

## SECTION 2 STRUCTURE AND FUNCTION

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# SECTION 2 STRUCTURE AND FUNCTION

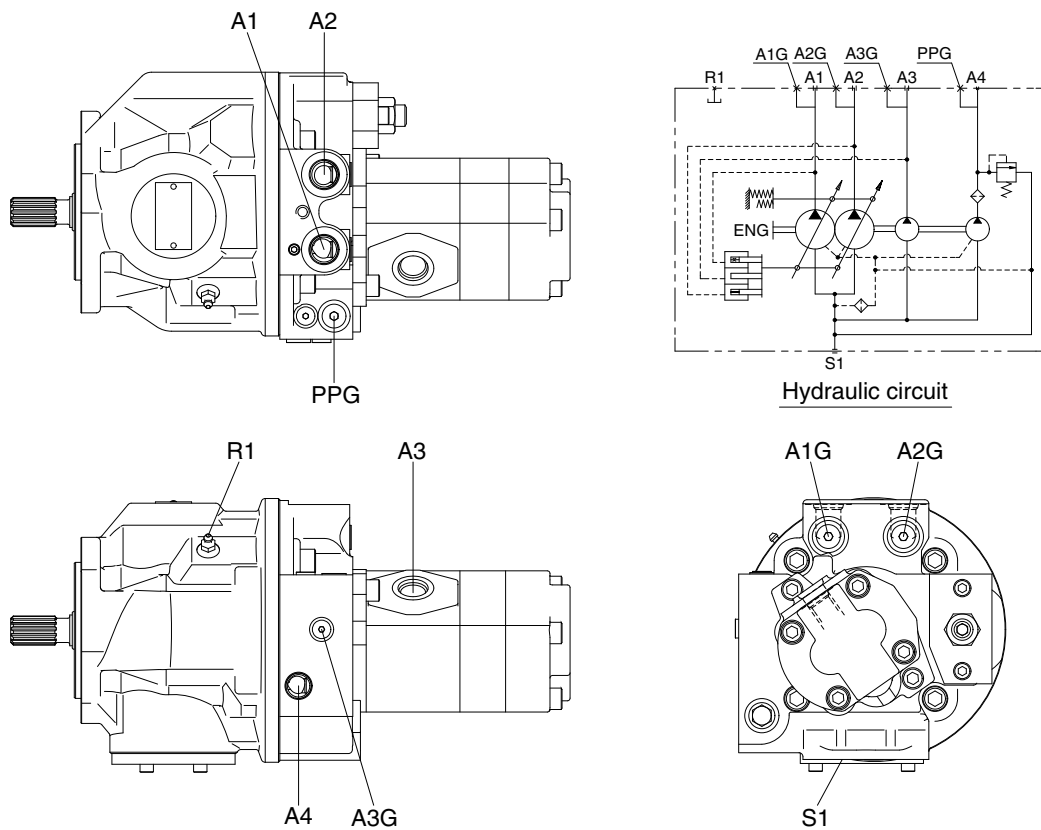
## GROUP 1 HYDRAULIC PUMP

### 1. GENERAL

This is a variable displacement double-piston pump for discharge with equal displacements from one cylinder block. This pump is so compact as to appear a single pump though this is actually a double pump.

Because this pump has one swash plate, the tilting angle is the same for two pumps. Tilting of the pump changes in response to the total pressure of P1 + P2. Namely, the output is controlled to the constant value so that the relationship between the discharge pressure and flow rate Q becomes constant,  $(P1 + P2) \times Q = \text{Constant}$ .

The third pump and pilot pump can be connected to the same shaft via a coupling.

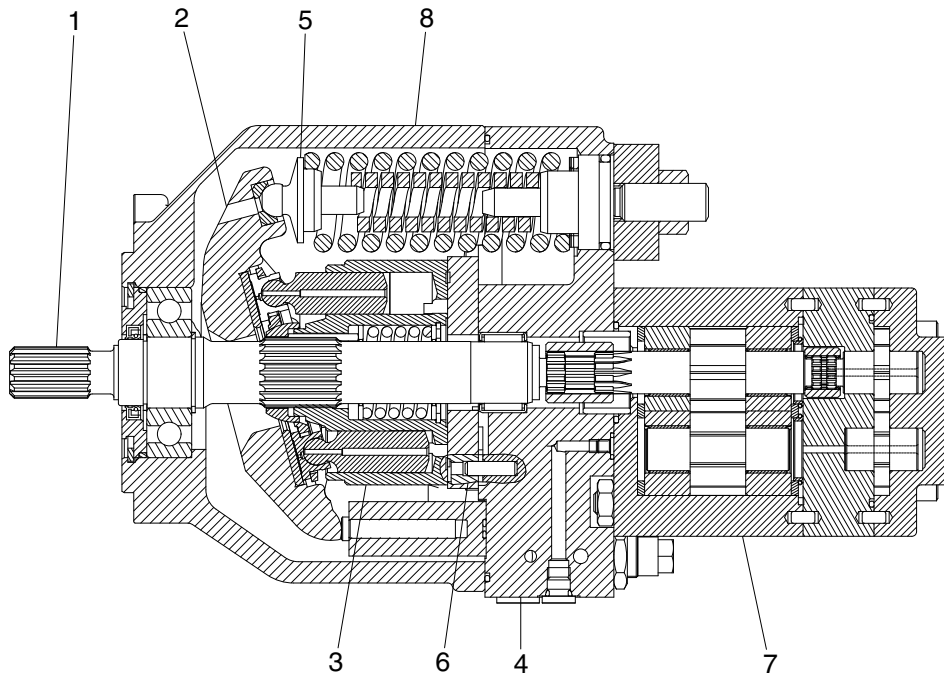


555C92MP01

### Description of the ports

Port	Name	Bore
S1	Suction port	SAE 1 1/2 (standard)
A1, A2	Discharge port	PF 1/2
A3	Discharge port	PF 1/2
A4	Discharge port	PF 1/4
A1G, A2G	Gauge port	PF 1/4 With quick coupler
A3G	Gauge port	PF 1/8 With quick coupler
A4G	Gauge port	PF 1/4 With quick coupler
R1	Air bleeder port	M10×1.0 (with bleeder valve)

## 2. PRINCIPAL COMPONENTS AND FUNCTIONS



R5572SF02

- |   |              |   |                |
|---|--------------|---|----------------|
| 1 | Drive shaft  | 5 | Control spring |
| 2 | Hanger       | 6 | Control piston |
| 3 | Rotary group | 7 | Gear pump      |
| 4 | Cover        | 8 | Housing        |

### SPECIFICATIONS

- Capacity :  $2 \times 27.5 + 18.3 + 4.5$  cc/rev
- Rated oil flow :  $2 \times 55 + 38.4 + 9.5$  l /min
- Rated pressure :  $3 \times 220 + 30$  kgf/cm<sup>2</sup>

This is a variable displacement double-piston pump for discharge with two equal displacements from one cylinder block. Because this is one rotary group, there is only one suction port.

The oil is divided into two equal flows by the control plate in the cover and directed to two discharge ports provided in the cover.

The discharge pressure directed to the control piston tilts the hanger by overcoming the spring force.

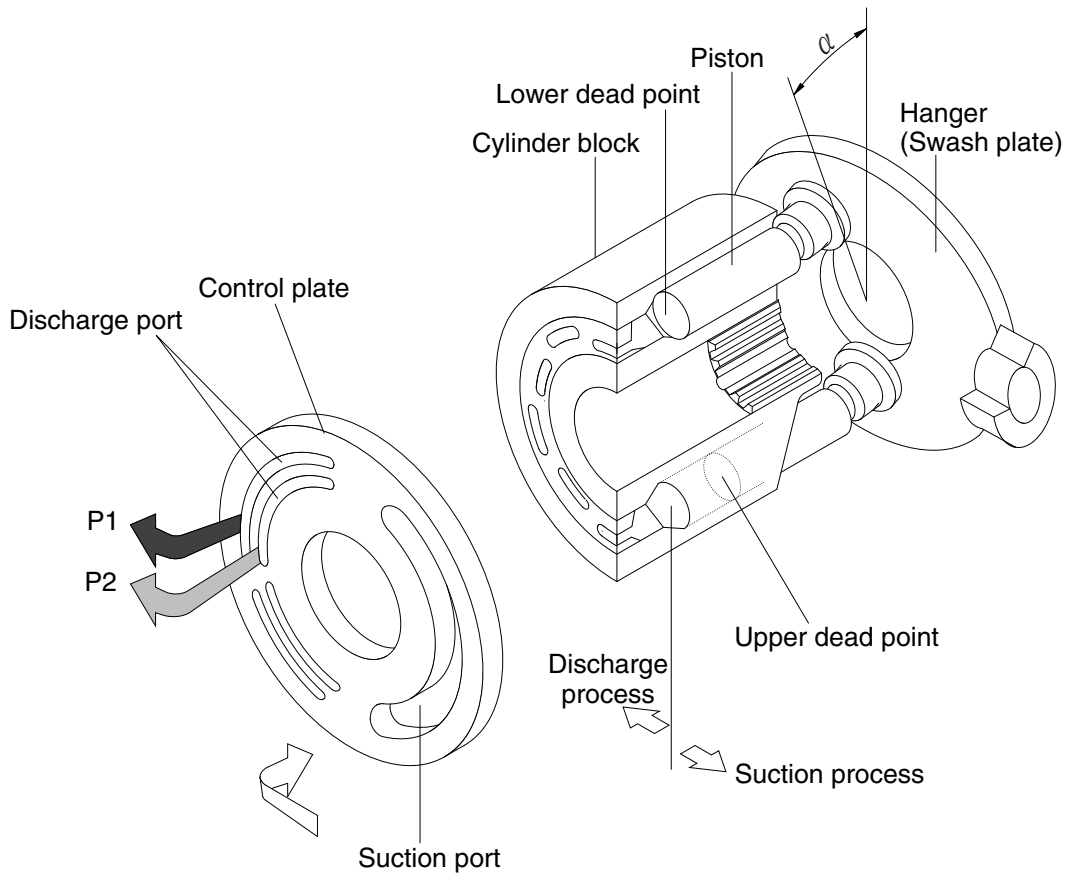
Since the piston stroke changes according to the tilting angle of the hanger, the flow can be changed.

The simultaneous tilting angle constant-output control method is employed.

The third pump and pilot pump can be connected to the same shaft via a coupling.

## 1) PRINCIPLE OF OPERATION

### (1) Function of pump



R5572SF03

The cylinder block is connected via spline and can rotate together with the drive shaft.

The piston assembled into the cylinder block performs reciprocal operation while following the swash plate on the hanger.

The piston moves in a direction to increase the displacement during a stroke from the lower to the upper dead points. The oil flows from the suction port via a port plate into the cylinder block (suction process).

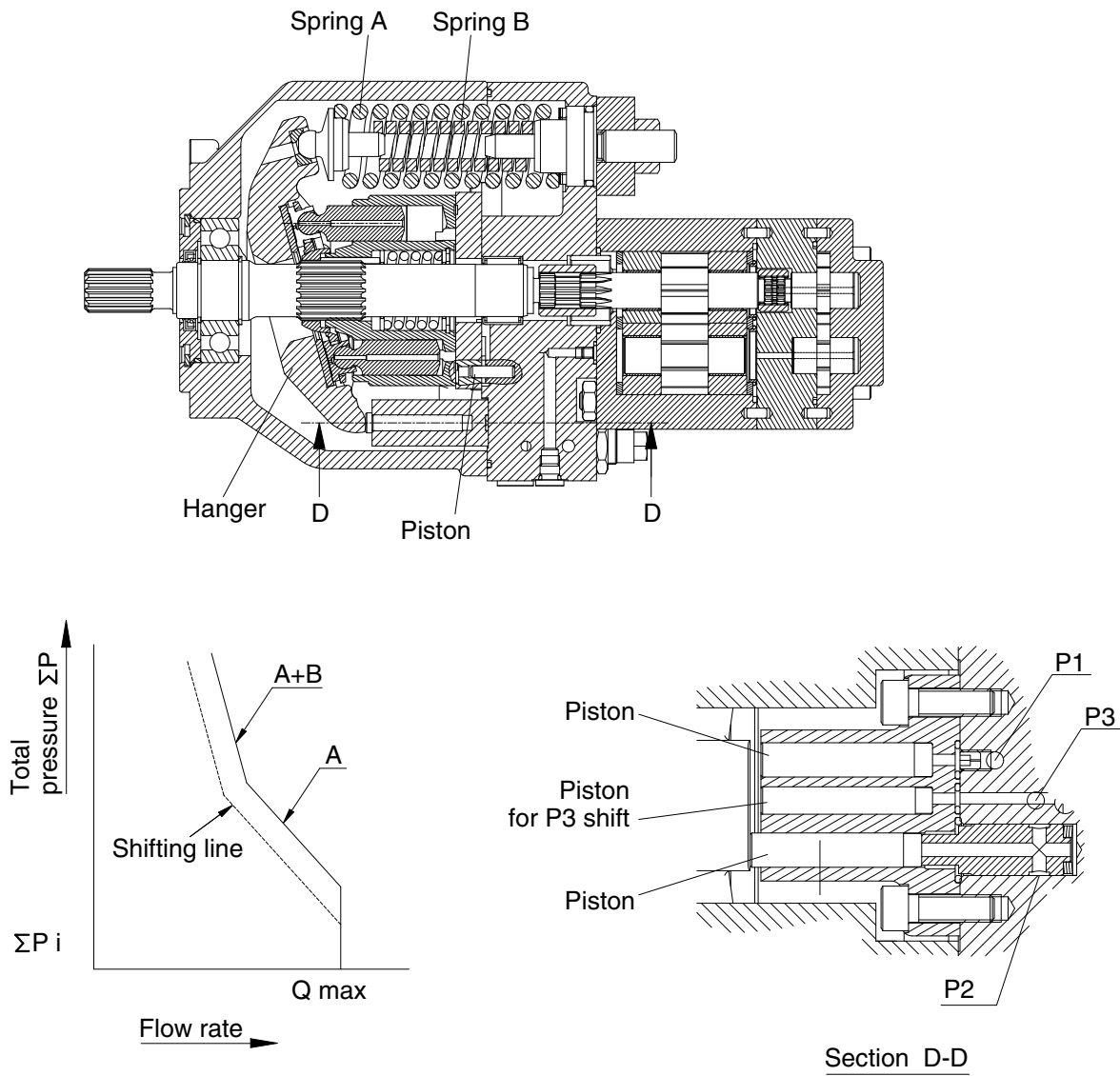
During a stroke from the upper to the lower dead points, the piston moves in a direction to decrease the displacement. The oil is discharged to the discharge port (discharge process).

The displacement can be changed by changing the tilting of the hanger (swash plate).

The oil sucked through the port in the cylinder block is discharged from the discharge port in the port plate.

The oil sucked through the port on the outside of the cylinder block is discharged from the discharge port on the outside of the port plate.

## 2) CONTROL FUNCTIONS



R5572SF04

The discharge pressures P1 and P2 are directed to the pistons of equal area act on the hanger. The spring is provided to act against the discharge pressure. When the oil pressure acting on the piston is less than the installation load of the spring A (outer spring), the hanger is fixed to the maximum tilting position. When the oil pressure acting on the piston exceeds the installation load of the spring A the hanger is tilted and kept tilted at a position where the oil pressure is balanced with the spring force. (region A in the middle of the figure above)

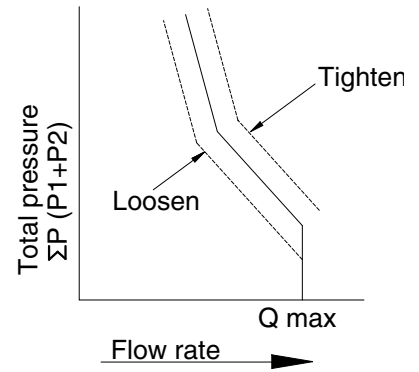
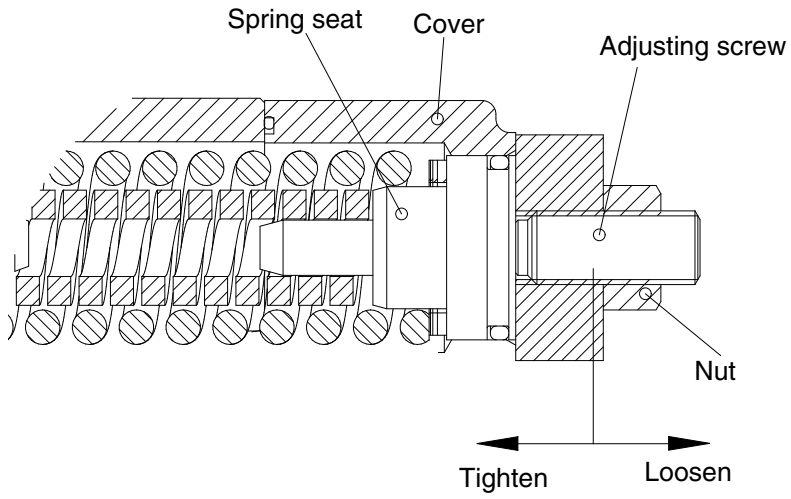
When the oil pressure acting on the piston rises further to reduce the tilting angle, the spring B which has been inactive up to now becomes active.

To overcome the spring force of two springs, the oil pressure must be higher and the shifting line becomes more steep. (regions A + B in the middle of the figure above)

When the P3 oil pressure acts on the shift piston, the control shifting line is shifted.

### 3) CONTROL / ADJUSTMENT PROCEDURE

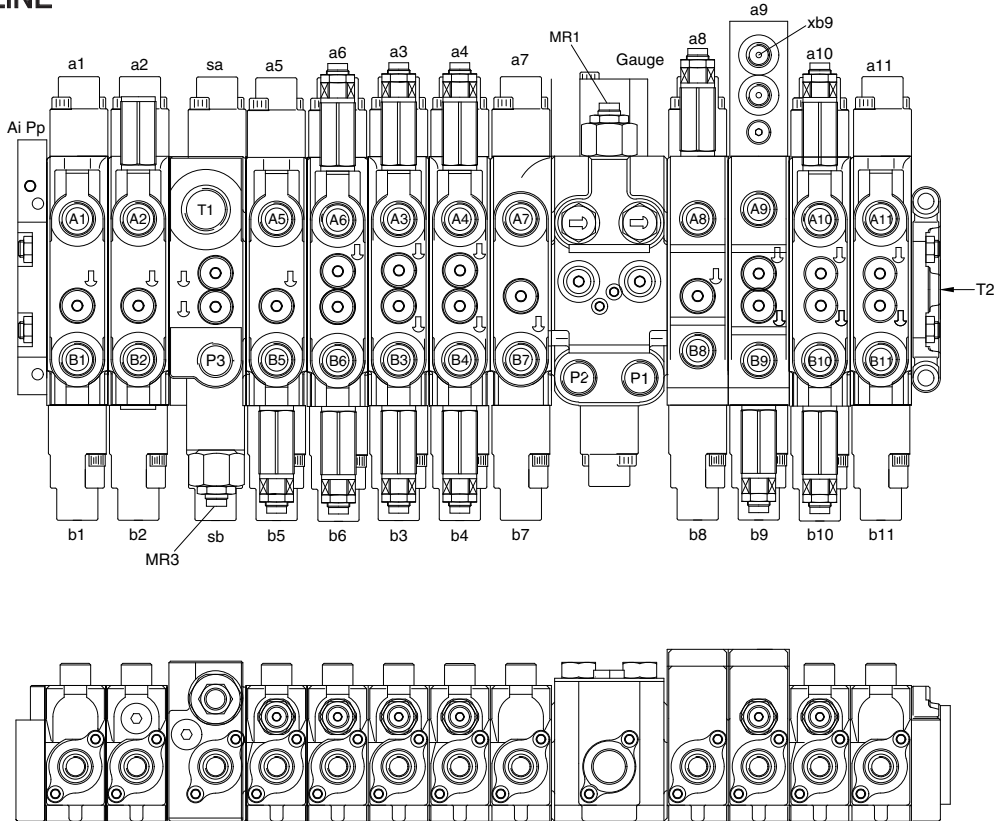
- (1) Loosen the hexagonal nut.
- (2) Tighten or loosen the adjusting screw to set the power shifting line.



