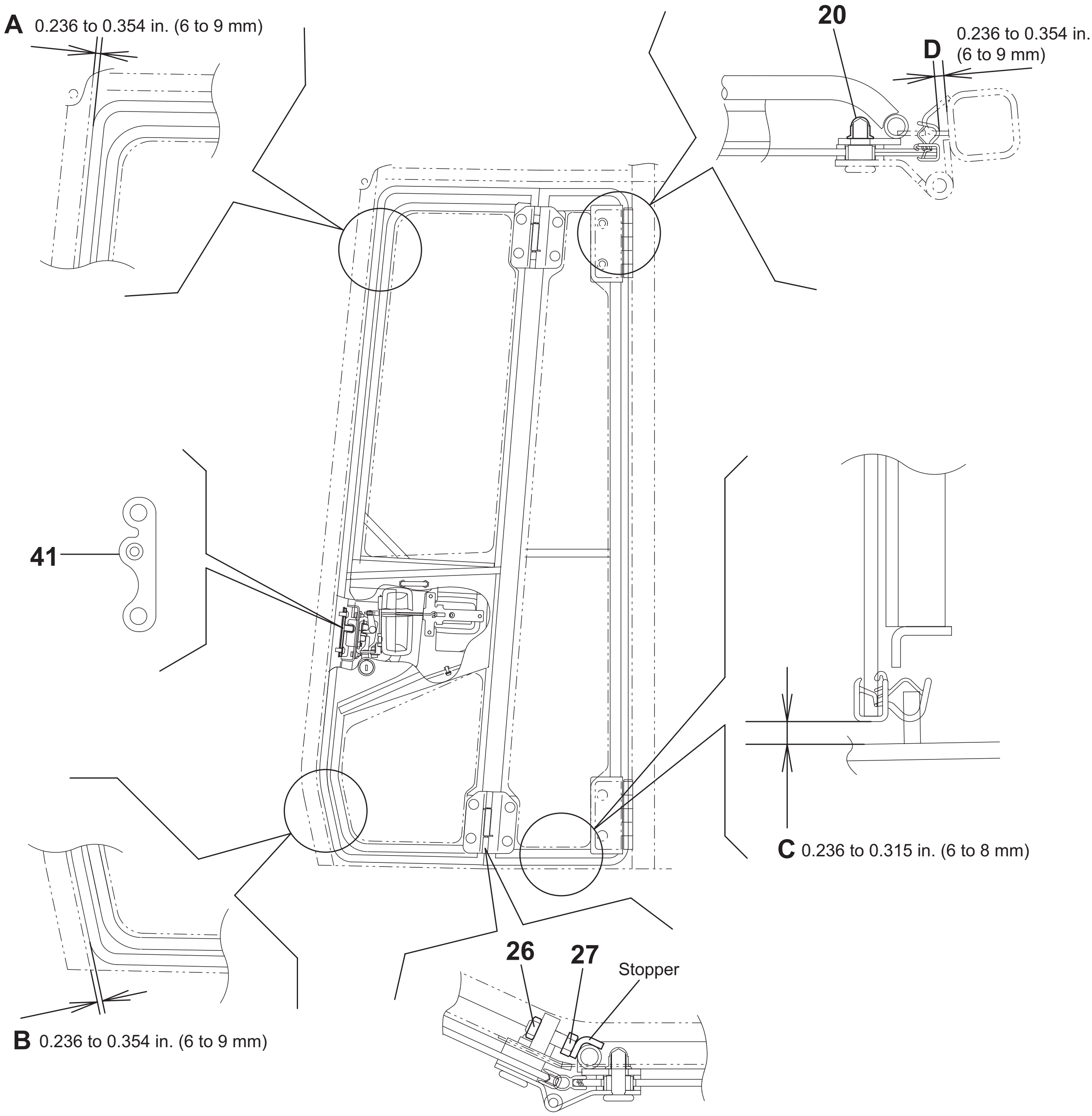
(1) Reinstall the cabin door in the reverse order of the removal procedure.

(2) Adjustment of cabin door

[1] Adjustment of clearance between the cabin door and the cabin body.
After adjusting the clearances **A**, **B**, **C**, and **D** to the respective specified values tighten the cap nuts **20**.

[2] Adjustment of striker

- Fully tighten the bolt **27** (for the stopper) in the lower part of the front door.
- Adjust the striker **41** in the front or back direction, and then set the operating force for closing the cabin door at 110.25 lbs. (50 kg) or less.
- Loosen the bolt **27** until it touches the stopper with the cabin door closed, and then lock it with the nut **26**.



[3] Adjustment of door catch

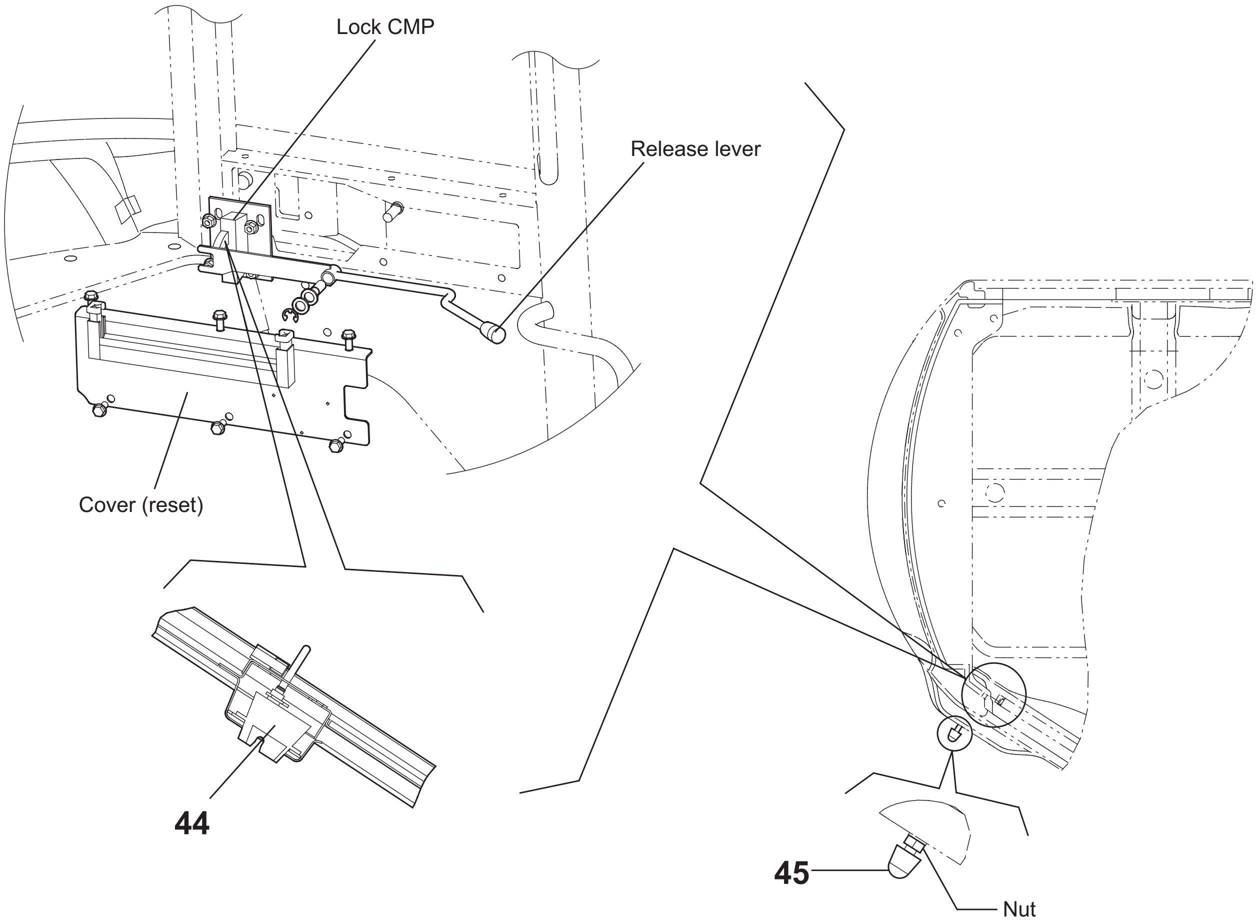
1. Hold the cabin door to the door catch **44**, and then adjust the door catch with the lock CMP so that the hook **6** can be caught smoothly.
2. Adjust the door catch with the lock CMP so that the hook **6** can be released smoothly when operating the release lever.

[4] Adjustment of stopper rubber

1. Fully tighten the stopper rubber **45** and hold the cabin door to the door catch **44**. Loosen the stopper rubber **45** until it contacts with the cabin door.
2. Loosen the stopper rubber two more turns and fix it with the lock nut.

Note :

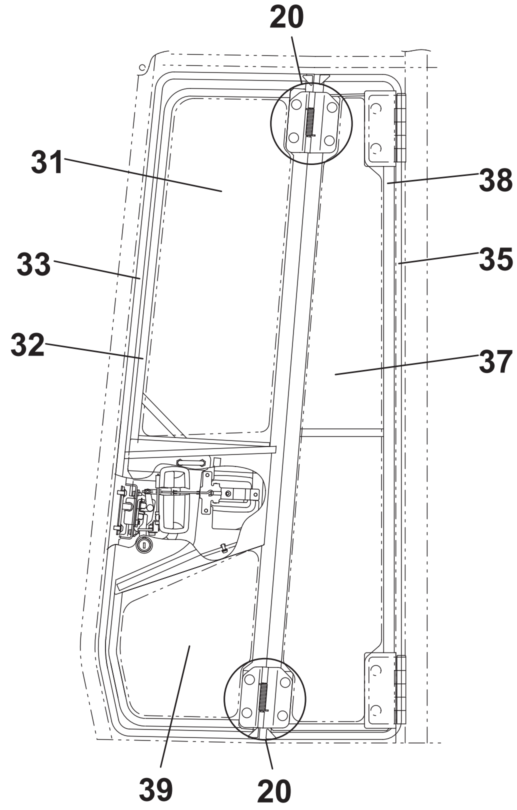
The stopper rubber should be adjusted within three turns after contacting with the cabin door.



Cap nut M10	
Adhesive	Apply loctite or its equivalent
Tightening torque	32.0 to 43.8 ft·lbf (43.3 to 59.3 N·m)

3. Replacement of Cabin Door Glass

1) Removal of Glass

Procedure	
(1) Remove the cabin door from the cabin. <Refer to "2. Removal and Reinstallation of Cabin Door".> (2) Remove the cap nuts **20** to take off the frame CMP **32** (of the door F) and **38** (of the door rear). (3) Remove the seal rubbers A **33** and B **35**. (4) Cut the adhesive on the glasses FU **31** and FL **39** of the frame CMP **32** (for the door F) and then remove the glass. (5) Cut the adhesive on the glass R **37** of the frame CMP **38** (of the door rear), and then remove the glass. ***Note :*** *For the procedure for cutting the adhesive, refer to the removal procedure of the front windshield.*	

2) Replacement of Glass

(1) Clean the primer areas not to leave any old adhesive.

(2) Use adhesive for glass.

Note :

Use the proper primer and cleaner for adhesive.

Type of adhesive
Sika. AG : Sika Tack-Ultrafast or its equivalent

(3) Apply the adhesive at a width of 0.315 in. (8 mm) or more.

Note :

Wipe any excessive adhesive away.

<table>
<tr><th>Procedure</th><th></th></tr>
<tr><td>

(4) Glue the dams (for the front door 380) and the dam (for the front door 390) onto the frame CMP **32** (of the door F).

(5) Put adhesive around the frame CMP **32** (of the door F), and then press the glass FU **31** and the glass FL **39** against the frame.

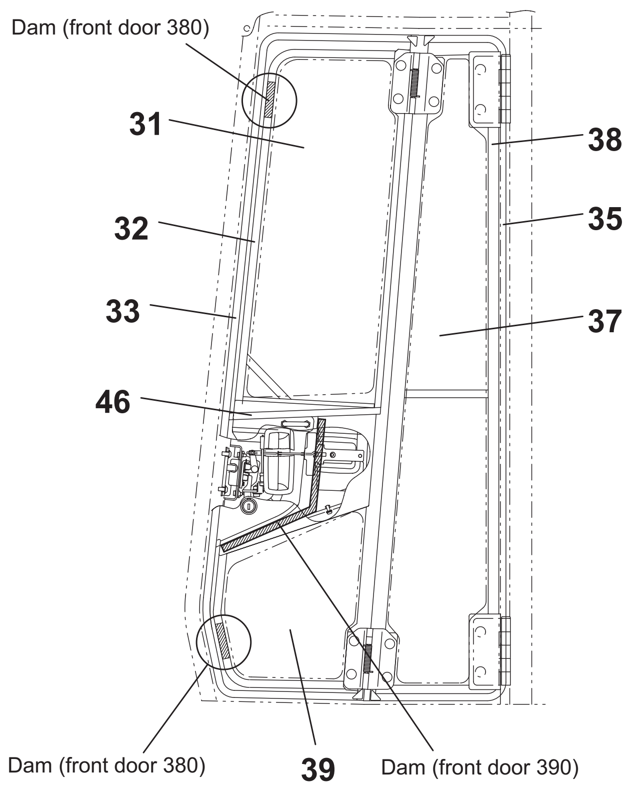
Notes :

- *Glue the glass so that the edge of the glass FL **39** and the frame are in a straight line.*
- *Install both edges of the trim 46 so that they are put into the weather strip of the seal rubber A **33**.*

(6) Put adhesive around the frame CMP **38** (of the door rear), and then press the glass R **37** against the frame.

(7) Install the seal rubbers A **33** and B **35**.

</td><td>



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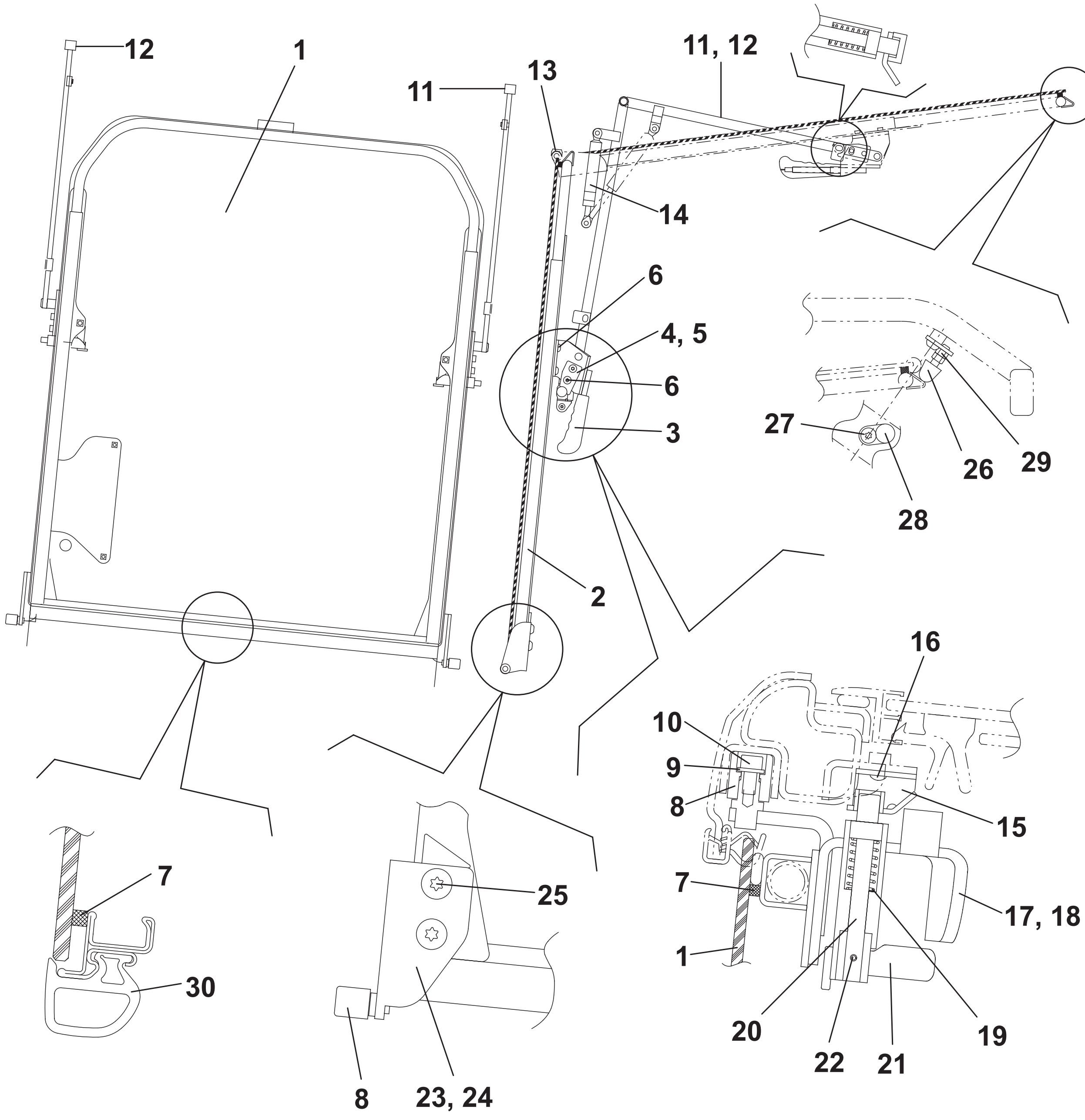
4. Removal and Reinstallation of Front Window

1) Structure and Component Parts



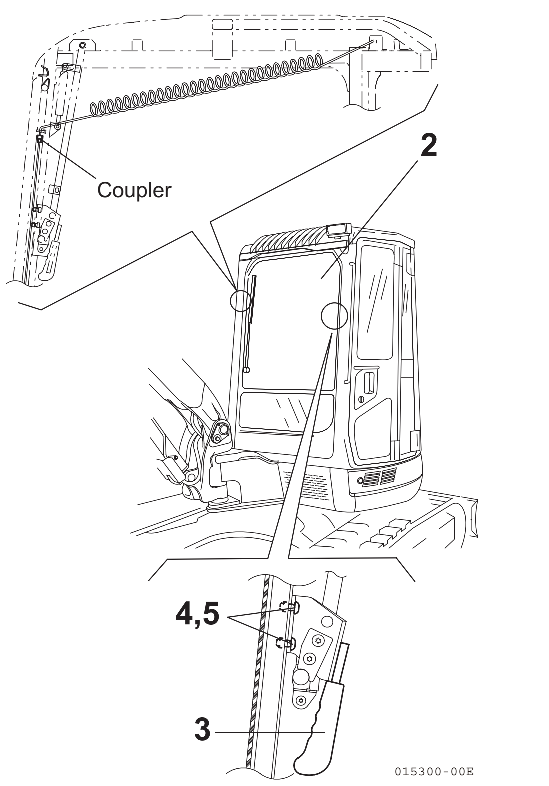
No.	Part	Q'ty	No.	Part	Q'ty	No.	Part	Q'ty
1	Windshield UP (front W)	1	11	Link L CMP	1	21	Lever CMP (F/W)	2
2	Frame CMP (front W)	1	12	Link R CMP	1	22	Spring pin 3.0A ×12	2
3	Grip	2	13	Stopper rubber	2	23	Roller shaft L CMP	1
4	Latch L CMP	1	14	Gas damper	2	24	Roller shaft R CMP	1
5	Latch R CMP	1	15	F/W holder	2	25	Torques M10×20	4
6	Bolt 8×16	8	16	Torques	4	26	Stopper rubber (door)	1
7	Dam seal 750 (F/W)	3	17	Handle R CMP	1	27	Torques M10×20	1
8	Roller 19.5×18	2	18	Handle L CMP	1	28	Plate CMP	1
9	Polished washer 6	2	19	Spring	2	29	Nut 10	1
10	Hexagon socket head bolt (6×10)	2	20	Latch pin	2	30	Seal rubber (F/W)	1

2) Removal

Procedure

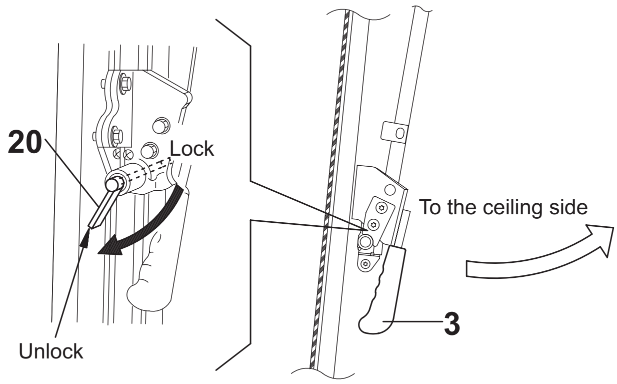
(1) Remove the coupler from the curl cable (for wiper wiring).

(2) Remove the installation bolts of handle CMP L **4** and R **5** with the frame CMP **2** (of the front window) closed.

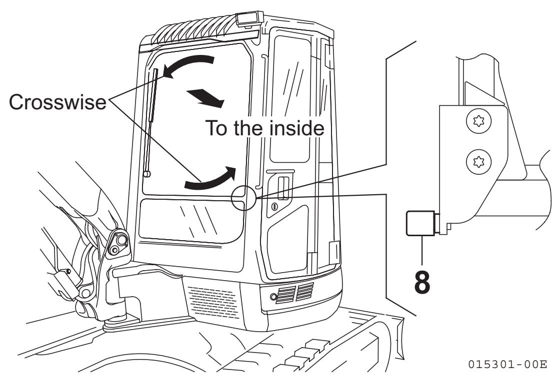


(3) Un lock the lever CMP **20** (for the front window), and then turn the grip **3** to the ceiling side.

Note :
*When the grip **3** is turned up after removing the installation bolt for the handle CMP, the frame CMP **2** leans this side.*



(4) Remove the frame CMP **2** from the cabin by taking the roller **8** out of the groove in the cabin frame while inclining the upper part of the frame CMP **2** to the inside of the cabin and moving the whole frame crosswise.



3) Reinstallation

Reinstall the front windshield in the reverse order of the removal procedure.

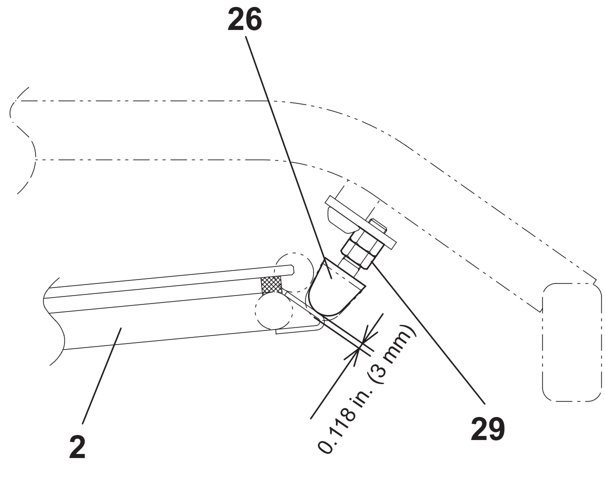
(1) When moving the front window to and from the storage space under the ceiling, check that the rollers move on the rail smoothly.

(2) Check that the slide latch returns automatically.

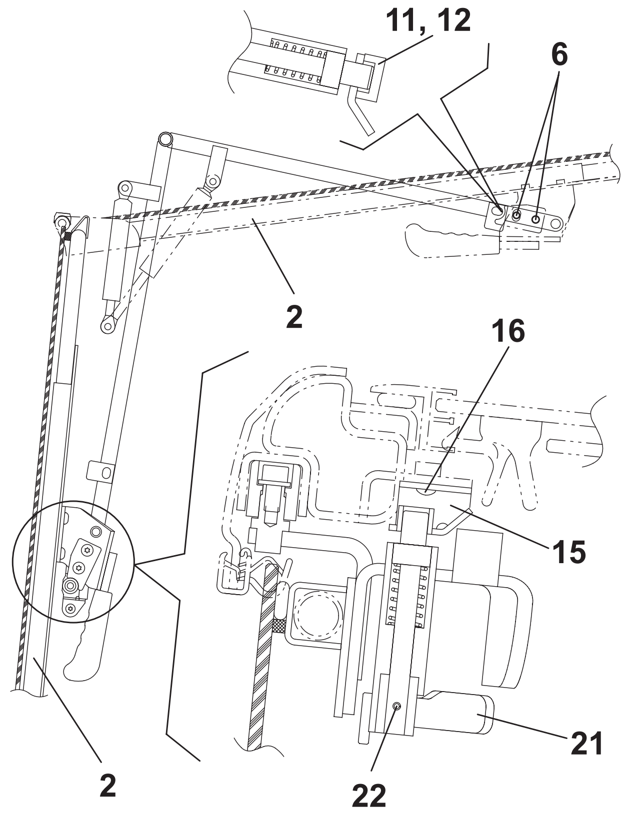
(3) When the front window is stored under the ceiling, check that the play is 0.079 in. (2 mm) or less.

Handle CMP installation bolt (M8)	
Adhesive	Three bond 1344 or its equivalent
Tightening torque	25.3 to 29.7 ft·lbf (34.3 to 40.2 N·m)

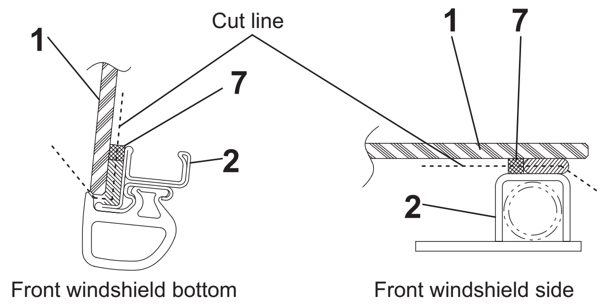
4) Adjustment of Stopper Rubber

Procedure	
(1) Loosen the nut **29** of the stopper rubber **26**, and then fully tighten the stopper rubber **26**. (2) Raise the frame CMP **2** and lock it under the ceiling. (3) Loosen the stopper rubber **26** until it contacts with the frame CMP **2**. (4) Lower the frame CMP **2**, and then loosen the stopper rubber **26** two more turns (approximately 0.118 in. [3 mm]) and tighten the nut **29**.	