R5572SF05

# GROUP 2 MAIN CONTROL VALVE

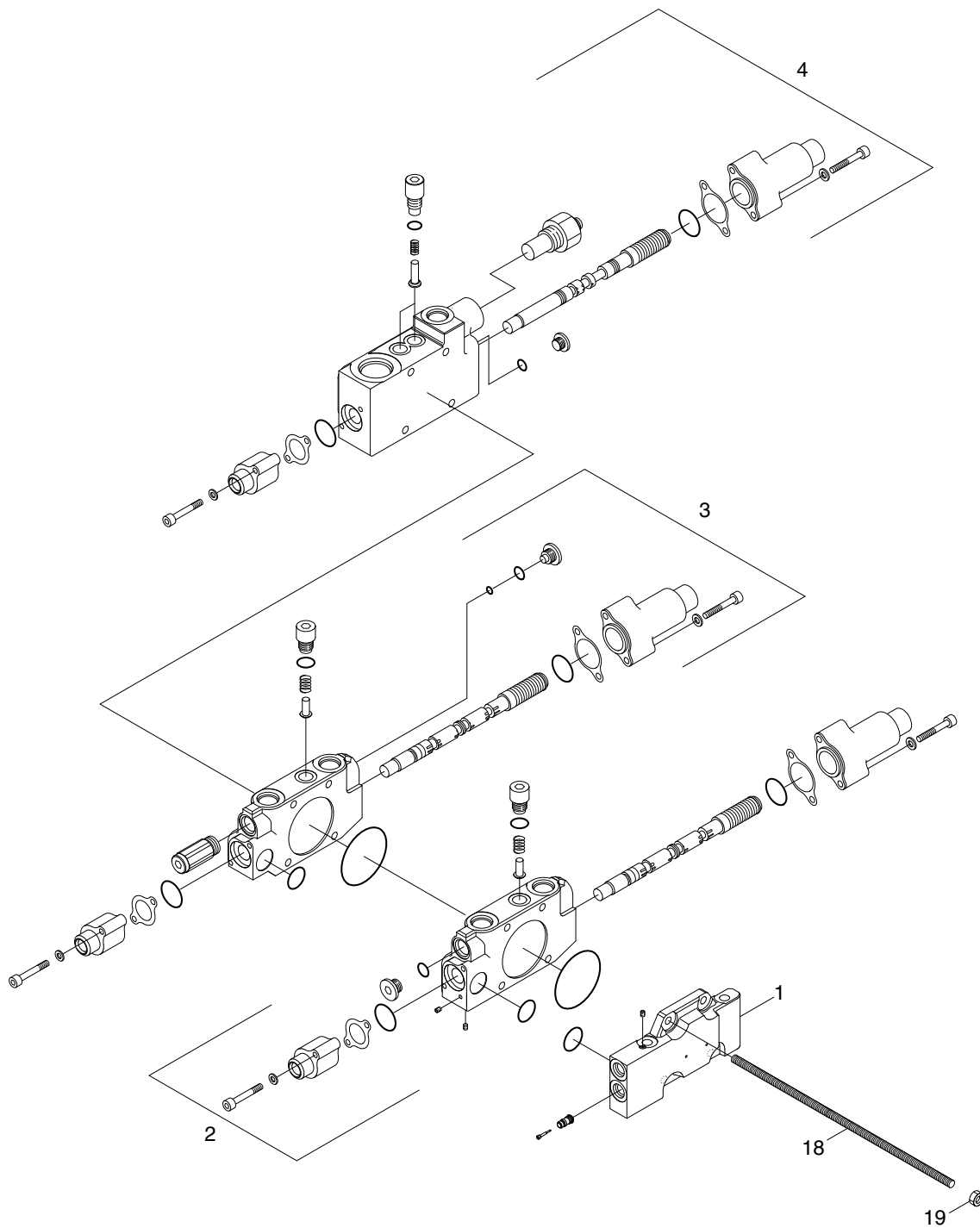
## 1. OUTLINE



65A2MC01

Mark	Port name	Port size	Tightening torque	Mark	Port name	Port size	Tightening torque
P1	P1 pump port	PF 1/2	6.0~7.0 kgf · m	B10	Bucket in port	PF1/2	6~7 kgf · m
P2	P2 pump port			B11	Arm 2 port	PF3/4	8~9 kgf · m
P3	P3 pump port			T2	Tank return port	PF3/4	8~9 kgf · m
A1	Swing port (LH)			T1	Tank return port	PF1	10~12 kgf · m
B1	Swing port (RH)			a1	Swing pilot port (LH)	PF1/4	2.5~3.0 kgf · m
A2	Dozer down port			b1	Swing pilot port (RH)		
B2	Dozer up port			a2	Dozer down pilot port		
A3	Boom swing port (LH)			b2	Dozer up pilot port		
B3	Boom swing port (RH)			a3	Boom swing pilot port (LH)		
A4	2 Way (opt)			b3	Boom swing pilot port (RH)		
B4	2 Way (opt)			a4	2 Way pilot port (opt)		
A5	Boom 2 port			b4	2 Way pilot port (opt)		
B5	Breaker port			a5	Boom 2 pilot port		
A6	Arm out port			b5	Breaker pilot port		
B6	Arm in port			a6	Arm out pilot port		
A7	Travel port [LH/FW]			b6	Arm in pilot port		
B7	Travel port [LH/RR]			a7	Travel pilot port (LH/FW)		
A8	Travel port [RH/FW]			b7	Travel pilot port (LH/RR)		
B8	Travel port [RH/RR]			a8	Travel pilot port (RH/FW)		
A9	Boom up port			b8	Travel pilot port (RH/RR)		
B9	Boom down port	a9	Boom up pilot port				
A10	Bucket out port	b9	Boom down pilot port				
MR1	Main relief valve	a10	Bucket out pilot port	PF1/4			
MR3		b10	Bucket in pilot port				
Pp		Auto idle signal port	Ai			Pilot supply port	

## 2. STRUCTURE (1/4)



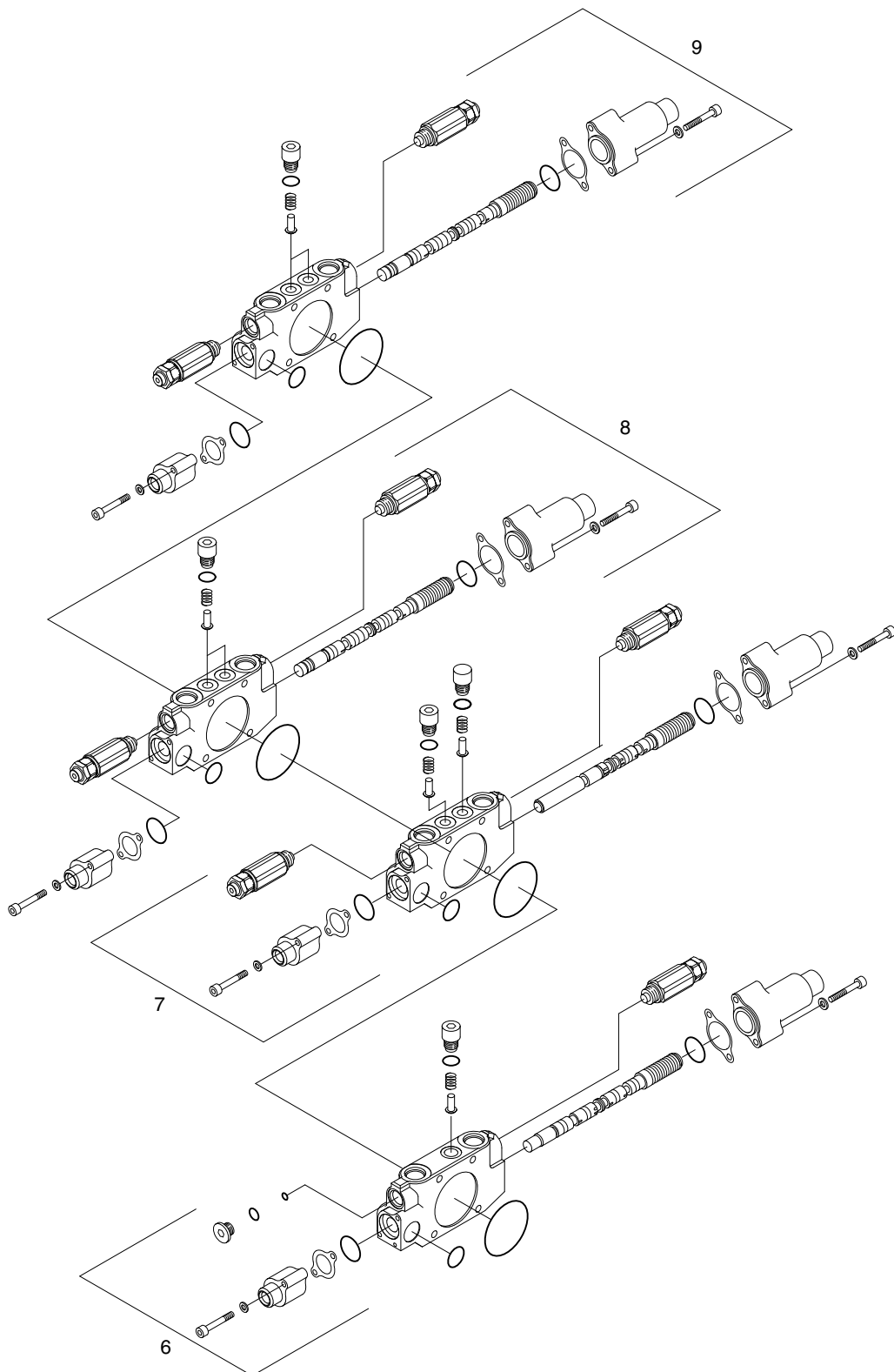
65A2MC02

- 1 Port cover
- 2 Swing section assy
- 3 Dozer section assy

- 4 Swing section assy
- 18 Tie bolt
- 19 Nut



## STRUCTURE (2/4)

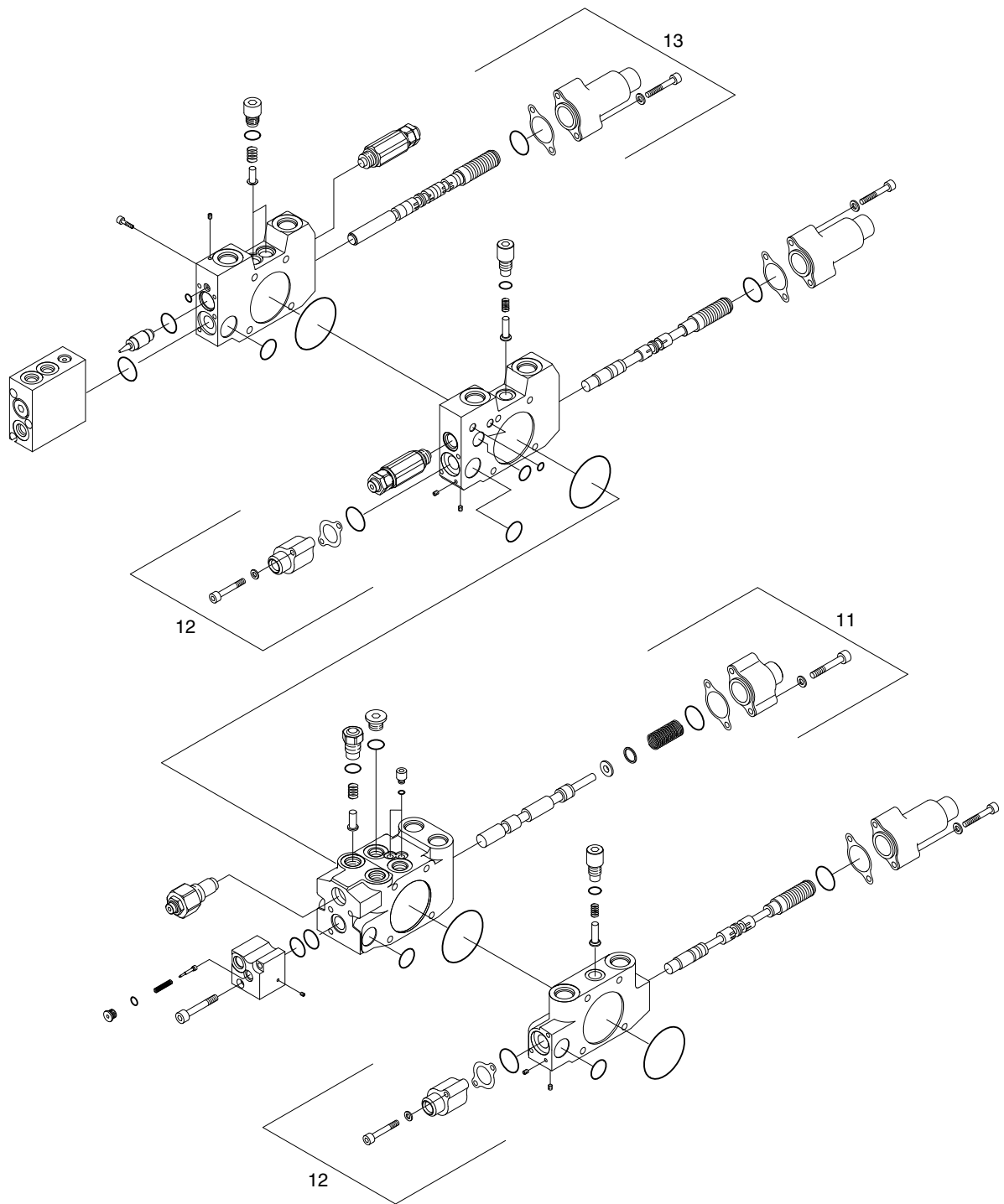


6 Boom 2 section assy  
7 Arm 1 section assy

8 Boom swing section assy  
9 Option section assy

65A2MC03

# STRUCTURE (3/4)

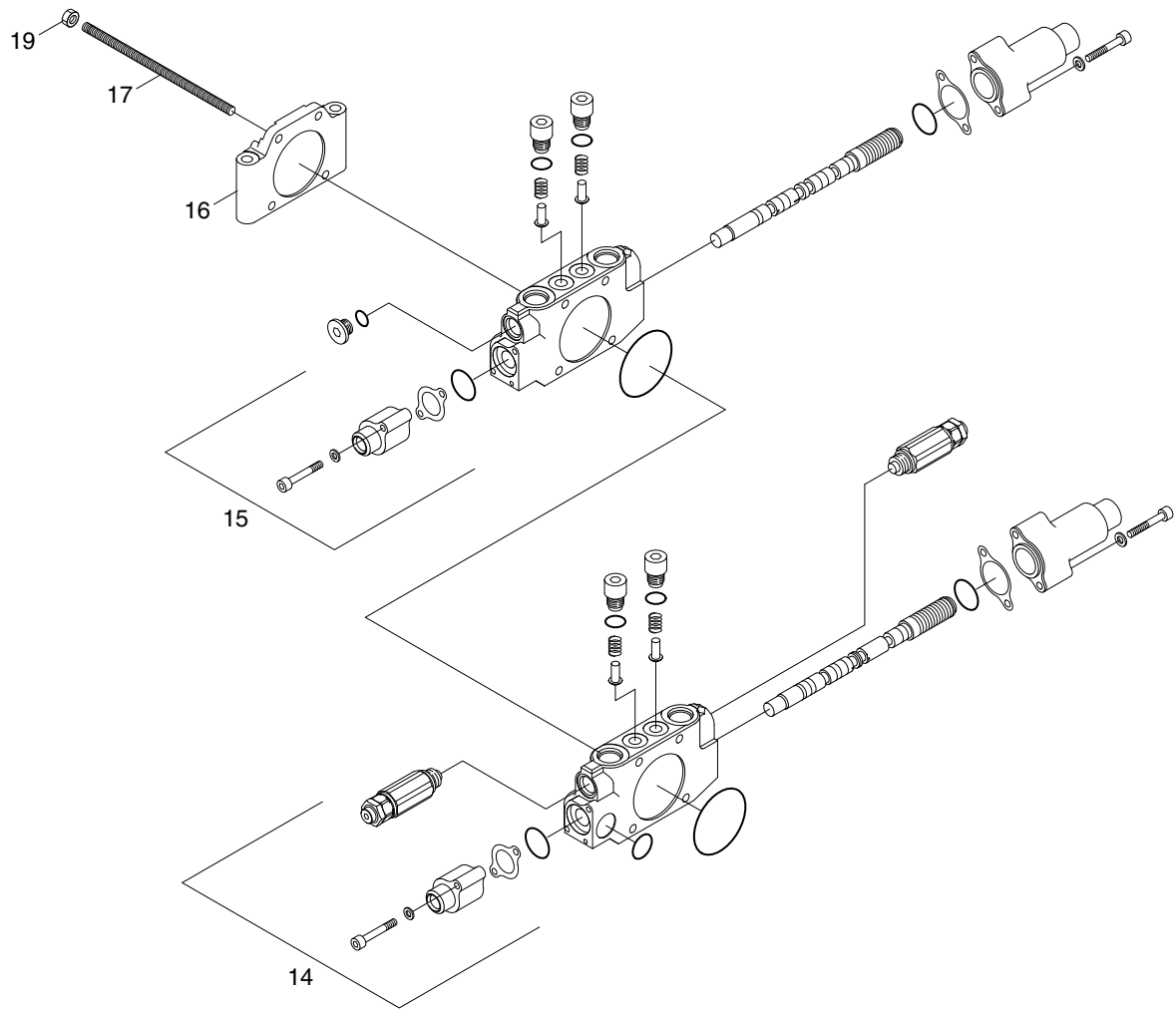


65A2MC04

10 Travel LH section assy  
11 Inlet section assy

12 Travel RH section assy  
13 Boom 1 section assy

## STRUCTURE (4/4)

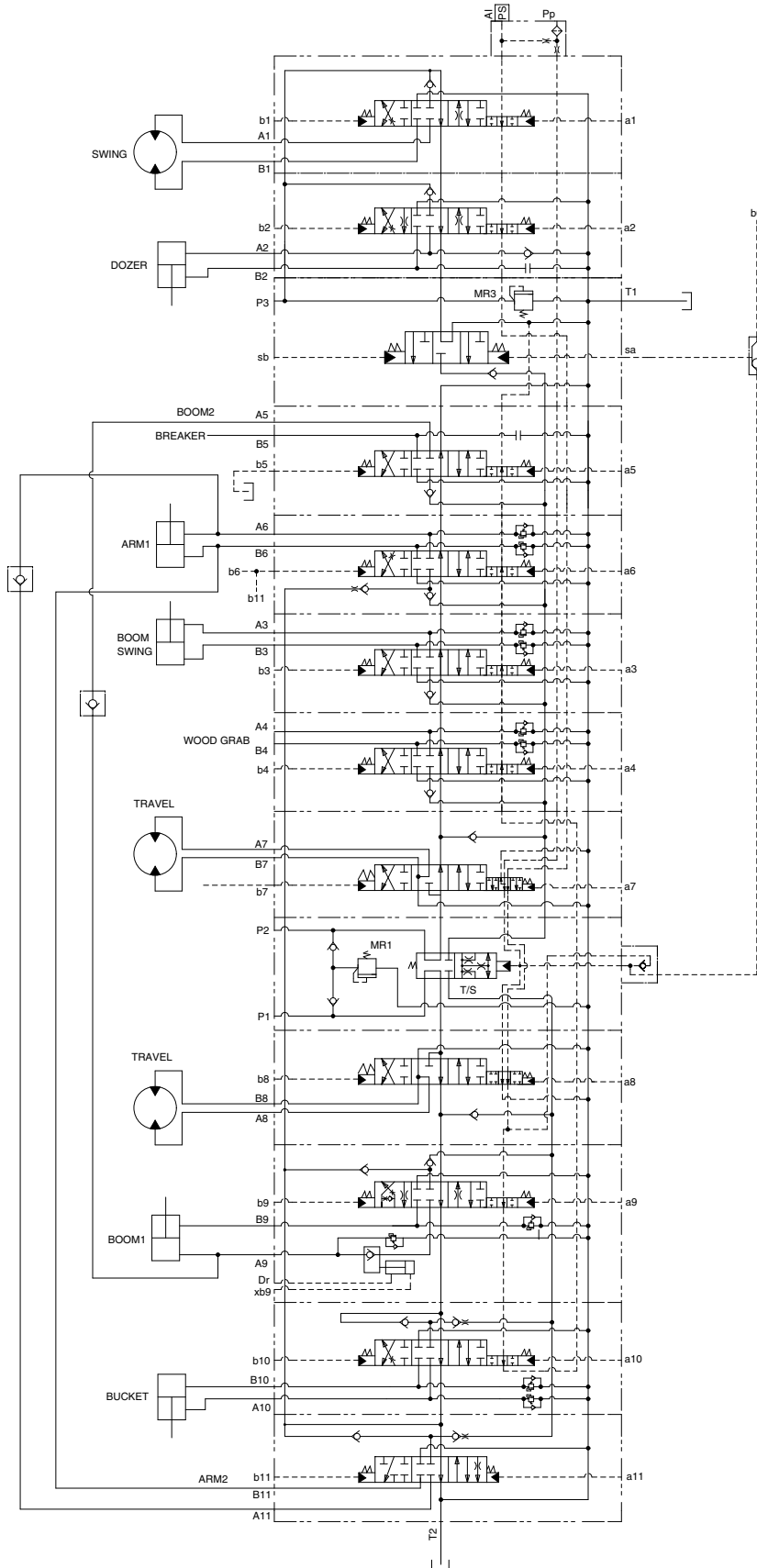


65A2MC05

- 14 Bucket section assy
- 15 Arm 2 section assy
- 16 End cover

- 17 Tie bolt
- 19 Nut

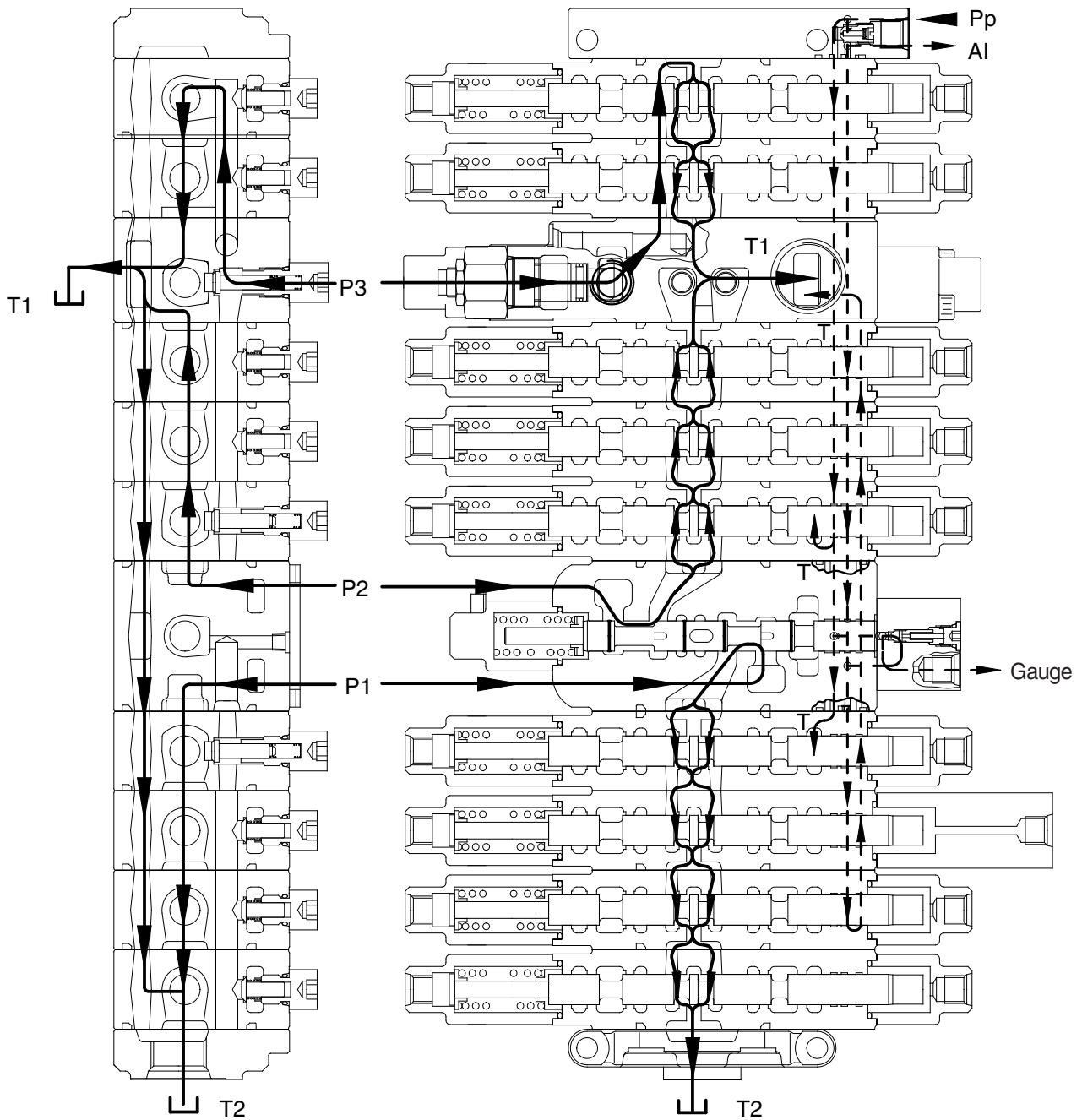
### 3. HYDRAULIC CIRCUIT



65A2MC06

#### 4. FUNCTION

##### 1) CONTROL IN NEUTRAL FUNCTION



555C92MC07

In neutral, spring sets the spool at the neutral position, the hydraulic oil from pumps flows to the tank through the center bypass.

**(1) P1**

The oil discharged from the hydraulic pump flows into control valve P1 port, and then flows the right side travel valve through the travel straight valve. In neutral, the oil flows through the center bypass passage in the direction of right travel → boom 1 → bucket → arm 2 spool, and then flows from the center bypass passage to the tank port T1 and T2.

**(2) P2**

The oil discharged from the hydraulic pump flows into control valve P2 port, and then flows the left side travel valve through the travel straight valve. In neutral, the oil flows through the center bypass passage in the direction of left travel → arm 1 → boom 2/breaker spool, and then flows from the center bypass passage to the tank port T1 and T2.

**(3) P3**

The oil discharged from the hydraulic pump flows into control valve P3.

In neutral, the oil flows through the center bypass passage in the direction of swing → dozer spool, and then flows from the center bypass passage to the tank port T1 and T2.

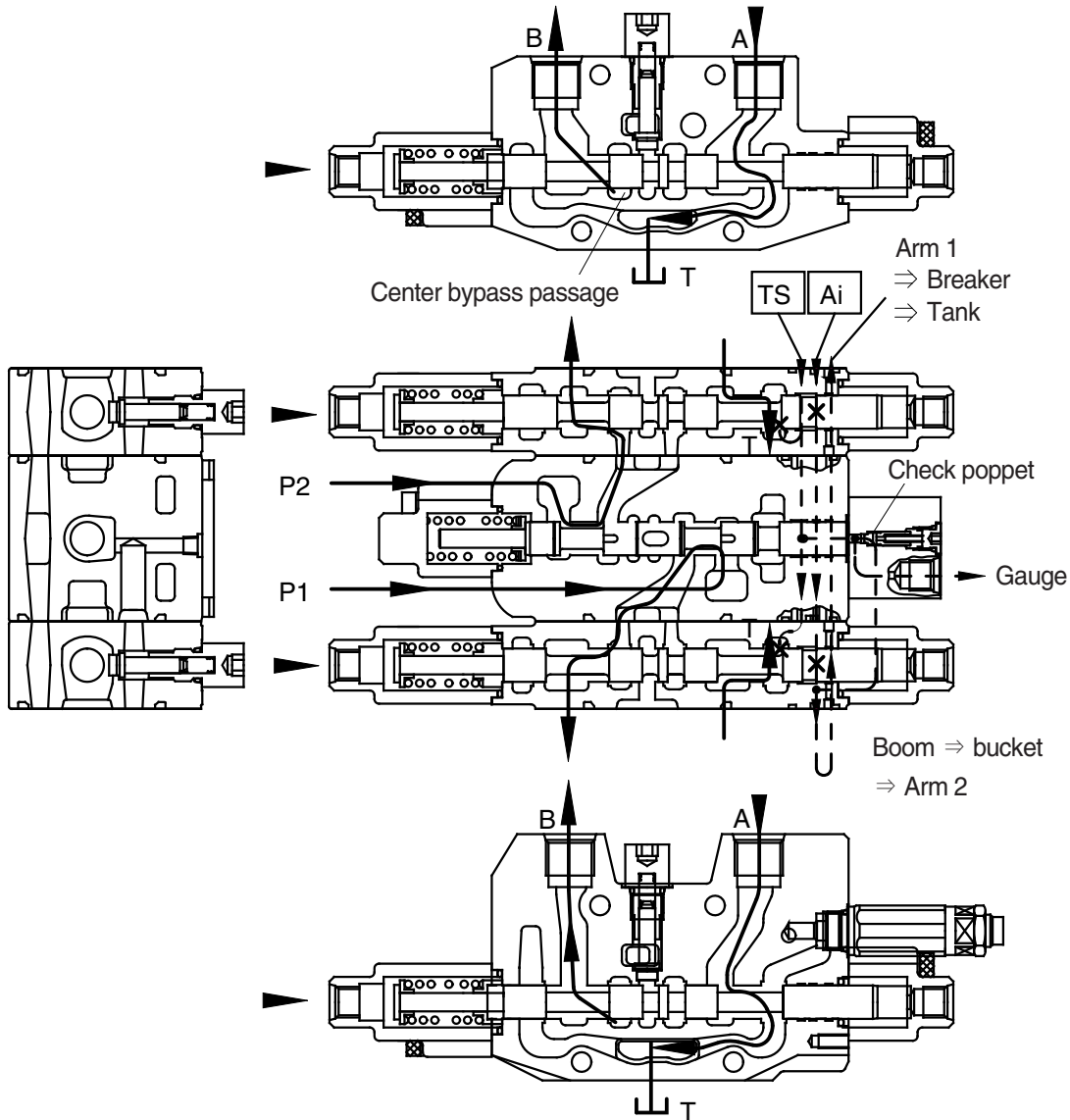
**(4) Pp**

When Pp port is applied with pilot pressure, the oil flows into the swing block through TS signal passage and Ai signal passage independently via an orifice.

With the spool in neutral, the oil flows into the tank passage through the all section of the control valve(except arm 2 section). As a result, the TS valve is not shifted and the auto idle signal pressure is not raised.

## 2) EACH SPOOL OPERATION

### (1) Travel operation (forward / backward)

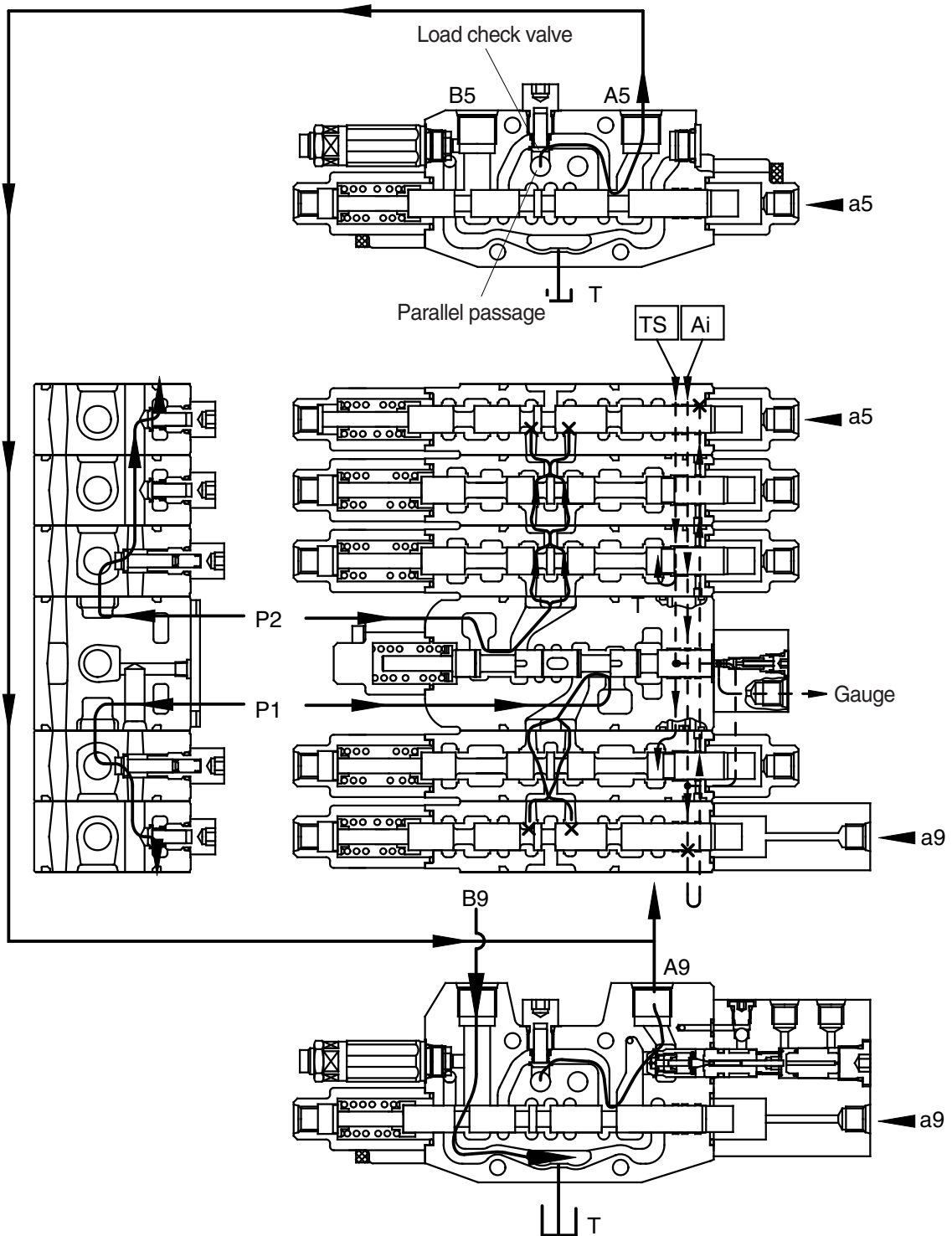


555C92MC08

- During travel (forward/backward) operation, the pilot pressure from RCV is supplied into the travel pilot port and shift the travel spool in the right direction.
- The hydraulic oil fluid from pump is entered center bypass passage of inlet block (P1, P2) and then flows into the port of travel motor.
- The oil from the port A of travel motor flows into the main control valve and return to the hydraulic oil tank through the tank passage.
- The TS signal passage is shut off by shifting of the travel spool, but it is connected with Ai signal passage and drain to the hydraulic oil tank. As a result, the travel straight spool is not shifted.
- The Ai signal passage is connected with travel block through swing and dozer block and it is shut off by shifting of the travel spool and then signal pressure of auto idle is raised.

(2) Boom operation

① Boom up operation (P1 and P2 summation)

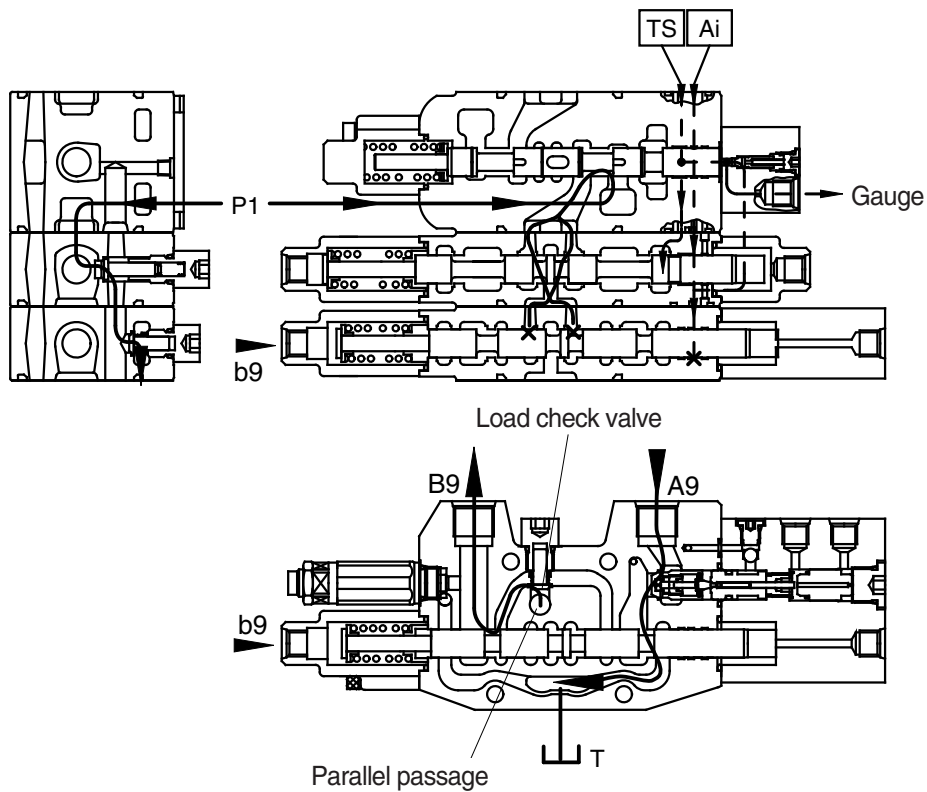


555C92MC09



- During boom up operation, the pilot pressure from RCV is supplied into the port a9 and shift the boom 1 spool in the left direction. The hydraulic oil fluid from pump P1 is entered P1 parallel passage and then passes through the load check valve then flows into the port A9. Following this, it flows into the head side of the boom cylinder.  
At the same time the pilot pressure through the port a5 shifts the boom 2 spool. The hydraulic oil fluid from pump P2 is entered P2 parallel passage and then passes through the load check valve then flows into the port A5. The flows combine in hydraulic hoses and are directed to the cylinder head side of boom cylinder.  
The flow from rod side of the boom cylinder return to the boom 1 spool through the port B9. There after it is directed to the hydraulic oil tank through the tank passage.
- The TS signal passage oil from the Pp port is drain to the hydraulic oil tank through the left/right travel valve and the signal pressure is not raised.
- The Ai signal passage oil from the Pp port is shut off by shifting of the boom 1 spool and then signal pressure of auto idle is raised.

## ② Boom down operation

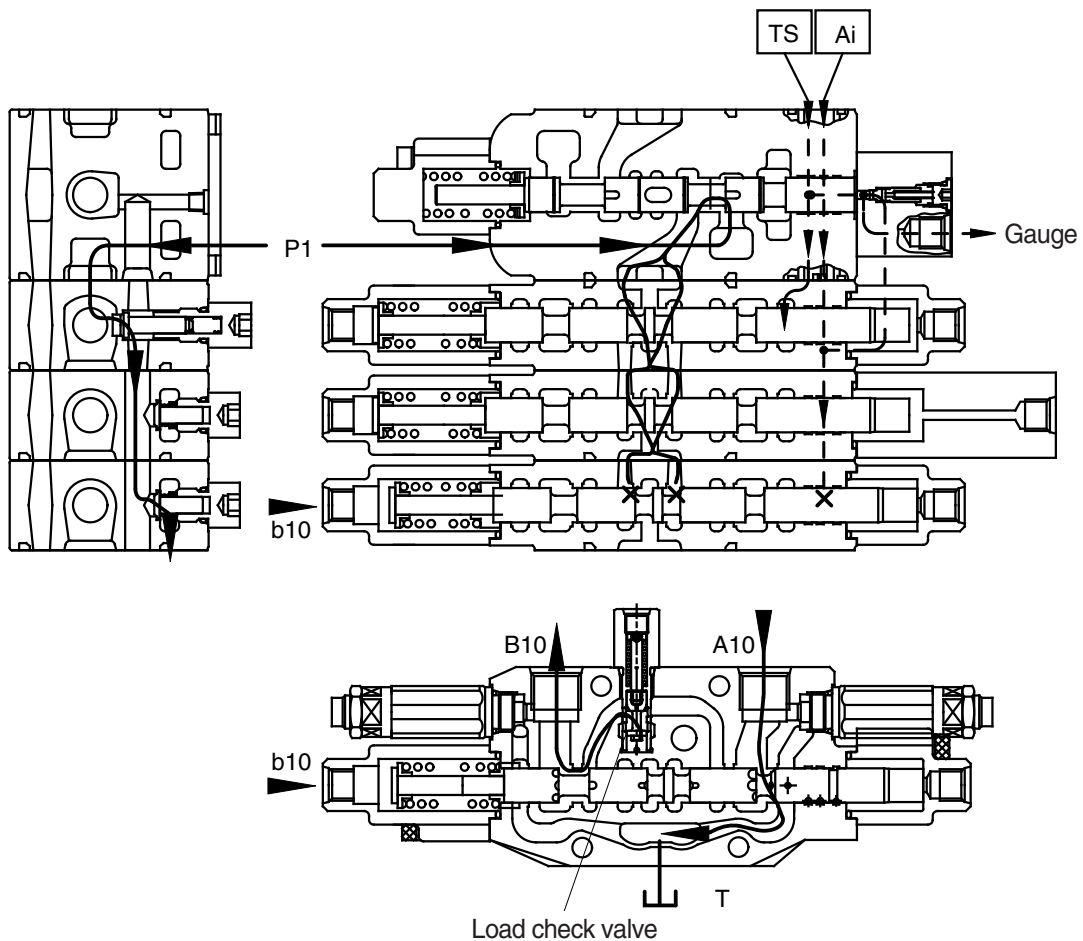


555C92MC10

- During the boom lowering operation, the pilot pressure from RCV is supplied to the port b9 and shift the boom 1 spool in the right direction.  
The hydraulic fluid from the pump P1 enters the parallel passage and is directed to the port B9 through the load check valve. Following this, it flows into the rod side of the boom cylinder. The return flow from the head side of the boom cylinder returns to the boom 1 spool through the port A9. Thereafter it is directed to the hydraulic oil tank through tank passage.
- The hydraulic oil flow from the Pp port is same as the boom up operation.