5) Adjustment of Frame CMP Lock

Procedure	
(1) Store the frame CMP **2** under the ceiling. (2) Loosen the installation bolt **6** for the lever CMP **21**, and then adjust and tighten the installation bolt **6** so that the latch pins **22** can be installed into the holes in the links L **11** and R **12** smoothly. (3) Loosen the installation bolt **16** for the front window holder **15** and lower the frame CMP **2.** Then, adjust and tighten the installation bolt **16** so that the latch pin can be installed into the hole in the holder **15** smoothly.	

6) Removal of Front Windshield

Procedure	
(1) Cut the adhesive between the front windshield **1** and the frame CMP **2** along the cut line with a metal spatula or a cutter.	

7) Replacement of Front Windshield

(1) Clean the primer not to leave any old adhesives.

(2) Use adhesive for glass.

Type of adhesive
Sika. AG : Sika Tack-Ultrafast or its equivalent

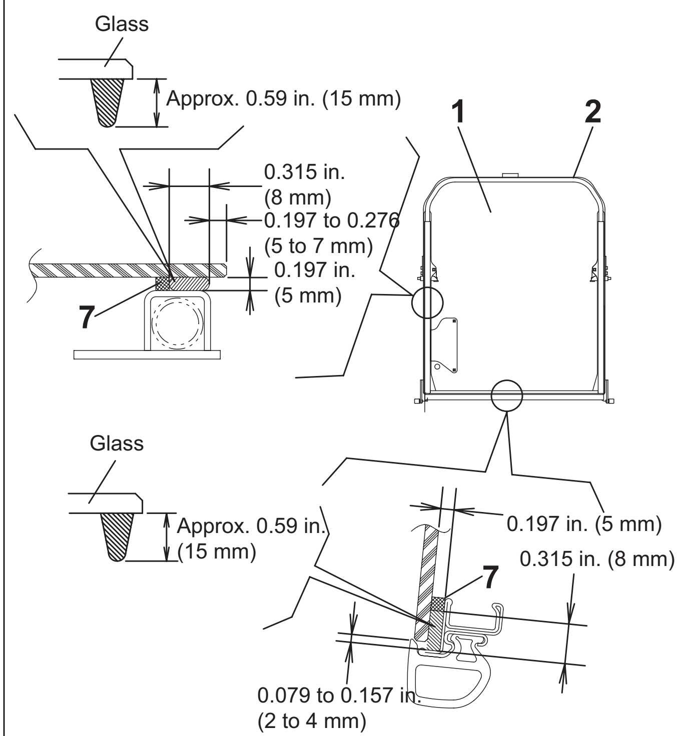
Note :

Use the proper primer and cleaner for the adhesive.

(3) Apply adhesive at a width of 0.315 in. (8 mm) or more.

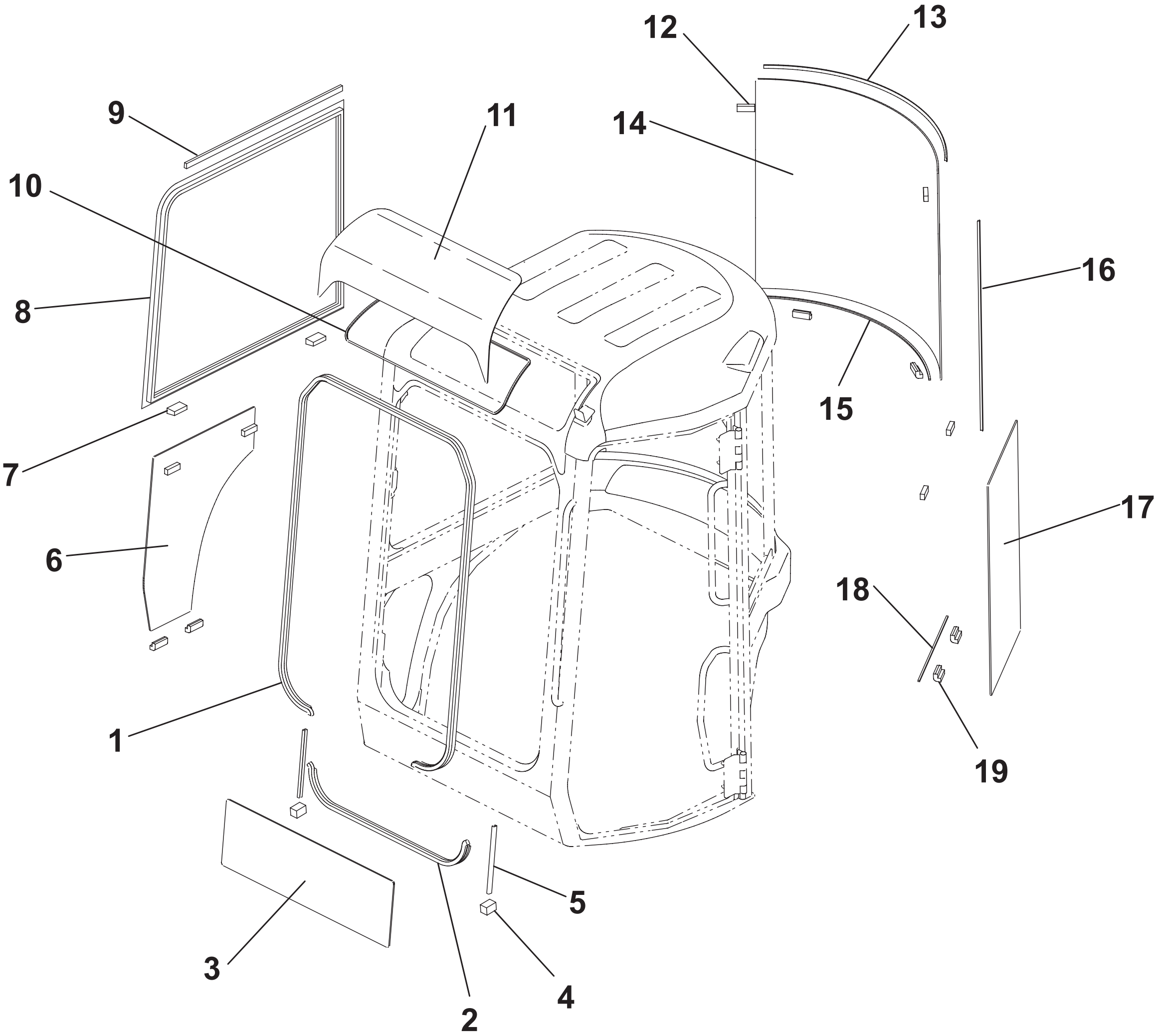
Note :

Wipe any excessive adhesive away.

Procedure	
(1) Clean the surface of the frame CMP with a cleaner (Cleaner No.1 manufactured by Sika or its equivalent). (2) After the cleaner dries up, glue the three dam seals **7** to the frame CMP **2**. (3) Put adhesive (Sika Tack-Ultrafast or its equivalent) around the windshield **1** and press it against the frame CMP **2**. ***Notes :*** • *Pressing height is 0.197 in. (5 mm).* • *The coating width is 0.315 in. (8 mm) or more.* • *After gluing the windshield, do not move the frame CMP **2** at least about 40 minutes.*	

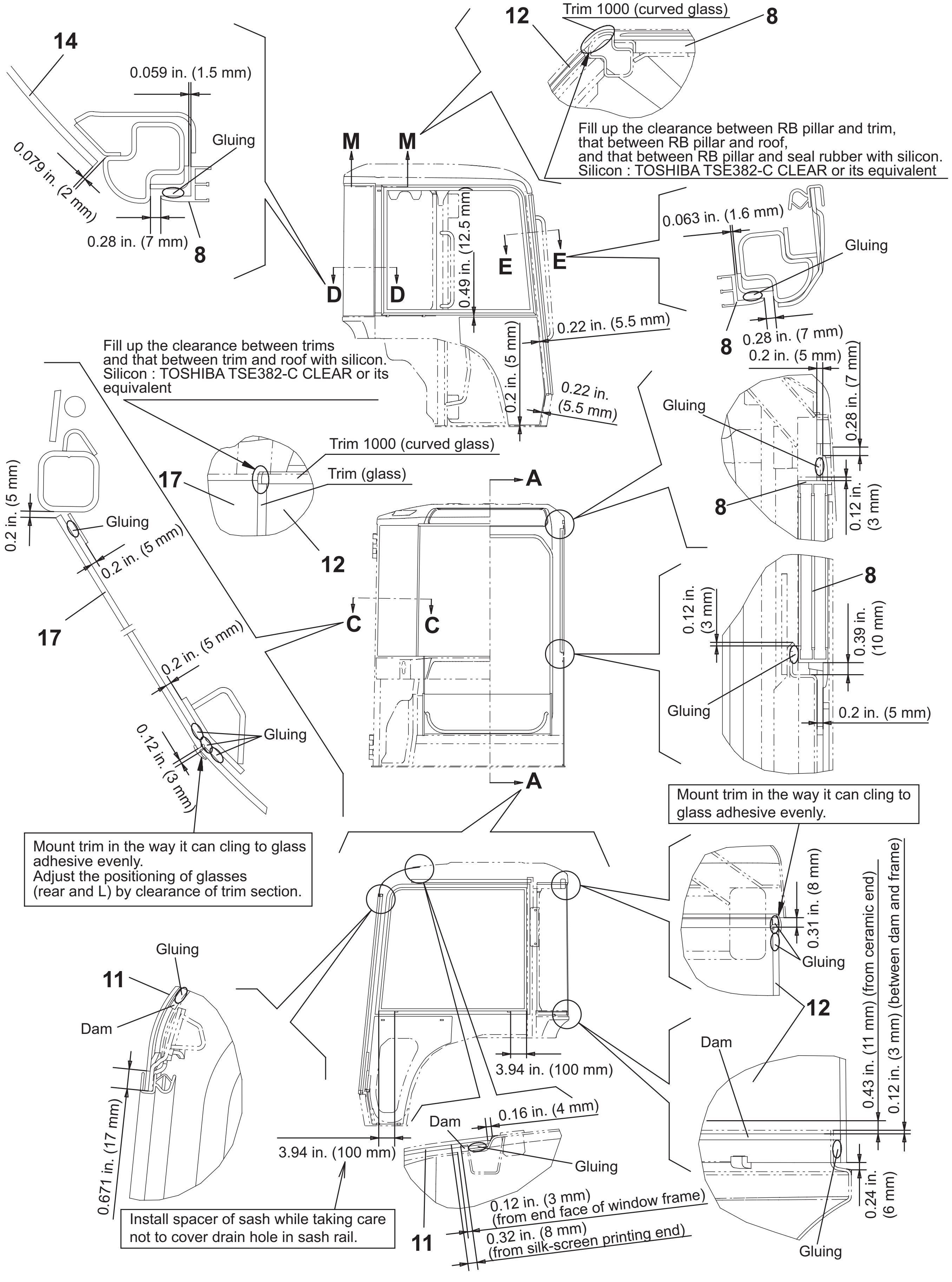
5. Cabin Glass

1) Structure and Component Parts



No.	Part	Q'ty	No.	Part	Q'ty	No.	Part	Q'ty
1	Seal rubber 3300 (F/W)	1	8	Sash assembly	1	15	Dam (rear 36.0 in. [915 mm[)	1
2	Seal rubber 800 (F/W)	1	9	Seal rubber (roof)	1	16	Trim (glass)	1
3	Glass LOW (F/W)	1	10	Dam (sun roof 73.2 in. [1860 mm])	1	17	Glass (L)	1
4	Stopper rubber	2	11	Sun roof	1	18	Dam (L17.7 in. [450 mm[)	1
5	Glass run 270	2	12	Spacer (upper)	6	19	Spacer (lower)	6
6	Glass (LOW R)	1	13	Trim 1000 (curved glass)	1			
7	Spacer	2	14	Glass (rear)	1			

2) Replacement of Glass



CHAPTER 8

PERIODIC INSPECTION AND SERVICING

8. Periodic Inspection and Servicing

8-1 List of Periodic Inspection and Servicing

◇ : Check ○ : Supply ● : Replace □ : Adjust (clean) ■ : Oil & grease

Check & service items			Daily	Every 50	Every 100	Every 250	Every 500	Every 1000 hrs
General	Check falling off, breakage of parts		◇					
	Check loosened bolts & nuts, retighten		◇					
	Check engine condition		◇					
	Clean		□					
Lube oil	*Swing gear case oil	Check, resupply				○		
		Replace			● 1st time			●
	Travel reduction gear oil	Check, resupply				○		
		Replace			● 1st time			●
	*Transmission oil	Check, resupply	◇					
		Replace			● 1st time			●
	*Differential gear oil	Check, resupply			◇			
		Replace			● 1st time			●
Hydraulic system	Hydraulic oil	Check, resupply	◇					
		Replace						●
	Clean suction filter					□ 1st time		□
	Replace return filter					● 1st time	●	
	Check for abnormality of hydraulic pump		◇					
Grease	Check grease-up positions, grease		■					
	Greasing the swing gears and the swing bearings			■				
	Greasing the track gauge change cylinder and the link fulcrum			■				
Undercar-riage	Check, adjust track tension		◇					
	*Check air pressure, wear, flaw in tyres		◇					
Steering equipment	*Check performance, play of steering lever		◇					
	Check performance, play of travel lever		◇					
	*Check performance of speed change lever		◇					
	*Check performance of forward/reverse pedal		◇					
	*Check performance, play of steering wheel		◇					
	*Brake pedal	Stroke	◇					
		Performance	◇					
	*Parking brake	Stroke	◇					
		Performance	◇					
	Check performance of accel. level		◇					
Electric equipment	Check front & work lights, horn		◇					
	Check hourmeter function		◇					
	Check function of change, oil and pilot lamps		◇					
	Check wire breakage, short-circuits, loosened terminals, retighten		◇					
	Check, resupply battery fluid		◇					
	Check specific gravity of electrolyte						□ As required	
	Check function of OK monitor		◇					

◇ : Check ○ : Supply ● : Replace □ : Adjust (clean) ■ : Oil & grease

Check & service items		Daily	Every 50	Every 200	Every 400	Every 1000	Every 2000 hrs
Fuel oil	Check & supply of oil to the tank	◇					
	Drain the fuel tank		□				
	Clean the oil/water separator		□				
	Replace the fuel filter element				●		
Lube oil	Check the quantity of engine oil	◇					
	Replace the engine oil		● 1st time	●			
	Replace the engine oil filter element		● 1st time	●			
Cooling water	Check & supply of cooling water	◇					
	Clean radiator fins			□			
	Check the fan-belt tension		◇ 1st time	□			
	Replace the cooling water					●	
	Clean & check the cooling water system					● within one year	
Rubber hose	Check & replace fuel oil pipe, cooling water pipe						●
Operation system	Check & adjust governor lever, accelerator	◇		□			
Intake system	Clean air cleaner & replace element			□	●		
	*Check turbocharger, adjust					□	
Cylinder head	Adjust the intake and exhaust valve clearance					□	
	Lapping the intake and exhaust valve						□
Fuel pump & injection valve	Check fuel valve nozzle, clean					□	
	Check & adjustment of fuel injection pressure & atomizing condition					□	
	Check fuel pump, adjust						□

*Applicable to models with the relevant equipment

Note :

- *When machine is used at dusty worksites clean and replace filter element twice or more frequently than specified in the table.*
- *Execution of periodic inspection and servicing is indispensable to conform the EPA emission control regulations. Keep a record of the results.*

CHAPTER 9

FUEL, LUBE OIL AND GREASE RECOMMENDED

9. Fuel, Lube Oil and Grease Recommended

Item	Recommended Type	Capacity
		ViO45-5 / ViO55-5
Fuel	Diesel light oil (JIS #2 or its equivalent)	16.9 Gals. (64 L)
Engine oil	Engine oil SAE 10 W30 (Class CD)	9.4 Qts. (8.9 L)
Hydraulic oil	Hydraulic oil (VG 56 or its equivalent)	Inside tank 10.0 Gals. (38 L) Other sections 6.9 Gals. (26 L) 16.9 Gals. (64 L)
Travel reduction Gear oil	Gear oil SAE 90 (GL-4)	1.27 Qts. (1.2 L) each
Idler	Engine oil SAE 30 (Class CC)	0.074 Qts. (0.07 L) each
Track roller		0.159 Qts. (0.15 L) each
Carrier roller	Albania EP-2 (Grease)	3.66 cu. in (60 cu. cm) each
Radiator	Soft water (Drinking water) + antirust and antifreeze	Radiator 6.67 Qts. (6.3 L) Sub-tank 0.43 Qts. (0.4 L) 7.1 Qts. (6.7 L)
Grease	Multipurpose EP (Extereme pressure) grease Albania EP-2 (Grease)	
Antifreeze	Long-life coolant	

* The numeral for the engine oil shows the total oil quantity when the oil filter is replaced.

Mixture ratio of cooling water and antifreeze

Lowest ambient temperature [°F (°C)]		23 (-5)	14 (-10)	5 (-15)	-4 (-20)	-13 (-25)	-22 (-30)	-31 (-35)	-40 (-40)
ViO45-5 ViO55-5	Antifreeze quantity [Qts. (L)]	1.1 (1.0)	1.8 (1.7)	2.1 (2.0)	2.4 (2.3)	2.9 (2.7)	3.2 (3.0)	3.6 (3.4)	3.9 (3.7)
	Water quantity [Qts. (L)]	6.0 (5.7)	5.3 (5.0)	5.0 (4.7)	4.7 (4.4)	4.2 (4.0)	3.9 (3.7)	3.5 (3.3)	3.2 (3.0)

Note :

At the delivery, water and antifreeze are mixed at the ratio for 5 °F (-15°C) temperature above.

CHAPTER 10

TROUBLESHOOTING

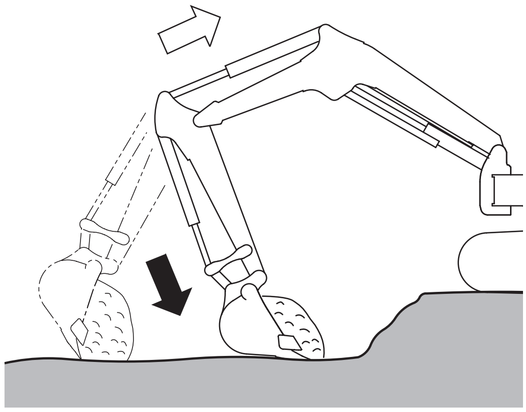
10. Troubleshooting

10-1 Non-breakdowns

10-1-1 Natural Release of Bucket

Phenomenon

When the arm is extended while scooping with the bucket, the scooping side of the bucket is restricted by the arm and causes back pressure because oil cannot be supplied to the bucket cylinder in time.
When the boom is raised immediately in this condition, the bucket is released naturally because of the back pressure in the piston side of the cylinder



Operation

This problem can be solved by using a sequence of three actions of bucket scooping, arm extension and boom raising.
(For the models that cannot make the triple sequence actions, extend the arm after raising the boom.)

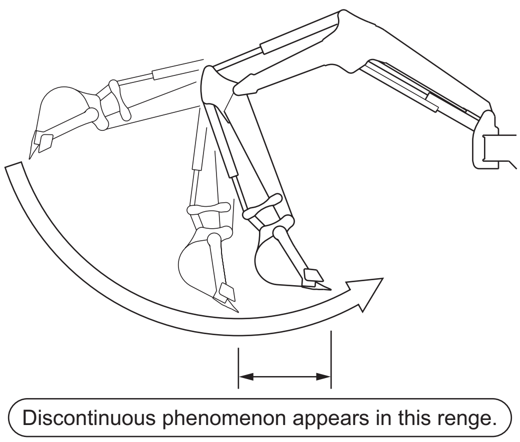
10-1-2 Discontinuous Arm Movement

When scooping with the arm, the arm tends to move slower as it draws near to the perpendicular and it may stop momentarily.

Reason

This may happen because the oil supply cannot catch up with the cylinder extension speed. This is a characteristic of hydraulic equipment.

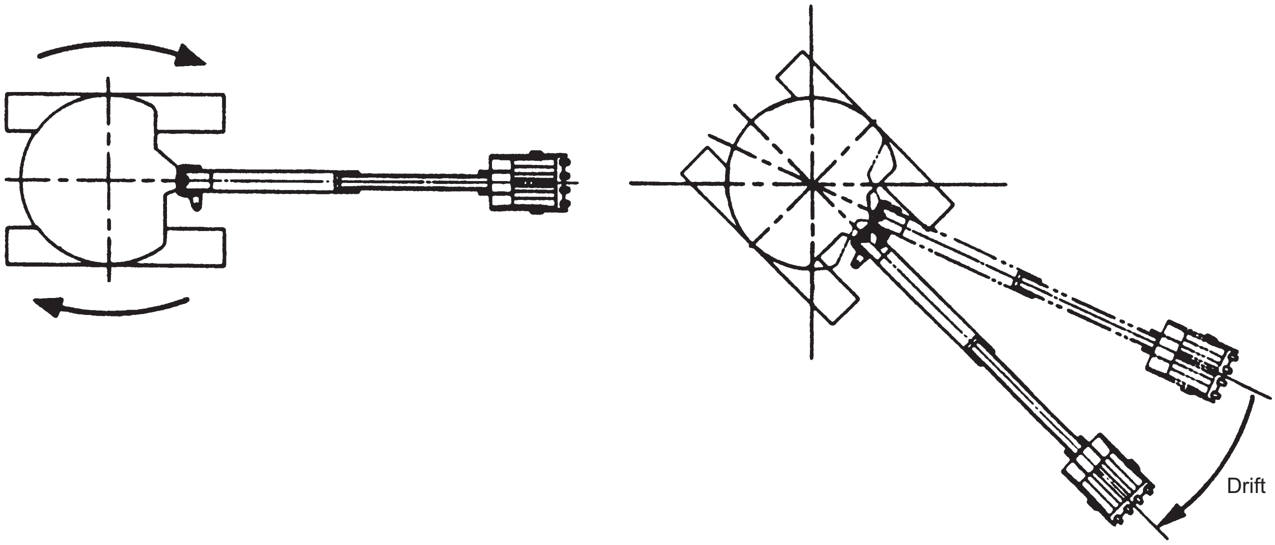
Specifically, this phenomenon appears when the engine speed is in the low to medium speed range.
Advise your users fully that this will happen in hydraulic equipment and that this is not a breakdown.



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

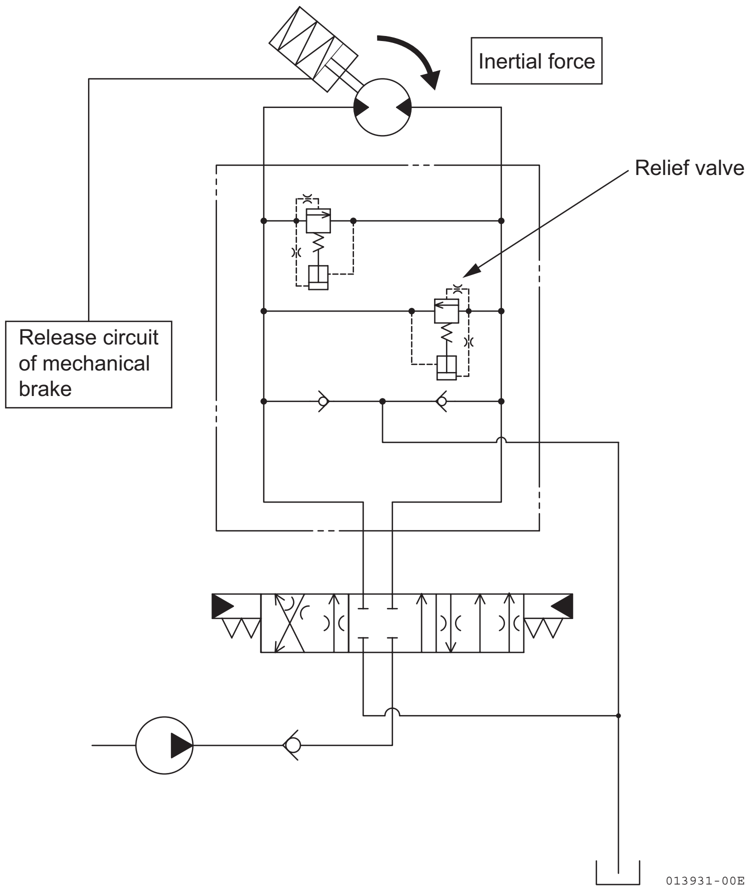
Phenomenon

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



Reason

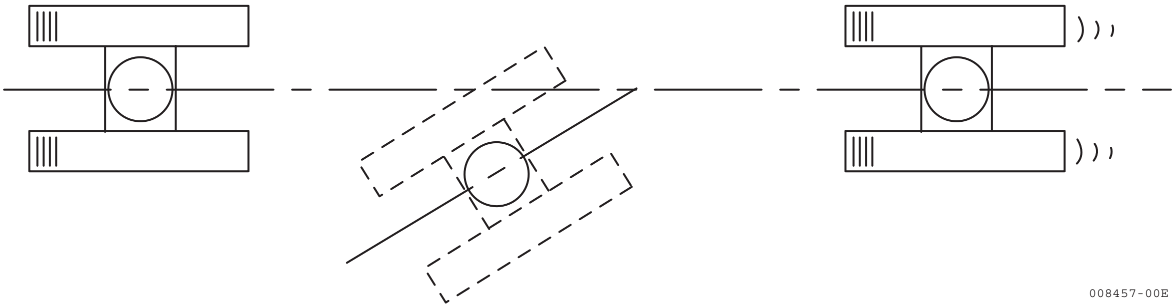
Inertial force is given to the upperstructure through the quick operation of the undercarriage, and high pressure is applied to the swing motor. The relief valve is activated to turn the swing motor.
(The mechanical brake is released when the engine is running.)