### (3) Bucket operation

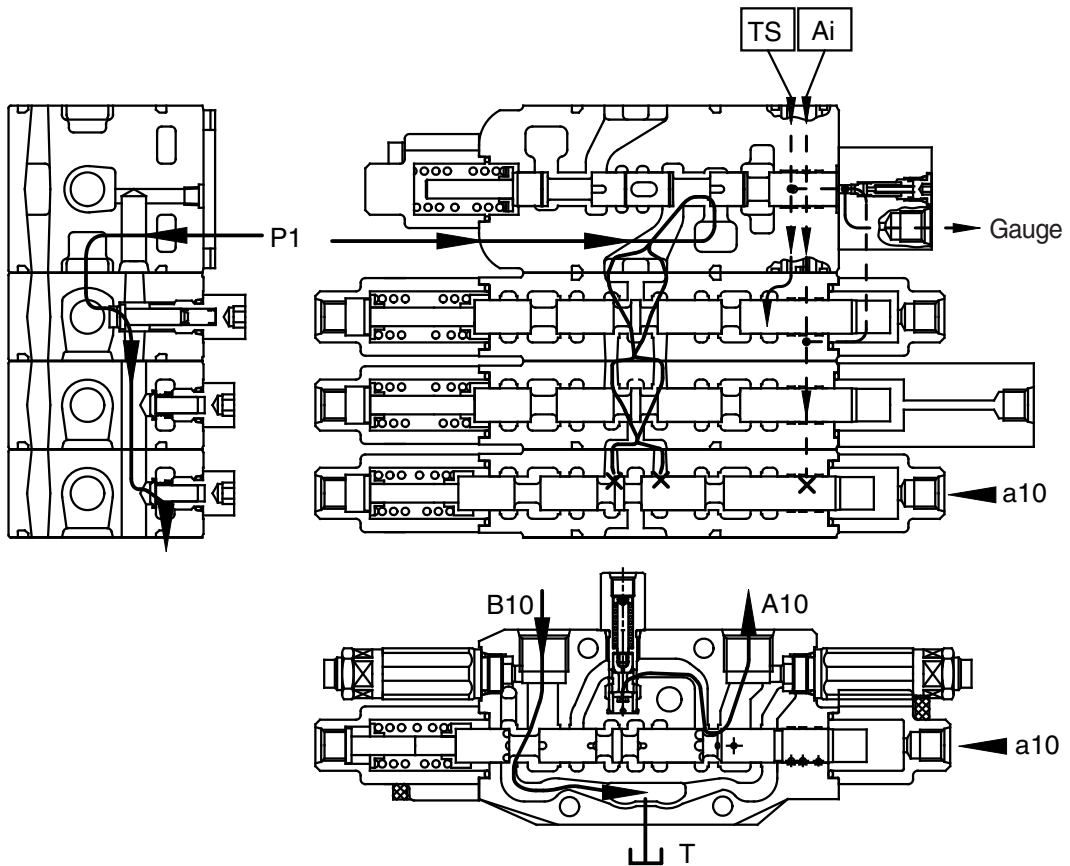
#### ① Bucket roll in operation



555C92MC11

- During the bucket roll in operation, the pilot pressure from RCV is supplied to port b10 and shift the bucket spool in the right direction.  
The hydraulic fluid from pump P1 entered P1 parallel passage and is directed to the port B10 through the load check valve.  
Following this, it flows into the head side of the bucket cylinder.  
The return flow from the rod side of the bucket cylinder returns to the bucket spool through the port A10. Thereafter it is directed to the hydraulic oil tank through the tank passage.
- The TS signal passage oil from the Pp port is drain to the hydraulic oil tank through the left/right travel valve and the signal pressure is not raised.
- The Ai signal passage oil from the Pp port is shut off by shifting of the bucket spool and then signal pressure of auto idle is raised.

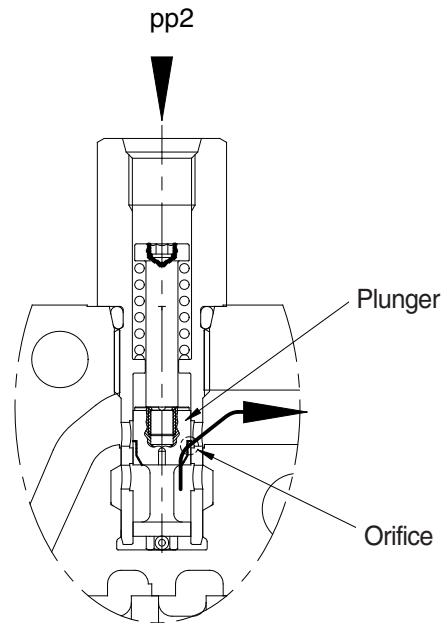
## ② Bucket roll out operation



555C92MC12

- In case of the bucket roll out operation, the operation is similar.
- The hydraulic oil flow from the Pp port is same as the bucket in operation.

### ③ Bucket load check valve operation



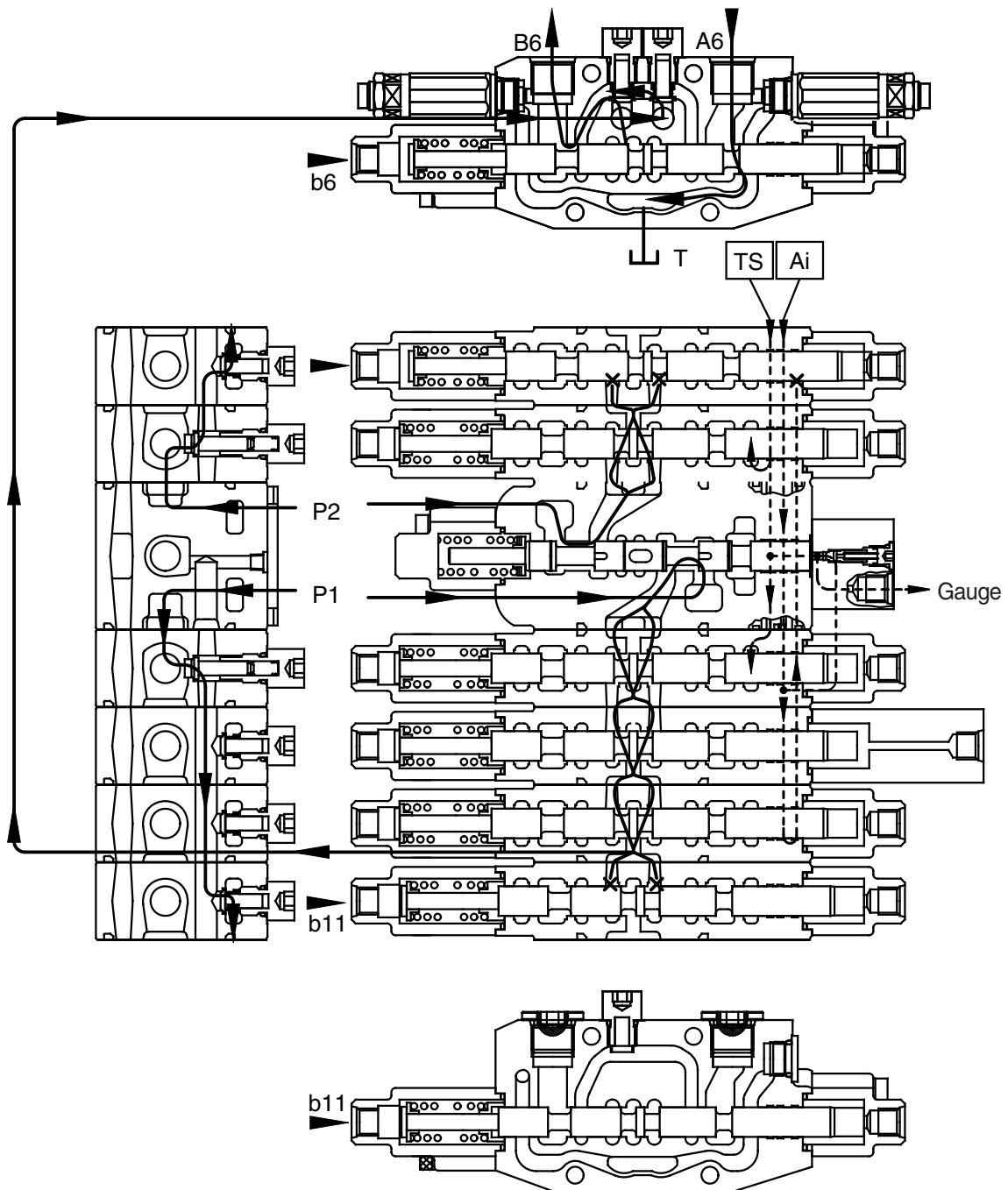
555C92MC13

- This function is used to speed up of the boom or arm by reducing the bucket speed when bucket operation with boom or arm operation simultaneously.
- When the signal pressure flows into port pp2, the plunger is shifted and orifice is made.
- The hydraulic oil from the port P1 flow into bucket cylinder via the orifice and then the speed of bucket cylinder is slow down.

Accordingly, the much fluid from the port P1 is supplied other cylinder than the bucket cylinder.

(4) Arm operation

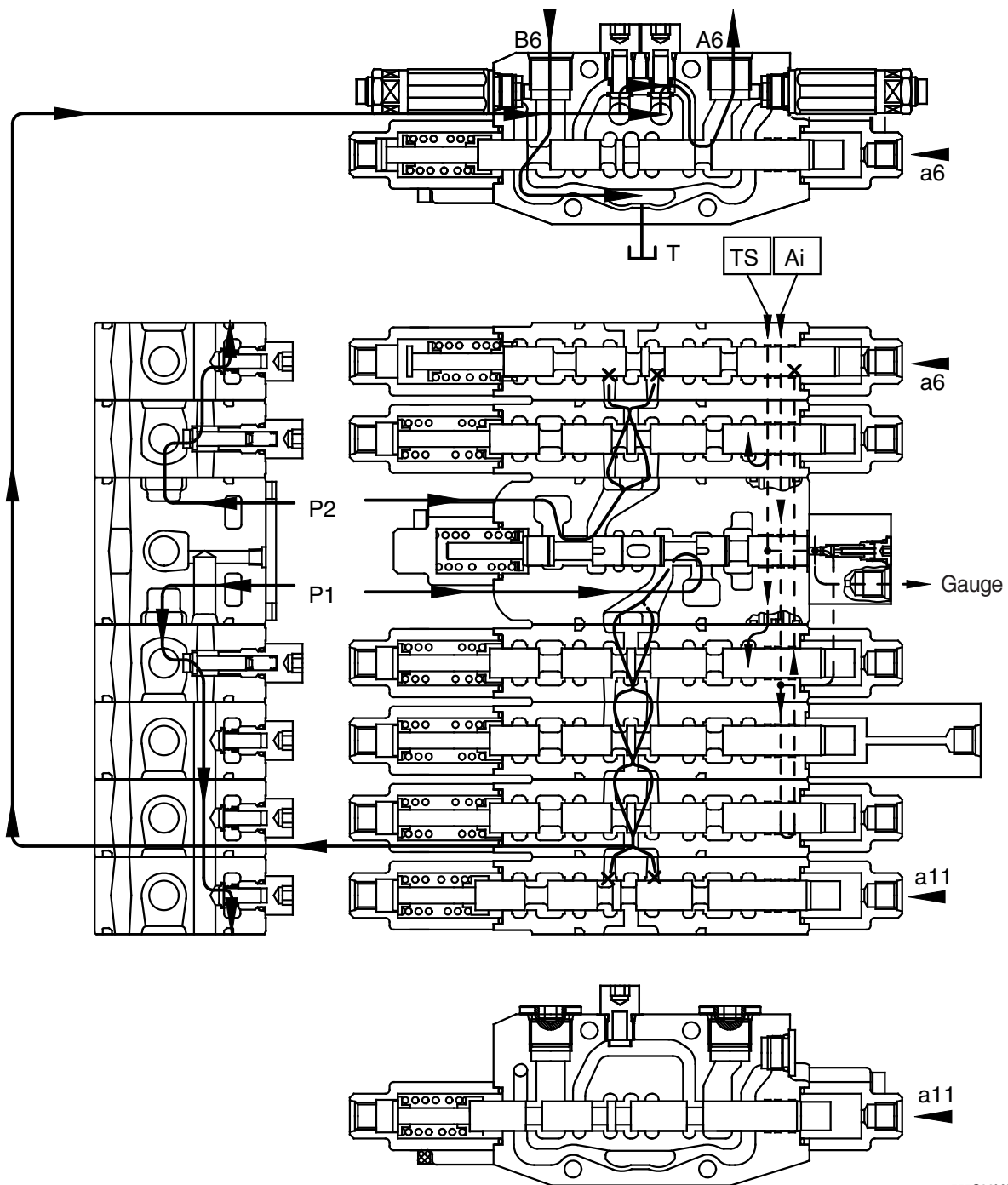
① Arm roll in operation (P1 and P2 summation)



555C92MC14

- During arm roll in operation the pilot pressure from the RCV is supplied to the port b6 and b11 and shifts arm 1 spool and arm 2 spool in the direction.  
The hydraulic oil from the pump P2 flows into the arm cylinder head side through P2 parallel passage, the load check valve and the port B6.  
At same time, the hydraulic fluid from the pump P1 flows into the arm summation passage in arm 1 spool through the arm 2 spool. Then it entered the arm cylinder head side with hydraulic fluid from arm 1 spool.
- The TS signal passage oil from the Pp port is drain to the hydraulic oil tank through the left/right travel valve and the signal pressure is not raised.
- The Ai signal passage oil from the Pp port is shut off by shifting of the arm spool and then signal pressure of auto idle is raised.

## ② Arm roll out operation

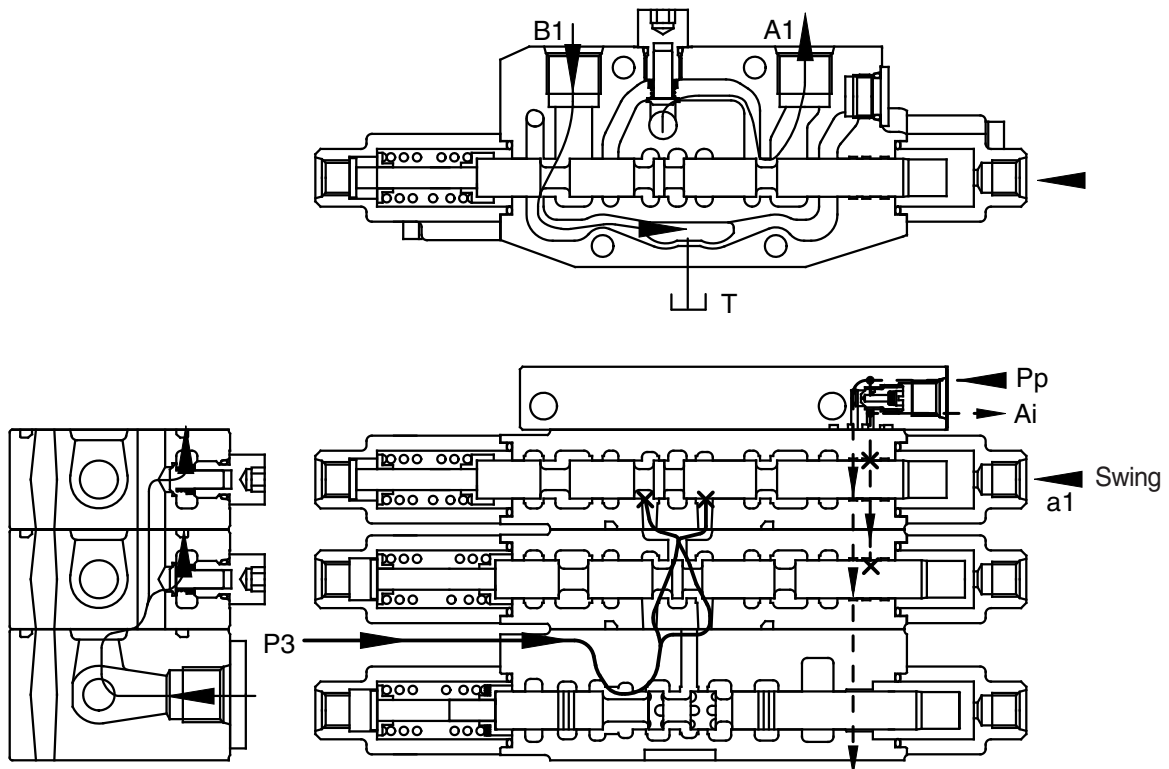


555C92MC15

- During arm roll out operation the pilot pressure from RCV is supplied to the port a6 and the a11 and shifts arm 1 spool and arm 2 spool in the left direction. The hydraulic fluid from pump P2 flows into arm 1 spool through the parallel passage. Then it enters into the arm cylinder rod side through the load check valve and the port A6. At same time, the hydraulic oil from the pump P1 flows into the arm summation passage in arm 1 spool through the arm 2 spool. The return flow from the arm cylinder head side returns to the hydraulic tank through the port B6 the arm1 spool and tank passage.
- The hydraulic oil flow from the Pp port is same as the arm roll in operation.



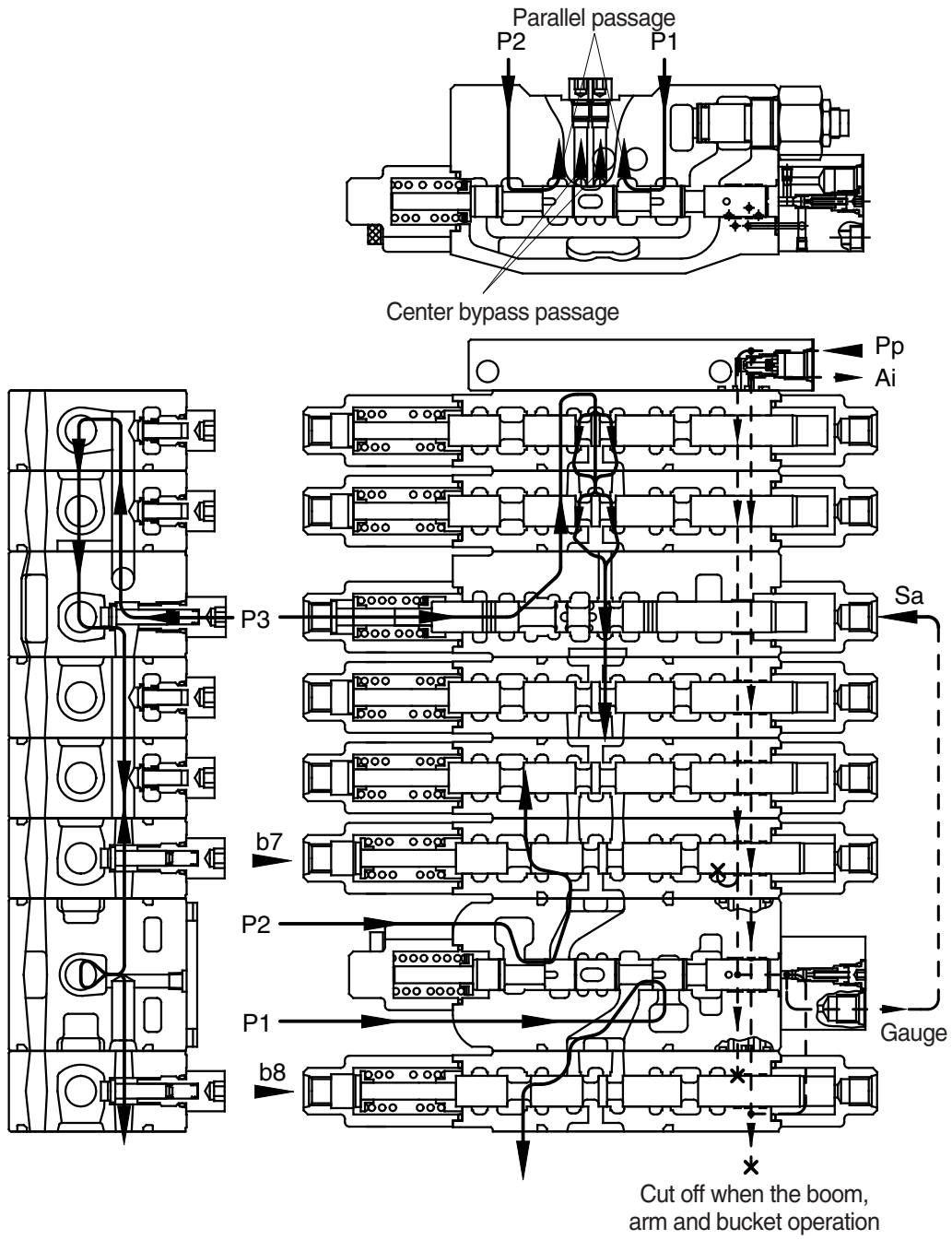
## (5) Swing operation



555C92MC16

- The pilot pressure from the RCV is supplied to the a1 and shift the swing spool in left direction. The hydraulic fluid from pump P3 flows into swing spool through the parallel passage. Then it is directed to swing motor through the port A1. As a result, swing motor turns and flow from the swing motor returns to the hydraulic oil tank through the port B1, swing spool and the tank passage.  
In case of swing left operation, the operation is similar.
- The TS signal passage oil from the Pp port is drain to the hydraulic oil tank through the left/right travel valve and the signal pressure is not raised.
- The Ai signal passage oil from the Pp port is shut off by shifting of the swing spool and then signal pressure of auto idle is raised.

(6) Travel straight function

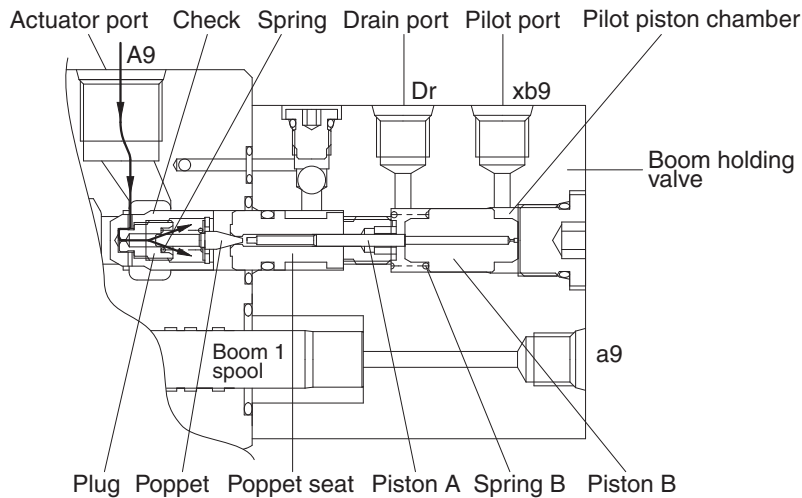


555C92MC17

- This function keeps straight travel in case of simultaneous operation of other actuators (boom, arm, bucket, swing, woodgrab) during a straight travel.
- ① During travel only :
  - The hydraulic fluid of the pump P1 is supplied to the travel motor and the pump P2 is supplied to the other motor.
  - Thus, the machine keep travel straight.
- ② The other actuator operation during straight travel operation.
  - When the other actuator spool(s) is selected under straight travel operation, the straight travel spool is moved.
  - Some of hydraulic fluid from pump P1 and P2 is supplied to the travel motors through parallel passage and the other hydraulic fluid is supplied to the actuator(s) through center bypass passage via orifice passage.
  - Thus, the machine keeps straight travel.
- The fluid flows into P3 pilot port Sa through the gauge port and the spool is shifted. As a result, the fluid of P3 pump is combined with the boom, arm and bucket and then the actuators speed up.

## (7) Holding valve operation

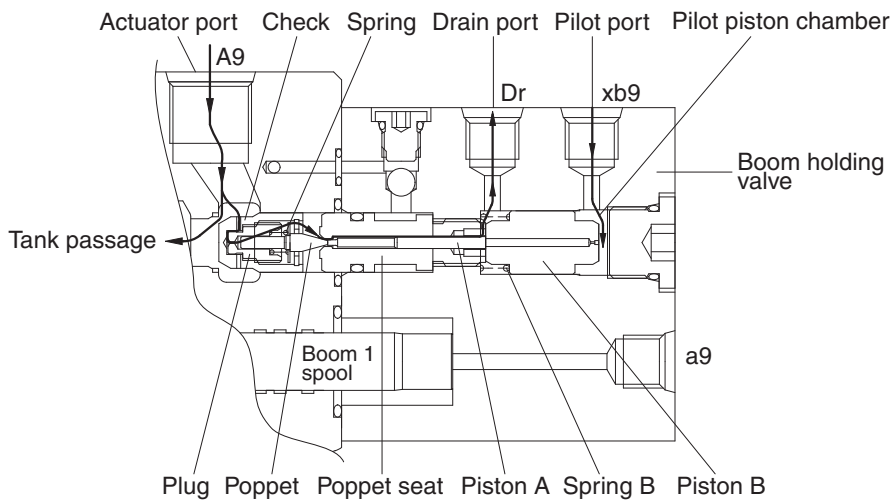
### ① Holding operation



55W72MC16

At neutral condition, the pilot piston chamber is connected to drain port through the pilot port. And the piston "B" is supported with spring "B". Also, the pressured fluid from actuator entered to inside of the holding valve through the periphery hole of check, crevice of the check and the plug and the periphery hole of plug. Then, this pressured oil pushed the poppet to the poppet seat and the check to the seat of body. So the hydraulic fluid from actuator is not escaped and the actuator is not moved.

### ② Release holding operation



55W72MC17

The pilot pressure is supplied to the pilot port for release holding valve and shifts the piston "B" in the left direction against the spring "B", and shifts the poppet in the left direction through piston "B" and piston "A" against spring "B" and shifts the spool in the left side. At same time, the return fluid from actuator returns to the drain port through the periphery hole of check, crevice of the check and the plug, the periphery hole of the plug, in side of holding valve, crevice of the poppet and the poppet seat, the periphery hole of the poppet seat, crevice of socket and spool and internal passage of spool. When the poppet is opened, pressure of inside of holding valve is decreased and the return fluid from actuator returns to the tank passage through the notch of spool.

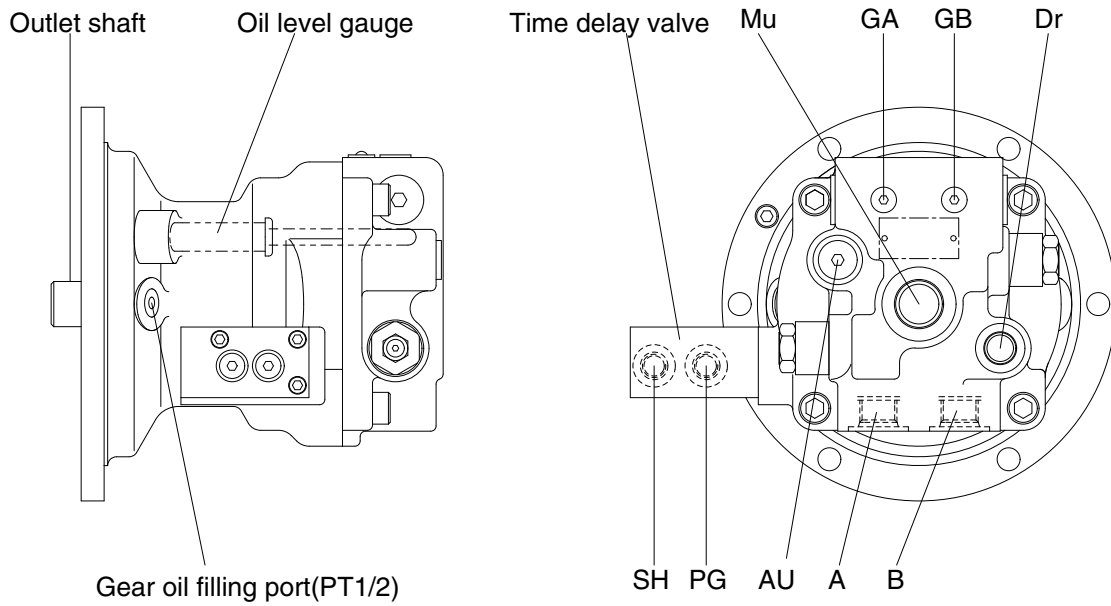
## GROUP 3 SWING DEVICE

### 1. STRUCTURE

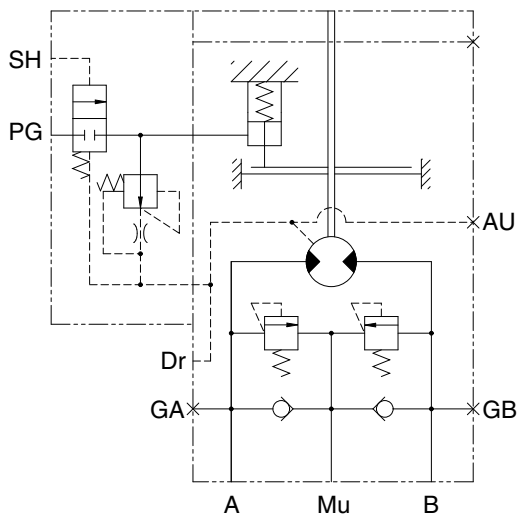
Swing device consists swing motor, swing reduction gear.

#### 1) SWING MOTOR

Swing motor include mechanical parking valve, relief valve, make up valve and time delay valve.

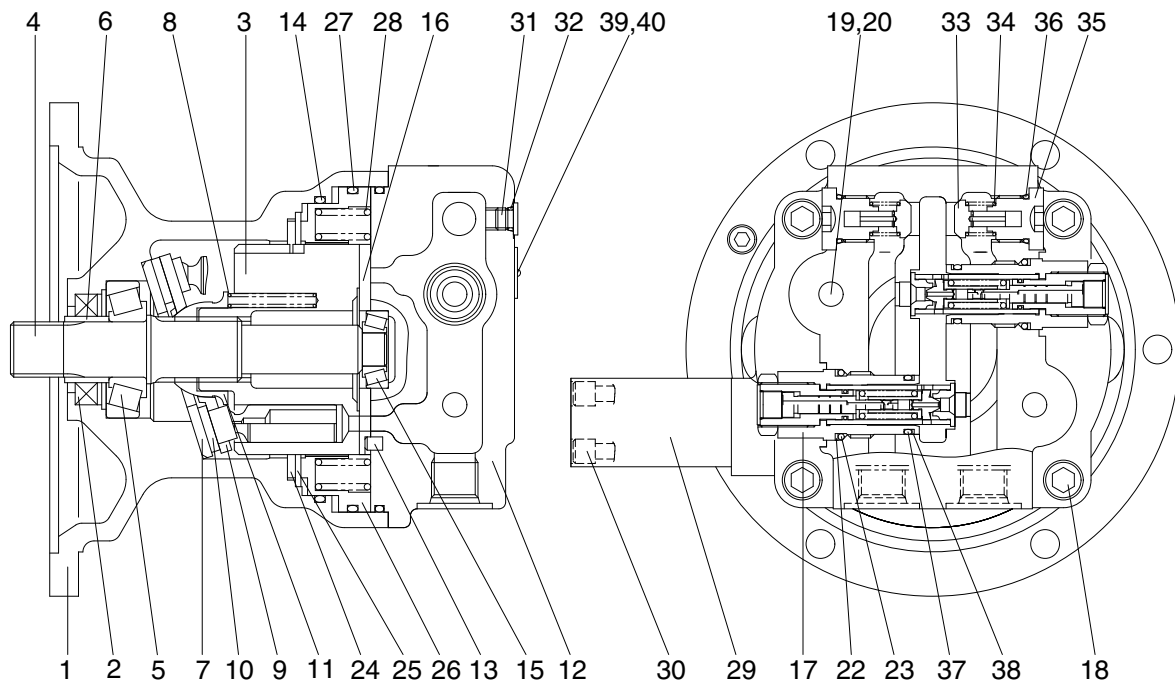


65A2SM01



Hydraulic circuit

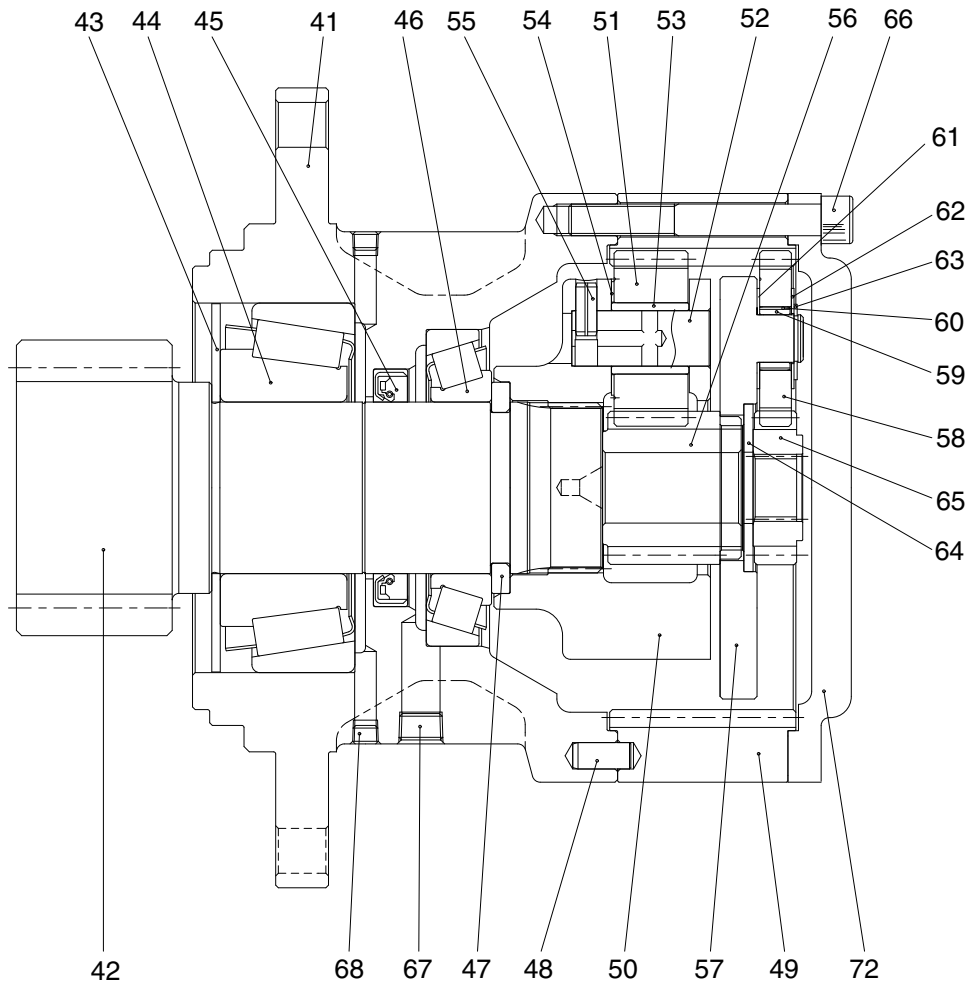
Port	Port name	Port size
A	Main port	PF 1/2
B	Main port	PF 1/2
Dr	Drain port	PF 3/8
Mu	Make up port	PF 3/4
PG	Brake release stand by port	PF 1/4
SH	Brake release pilot port	PF 1/4
GA,GB	Gauge port	PF 1/4
AU	Air vent port	PF 3/8



HX60A2SM03

- |    |                  |    |                   |    |              |
|----|------------------|----|-------------------|----|--------------|
| 1  | Body             | 15 | Taper bearing     | 30 | Socket bolt  |
| 2  | Oil seal         | 16 | Valve plate       | 31 | Plug         |
| 3  | Cylinder block   | 17 | Relief valve assy | 32 | O-ring       |
| 4  | Shaft            | 18 | Socket bolt       | 33 | Valve        |
| 5  | Taper bearing    | 19 | Plug              | 34 | Spring       |
| 6  | Bushing          | 20 | O-ring            | 35 | Plug         |
| 7  | Shoe plate       | 22 | Back up ring      | 36 | O-ring       |
| 8  | Spring           | 23 | O-ring            | 37 | O-ring       |
| 9  | Set plate        | 24 | Friction plate    | 38 | Back up ring |
| 10 | Piston shoe assy | 25 | Plate             | 39 | Name plate   |
| 11 | Ball guide       | 26 | Parking piston    | 40 | Rivet        |
| 12 | Rear cover       | 27 | O-ring            |    |              |
| 13 | Pin              | 28 | Spring            |    |              |
| 14 | O-ring           | 29 | Time delay valve  |    |              |

## 2) REDUCTION GEAR



HX60A2SM02

41 Case	52 Pin 2	63 Snap ring
42 Pinion gear	53 Needle roller bearing	64 Side plate
43 Bearing cover	54 Thrust washer 2	65 Sun gear 1
44 Taper roller bearing	55 Spring pin	66 Lench bolt
45 Oil seal	56 Sun gear 2	67 Plug
46 Taper roller bearing	57 Carrier assy 1	68 Plug
47 Lock collar	58 Planet gear 1	69 Level bar
48 Pin	59 Needle roller bearing	70 Level pipe
49 Ring gear	60 Collar	71 Air breather
50 Carrier assy 2	61 Thrust washer 1	72 Cover
51 Planet gear 2	62 Thrust washer 2	

## 2. FUNCTION

### 1) ROTARY PART

When high pressurized oil enters a cylinder through port(a), which is the inlet of balance plate(16), hydraulic pressure acting on the piston causes axial force F. The pressure force F works via the piston(10) upon the return plate(9) which acts upon the swash plate(7) via an hydrostatic bearing. Force F1 perpendicular to swash plate(7) and force F2 perpendicular to cylinder center.

Being transferred to the cylinder block(3) through piston, force F2 causes rotational moment at surroundings of cylinder.

Since cylinder block has 9 equidistantly arrayed pistons, rotational torque is transmitted to cylinder shaft in order by several pistons connected to the inlet port of high pressurized oil. When the direction of oil flow is reversed, rotational direction of cylinder is also reversed. Output torque is given by the equation.

$$T = \frac{p \times q}{2\pi}, q = Z \cdot A \cdot \text{PCD} \cdot \tan \theta, F_1 = \frac{F}{\cos \theta}, F_2 = F \tan \theta, S = \text{PCD} \times \tan \theta$$

Where p : Effective difference of pressure (kgf/cm<sup>2</sup>)

q : Displacement (cc/rev)

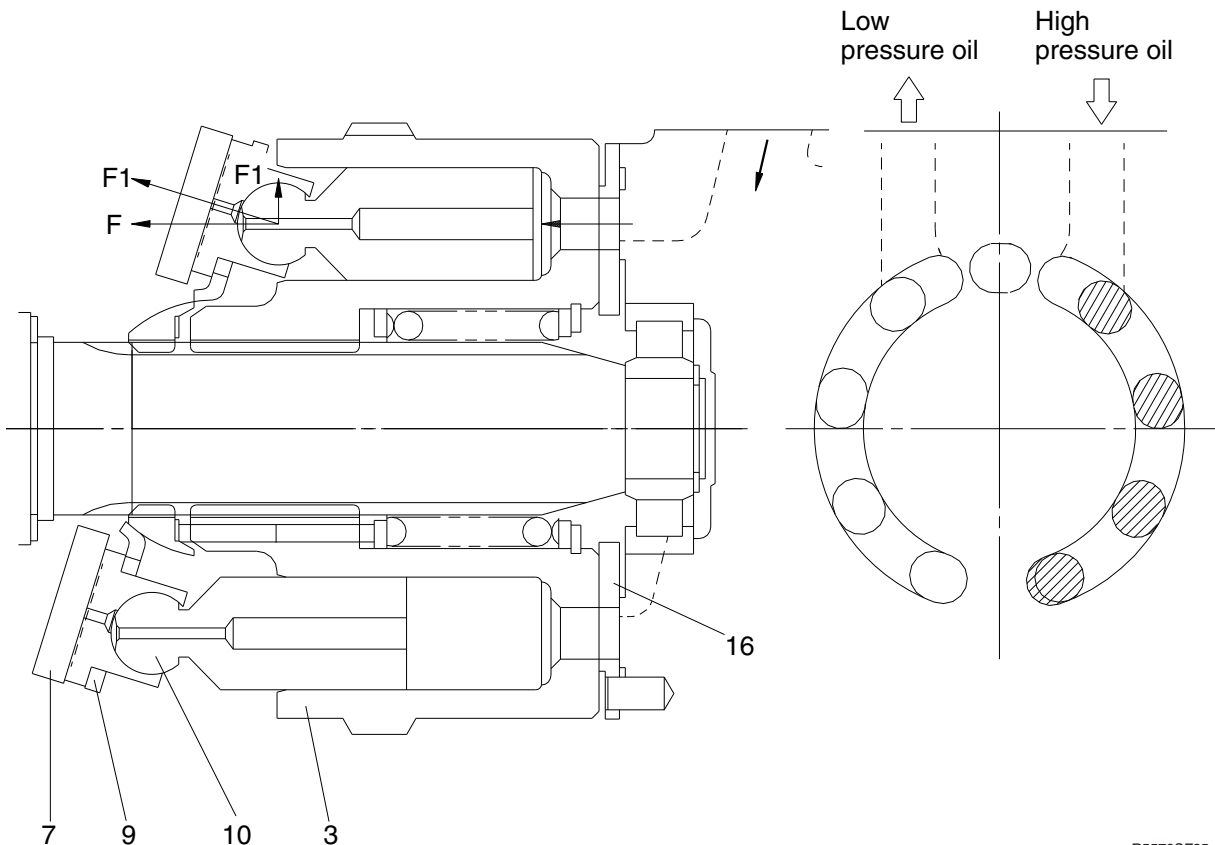
T : Output torque (kgf · cm)

Z : Piston number (9EA)

A : Piston area (cm<sup>2</sup>)

θ : Tilting angle of swash plate (degree)

S : Piston stroke (cm)



R5572SF35



## 2) MAKE UP VALVE

### (1) Outline

The safety valve portion consists of a check valve and safety valve.

### (2) Function

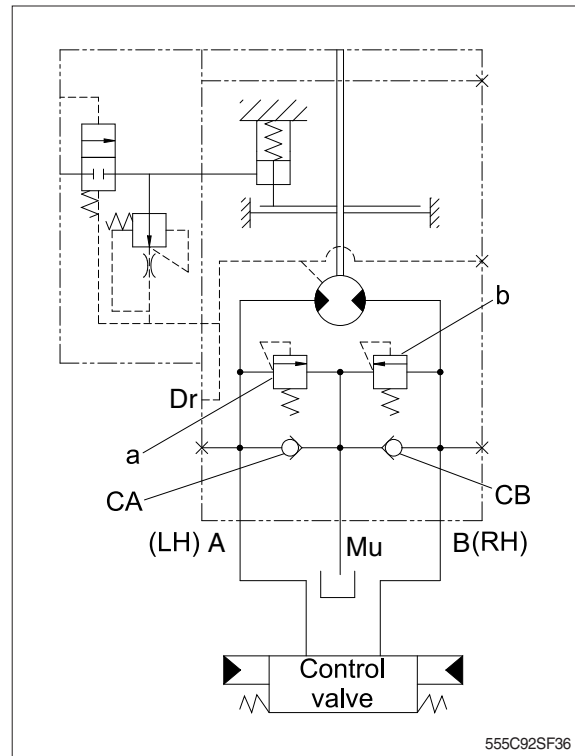
When the swing is stopped, the output circuit of the motor continues to rotate because of inertia. For this reason, the pressure at the output side of the motor becomes abnormally high, and this will damage the motor. To prevent this, the oil causing the abnormal hydraulic pressure is allowed to escape from the outlet port (high-pressure side) of the motor to port Mu, thereby preventing damage to the motor.

Compared with a counterbalance valve, there is no closed-in pressure generated at the outlet port side when slowing down the swing speed. This means that there is no vibration when slowing down, so the ease of swing control is improved.

### (3) Operation

#### ① When starting swing

When the swing control lever is operated to left swing, the pressurized oil from the pump passes through the control valves and is supplied to port B. Because of this, the pressure at port B rises, starting torque is generated in the motor, and the motor starts to rotate. The oil from the outlet port of the motor passes from port A through the control valve and returns to the tank.