10-1-4 Thermal Shock of Travel Motor

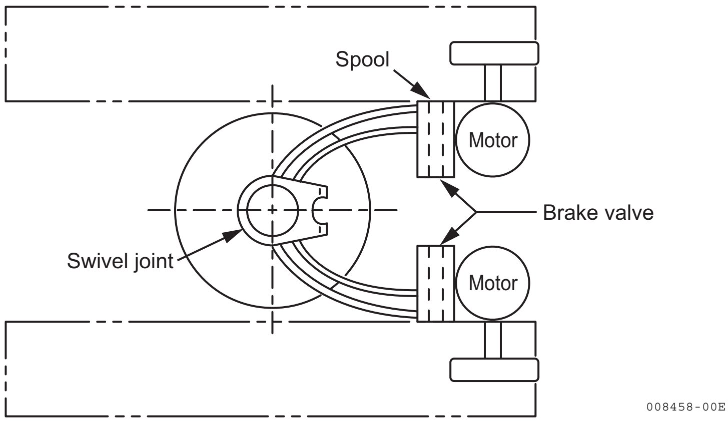
Phenomenon

When the travelling operation is made for pivot turning in cold temperatures after raising the hydraulic oil to more than 140°F (60°C) higher than the ambient temp. through relief valve operation, etc., without travelling after starting the engine, the machine may travel straight instead of making a pivot turn.



(Travel straight in spite of turning operation.)

Reason



When the hot hydraulic oil is suddenly fed to the cold brake valve and motor, the spool in the brake valve sticks momentarily due to thermal expansion, canceling the braking force.

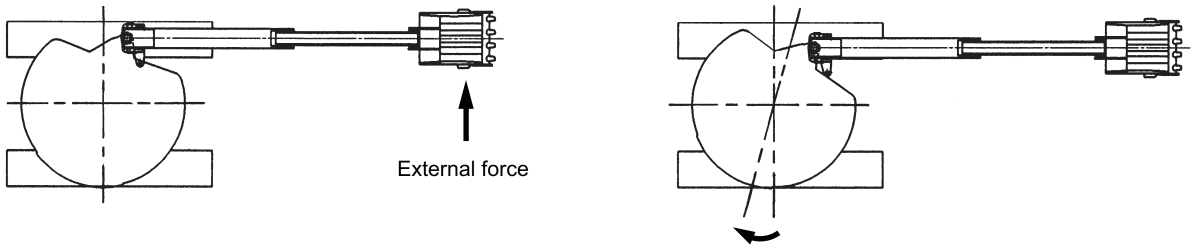
Evaluation

Since the phenomenon disappears in 20 to 30 seconds and this situation is generally rare, this phenomenon presents no problem.

10-1-5 Elongation of Boom Swing Cylinder on 70 degrees Swing

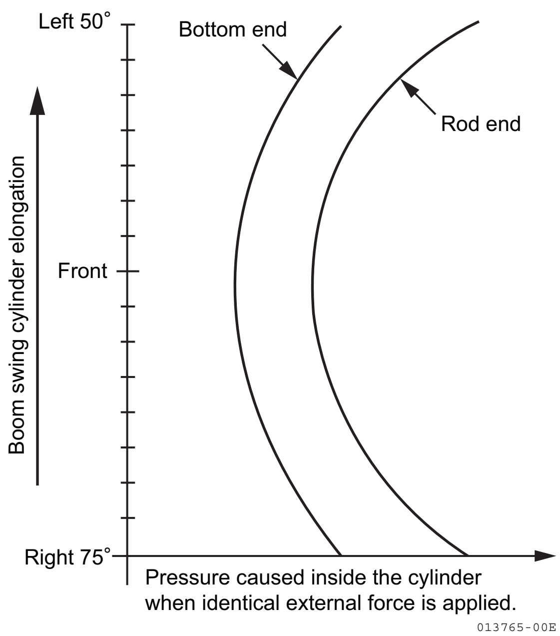
Phenomenon

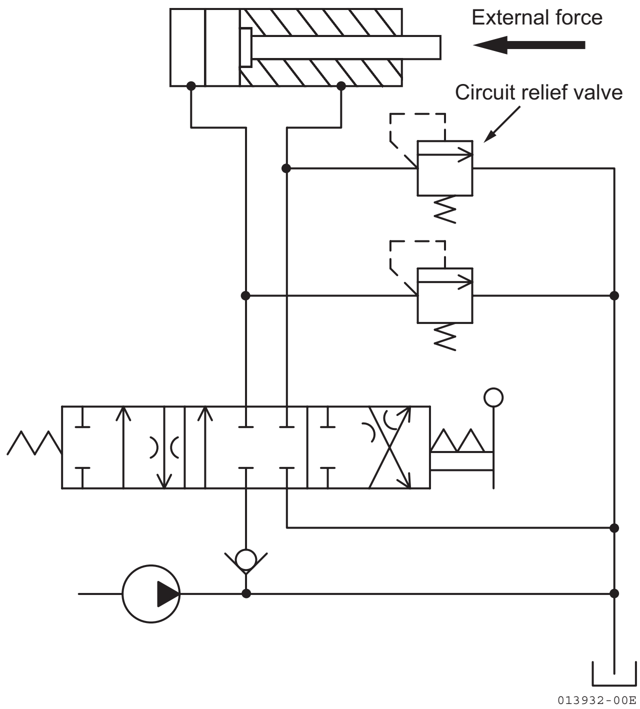
The boom swing cylinder elongates in digging operation at a 70 degrees swing.



Reason

When an outside sideways force is applied to the bucket, the force extends (retracts) the boom swing cylinder. At the 70 degrees swing position, however, the cylinder's internal pressure is higher than in other positions due to the link ratio. This activates the circuit relief valve and elongates the boom swing cylinder.

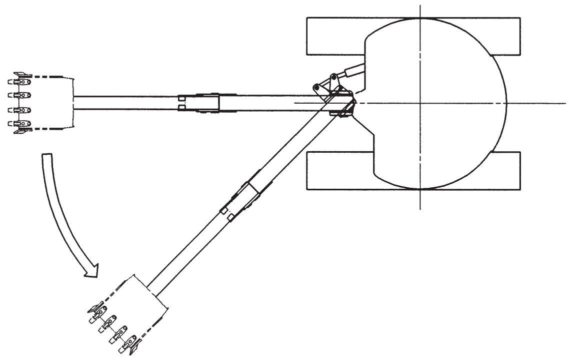




10-1-6 Telescopic Motion of Boom Swing Cylinder with Lock Lever Set to Lock Position

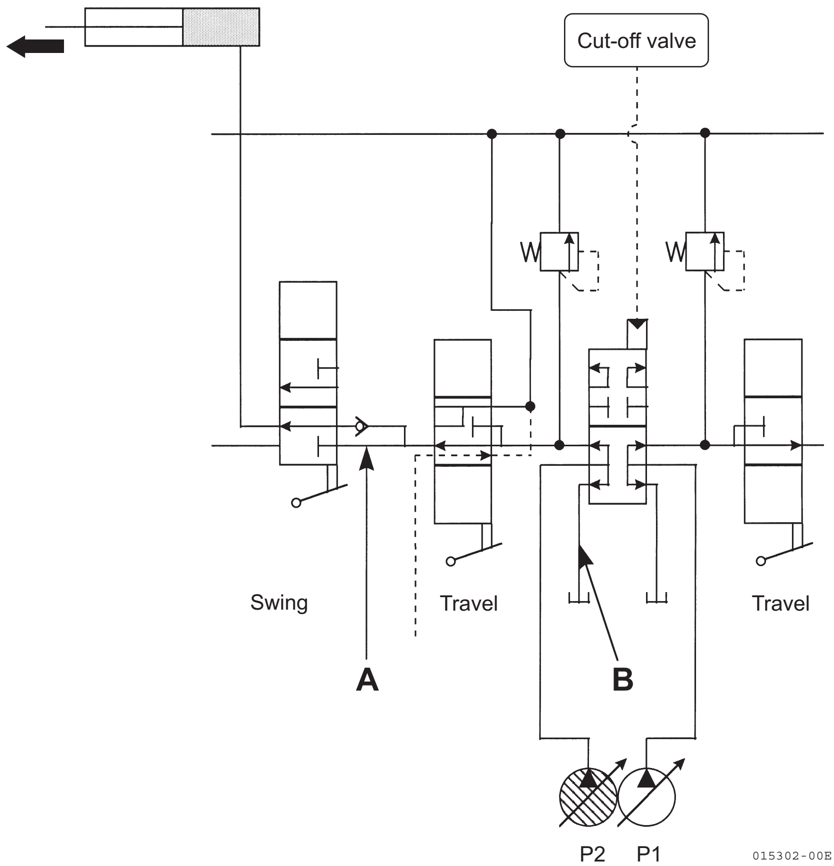
Phenomenon

When the boom swing pedal is moved with the lock lever set to the Lock position, the boom swings at very low speed.



Reason

When the lock lever is in the Lock position, the oil flowing through the passage A of the control valve from the hydraulic pump is unloaded into the hydraulic oil tank through the passage B. However, a very small pressure is generated by the resistance in the piping to the hydraulic oil tank. Therefore, when the boom swing pedal is moved, the very small pressure is applied to the boom swing cylinder and the boom swings at very low speed.



Note :

Typical schematic is shown above just for example. Refer to the chapter 5 for more details.

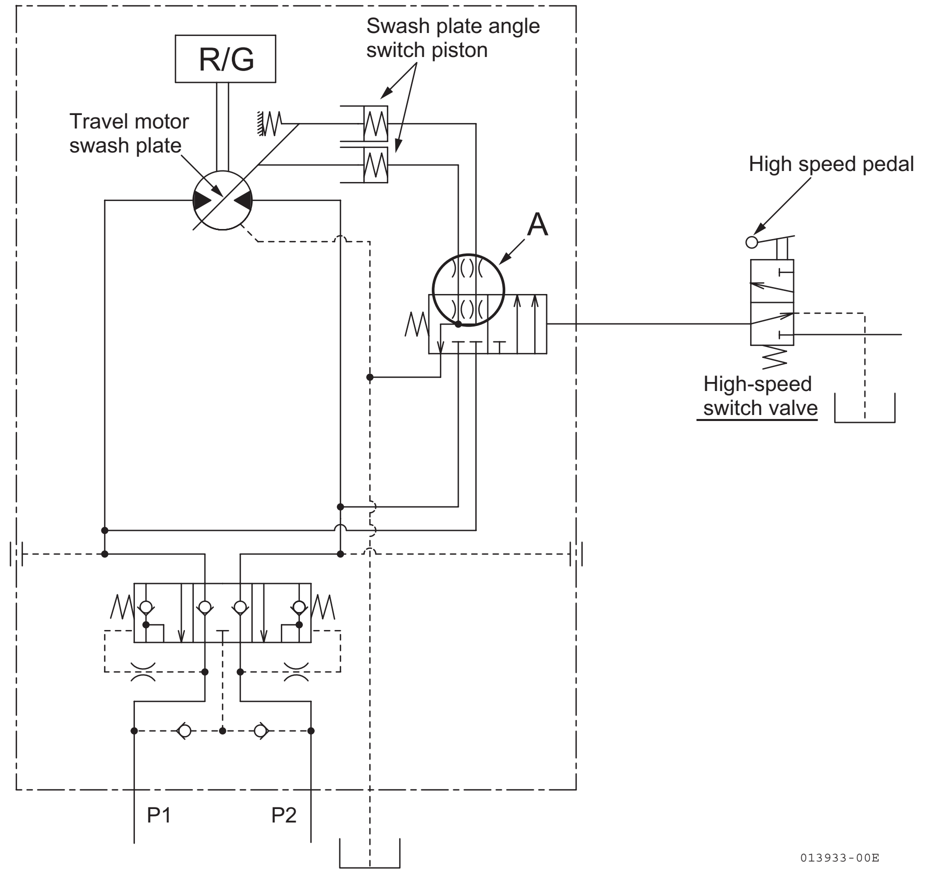
10-1-7 Time Lag on Travel Speed Switching

Phenomenon

At cold temperatures, there is a time lag in switching from the high-speed to low-speed (with the high-speed pedal released).

Reason

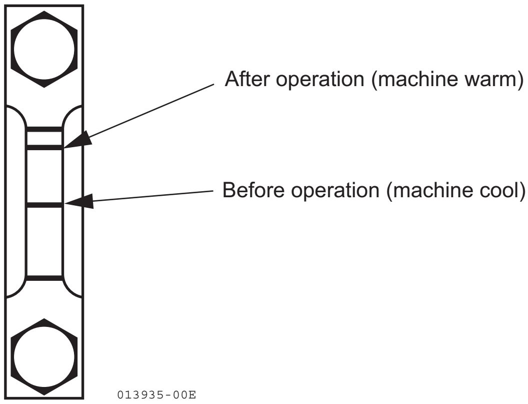
The shock caused during switching from the high-speed to low-speed is lightened by the throttles of A. At cold temperatures, however, the passage resistance of the throttles becomes larger and it takes more time for the swash plate of the travel motor to return to the low-speed.



10-1-8 Fluctuation in Oil Level of Hydraulic Oil Tank Due to Temperature Change

Phenomenon

The oil level of the hydraulic oil tank varies between before operation (the machine is cool) and after operation (the machine is warm).

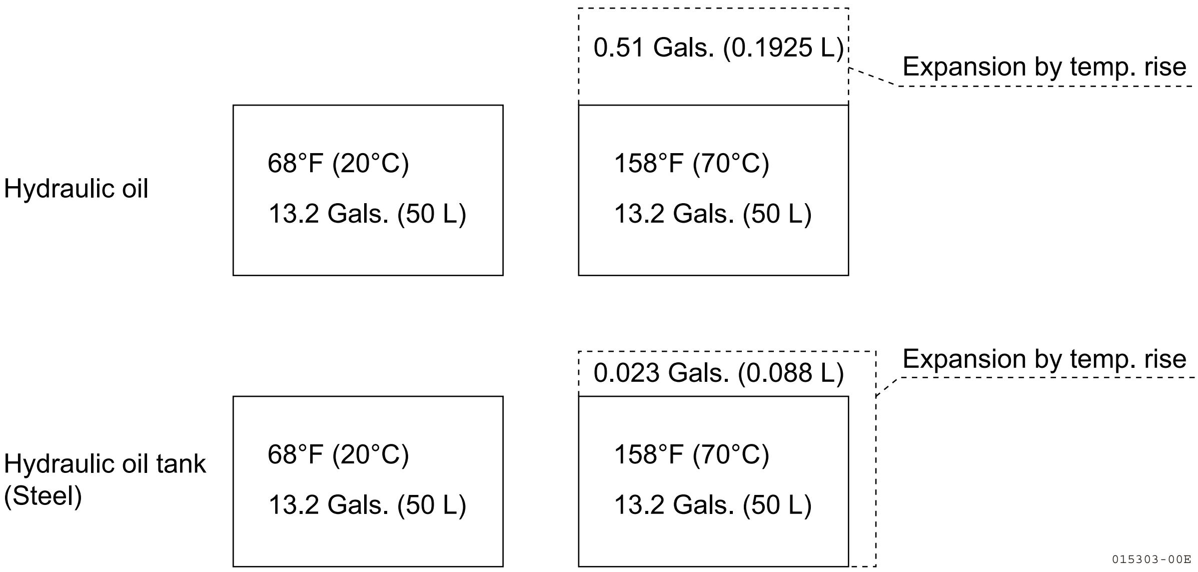


Reason

The oil level changes because the thermal expansion factor of oil is far larger (about 20 times) than that of steel.

1. Liner thermal expansion factor of steel : 11.7×10^{-6}
2. Cubical thermal expansion factor of steel : 3.51×10^{-5}
3. Cubical thermal expansion factor of hydraulic oil : 7.7×10^{-4}

(Example)



10-1-9 Operation of Quick Coupler Cylinder (for Quick Coupler Type)

Phenomena

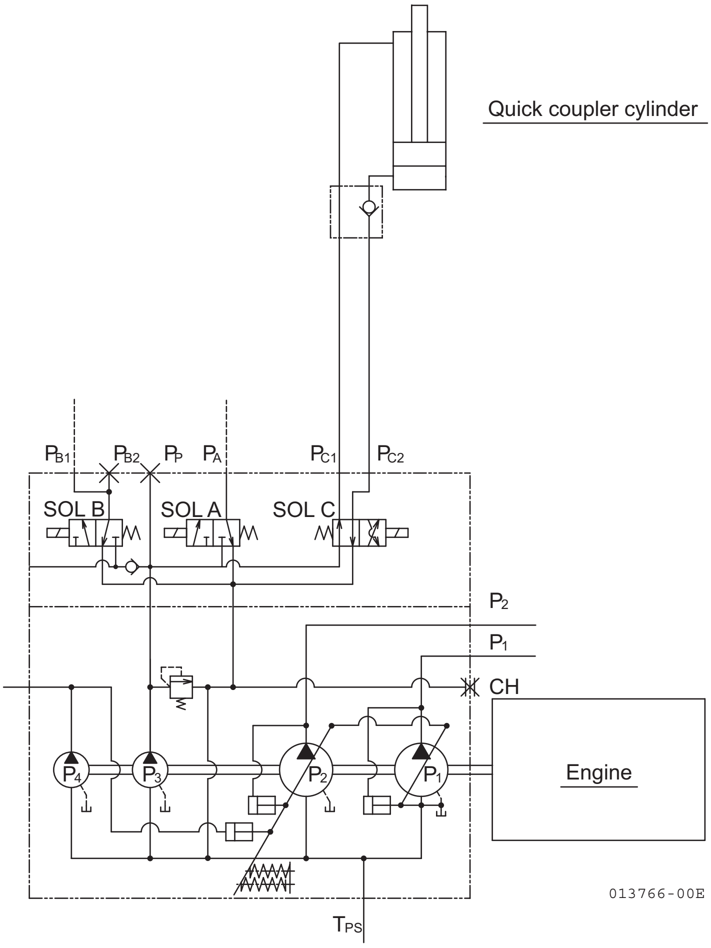
(1) When the control switch of the quick coupler is in the removal mode, stop the engine and then restart it, and the hook of the quick coupler open.

(2) The speed of hook slows down when mounting or dismounting operation is performed at a cold temperature.

Reasons

(1) The quick coupler cylinder has a circuit, where oil is provided at all times. Therefore, the oil is fed to the quick coupler cylinder to move the hook as soon as the engine starts.

(2) The oil viscosity becomes higher at low temperatures, and it increases the passage resistance of the hoses, preventing oil from flowing smoothly.



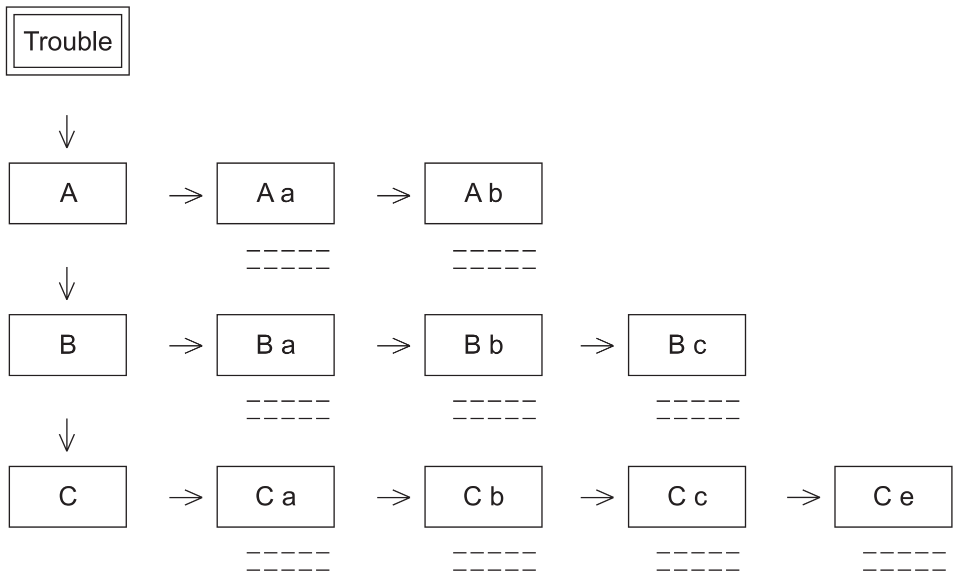
*Pressure oil from the pump P4 is constantly supplied to the quick coupler cylinder through the SOL C.

10. TROUBLESHOOTING

10-2 Troubleshooting

10-2-1 Machine and Engine

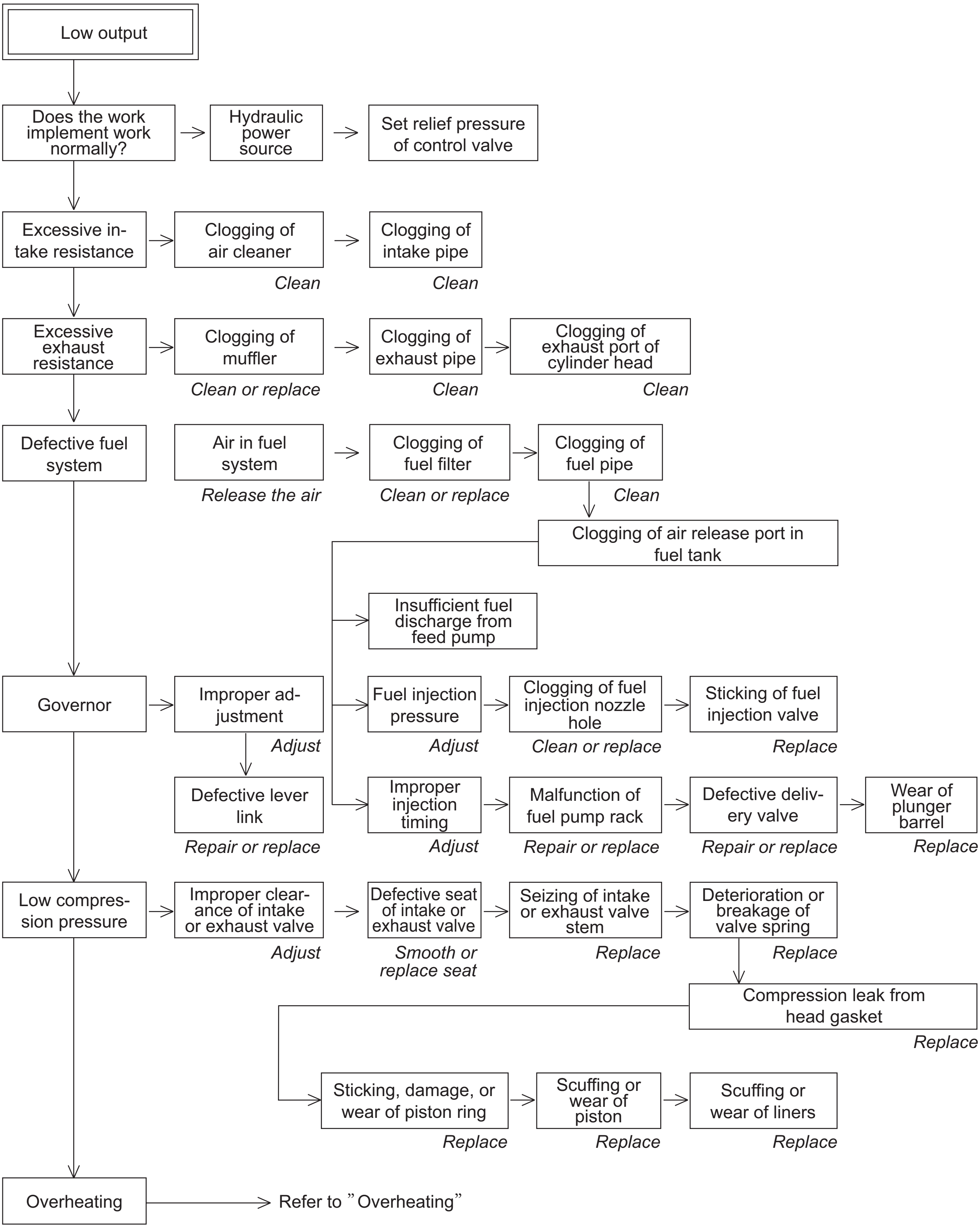
(How to use the charts)



Factors related to the trouble are enumerated in the columns and instructions for corrective procedures are given below. It is recommended that the troubles be inspected and corrected one by one according to the chart.