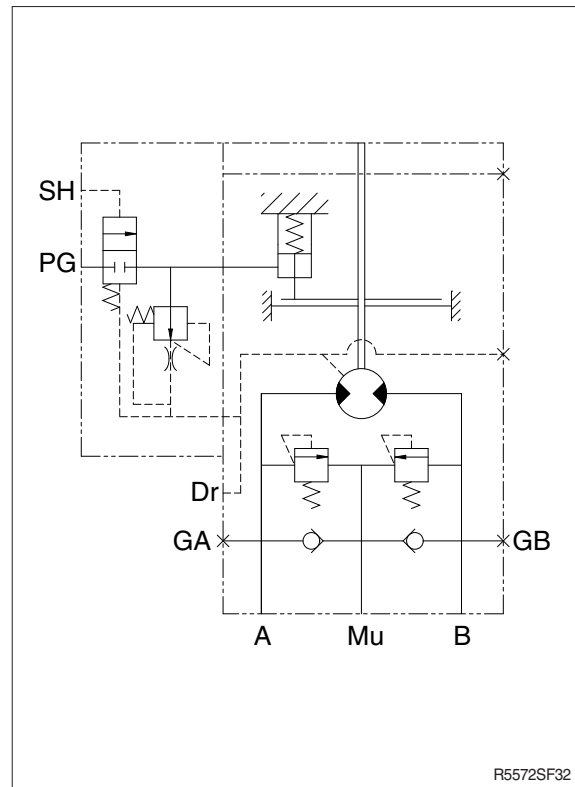


② When stopping swing

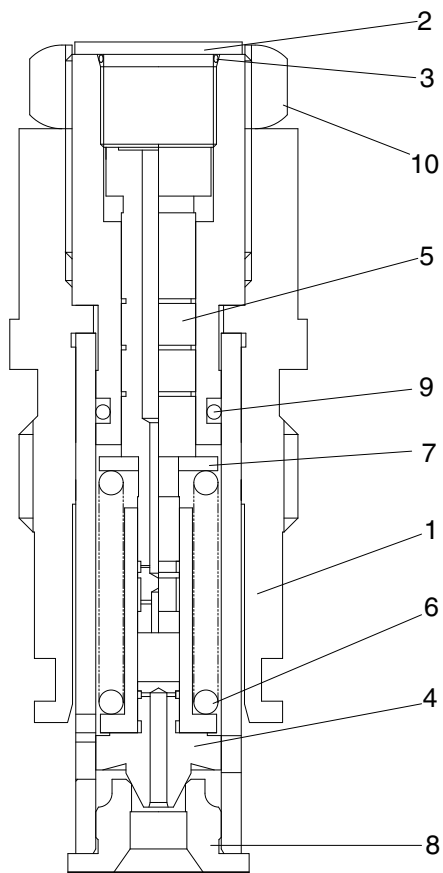
- When the swing control lever is returned to neutral, no pressurized oil is supplied from the pump to port B.

The return circuit to the tank is closed by the control valve. So the oil from the outlet port of the motor increases in pressure at port A. Resistance to the rotation of the motor is created, and the brake starts to act.

- The pressure at port A rises to the set pressure of make up valve a, and in this way, a high brake torque acts on the motor, and the motor stops.
- When make up valve a is being actuated, the relief oil from make up valve a and the oil from port Mu pass through check valve CB and are supplied to port B. This prevents cavitation from forming at port B.



### 3) RELIEF VALVE



- 1 Body
- 2 Plug
- 3 O-ring
- 4 Plunger
- 5 Piston
- 6 Spring
- 7 Spring seat
- 8 Seat
- 9 O-ring
- 10 Nut

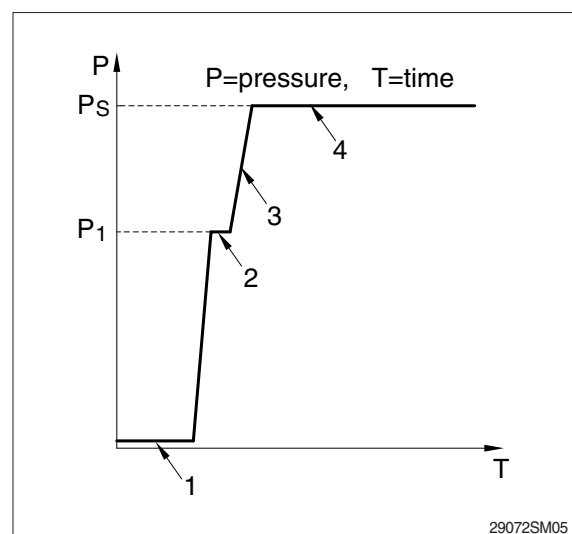
555C92SF37

#### (1) Construction of relief valve

The valve casing contains two cartridge type relief valves that stop the regular and reverse rotations of the hydraulic motor. The relief valves relieve high pressure at start or at stop of swing motion and can control the relief pressure in two steps, high and low, in order to insure smooth operation.

#### (2) Function of relief valve

Figure illustrates how the pressure acting on the relief valve is related to its rising process. Here is given the function, referring to the figure following page.



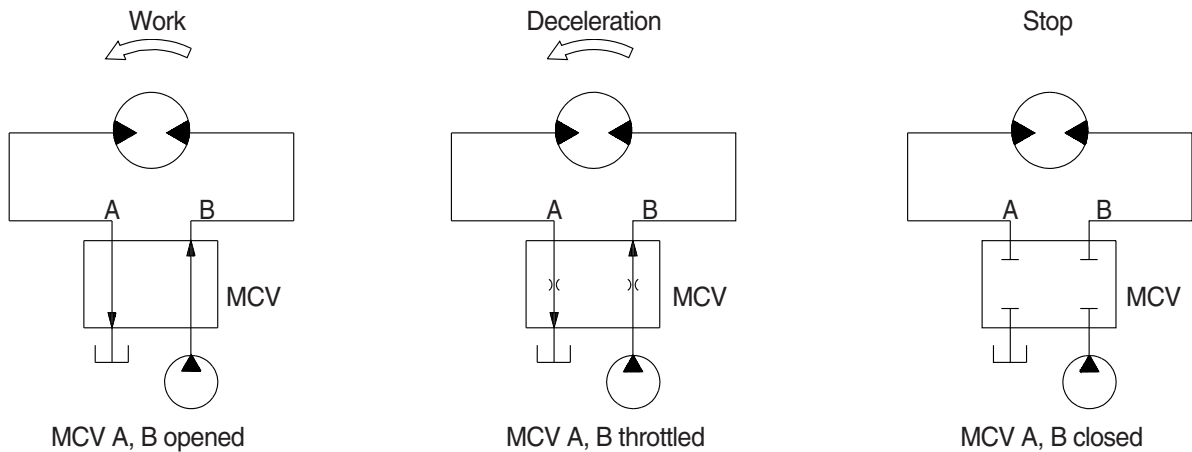
29072SM05

## 4) BRAKE SYSTEM

### (1) Control valve swing brake system

This is the brake system to stop the swing motion of the excavator during operation.

In this system, the hydraulic circuit is throttled by the swing control valve, and the resistance created by this throttling works as a brake force to slow down the swing motion.



210-7 2-48(1)

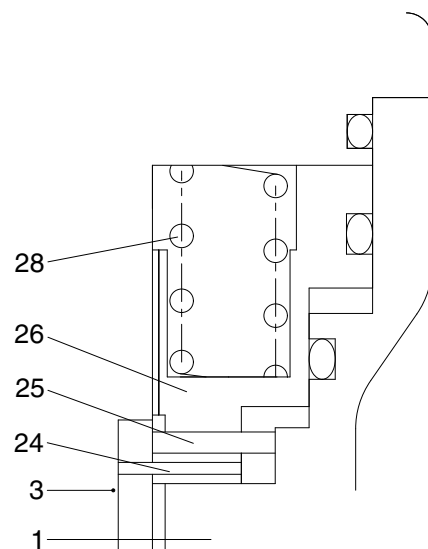
### (2) Mechanical swing parking brake system

The mechanical swing parking brake system is installed to prevent the upper structure from swinging downhill because of its own weight when the excavator is parked on a slope since it completely eliminates the hydraulic drift of swing motion while the excavator is on a slope, work can be done more easily and safely.

#### ① Brake assembly

Circumferential rotation of separate plate (25) is constrained by the groove located at body (1). When housing is pressed down by brake spring (28) through friction plate (25), separate plate (25) and brake piston (26), friction force occurs there.

Cylinder block (3) is constrained by this friction force and brake acts, while brake releases when hydraulic force exceeds spring force.



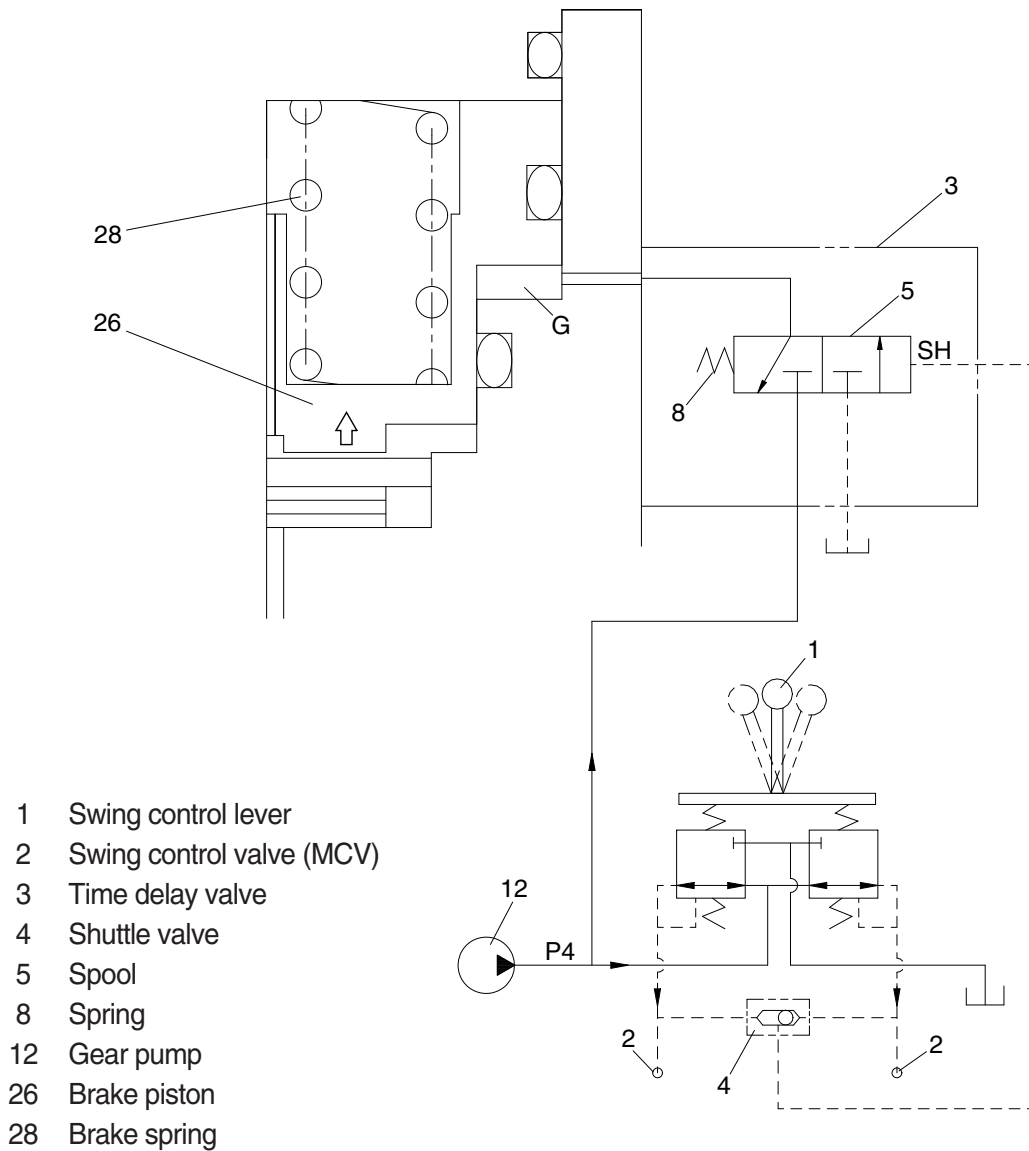
HX60A2SF38

1	Body	25	Separate plate
3	Cylinder block	26	Brake piston
24	Friction plate	28	Brake spring

## ② Operating principle

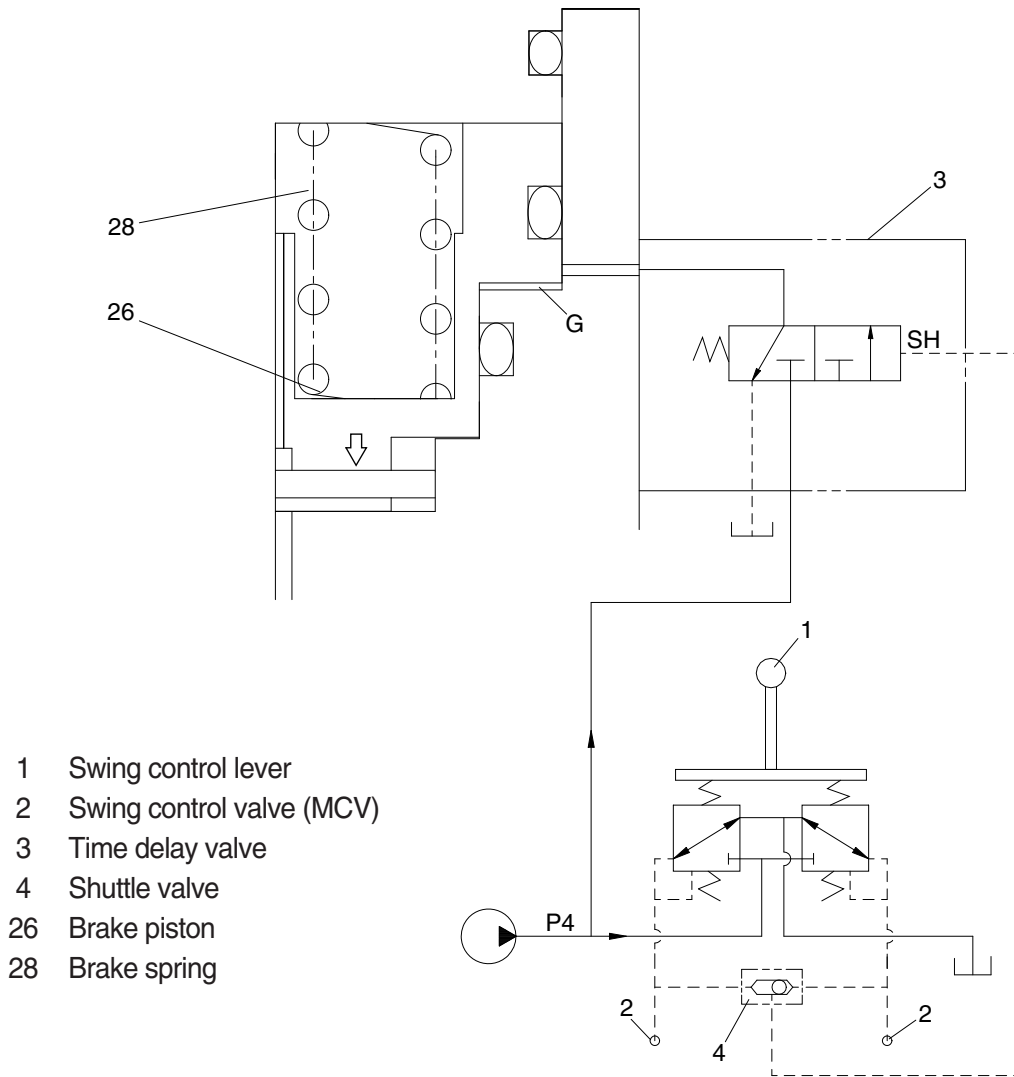
- a. When the swing control lever is set to the swing position, the pilot oil goes to the swing control valve (2) and to SH of the time delay valve (3) via the shuttle valve (4), this pressure move spool (5) to the leftward against the force of the spring (8), so pilot pump charged oil (P4) goes to the chamber G.

This pressure is applied to move the piston (26) to the upward against the force of the spring (28). Thus, it releases the brake force.



HX60A2SF39

- b. When the swing control lever (1) is set the neutral position, the time delay valve (3) shifts the neutral position and the pilot oil blocked chamber G.
- Then, the piston (26) is moved lower by spring (28) force and the return oil from the chamber G is drain.



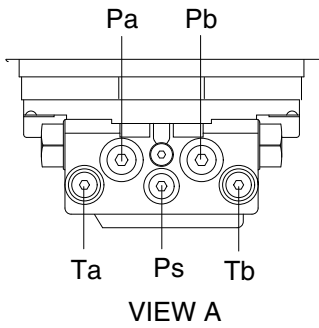
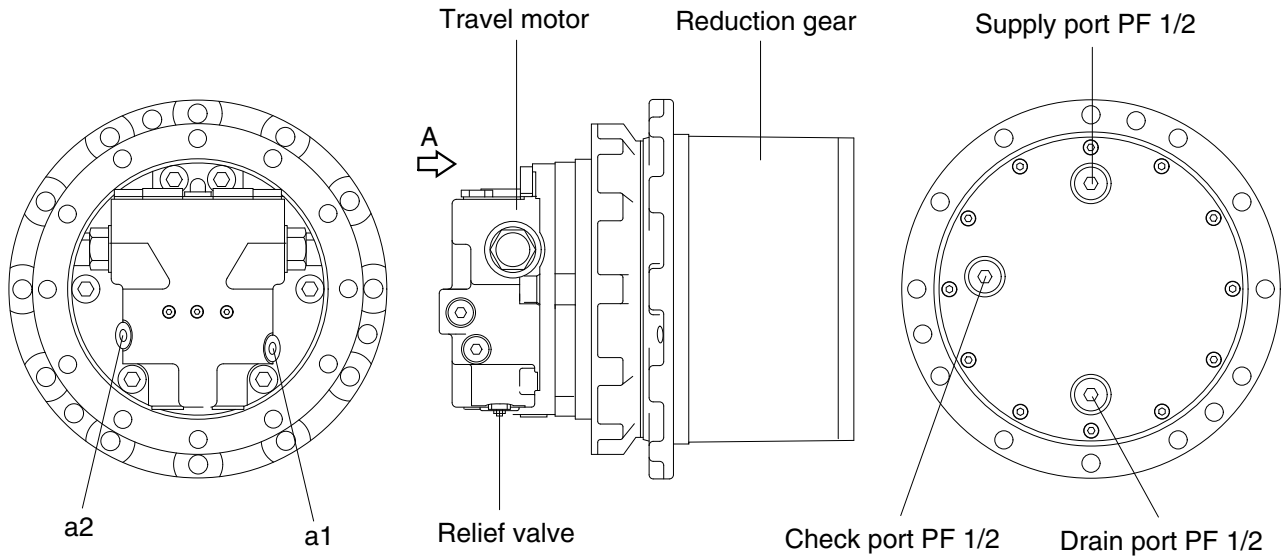
HX60A2SF40

# GROUP 4 TRAVEL DEVICE

## 1. CONSTRUCTION

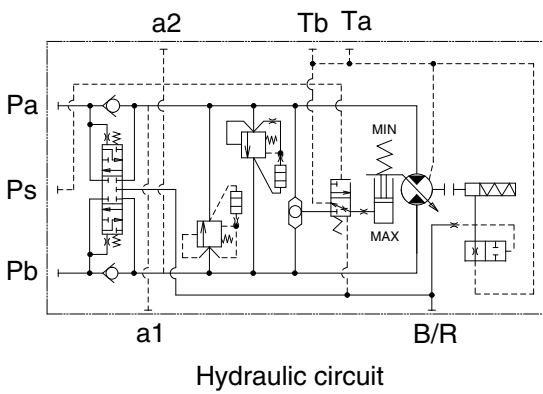
Travel device consists travel motor and gear box.

Travel motor includes brake valve, parking brake and high/low speed changeover mechanism.

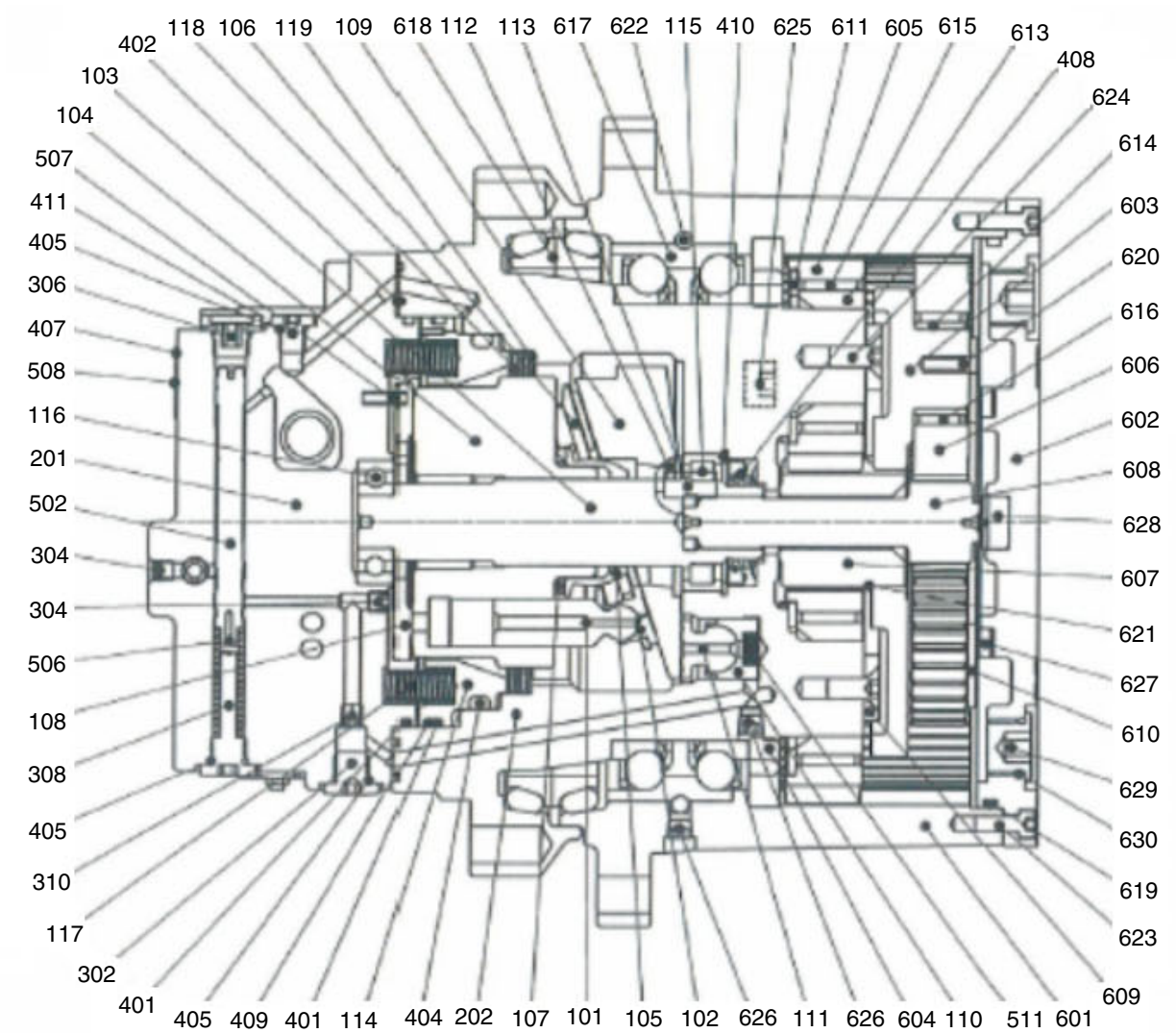
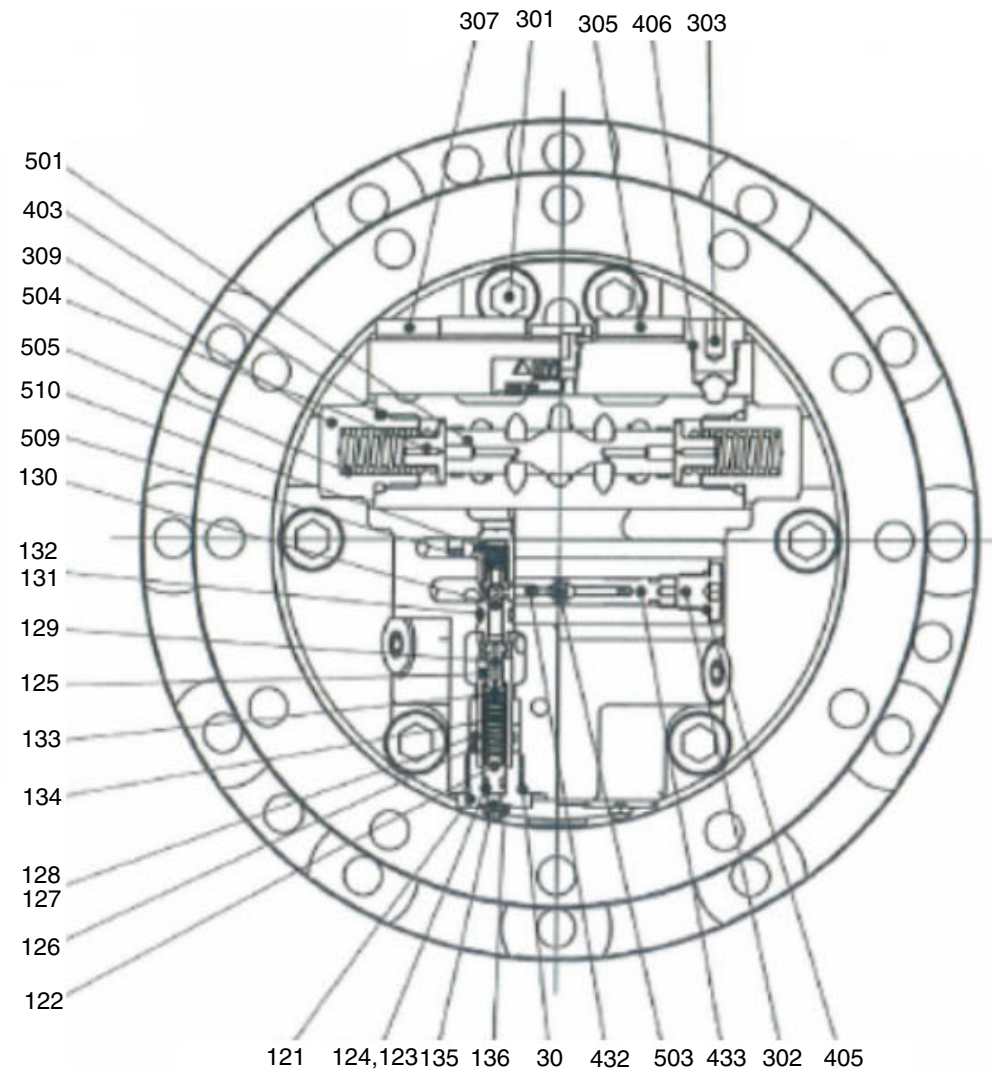


HX60A2TM50E

Port	Port name	Port size
Pa	Main port	PF 1/2
Pb	Main port	PF 1/2
a1,a2	Gauge port	PT 1/4
Ta,Tb	Drain port	PF 3/8
Ps	2 speed control port	PF 1/4



# 1) STRUCTURE



30 Relief valve assy	118 Friction plate	137 O-ring	405 O-ring	510 Cap	618 Floating seal kit
101 Piston	119 Separator plate	201 Valve casing	406 O-ring	511 Swash piston spring	619 O-ring
102 Shoe	121 Plug	202 Casing	407 Name plate	601 Housing	620 Spring pin
103 Drive shaft	122 Guide	301 Socket bolt	408 Oil seal	602 Cover	621 Snap ring
104 Cylinder block	123 O-ring	302 Plug	409 Back up ring	603 Holder	622 Steel ball
105 Spherical bushing	124 Back up ring	303 Drain plug	410 Snap ring	604 Ring nut	623 Socket bolt
106 Set plate	125 Sleeve	304 NPTF plug	411 O-ring	605 Planetary gear F	624 Bolt
107 Cylinder spring	126 Piston	305 Dust plug	432 Seat	606 Planetary gear R	625 Plug
108 Valve plate	127 O-ring	306 Dust plug	433 Seat casing	607 Sun gear	626 Plug
109 Swash plate	128 Back up ring	307 Dust plug	501 Main spool	608 Ring nut	627 Side plate A
110 Swash piston	129 Poppet	308 2 speed plug	502 2 speed spool	609 Thrust plate F	628 Side plate B
111 Swash shoe	130 Poppet seat	309 Set plug	503 Steel ball	610 Thrust plate R	629 Plug
112 Pivot	131 O-ring	310 Restrictor	504 Plunger	611 Thrust washer	630 O-ring
113 Pivot pin	132 Back up ring	311 Plug	505 Main spool spring	613 Collar	
114 Brake piston	133 Spring seat	401 O-ring	506 2 speed spool spring	614 Inner race	
115 Roller bearing	134 Spring	402 O-ring	507 Spring pin	615 Needle bearing	
116 Ball bearing	135 Adjust screw	403 O-ring	508 Pin	616 Needle bearing	
117 Brake spring	136 Hex nut	404 O-ring	509 Spring cap	617 Angular bearing	

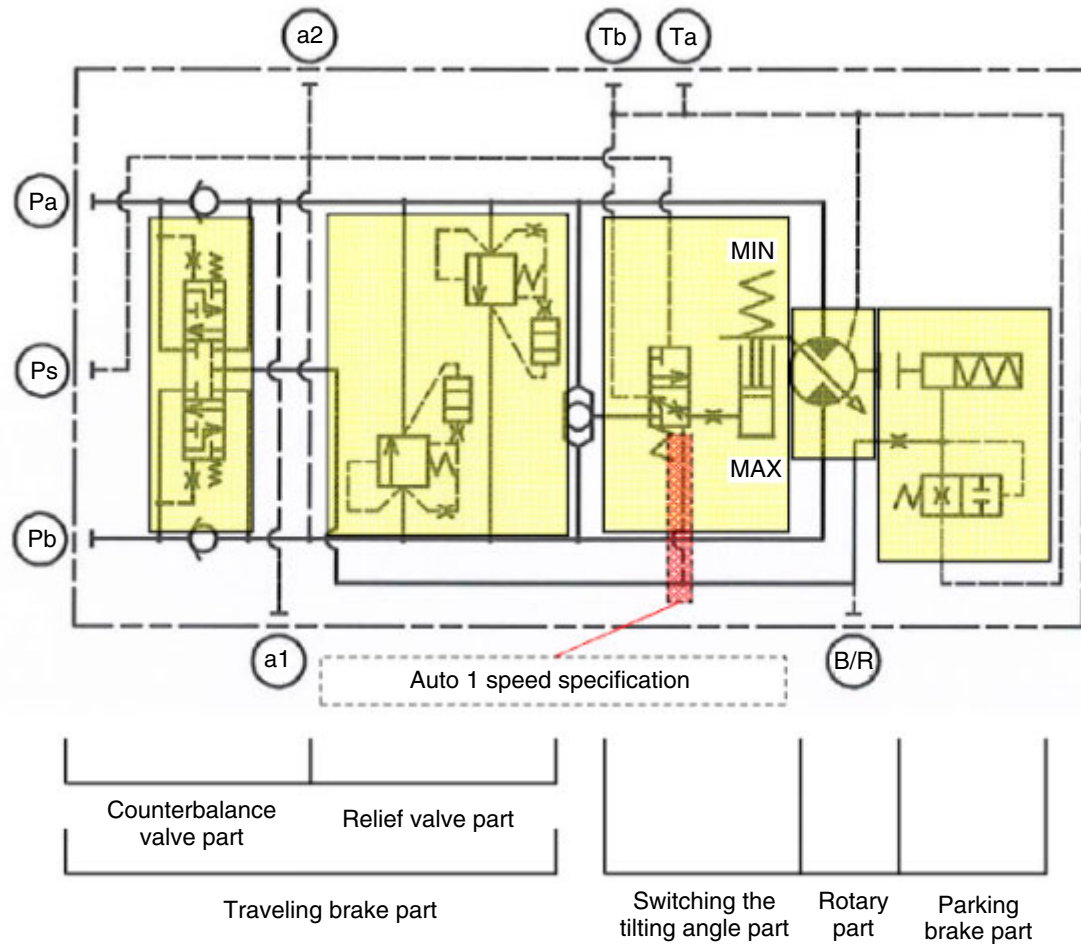
HX60A2TM51



## 2) MAJOR COMPONENT

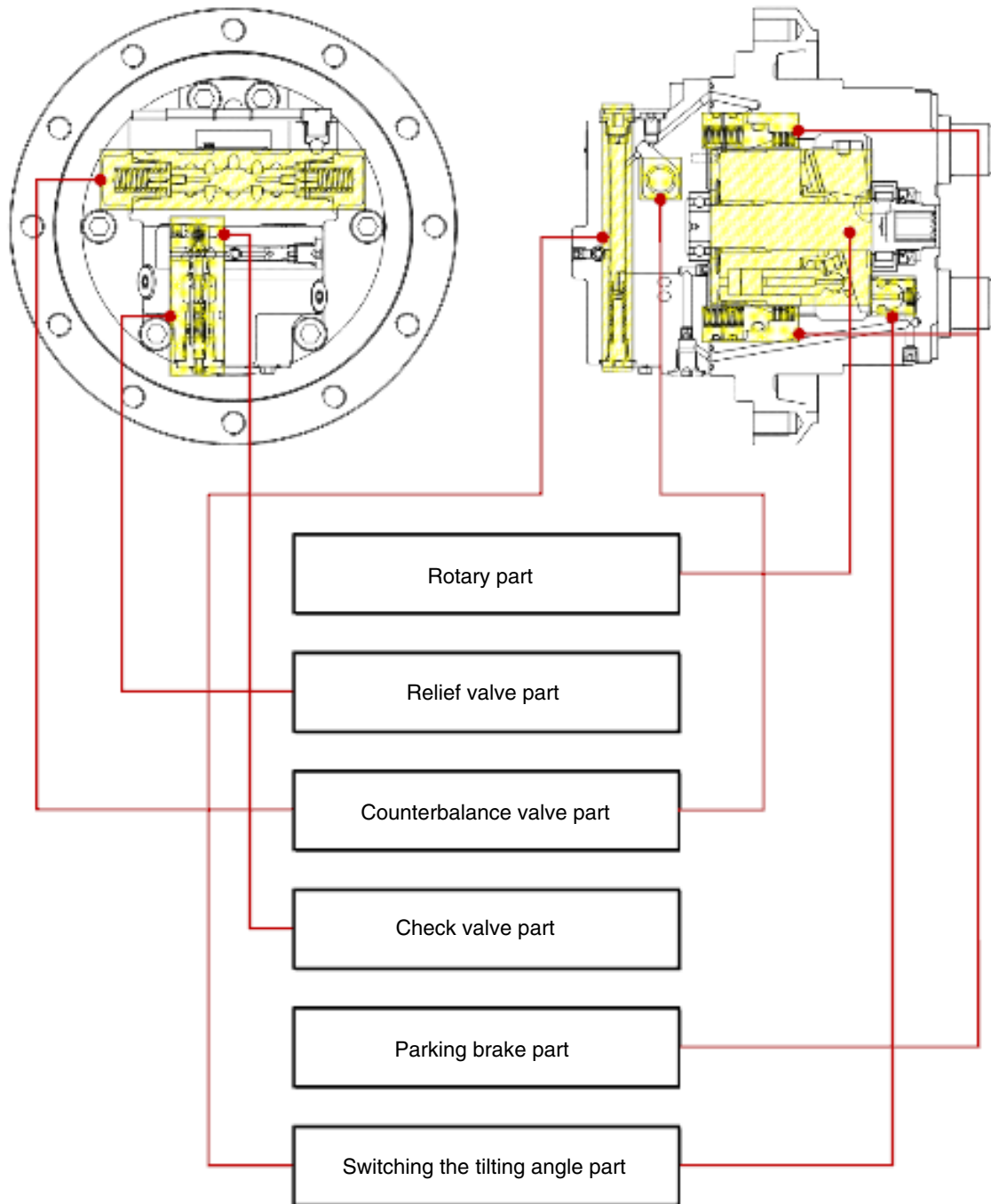
This product is only composed of hydraulic motor. Reduction parts are not composed.  
 This hydraulic motor is variable swash plate axial piston motor. It is composed of 4 parts.

- Rotary part which makes rotatory power
- Traveling brake valve part
- Parking brake part
- Switching the tilting angle part (auto 1/2 speed control part)



559A2TM52

### 3) BASIC STRUCTURE



559A2TM53

## 2. WORKING PRINCIPLE

### 1) HYDRAULIC MOTOR SECTION

When high pressure oil passes from pump through the inlet port of the valve plate(108) and flows into the cylinder (104) as shown in figure, the oil pressure acts upon the piston (101) to generate the axial force "F". The force "F" acts on the swash (109) plane in the axial direction.

$$F = P \times A \quad (P : \text{Pressure, } A : \text{Area})$$

The swash plate (109) is fixed with an inclination angle of  $\alpha$  to the axis of the drive shaft (103).

Therefore, this force is divided into two vector forces through the shoe (102) : namely, the force F1 vertical to the swash plate (109) and the force F2 perpendicular to the drive shaft (103).

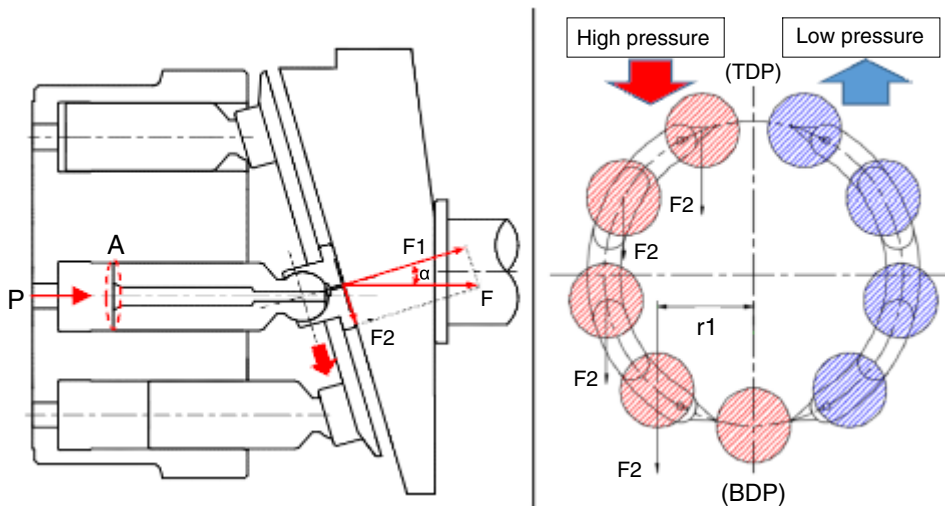
Because of the force "F2", piston (101) slides along with shoe (102) in the direction of the arrow in Figure. This force "F2" is transmitted to the cylinder block (104) via the piston (101) and generates a couple of forces which turn the output drive shaft (103).

In the cylinder block (104) nine pistons are equispaced and the pistons connected to the high pressure oil inlet ports give their rotating torque to the output shaft sequentially.

When the oil inflow/outflow direction are reversed, the rotating direction of the output shaft is reversed.

The theoretical output torque "T [N/m]" is given by the flowing.

$$T = \frac{P \times q}{2\pi} \quad P : \text{Effective pressure difference (Mpa), } q : \text{Displacement per revolution (cm}^3\text{)}$$



559A2TM54

## 2) TRAVELING BRAKE VALVE

Traveling brake valve is composed of relief valve, counterbalance valve and check port A is connected with hydraulic pump and port B is connected with tank.

### (1) In case of traveling

When the compressed oil, which is supplied along the inlet port, exceeds certain pressure, it pushes cap (509). And, it is supplied to one side of the casing (202).

It is trying to rotate the hydraulic motor.

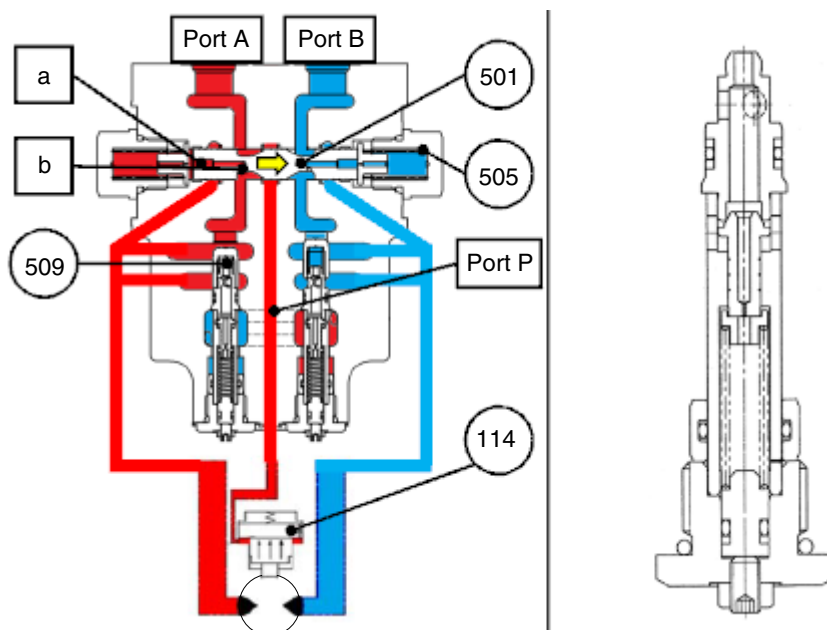
At the same time, the compressed oil enters the chamber {a} along small hole {b} of main spool (501) and acts on the face of main spool (501). After increasing pressure of oil, when this pressure exceeds the spring elasticity force of main spool spring (505), main spool (501), which is held in neutral by the spring elasticity force, moves to the right.

The inlet side and outlet side that was blocked by main spool (501) during stop connect with each other. So, return oil returns to the oil tank, so the hydraulic motor rotates.

Furthermore as main spool (501) moves, the path of parking brake (port P) is connected.

When compressed pressure, which enter to (port P), becomes brake release pressure, it operates brake piston (114) and parking brake is released.

If the direction of oil inlet is reversed, main spool (501) and check valve motion is reversed. Output rotation direction is also reversed.