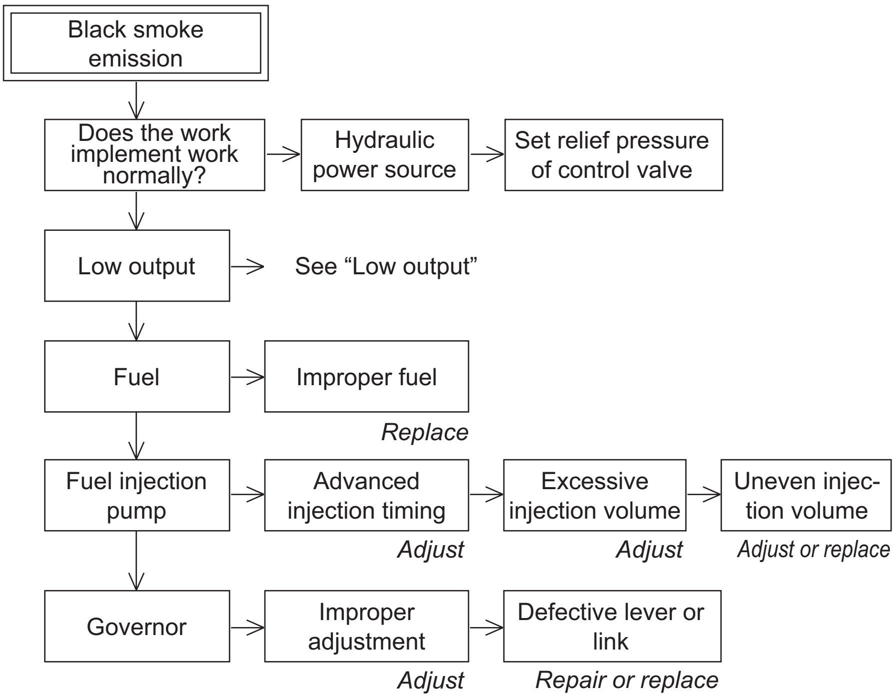
← Inspection item

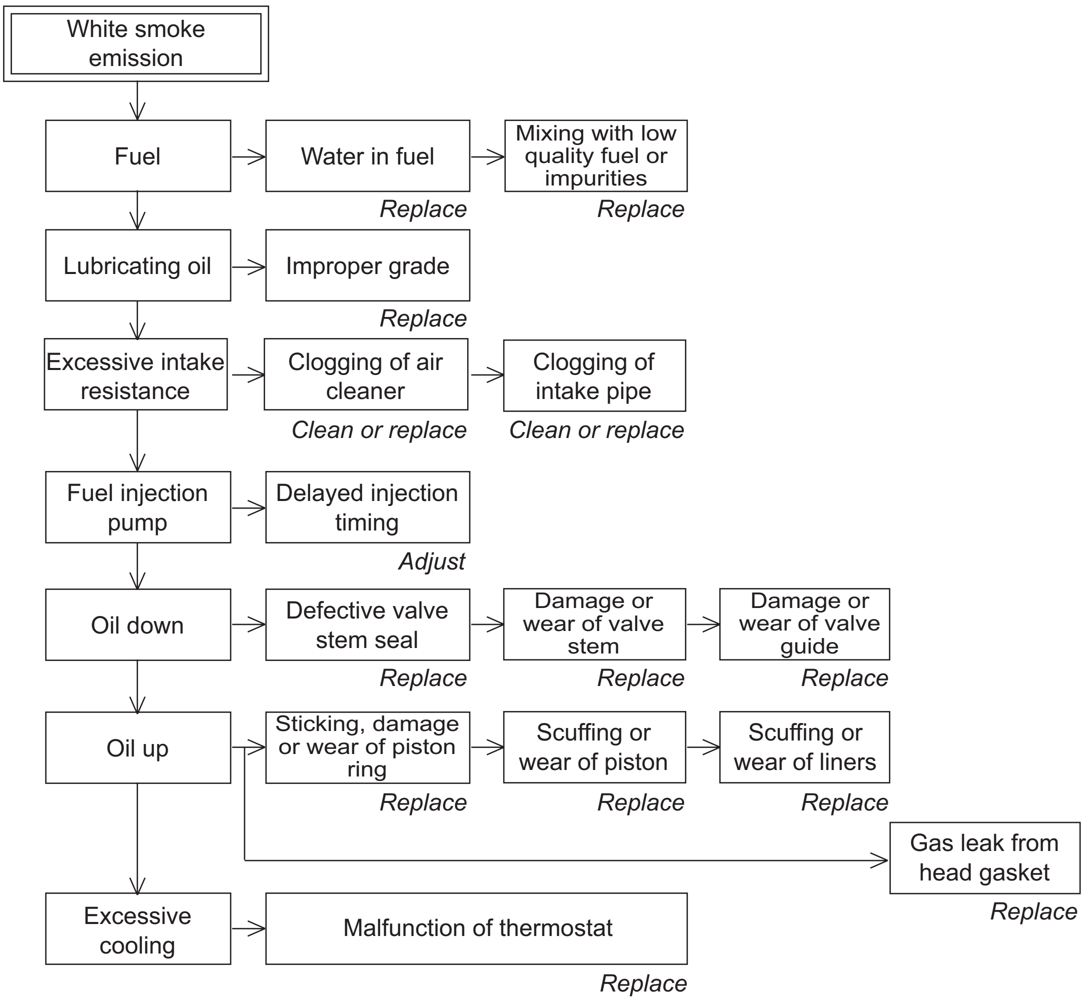
------------ ← Remedy for failure


Low output
Does the work implement work normally?
Hydraulic power source
Set relief pressure of control valve
Excessive in-take resistance
Clogging of air cleaner
Clean
Clogging of intake pipe
Clean
Excessive exhaust resistance
Clogging of muffler
Clean or replace
Clogging of exhaust pipe
Clean
Clogging of exhaust port of cylinder head
Clean
Defective fuel system
Air in fuel system
Release the air
Clogging of fuel filter
Clean or replace
Clogging of fuel pipe
Clean
Clogging of air release port in fuel tank
Insufficient fuel discharge from feed pump
Governor
Improper ad-justment
Adjust
Defective lever link
Repair or replace
Fuel injection pressure
Adjust
Clogging of fuel injection nozzle hole
Clean or replace
Sticking of fuel injection valve
Replace
Improper injection timing
Adjust
Malfunction of fuel pump rack
Repair or replace
Defective deliv-ery valve
Repair or replace
Wear of plunger barrel
Replace
Low compres-sion pressure
Improper clear-ance of intake or exhaust valve
Adjust
Defective seat of intake or exhaust valve
Smooth or replace seat
Seizing of intake or exhaust valve stem
Replace
Deterioration or breakage of valve spring
Replace
Compression leak from head gasket
Replace
Sticking, damage, or wear of piston ring
Replace
Scuffing or wear of piston
Replace
Scuffing or wear of liners
Replace
Overheating
Refer to "Overheating"

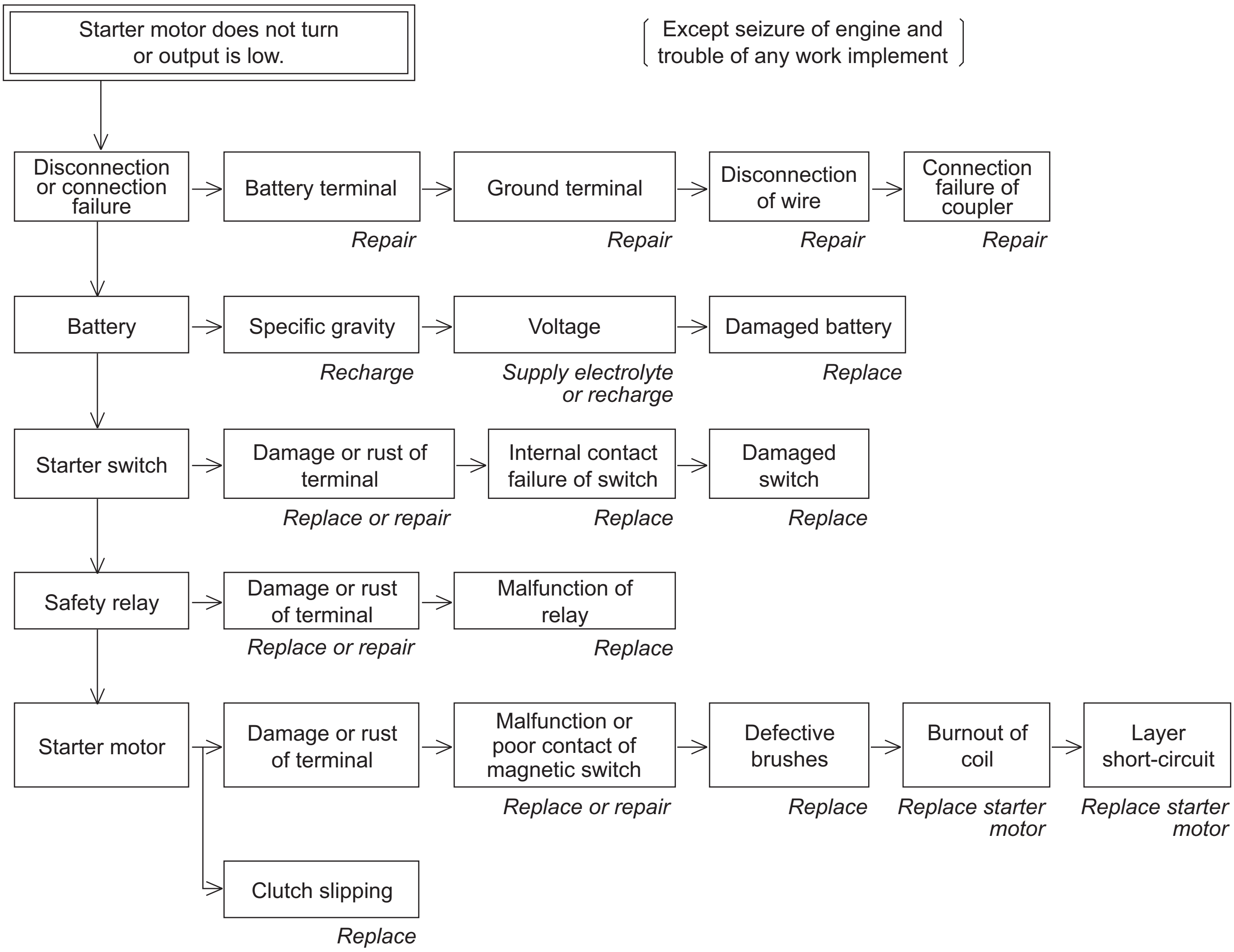
Overheating

- Does the work implement work normally? → Hydraulic power source → Set relief pressure of control valve
- Cooling water system → Low cooling water level (*Supply*) → Loose fan belt (*Adjust*) → Damage or wear of fan belt (*Replace*) → Clogging of radiator (*Clean*) → Excessive exhaust resistance (*Clean*) → Clogging or defect of radiator cap (*Clean or replace*) → Defective thermostat (*Replace*) → Clogging of radiator hose (*Clean*) → Malfunction of cooling water pump (*Replace*) → Malfunction of radiator (*Replace*)
- Excessive intake resistance → Clogging of air cleaner (*Clean or replace*) → Clogging of intake pipe (*Clean*)
- Excessive exhaust resistance → Clogging of muffler (*Clean*) → Clogging of exhaust pipe (*Clean*) → Clogging of cylinder head exhaust port (*Clean*)
- Cylinder head → Gas leak from head gasket (*Replace*) → Crack of cylinder head (*Replace*)
- Fuel system → Improper injection timing (*Correct*) → Defective fuel injection valve (*Repair or replace*)
- Intake or exhaust valve opening/closing timing → Improper clearance of intake or exhaust valve (*Adjust*) → Improper valve opening/closing timing (*Adjust*)
- Piston → Seizing (*Replace*)


Black smoke emission
Does the work implement work normally?
Hydraulic power source
Set relief pressure of control valve
Low output
See “Low output”
Fuel
Improper fuel
Replace
Fuel injection pump
Advanced injection timing
Adjust
Excessive injection volume
Adjust
Uneven injec- tion volume
Adjust or replace
Governor
Improper adjustment
Adjust
Defective lever or link
Repair or replace


White smoke emission
Fuel
Water in fuel
Replace
Mixing with low quality fuel or impurities
Replace
Lubricating oil
Improper grade
Replace
Excessive intake resistance
Clogging of air cleaner
Clean or replace
Clogging of intake pipe
Clean or replace
Fuel injection pump
Delayed injection timing
Adjust
Oil down
Defective valve stem seal
Replace
Damage or wear of valve stem
Replace
Damage or wear of valve guide
Replace
Oil up
Sticking, damage or wear of piston ring
Replace
Scuffing or wear of piston
Replace
Scuffing or wear of liners
Replace
Gas leak from head gasket
Replace
Excessive cooling
Malfunction of thermostat
Replace

10. TROUBLESHOOTING

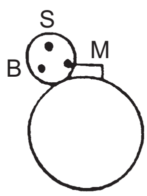


Inspection procedures

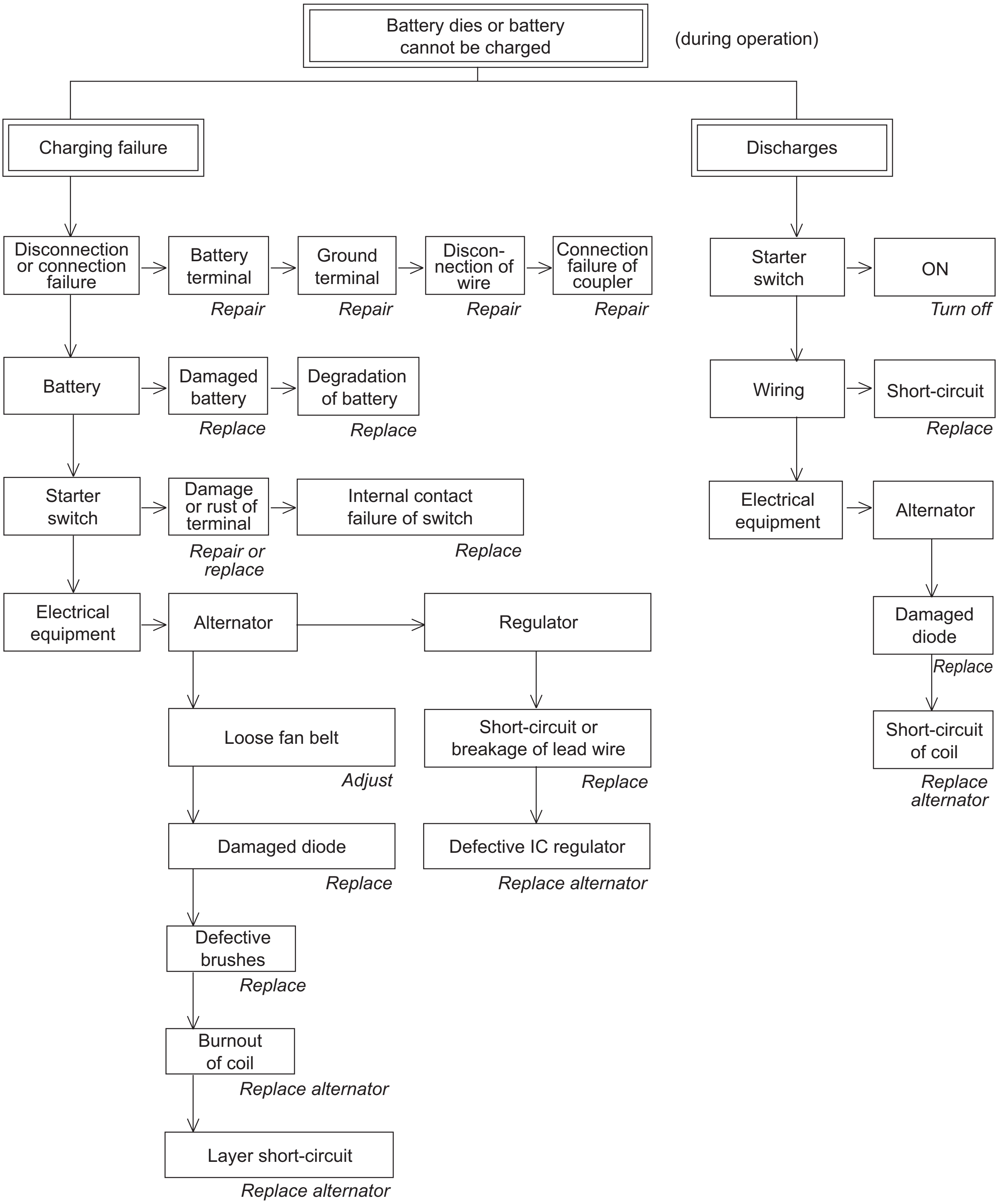
When the starter motor cannot be started by turning the starter switch on, check it as follows.
(Battery, starter switch and wiring assumed to be normal.)

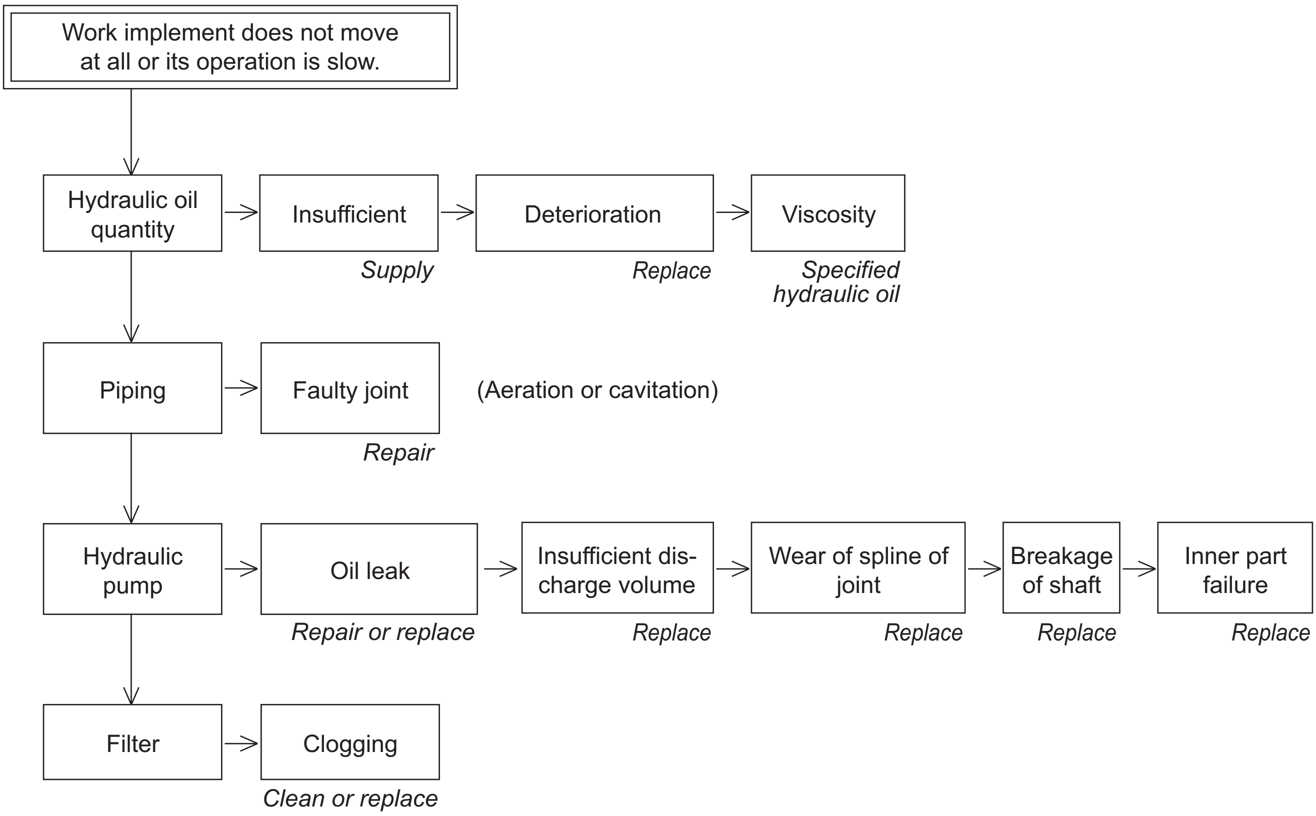
(1) Safety relay & starter motor magnetic switch
   Connect the S-and B-terminals of the starter motor directly.
   [1] When the starter motor turns : The safety relay is faulty.
   [2] When the starter motor does not turn : Either the starter motor magnetic switch or the starter motor is faulty.

(2) Starter motor
   Connect the B-and M-terminals of the starter motor directly.
   [1] When the starter motor turns : Magnetic switch is faulty.
   [2] When the starter motor does not turn : Starter motor is faulty.

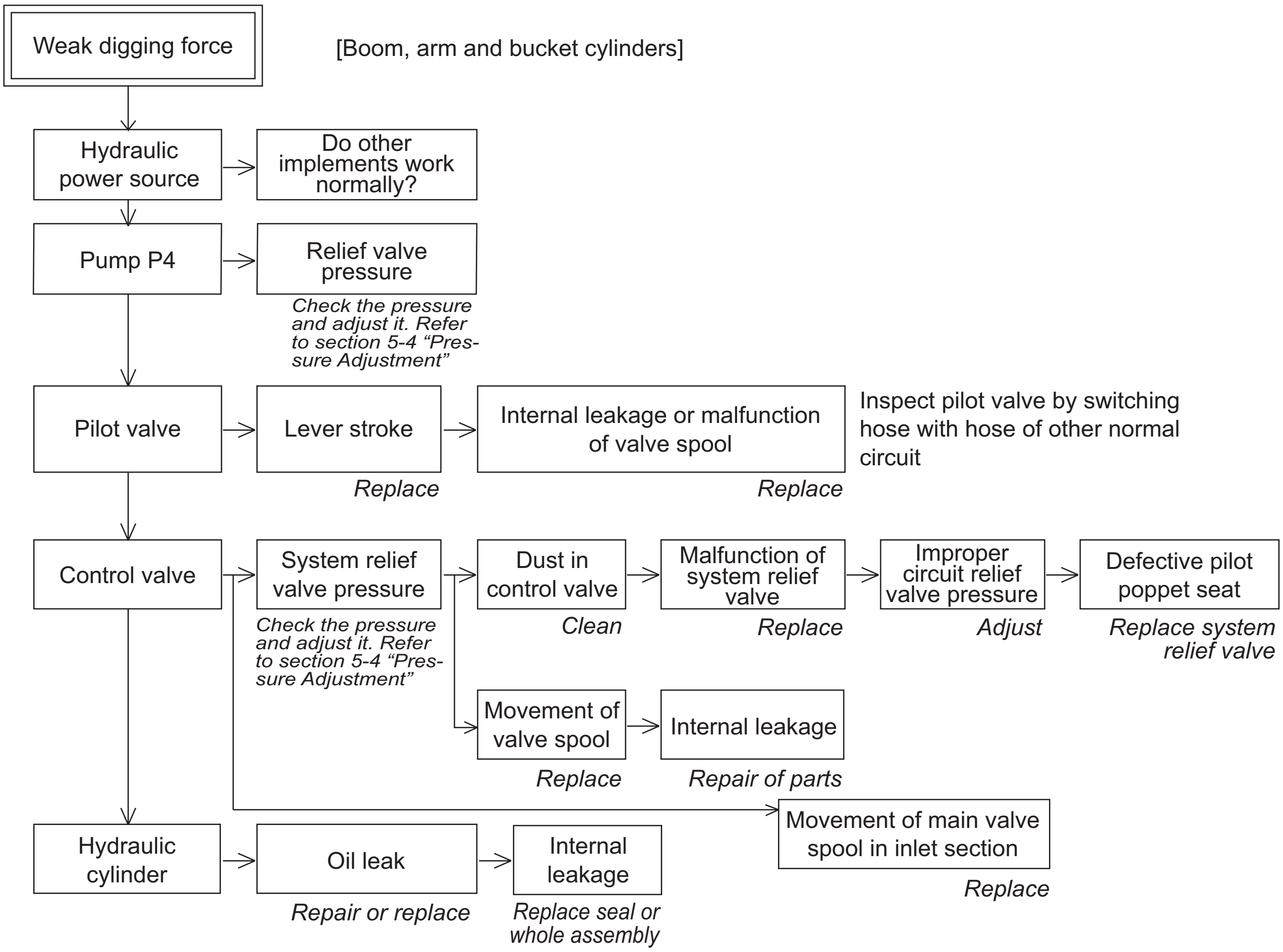


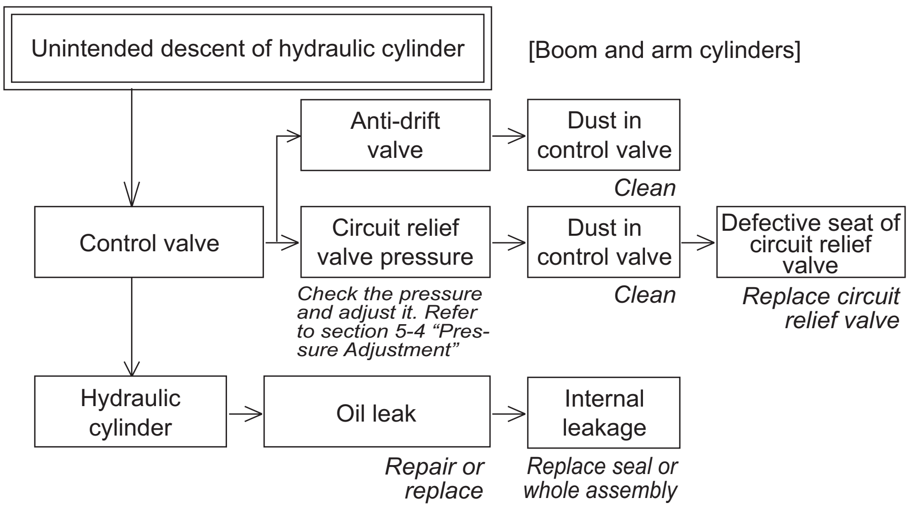
10. TROUBLESHOOTING




Work implement does not move
at all or its operation is slow.
Hydraulic oil quantity
Insufficient
Supply
Deterioration
Replace
Viscosity
Specified hydraulic oil
Piping
Faulty joint
Repair
(Aeration or cavitation)
Hydraulic pump
Oil leak
Repair or replace
Insufficient discharge volume
Replace
Wear of spline of joint
Replace
Breakage of shaft
Replace
Inner part failure
Replace
Filter
Clogging
Clean or replace

Work Implements





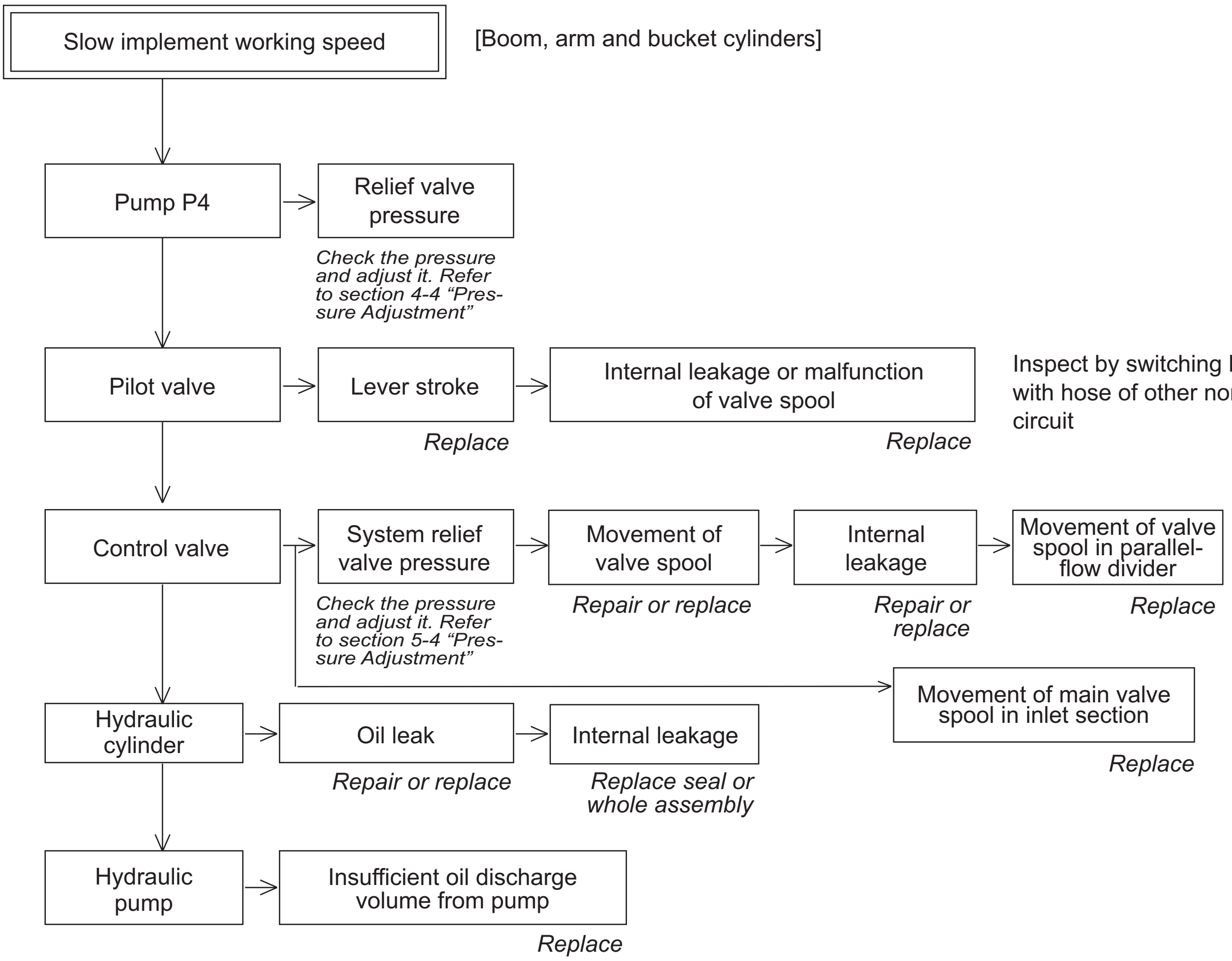
Inspection procedure

Switch the hose with the hose of the other circuit using the control valve.

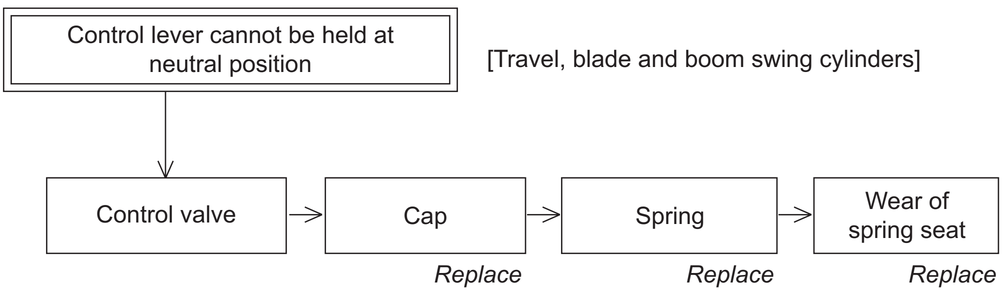
[1] No descent : Control valve is faulty.

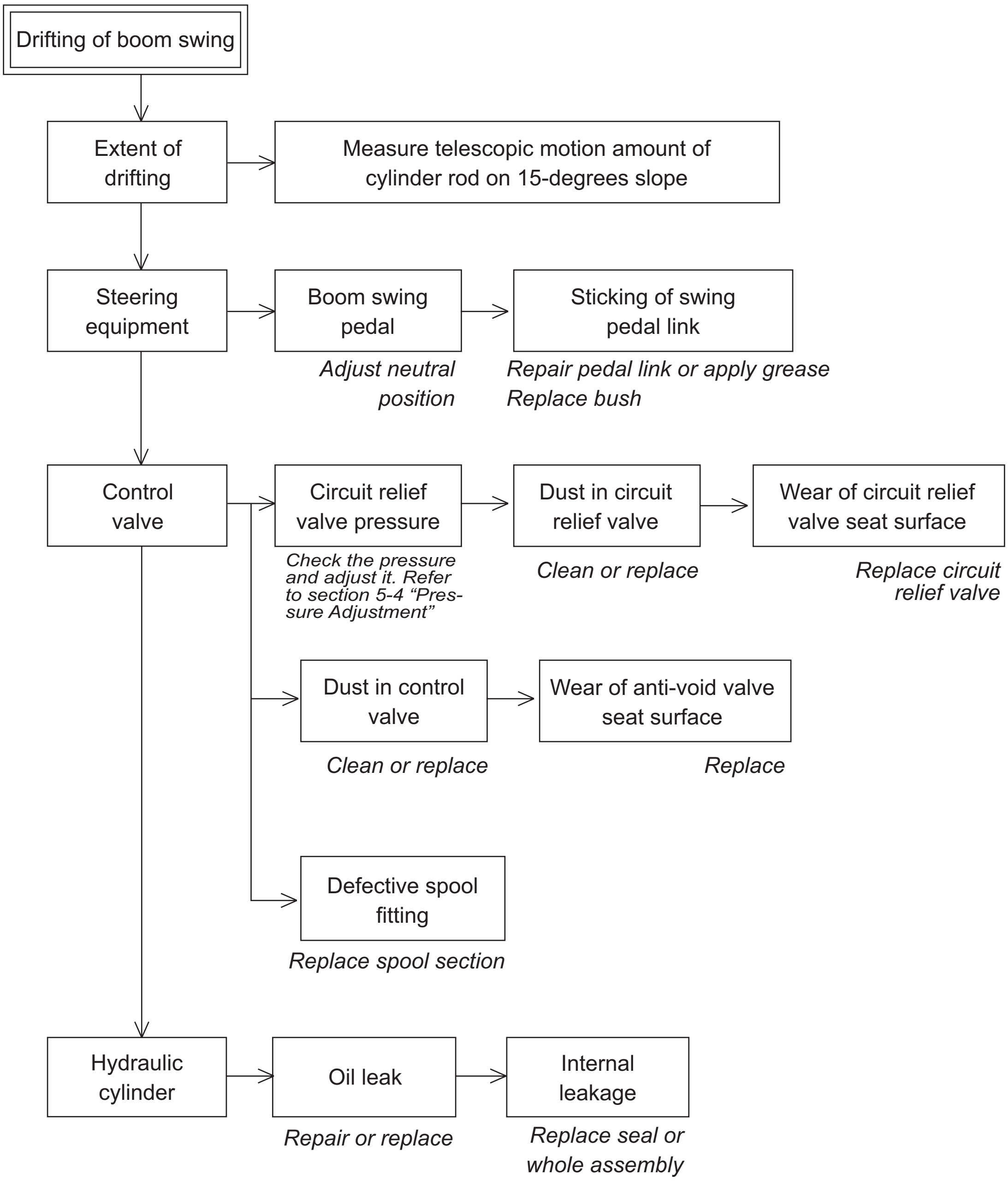
[2] Descent : Cylinder is faulty.

[Boom, arm and bucket cylinders]



[Travel, blade and boom swing cylinders]



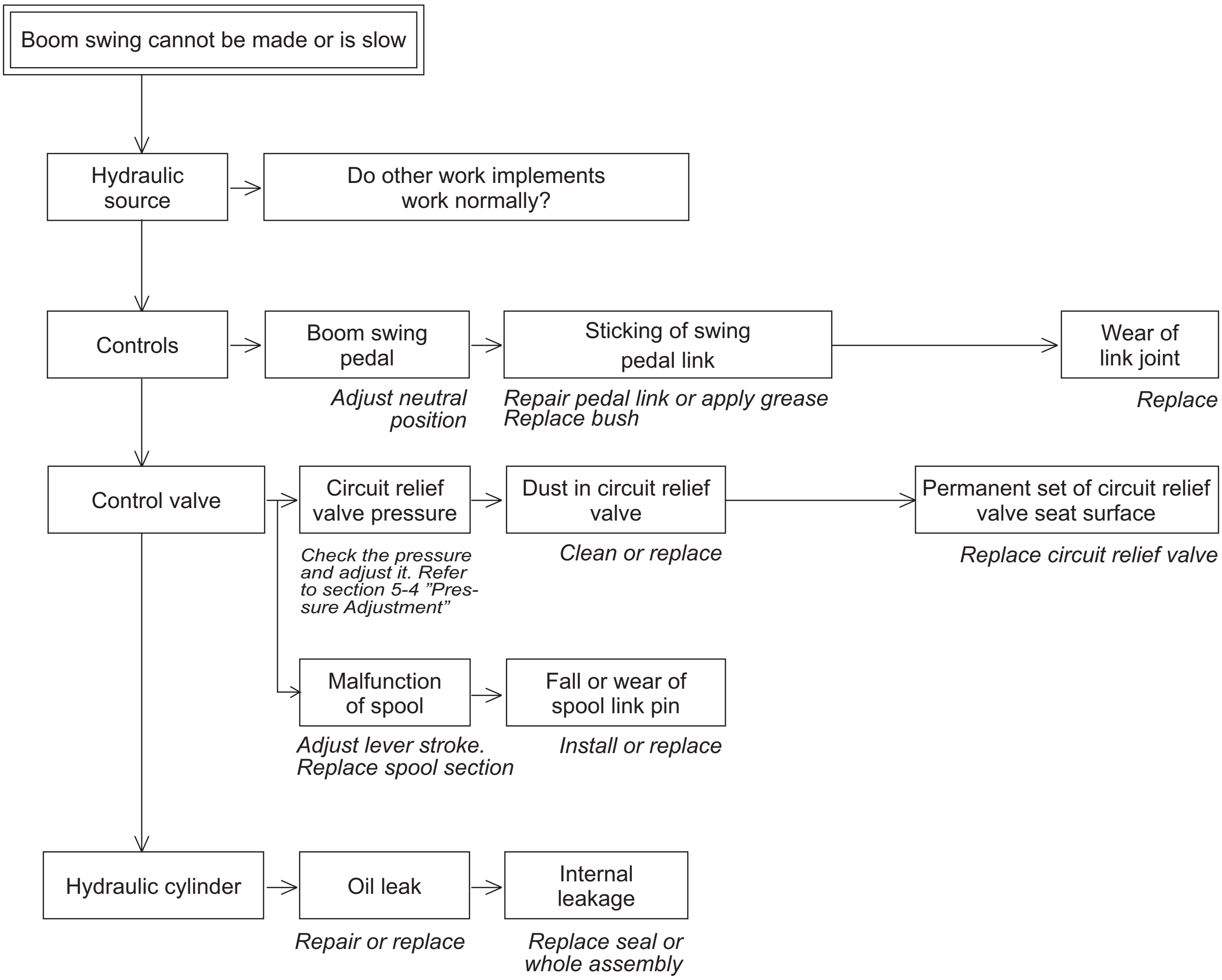


Inspection procedure

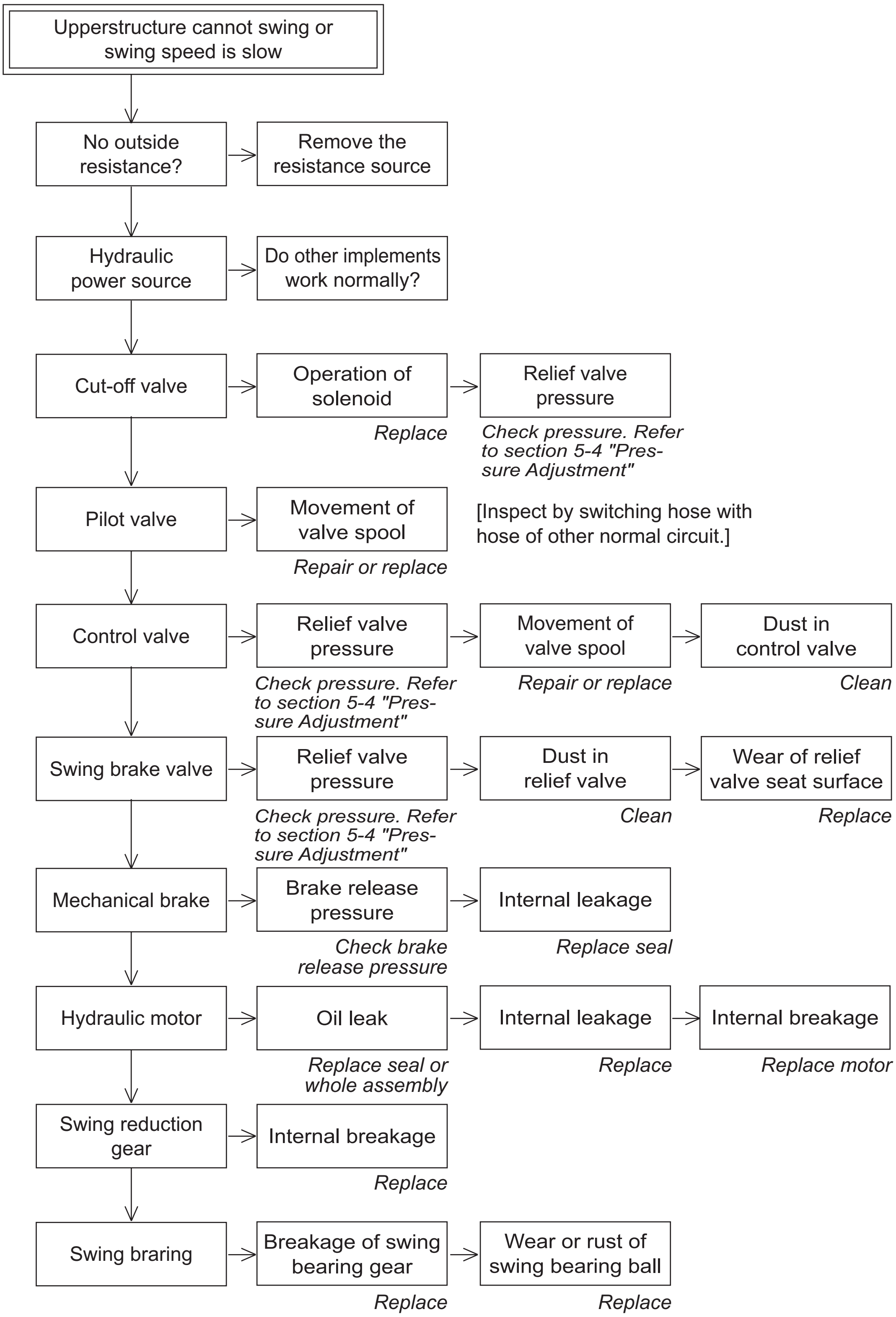
Switch the hose with the hose of the other circuit using the control valve.

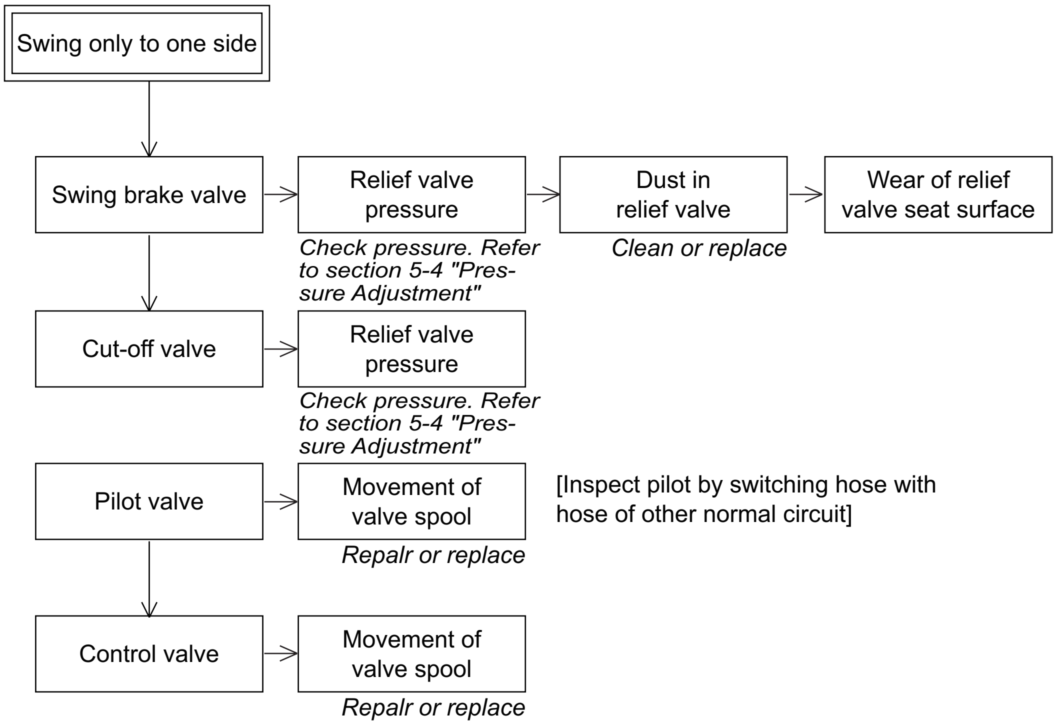
[1] No boom swing drifting : Control valve is faulty.

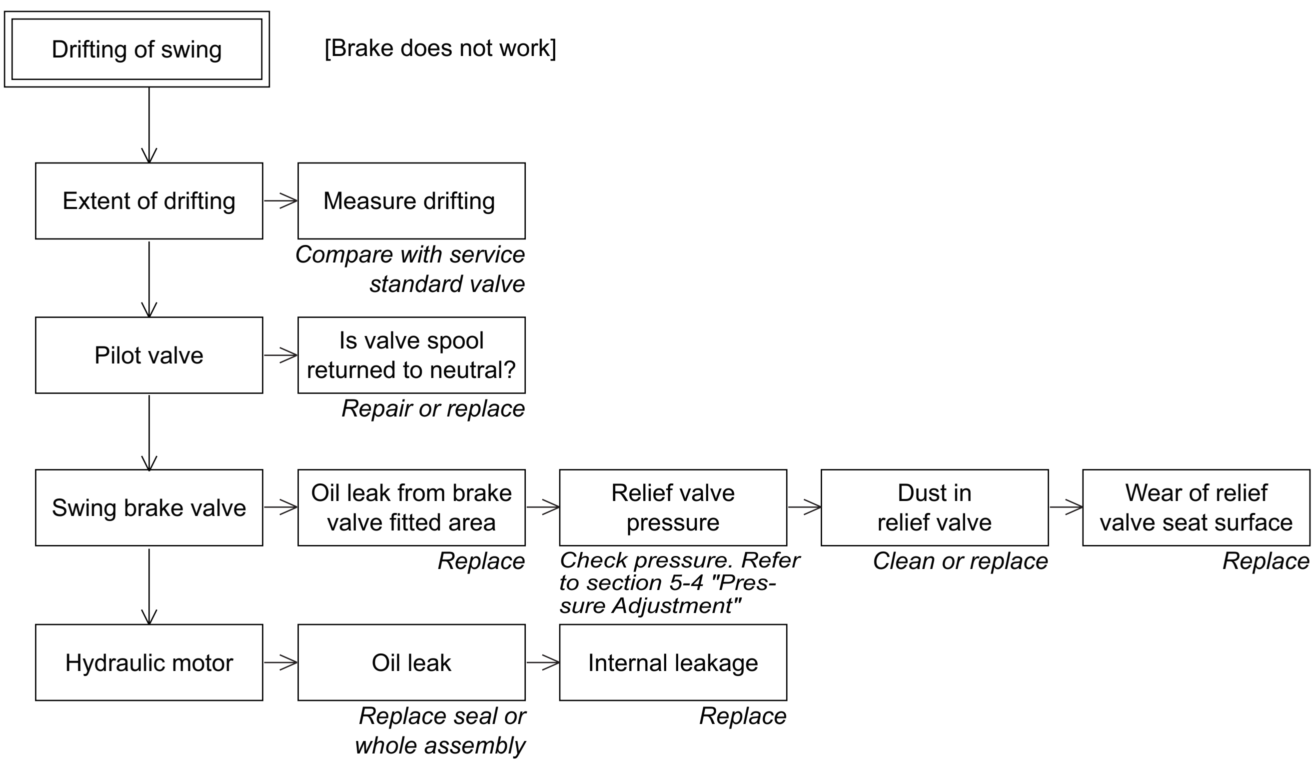
[2] Boom swing drifting : Hydraulic cylinder is faulty.

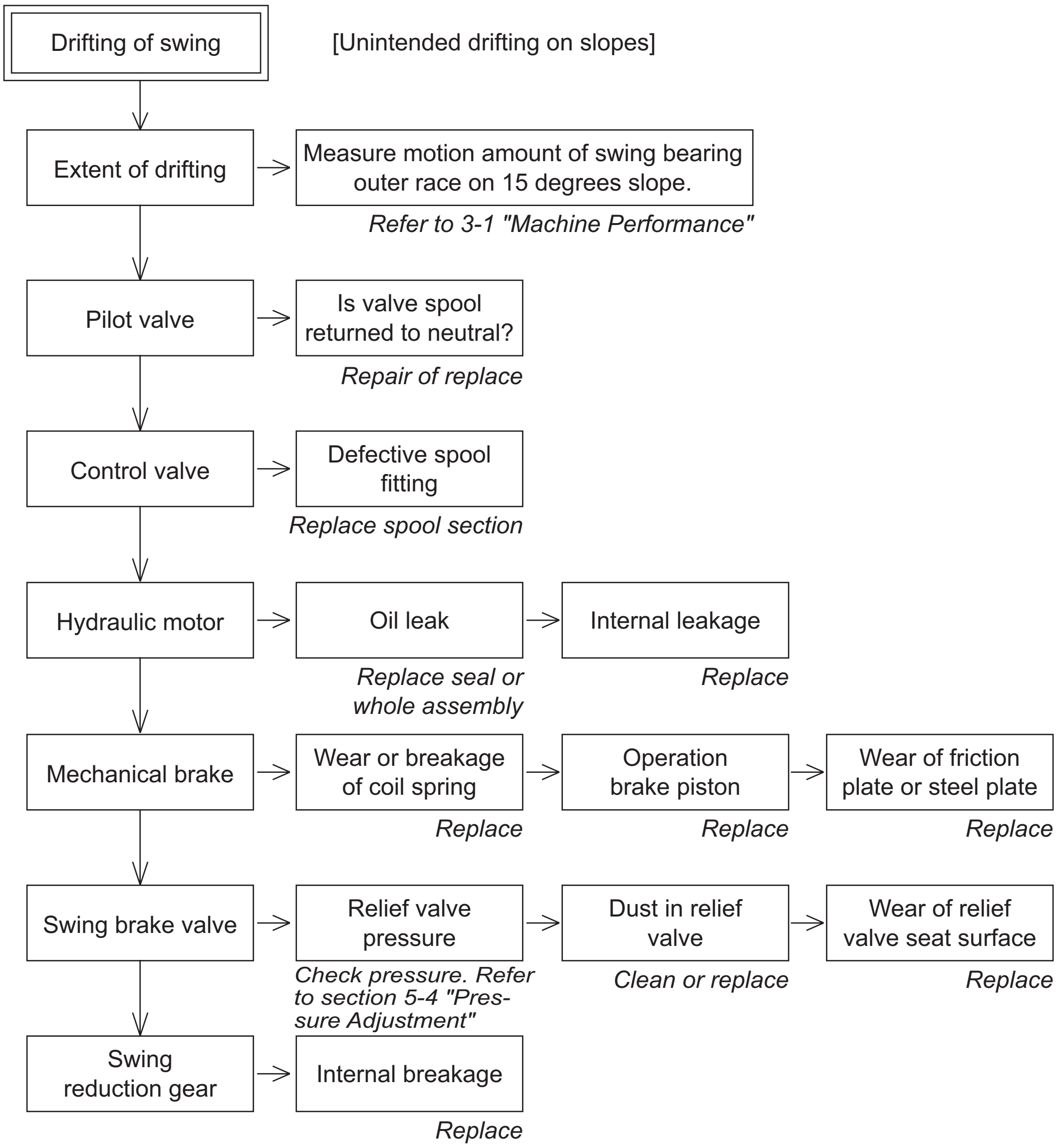


Boom swing cannot be made or is slow
Hydraulic source
Do other work implements work normally?
Controls
Boom swing pedal
Adjust neutral position
Sticking of swing pedal link
Repair pedal link or apply grease
Replace bush
Wear of link joint
Replace
Control valve
Circuit relief valve pressure
Check the pressure and adjust it. Refer to section 5-4 "Pressure Adjustment"
Dust in circuit relief valve
Clean or replace
Permanent set of circuit relief valve seat surface
Replace circuit relief valve
Malfunction of spool
Adjust lever stroke.
Replace spool section
Fall or wear of spool link pin
Install or replace
Hydraulic cylinder
Oil leak
Repair or replace
Internal leakage
Replace seal or whole assembly


Upperstructure cannot swing or swing speed is slow
No outside resistance?
Remove the resistance source
Hydraulic power source
Do other implements work normally?
Cut-off valve
Operation of solenoid
Replace
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Pilot valve
Movement of valve spool
Repair or replace
[Inspect by switching hose with hose of other normal circuit.]
Control valve
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Movement of valve spool
Repair or replace
Dust in control valve
Clean
Swing brake valve
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Dust in relief valve
Clean
Wear of relief valve seat surface
Replace
Mechanical brake
Brake release pressure
Check brake release pressure
Internal leakage
Replace seal
Hydraulic motor
Oil leak
Replace seal or whole assembly
Internal leakage
Replace
Internal breakage
Replace motor
Swing reduction gear
Internal breakage
Replace
Swing braring
Breakage of swing bearing gear
Replace
Wear or rust of swing bearing ball
Replace

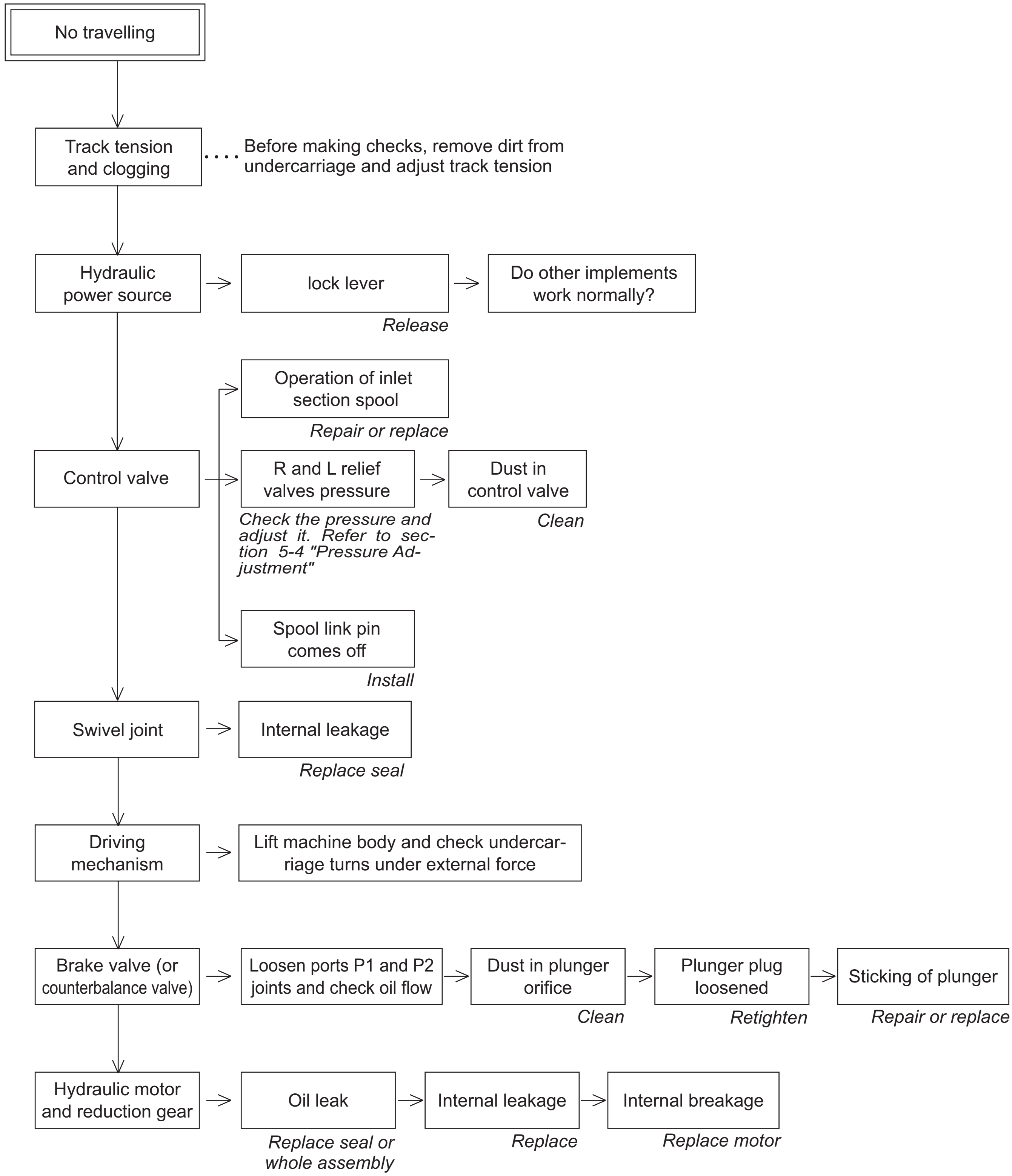

Swing only to one side
Swing brake valve
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Dust in relief valve
Clean or replace
Wear of relief valve seat surface
Cut-off valve
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Pilot valve
Movement of valve spool
Repalr or replace
[Inspect pilot by switching hose with hose of other normal circuit]
Control valve
Movement of valve spool
Repalr or replace

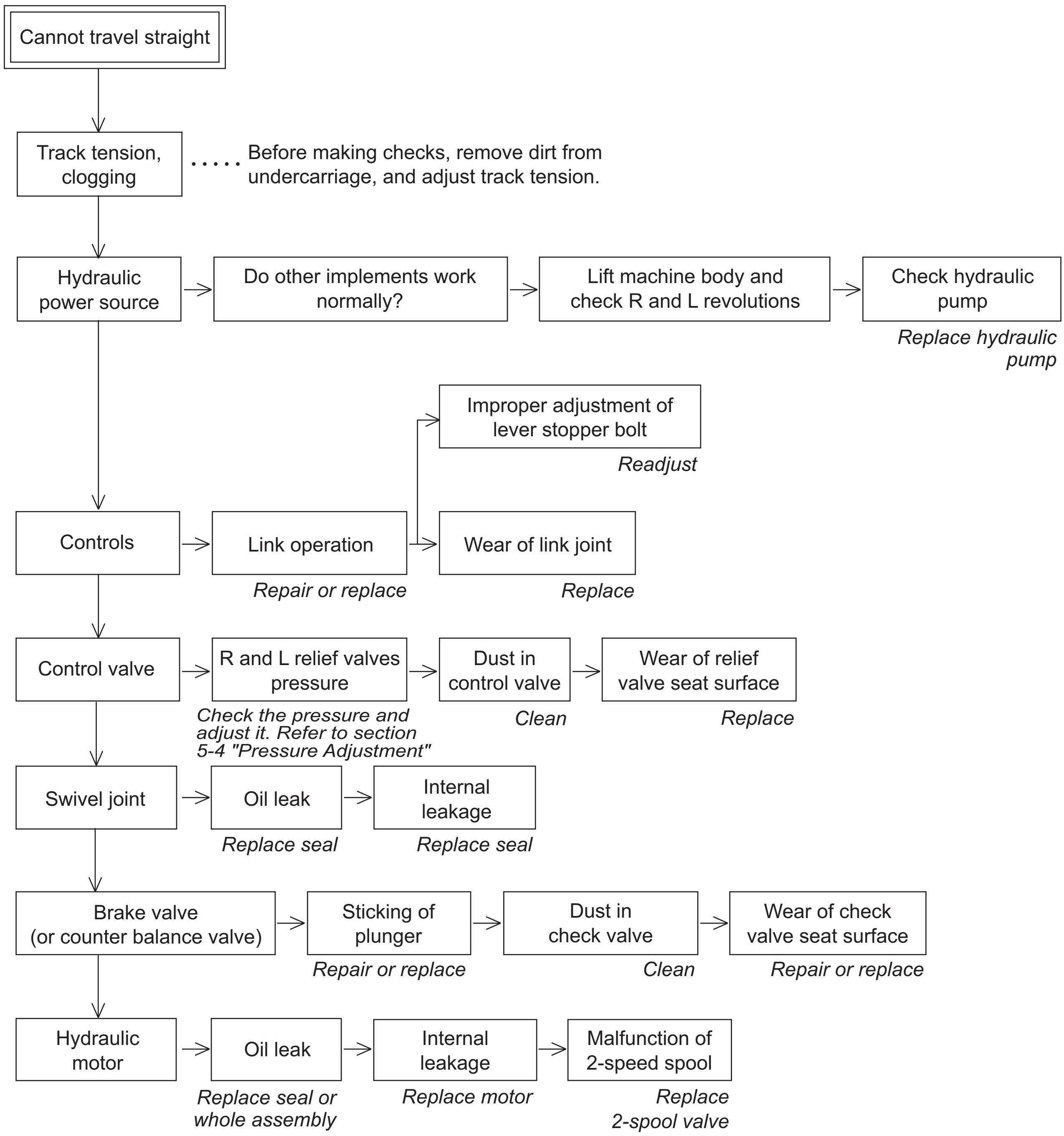

Drifting of swing
[Brake does not work]
Extent of drifting
Measure drifting
Compare with service standard valve
Pilot valve
Is valve spool returned to neutral?
Repair or replace
Swing brake valve
Oil leak from brake valve fitted area
Replace
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Dust in relief valve
Clean or replace
Wear of relief valve seat surface
Replace
Hydraulic motor
Oil leak
Replace seal or whole assembly
Internal leakage
Replace



Drifting of swing
[Unintended drifting on slopes]
Extent of drifting
Measure motion amount of swing bearing outer race on 15 degrees slope.
Refer to 3-1 "Machine Performance"
Pilot valve
Is valve spool returned to neutral?
Repair of replace
Control valve
Defective spool fitting
Replace spool section
Hydraulic motor
Oil leak
Replace seal or whole assembly
Internal leakage
Replace
Mechanical brake
Wear or breakage of coil spring
Replace
Operation brake piston
Replace
Wear of friction plate or steel plate
Replace
Swing brake valve
Relief valve pressure
Check pressure. Refer to section 5-4 "Pressure Adjustment"
Dust in relief valve
Clean or replace
Wear of relief valve seat surface
Replace
Swing reduction gear
Internal breakage
Replace

Travel Equipment




Cannot travel straight
Track tension, clogging
Before making checks, remove dirt from undercarriage, and adjust track tension.
Hydraulic power source
Do other implements work normally?
Lift machine body and check R and L revolutions
Check hydraulic pump
Replace hydraulic pump
Improper adjustment of lever stopper bolt
Readjust
Controls
Link operation
Repair or replace
Wear of link joint
Replace
Control valve
R and L relief valves pressure
Check the pressure and adjust it. Refer to section 5-4 "Pressure Adjustment"
Dust in control valve
Clean
Wear of relief valve seat surface
Replace
Swivel joint
Oil leak
Replace seal
Internal leakage
Replace seal
Brake valve (or counter balance valve)
Sticking of plunger
Repair or replace
Dust in check valve
Clean
Wear of check valve seat surface
Repair or replace
Hydraulic motor
Oil leak
Replace seal or whole assembly
Internal leakage
Replace motor
Malfunction of 2-speed spool
Replace 2-spool valve

Inspection procedures

1. When the hydraulic tester is not used :

(1) Reverse the hoses of the hydraulic pumps P1 and P2.
Phenomenon : Reversed .... Replace the hydraulic pump.

(2) Reverse the hoses between the control valve and the swivel joint.
Phenomenon : Reversed .... Overhaul or replace the control valve.

(3) Reverse the hoses between the swivel joint and the brake valve (or counter balance valve).
Phenomenon : Reversed .... Overhaul or replace the swivel joint.

(4) Reverse the left and right hydraulic motors.
Phenomenon : Reversed .... Replace the counter balance valve (or counter balance valve) or the motor.

2. When the hydraulic tester is used :

(1) Flow volume at no load (Check the difference between the right and left motors.)

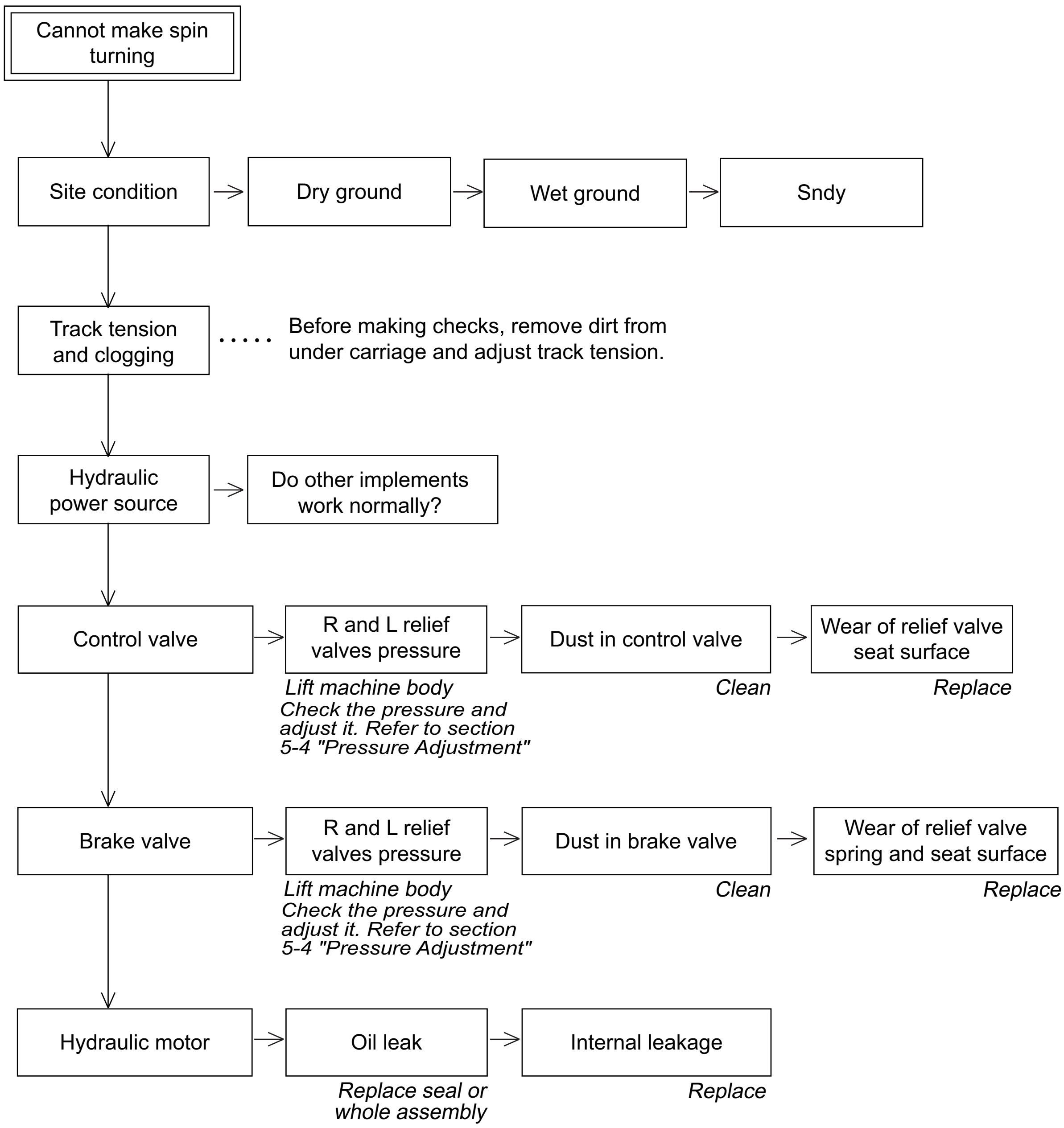
(2) Flow volume when loaded (Check the difference between the right and left motors.)

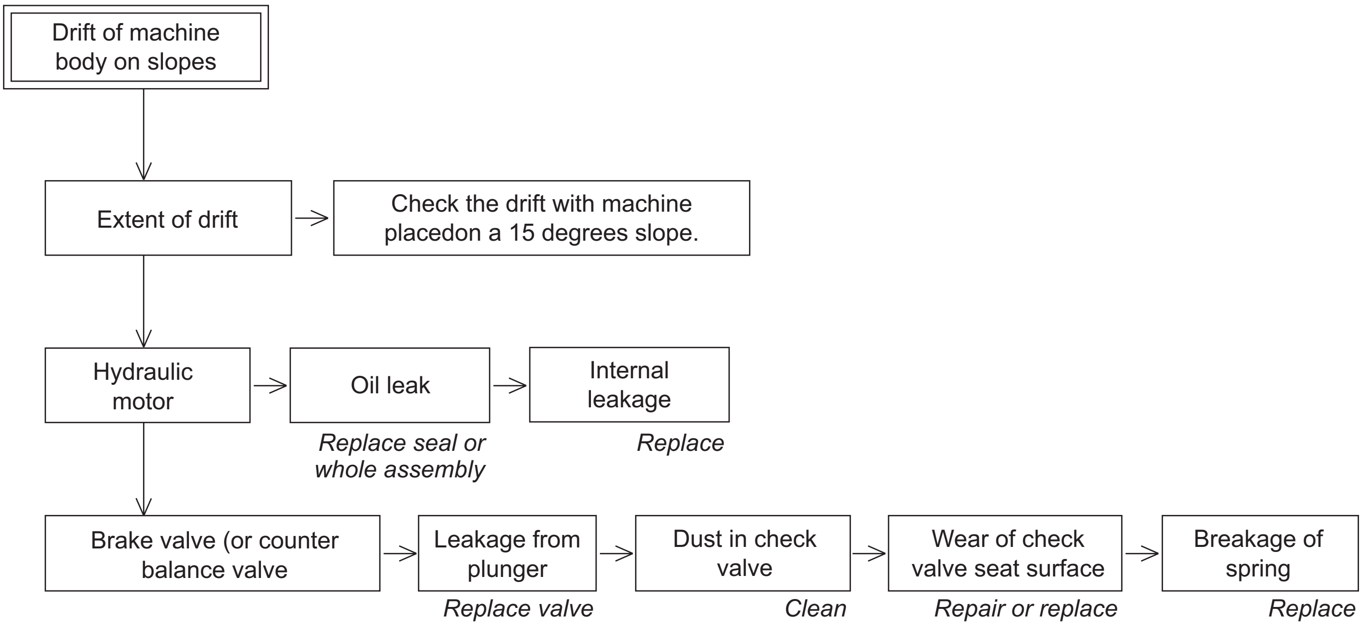
Conditions :

(1) Discharge volume at no load
(2) Discharge volume when loaded
} Make judgment by reading the difference between the right and left motors.

(3) Engine at rated speed.

(4) Hydraulic oil temp. at 122 to 140˚F (50 to 60˚C)


Cannot make spin turning
Site condition
Dry ground
Wet ground
Sndy
Track tension and clogging
Before making checks, remove dirt from under carriage and adjust track tension.
Hydraulic power source
Do other implements work normally?
Control valve
R and L relief valves pressure
Lift machine body
Check the pressure and adjust it. Refer to section 5-4 "Pressure Adjustment"
Dust in control valve
Clean
Wear of relief valve seat surface
Replace
Brake valve
R and L relief valves pressure
Lift machine body
Check the pressure and adjust it. Refer to section 5-4 "Pressure Adjustment"
Dust in brake valve
Clean
Wear of relief valve spring and seat surface
Replace
Hydraulic motor
Oil leak
Replace seal or whole assembly
Internal leakage
Replace

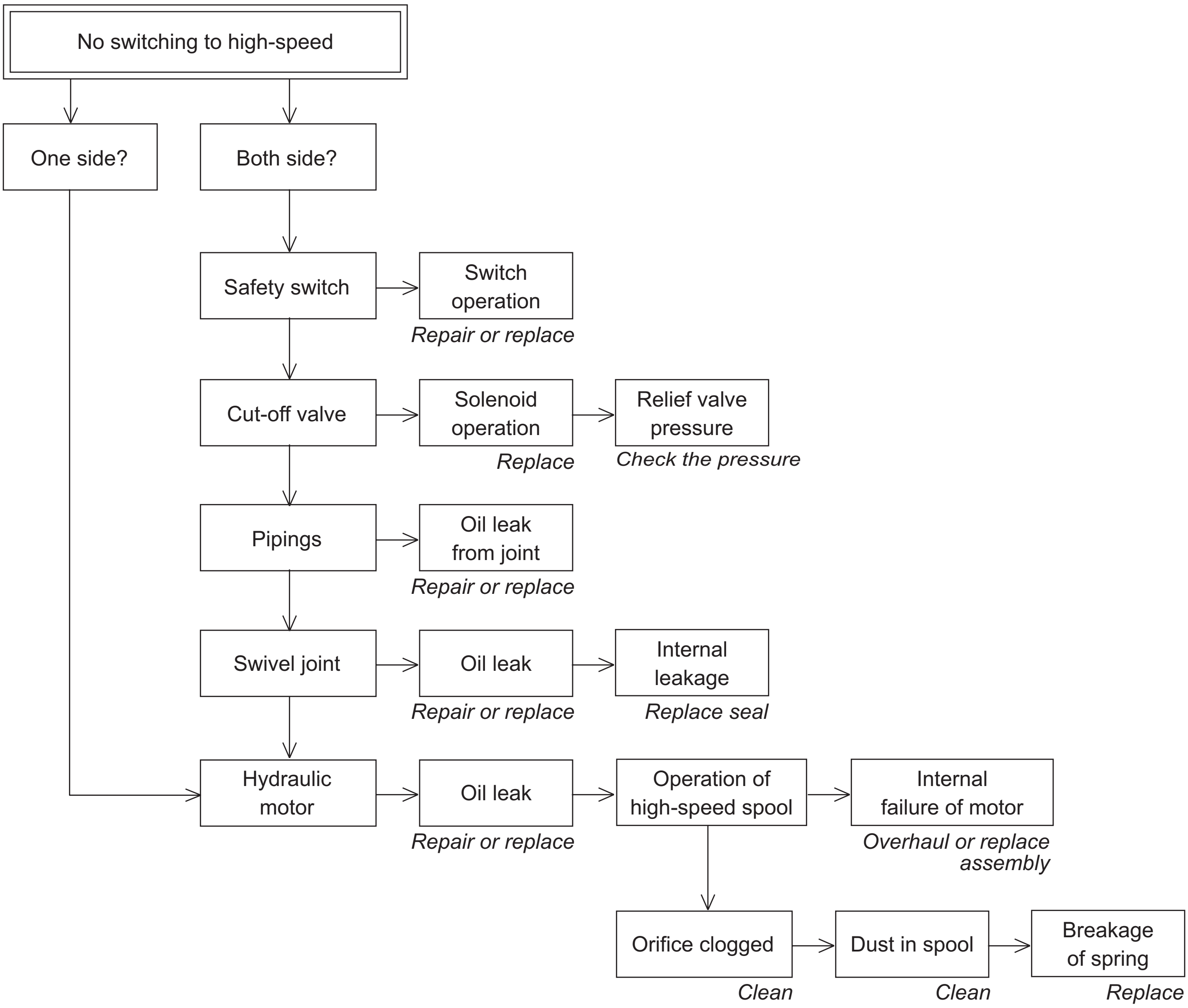


Inspection procedures

Check the drift with the machine placed on a slope with an inclination angle below 15 degrees.

[1] Continuous drift : Brake valve (or counter balance valve) is faulty.

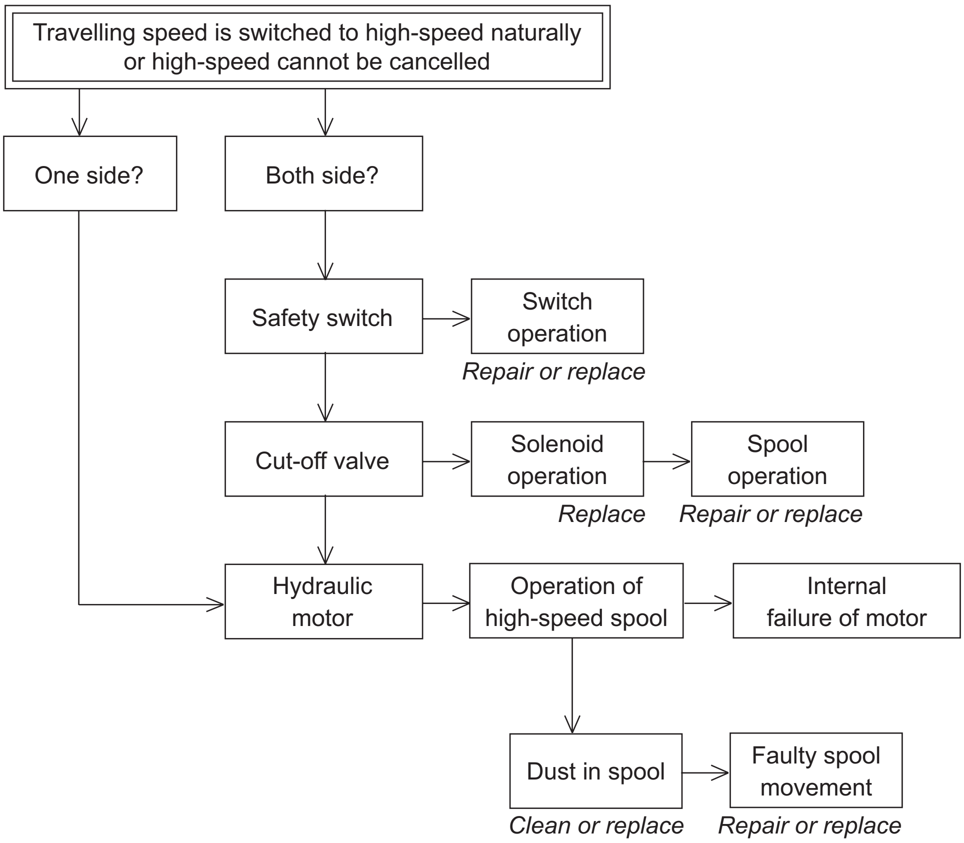
[2] Discontinuous drift : Hydraulic motor is faulty.



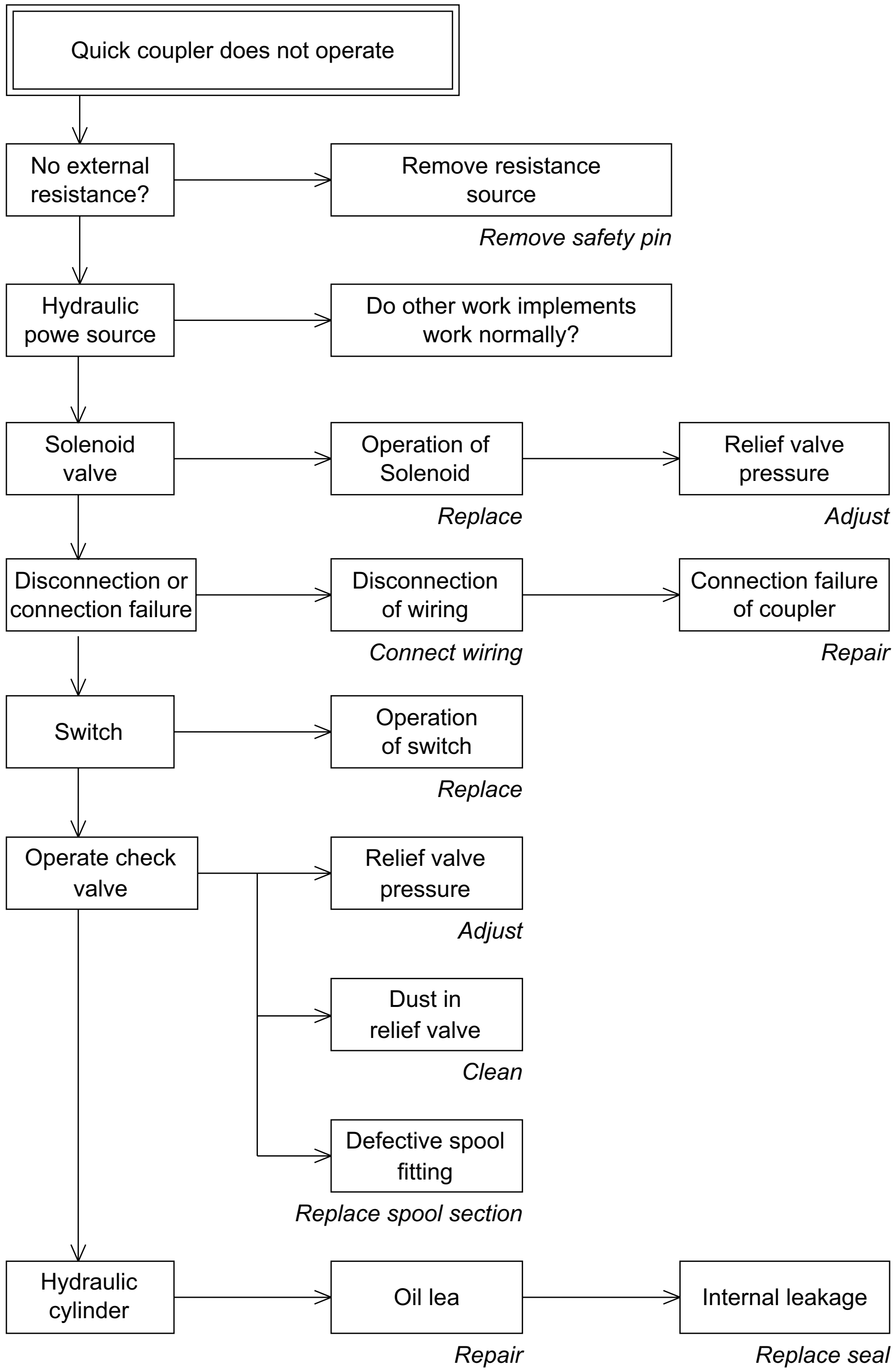
Note :

When the oil temp. is still very low, switching to high-speed may not be made immediately when treading on the high-speed pedal. This problem disappears as the oil temperature rises.

(Refer to Section "10-1-7 Time Lag on Travel Speed Switching".)

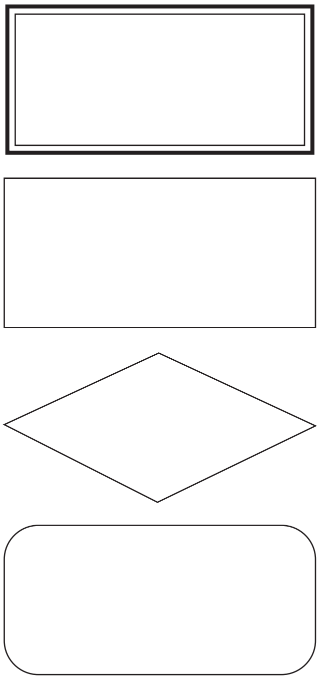

Travelling speed is switched to high-speed naturally or high-speed cannot be cancelled
One side?
Both side?
Safety switch
Switch operation
Repair or replace
Cut-off valve
Solenoid operation
Replace
Spool operation
Repair or replace
Hydraulic motor
Operation of high-speed spool
Internal failure of motor
Dust in spool
Clean or replace
Faulty spool movement
Repair or replace

Quick Coupler Type



10-2-2 Electrical Equipment on Panel

(1) How to read the chart



: Trouble

: Inspection/repair instructions

: Check item

: Factors in trouble or treatment

(2) Refer to the wiring diagram for the number of the connector terminal and lead wire color.

(3) Color marks of leads

W (White)	B(Black)	R (Red)	Y (Yellow)
G (Green)	L (Blue)	Br (Brown)	Lg (Light green)
O (Orange)	Gr (Grey)		

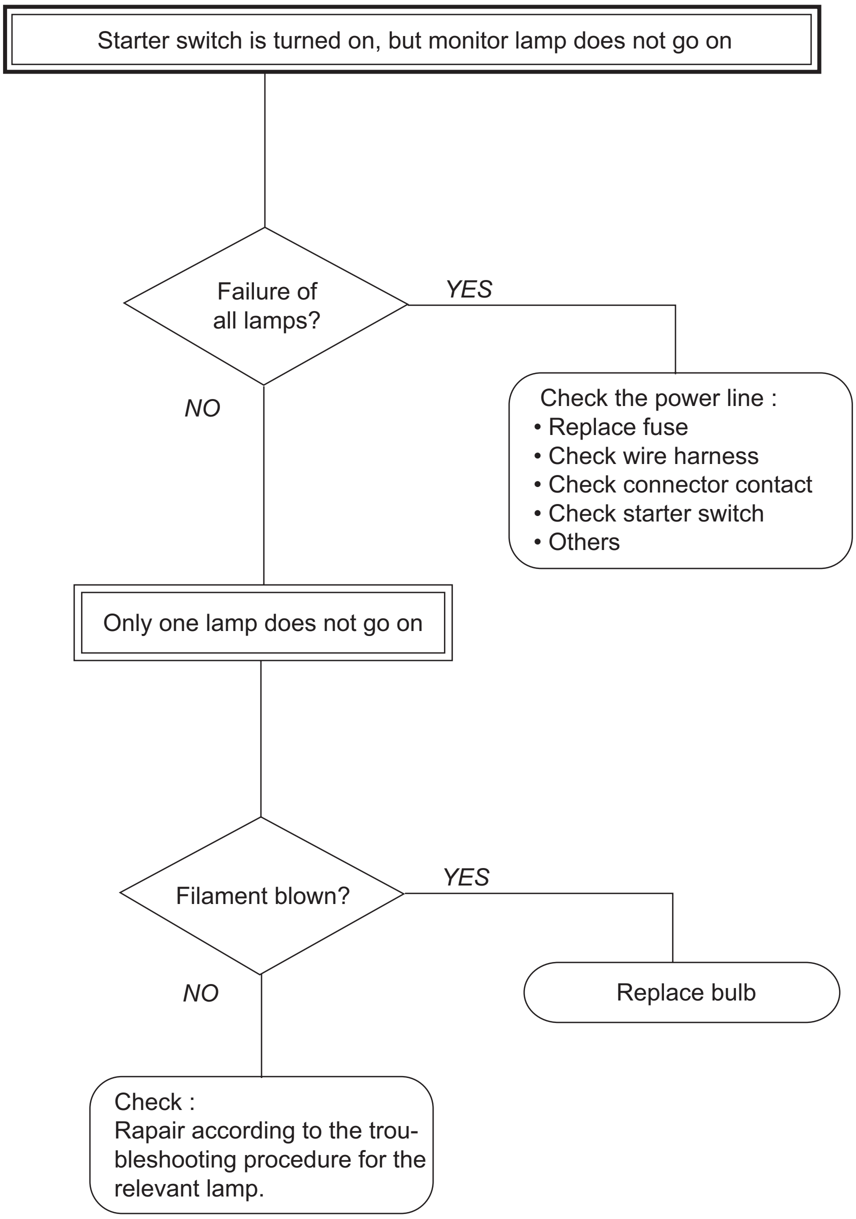
Combination of colors

Example : W R ....(Red stripes on white background)

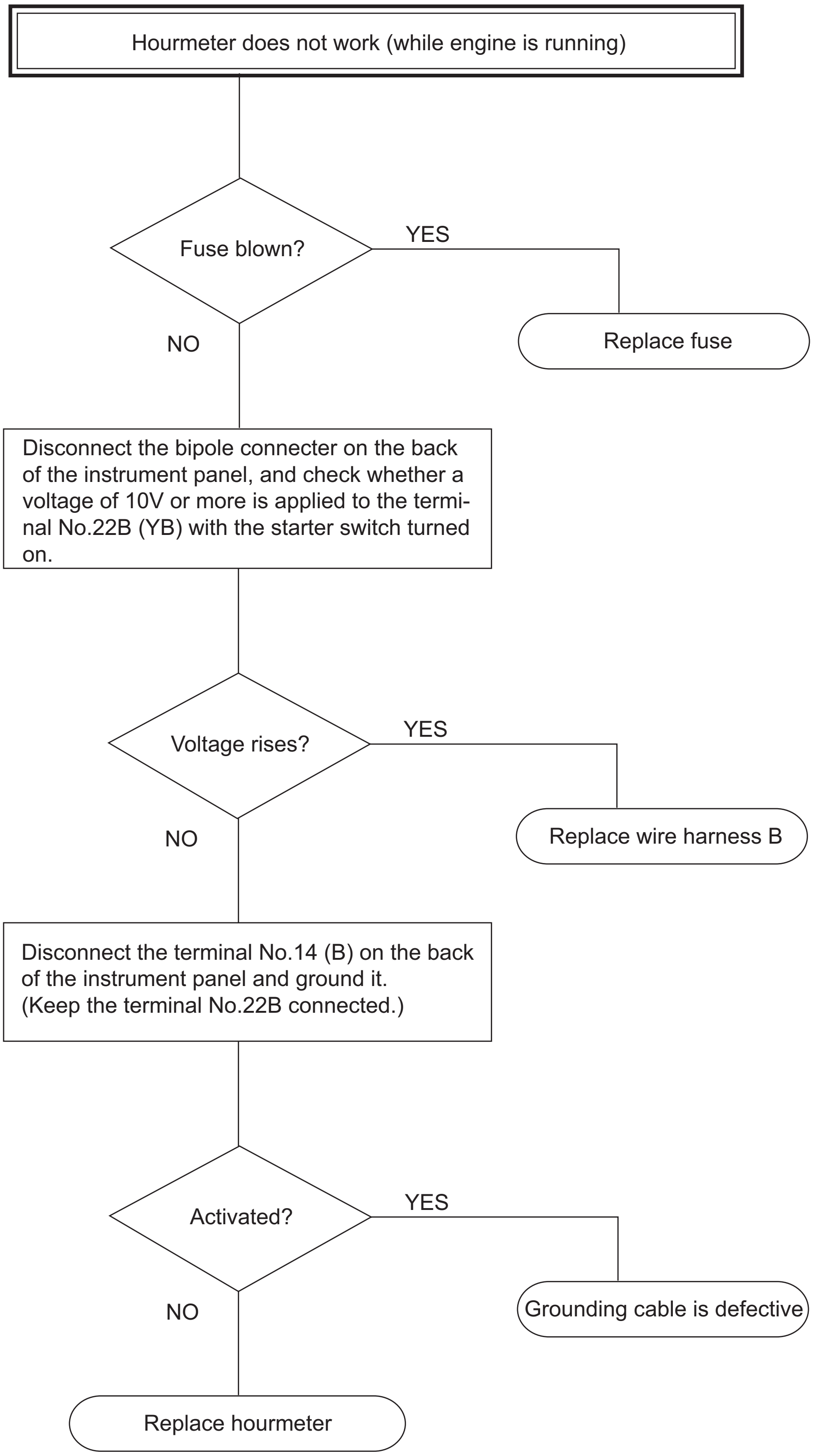
Marking color

Background color

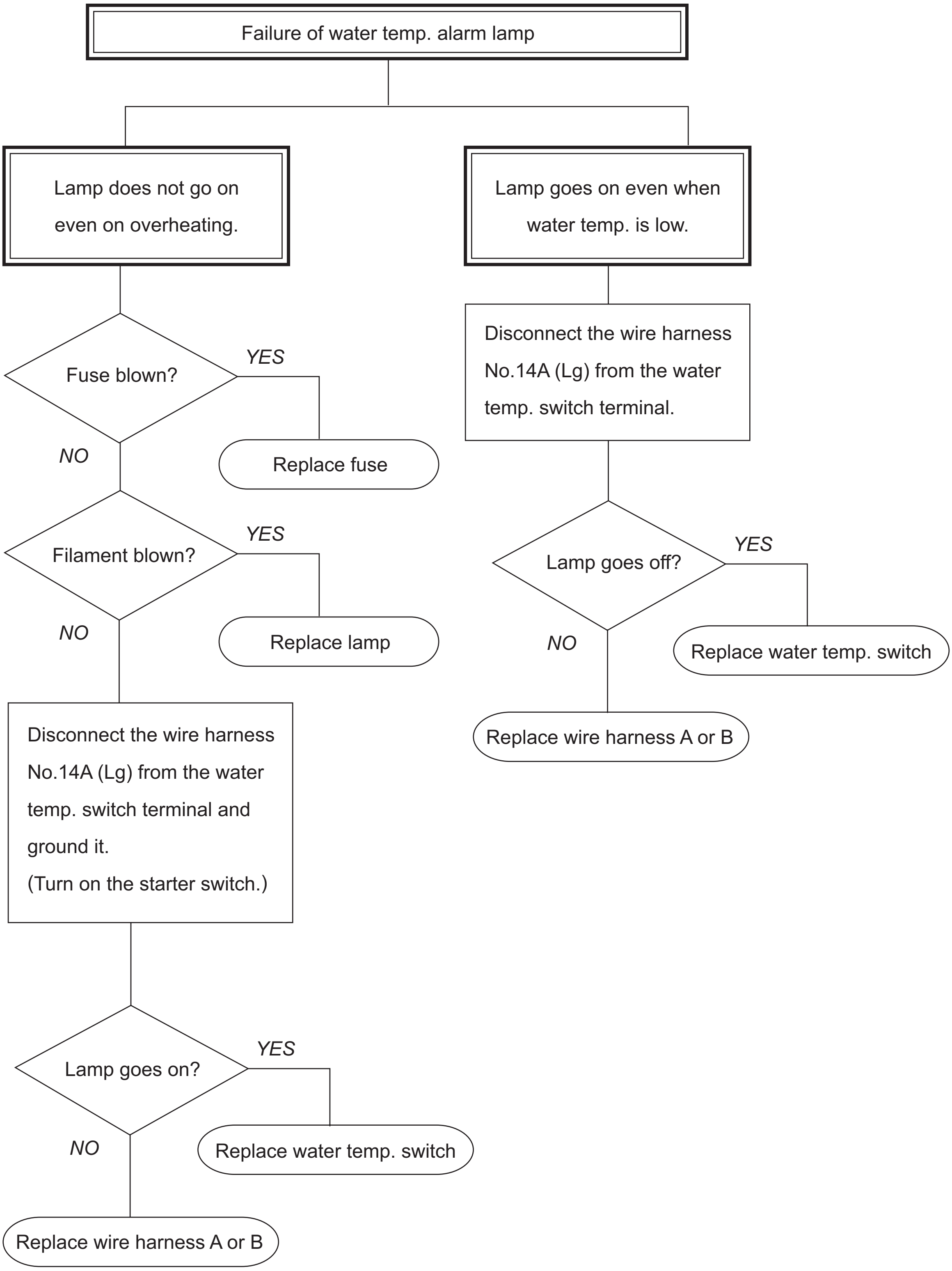
Monitor Lamps



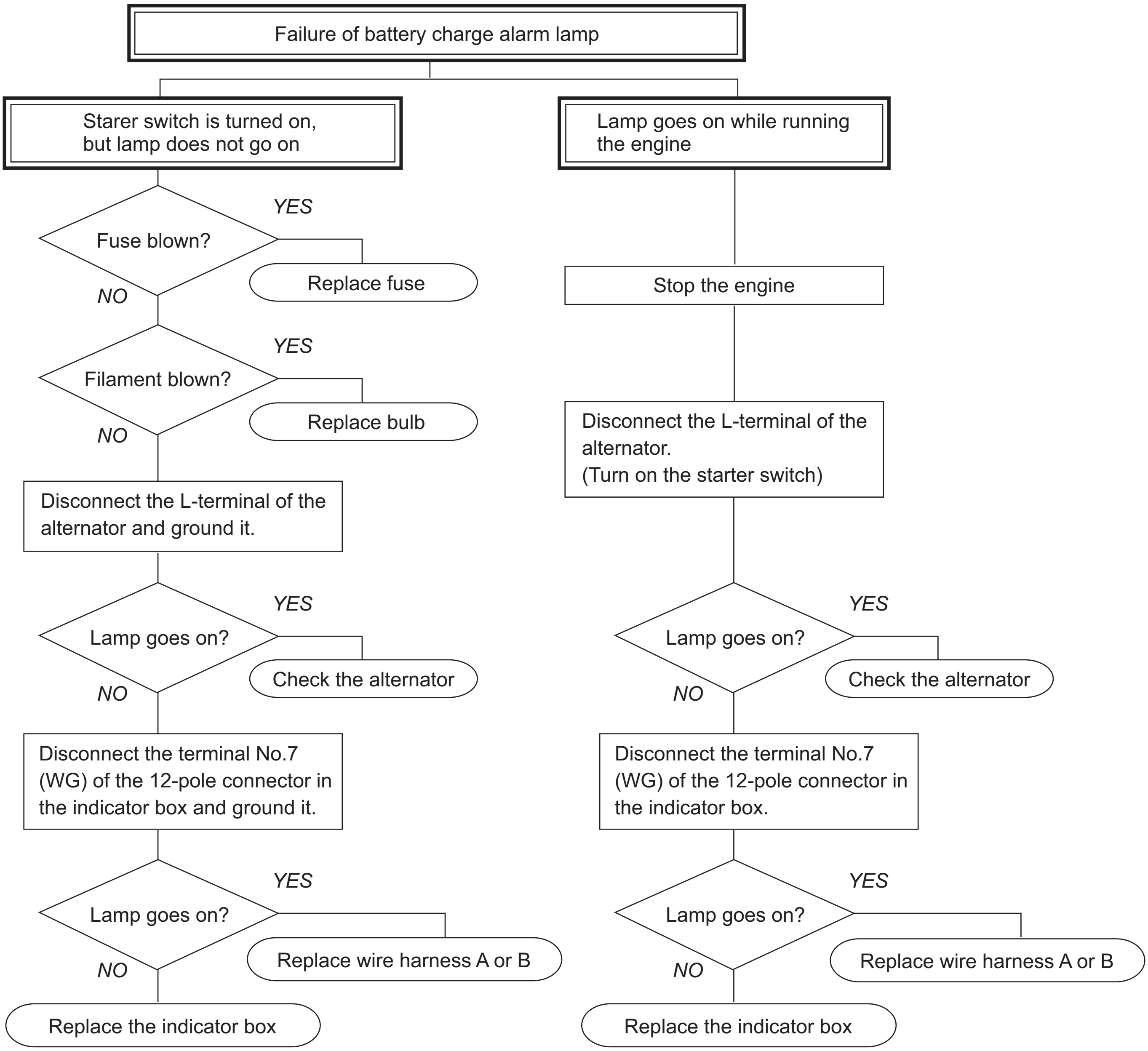
Hourmeter


Hourmeter does not work (while engine is running)
Fuse blown?
YES
Replace fuse
NO
Disconnect the bipole connecter on the back of the instrument panel, and check whether a voltage of 10V or more is applied to the terminal No.22B (YB) with the starter switch turned on.
Voltage rises?
YES
Replace wire harness B
NO
Disconnect the terminal No.14 (B) on the back of the instrument panel and ground it.
(Keep the terminal No.22B connected.)
Activated?
YES
Grounding cable is defective
NO
Replace hourmeter

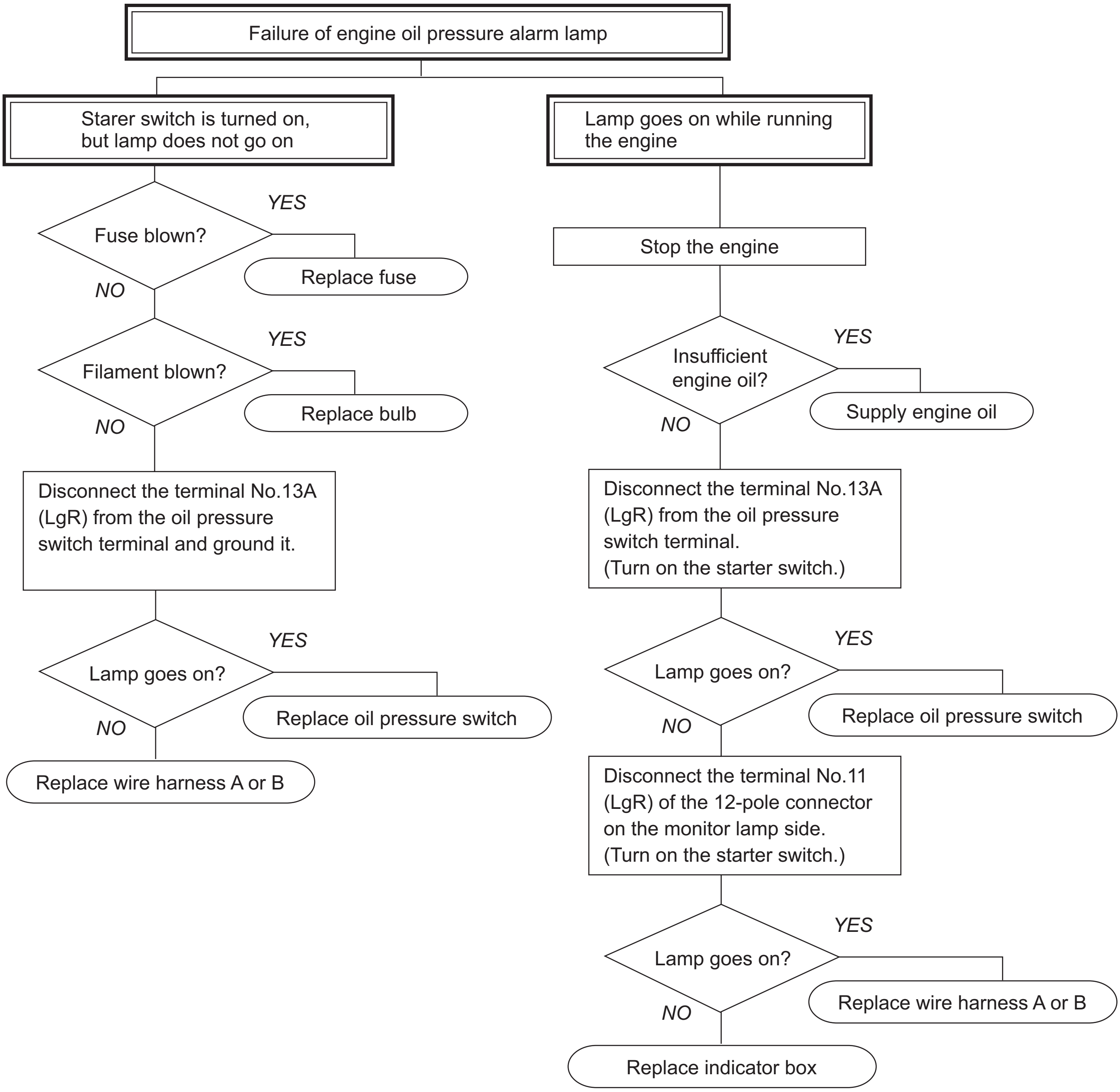
Water Temp. Alarm Lamp



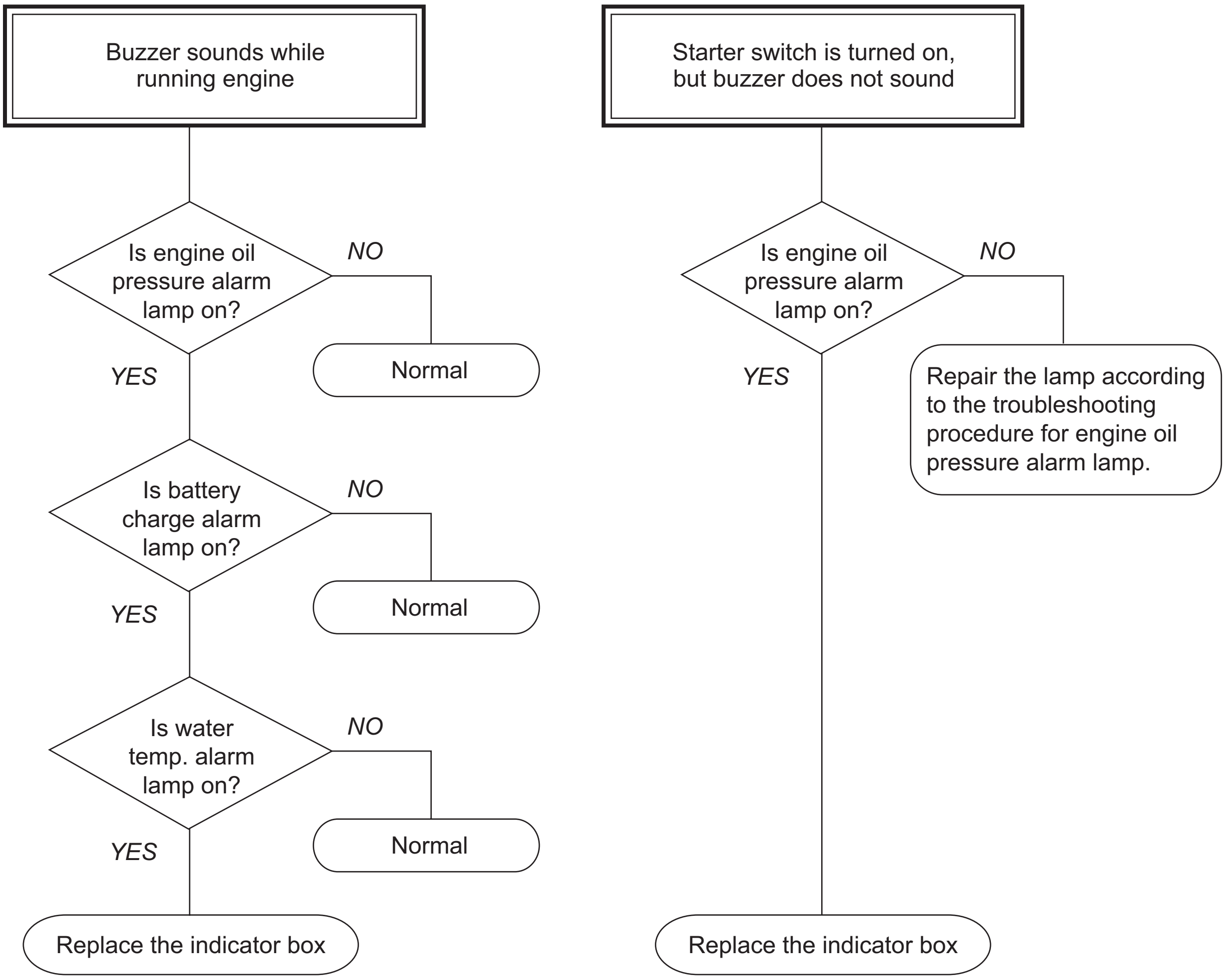
Battery Charge Alarm Lamp



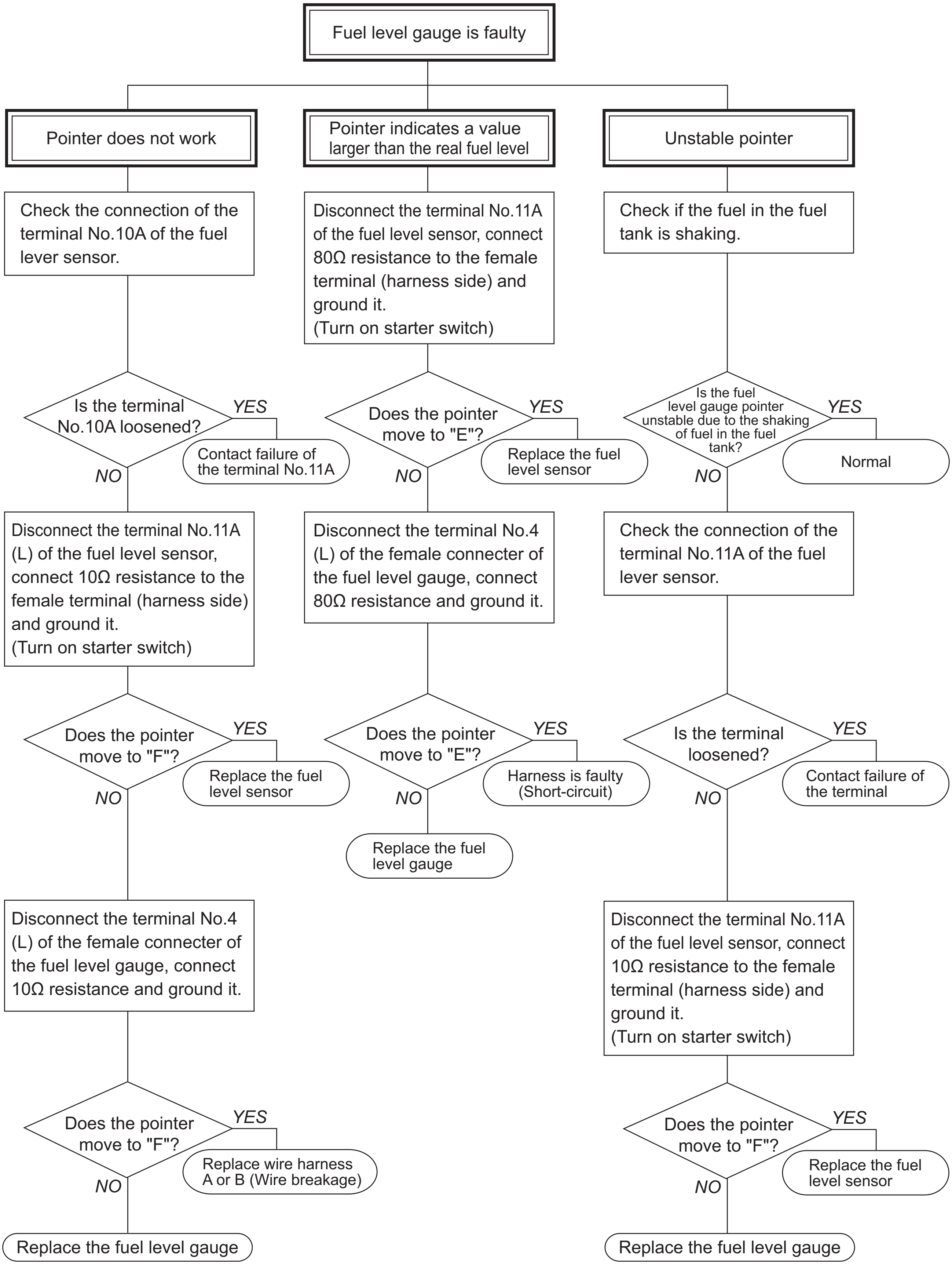
Engine Oil Pressure Alarm Lamp



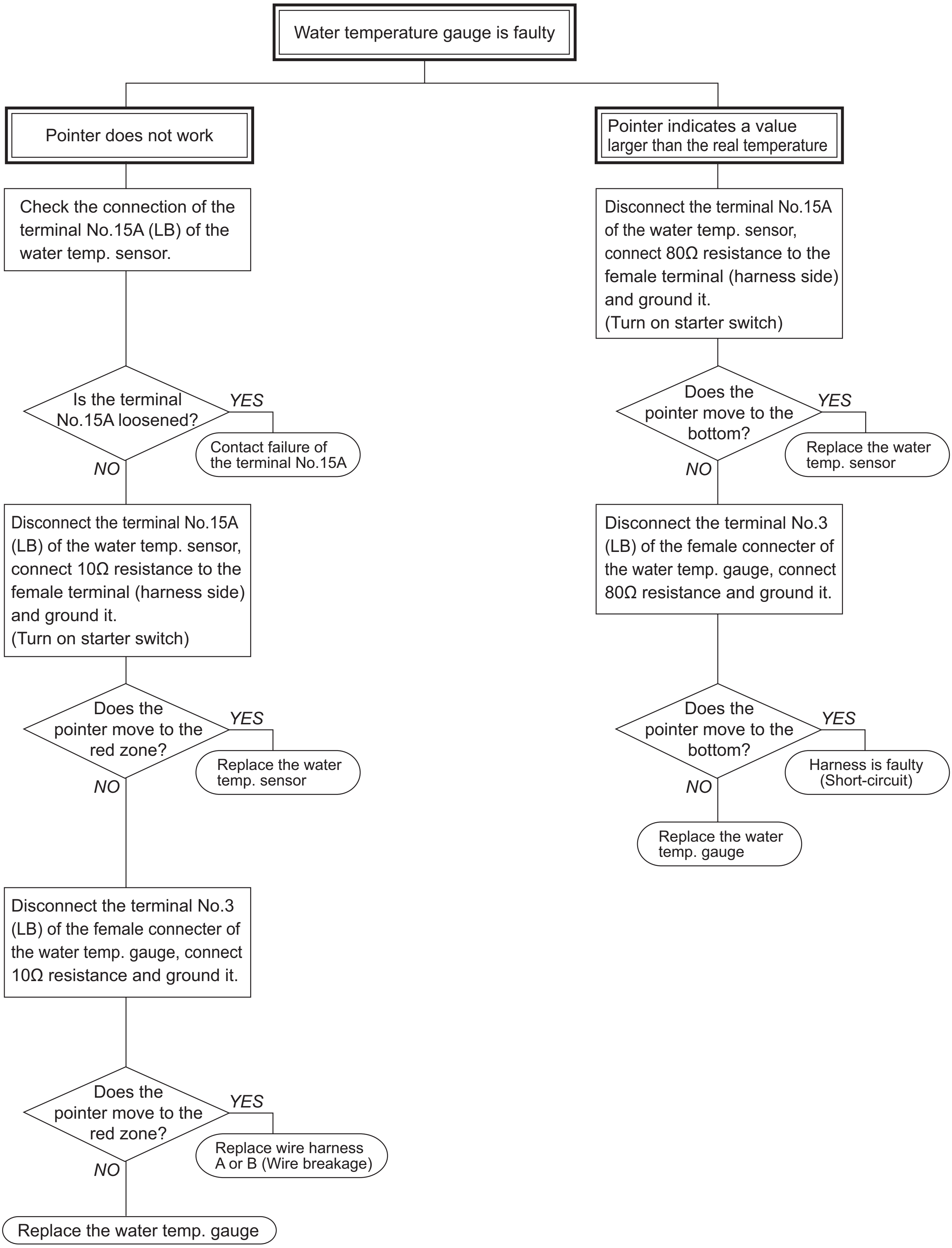
Warning Buzzer



Fuel Level Gauge



Water Temperature



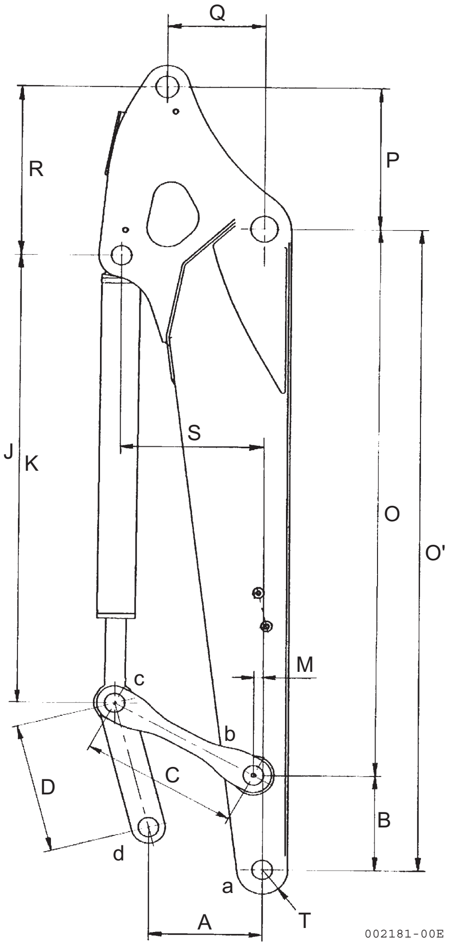
CHAPTER 11

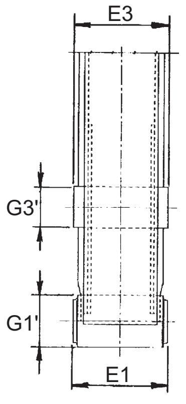
REFERENCE DATA

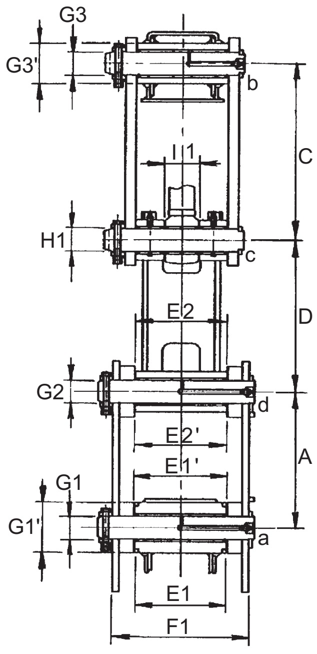
11. Reference Data

11-1 Dimensions and Specifications for Attachment

1) ViO45-5







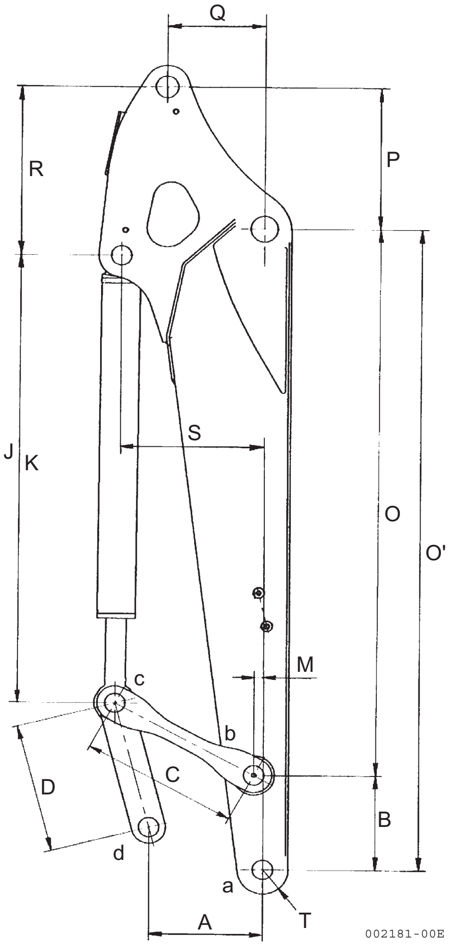
Unit : in. (mm)

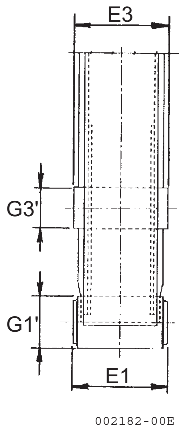
Model			ViO45-5 Q/C	ViO45-5 Without Q/C
Dimensions				
	A		10.63 (270.1)	
	B		8.66 (220)	
	C		13.78 (350)	
	D		11.81 (300)	
	E 1	; External width of arm end boss	6.46 (164)	
	E 1'	; Internal width of bucket pin boss	6.50 (165)	
	E 2	; External width of bucket link boss	6.46 (164)	
	E 2'	; Internal width of bucket pin boss	6.50 (165)	
	E 3	; External width of bucket arm pivot pin boss	6.46 (164)	
	F 1	; External width of bucket arm	9.65 (245)	
	G 1	; Bucket pin diameter	ø1.77 (ø45)	
	G 1'	; Arm end boss diameter	ø3.94 (ø100)	
	G 2	; Bucket pin diameter	ø1.77 (ø45)	
	G 3	; Bucket arm pivot pin diameter	ø1.77 (ø45)	
	G 3'	; Bucket arm pivot pin boss diameter	ø3.15 (ø80)	
	H 1	; Bucket cylinder rod end pin diameter	ø1.77 (ø45)	
	I 1	; Bucket cylinder rod end boss thickness	2.36 (60)	
	H 2	; Bucket cylinder bottom boss thickness	ø1.77 (ø45)	
	I 2	; Bucket cylinder bottom boss thickness	1.97 (50)	
	J	; Cylinder length when it is fully retracted	36.61 (930)	
	K	; Cylinder length when it is fully extended	61.42 (1560)	
	M		0.79 (20)	
	O		50.39 (1280)	
	O'		59.06 (1500)	
	P		15.39 (391)	15.91 (404)
	Q		8.17 (207.5)	5.87 (149)
	R		17.83 (453)	18.35 (466)
	S		12.40 (315)	
	T		R1.97 (R50)	
Oil pressure specifications				
	Hydraulic pump discharge volume GPM (L/min)	P1	10.6 (40.3)	
		P2	10.6 (40.3)	
		P3	10.6 (40.3)	
	Total oil flow for P.T.O. GPM (L/min)		21.3 (80.6)	
	Set pressure of system relief valve [PSI (MPa)] P1, P2		3128 (21.6)	
	Set pressure of system relief valve [PSI (MPa))] P3		3128 (21.6)	
	Set pressure of bucket circuit relief valve [PSI (MPa))]		3555 (24.5)	

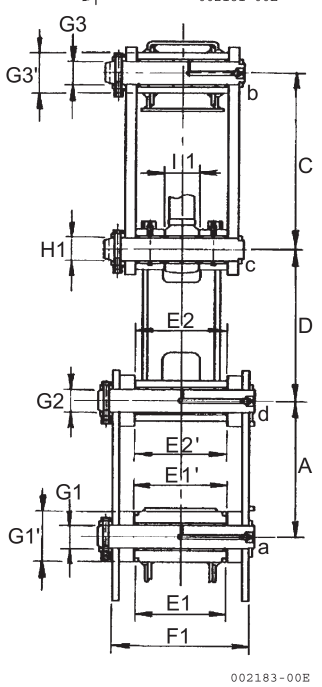
Note :

The dimensions of P, Q and R are determined by the position of the pin bore on the arm.

2) ViO55-5







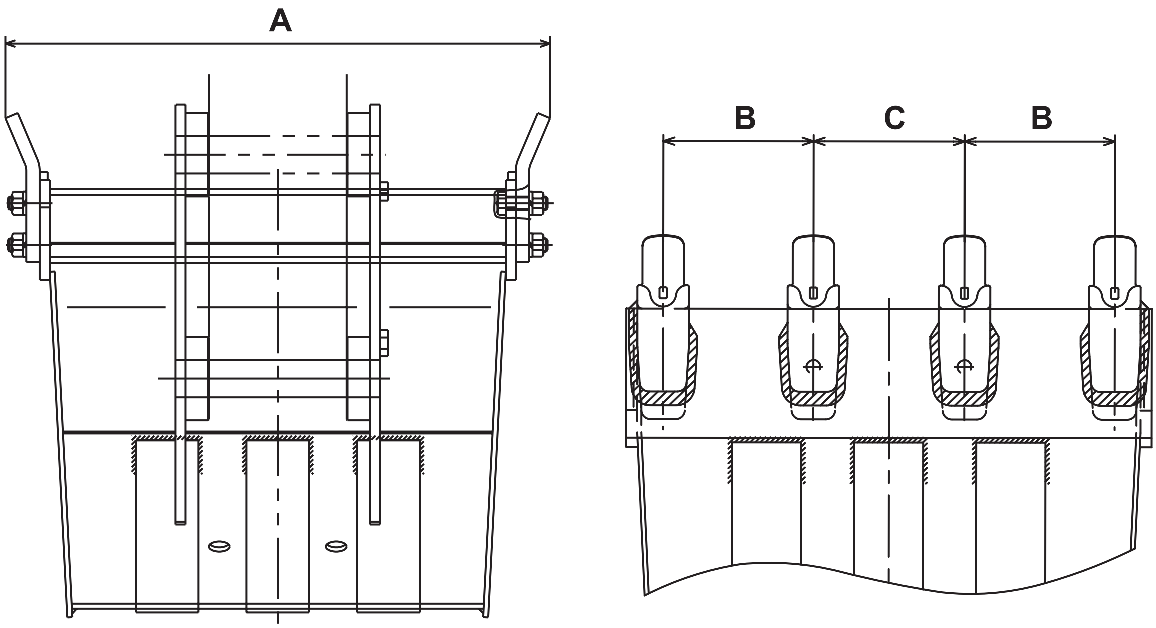
Unit : in. (mm)

Model		ViO55-5 Q/C	ViO55-5 Without Q/C
Dimensions			
A		10.63 (270.1)	
B		8.66 (220)	
C		13.78 (350)	
D		11.81 (300)	
E 1	; External width of arm end boss	6.46 (164)	
E 1'	; Internal width of bucket pin boss	6.50 (165)	
E 2	; External width of bucket link boss	6.46 (164)	
E 2'	; Internal width of bucket pin boss	6.50 (165)	
E 3	; External width of bucket arm pivot pin boss	6.46 (164)	
F 1	; External width of bucket arm	9.65 (245)	
G 1	; Bucket pin diameter	ø1.77 (ø45)	
G 1'	; Arm end boss diameter	ø3.94 (ø100)	
G 2	; Bucket pin diameter	ø1.77 (ø45)	
G 3	; Bucket arm pivot pin diameter	ø1.77 (ø45)	
G 3'	; Bucket arm pivot pin boss diameter	ø3.15 (ø80)	
H 1	; Bucket cylinder rod end pin diameter	ø1.77 (ø45)	
I 1	; Bucket cylinder rod end boss thickness	2.36 (60)	
H 2	; Bucket cylinder bottom boss thickness	ø1.77 (ø45)	
I 2	; Bucket cylinder bottom boss thickness	1.97 (50)	
J	; Cylinder length when it is fully retracted	36.61 (930)	
K	; Cylinder length when it is fully extended	61.42 (1560)	
M		0.79 (20)	
O		58.27 (1480)	
O'		66.93 (1700)	
P		16.22 (412)	16.48 (418.5)
Q		6.38 (162)	4.04 (102.5)
R		26.54 (674)	26.79 (680.5)
S		12.40 (315)	
T		R1.97 (R50)	
Oil pressure specifications			
Hydraulic pump discharge volume GPM (L/min)	P1	10.6 (40.3)	
	P2	10.6 (40.3)	
	P3	10.6 (40.3)	
Total oil flow for P.T.O. GPM (L/min)		21.3 (80.6)	
Set pressure of system relief valve [PSI (MPa)] P1, P2		3555 (24.5)	
Set pressure of system relief valve [PSI (MPa))] P3		3555 (24.5)	
Set pressure of bucket circuit relief valve [PSI (MPa))]		3982 (27.5)	

Note :

The dimensions of P, Q and R are determined by the position of the pin bore on the arm.

3) Bucket Teeth



Unit : in. (mm)

No.	Bucket width	Teeth installation pitch		Number of teeth
	A	B	C	
1	17.72 (450)	5.71 (145)	-	3
2	23.62 (600)	5.77 (146.5)	5.79 (147)	4
3	25.59 (650) [ViO45-5 standard]	6.42 (163)	6.46 (164)	4
4	27.56 (700) [ViO55-5 standard]	7.09 (180)		4
5	29.53 (750) [ViO55-5 only]	5.81 (147.5)		5

*Tolerance : -0.06 to +0.06 in. (-1.5 to 1.5 mm)

ViO45-5, ViO55-5

Service Manual

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