559A2TM55

## (2) In case of stop

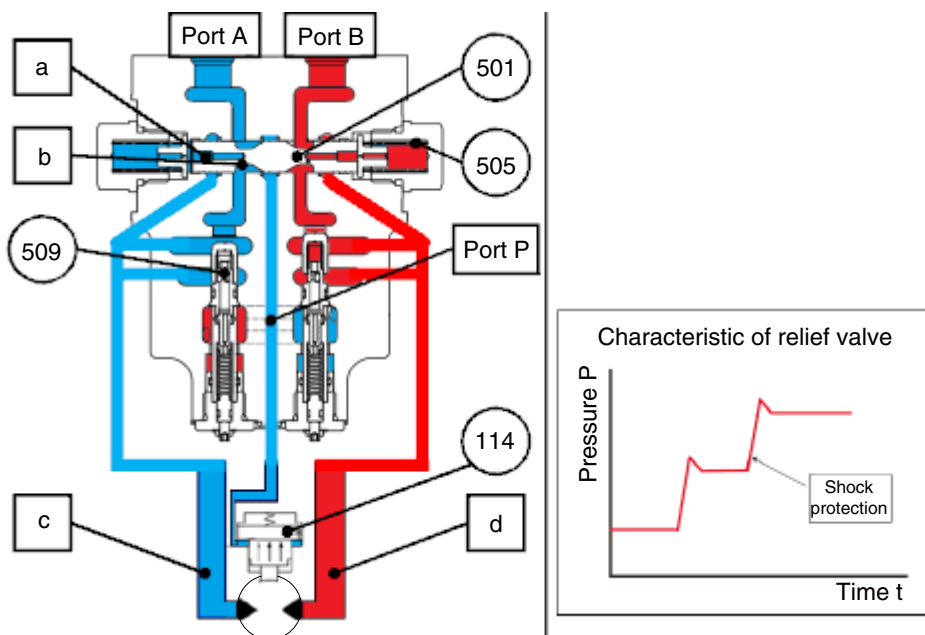
If the pressure supplied along the port to the inlet breaks while traveling, the pressure applied to the section of the main spool (501) is removed. Therefore, the main spool (501), which was pushed to the right, returns to neutral due to the spring elasticity force of the main spool spring (505).

The rotary part continues to rotate under inertia even if pressure is lost from the inlet side. As the main spool (501) returns to neutral, the connected inlet and outlet sides of the flow path are blocked. Since there is no escape location for the returned oil, the pressure of the exit side (D) is raised.

The returned oil with increased pressure enters the relief valve (30). If it exceeds the set pressure of the relief valve (30), it operates the relief valve (30). The flow path from the outlet side {D} to the inlet side {C} is connected. And it controls the pressure on the outlet side.

At the same time it prevents cavitation on the inlet side.

It also relieves the shock during stop while controlling pressure on the outlet side with relief valve (30) in two stages, and apply soft braking to the hydraulic motor by applying an orifice and notch on the main spool (501).



559A2TM56

## (2) In case of stop

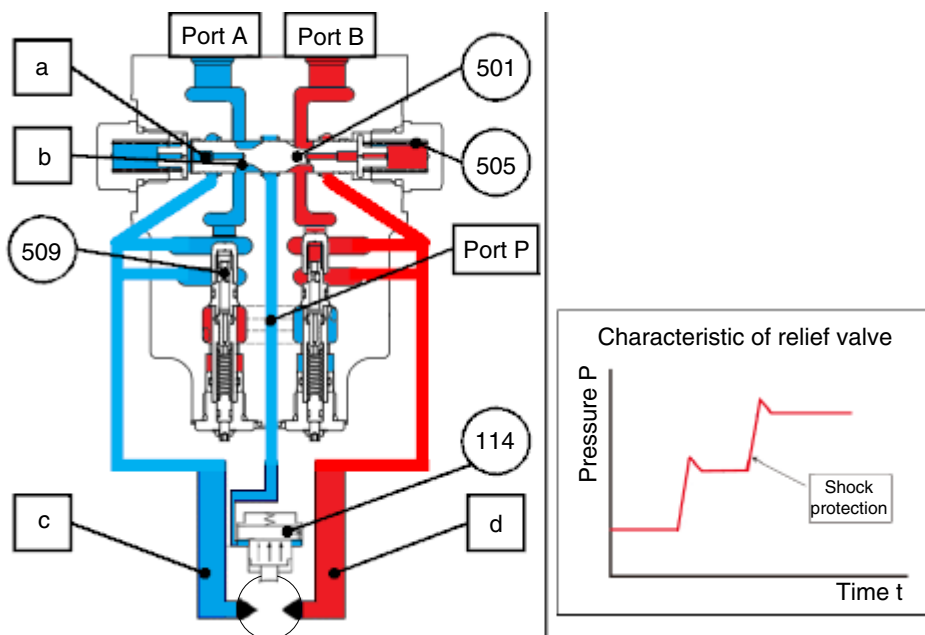
If the pressure supplied along the port to the inlet breaks while traveling, the pressure applied to the section of the main spool (501) is removed. Therefore, the main spool (501), which was pushed to the right, returns to neutral due to the spring elasticity force of the main spool spring (505).

The rotary part continues to rotate under inertia even if pressure is lost from the inlet side. As the main spool (501) returns to neutral, the connected inlet and outlet sides of the flow path are blocked. Since there is no escape location for the returned oil, the pressure of the exit side (D) is raised.

The returned oil with increased pressure enters the relief valve (30). If it exceeds the set pressure of the relief valve (30), it operates the relief valve (30). The flow path from the outlet side {D} to the inlet side {C} is connected. And it controls the pressure on the outlet side.

At the same time it prevents cavitation on the inlet side.

It also relieves the shock during stop while controlling pressure on the outlet side with relief valve (30) in two stages, and apply soft braking to the hydraulic motor by applying an orifice and notch on the main spool (501).



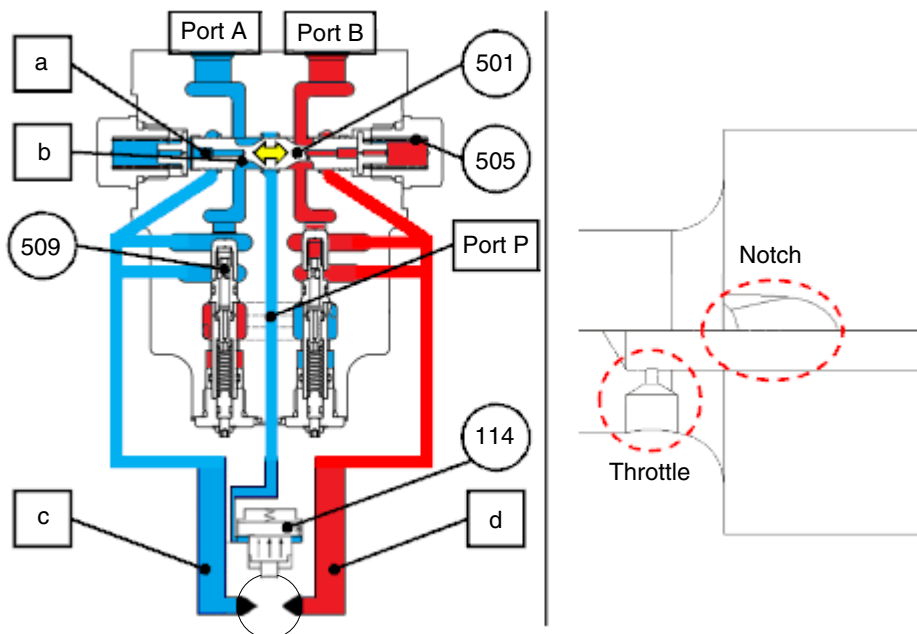
559A2TM56

### (3) In case of overrun

Overrun is when the excavator's speed is increased by its gravity (inertia), such as when an excavator is going downhill, causing the hydraulic motor to rotate above the supply flow of the hydraulic pump.

In the case of overrun, the compressed oil on the inlet side is entered into the rotary and the pressure on the inlet side is reduced. Therefore, due to the spring elasticity force of the main spool spring (505), main spool (501) returns to neutral, as it stops.

At the same time, back pressure is generated due to the throttle (notch of main spool) between the outlet side (D) and the outlet port (port B) passage. The back pressure controls the return speed of the main spool (501) and hydraulic motor, which is about to be rotated by inertia forces, is decelerated. The operation of main spool (501) is controlled by the notch of main spool (501) and throttle. So motor smoothly moves according to the supply flow rate.



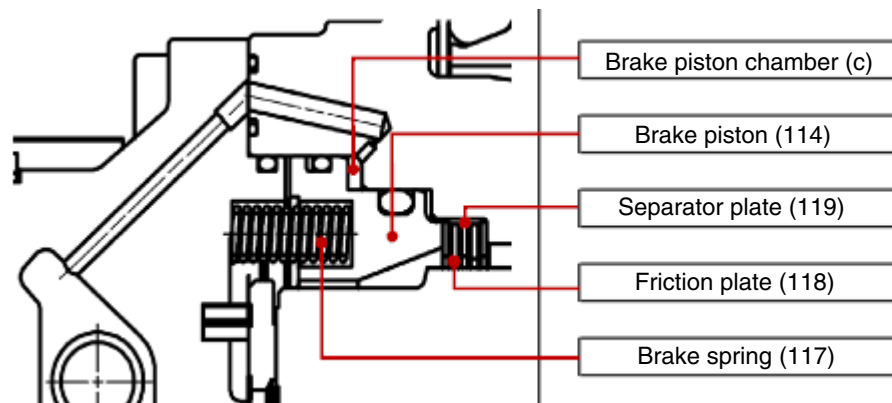
559A2TM57

### 3) PARKING BRAKE

The parking brake is wet-type multiple disk brakes. It is a negative brake system which is released when the brake release pressure enters the brake piston chamber.

The internal structure of parking brake is shown in figure. Friction plate (118) and separator plate (119) are alternately stacked, and acting on springs to produce brake torque with friction forces.

It prevents not only the braking of excavators but also overrun or slip during traveling and stopping on the slip.



559A2TM58

#### (1) In case traveling

The cylinder block (104) is connected to the drive shaft (103) with spline. In addition, the separator plate (119) is restrained from circumferentially-rotating by an arc groove cut on the casing (202).

The friction plate (118) which is connected to the arc groove cut on cylinder block (104), can be rotated along the cylinder block (104).

When pressurized oil is supplied from the inlet side during traveling operation, the blocked flow path is opened. so pressurized oil is supplied to the brake piston chamber (c) that is comprised inside brake piston (114) and casing (202).

If the hydraulic force  $F_4$  of the brake piston chamber (c) is greater than the spring elasticity force  $F_3$  of the brake spring (117), then brake piston (114) move to valve casing. (above brake release pressure)

$F_3 = k \times n$  ,  $k$  : Spring constant,  $x$  : Spring stroke,  $n$  : Number of spring brake

$F_4 = P \times (A_1 - A_2)$ ,  $P$  : Main pressure of input,  $(A_1 - A_2)$  : Area difference of brake piston

The force that friction plate (118) and separator plate (119) pressurize the casing (202) disappears and the brake releases.

So, the hydraulic motor can rotate.



## (2) In case of stop

If the pressurized oil supplied by the inlet is cut off during stop, the pressurized oil supplied to the brake piston chamber (c) will also be blocked. (below brake release pressure)

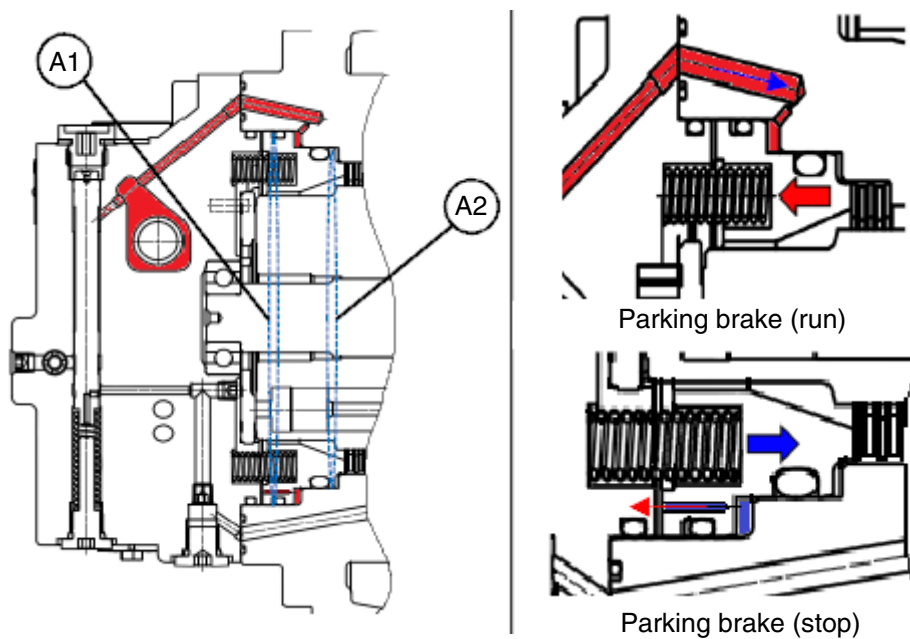
If the spring elasticity force  $F_3$  of the brake spring (117) is greater than the hydraulic force  $F_4$  of the brake piston chamber (c), then brake piston (114) move to casing by spring elasticity force. The hydraulic oil of the brake piston (114) is drained through the throttle. Therefore brake piston (114) smoothly operates.

$$F_3 < F_4$$

$F_3 = k \times n$ ,  $k$ : Spring constant,  $x$ : Spring stroke,  $n$ : Number of spring brake

$F_4 = P \times (A_1 - A_2)$ ,  $P$ : Main pressure of input,  $(A_1 - A_2)$ : Area difference of brake piston

When the brake piston (114) pushes casing (202) by the brake spring (117), the frictional force appears between friction plate (118), casing (202), separator plate (119) and brake piston (114). parking brake appears by friction force and spring elasticity of the brake spring (117), the drive shaft (103) is constrained.



559A2TM59

#### 4) 1/2 SPEED SWITCHING OPERATION (AUTOMATIC 1/2 SPEED CONTROL PART)

##### (1) Low speed traveling

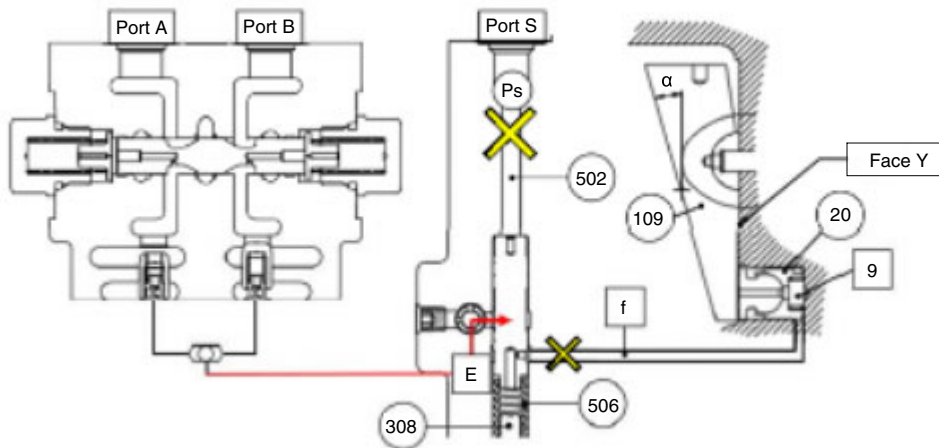
If pilot pressure is not supplied on pilot port (port S), 2 speed spool (502) is pushed in the direction of the port S by spring elasticity of 2 speed spool spring (506).

As a result, the compressed oil from the high pressure selection check valve (E) is not connected to the swash piston chamber (g).

The compressed oil of swash piston chamber {g} is drained through the flow path of 2 speed spool chamber (f).

So, the compressed oil from the high pressure selection check valve (E) is not connected to the swash piston chamber {g}. As a result, the swash plate (109) will be the maximum angle  $\alpha$  and the stroke of the piston (101) will be long. So, a large amount of oil will be required for rotating the motor once.

Therefore the displacement of the hydraulic motor is maximized and rotated at low speed.



559A2TM60

## (2) High speed traveling

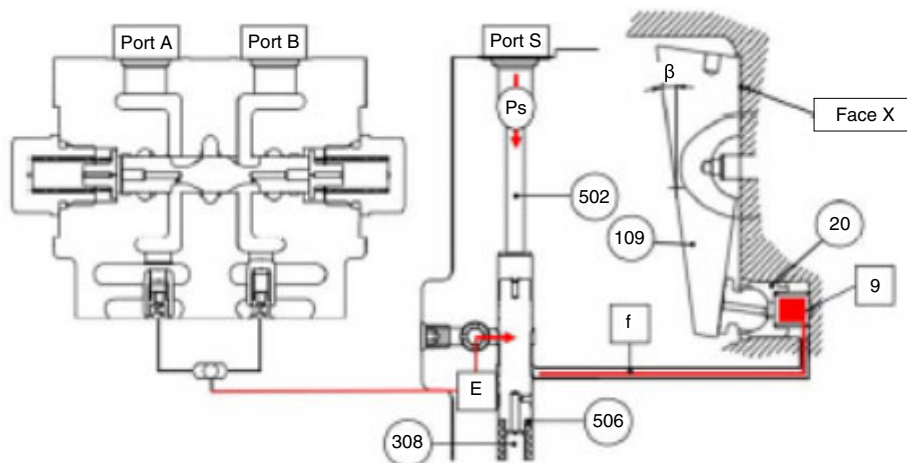
If the pilot pressure (20~50 kgf/cm<sup>2</sup>) is supplied to the port (port S), the pilot pressure overcomes the oil pressure in the main port and the spring elasticity force of the 2 speed spool spring (506), and it pushes the 2 speed spool (502) to the 2 speed plug (308) direction.

This is why the pressure from the high pressure selection check valve (E) is connected to the flow path (f).

The pressurized oil flows into the {g} chamber along the flow path {f} and pushes swash piston (20) to contact the face 'X' of swash plate (109) with the wall of the casing (202).

As a result, the swash plate (109) is the minimum angle  $\beta$ . Because stroke of piston (101) is shortened, a small amount of oil is used for one revolution.

Therefore, the displacement of the hydraulic motor is minimized and is rotated at high speed.



559A2TM61

### (3) Automatic 1/2 speed control part

If the load is increased during the 2-speed driving, the hydraulic pressure on the main port is increased. The pressure ( $\Delta P$ ) of main port and spring elasticity force of 2 speed spool spring (506) will overcome the pressure of pilot, 2 speed spool (502) is pushed in port S direction.

$$F5 < [F6 \times (A4 - A3)] + (F_{spring})$$

$$F5 = P_S \times A3, P_S : \text{Pilot pressure, } A3 : \text{2 speed spool area}$$

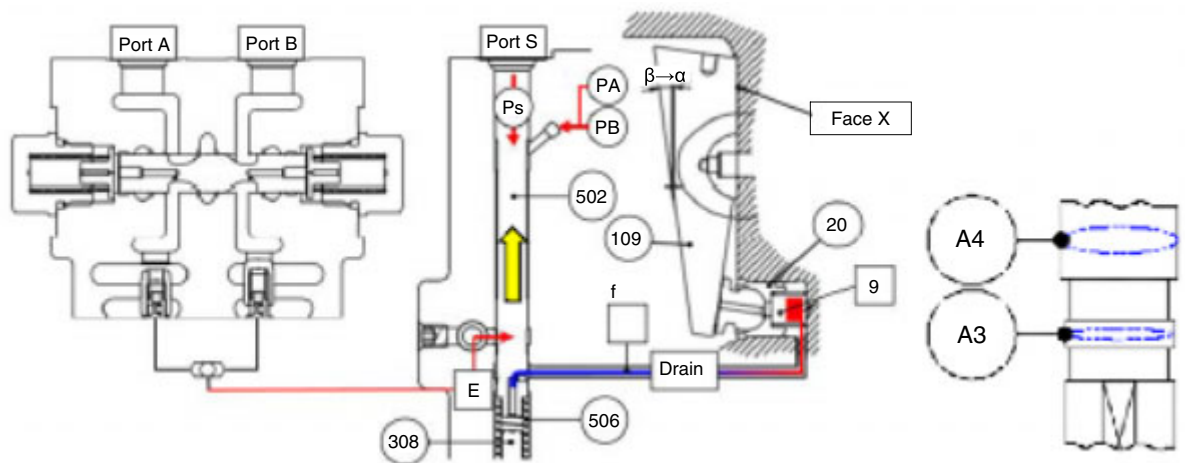
$$F6 = (P_A \text{ or } P_B) \times (A4 - A3), (P_A \text{ or } P_B) : \text{Main pressure difference between inlet side and outlet side}$$

$$F_{spring} = K \times X ; K : \text{Spring constant of 2 speed spool spring, } X : \text{Spring stroke}$$

Therefore, flow path from the high pressure selection check valve (E) to (f) is blocked.

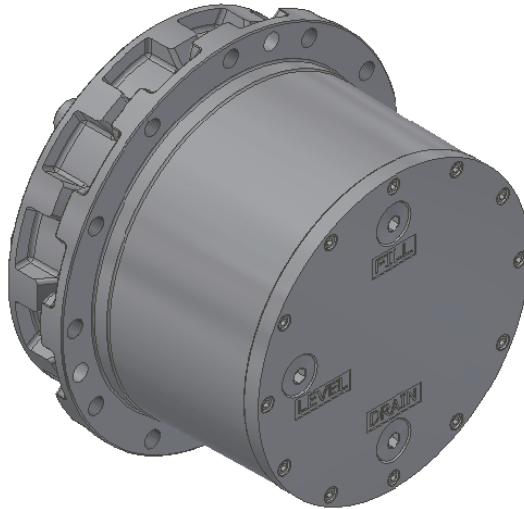
And the pressure of (g) is slowly drained to 2 speed spool chamber (f) through throttle and a notch of 2 speed spool.

The angle of swash plate (109) transfers from  $\beta$  to  $\alpha$ , and the motor automatically switches from 2 speed to 1 speed to rotate at low speed.



559A2TM62

## 5) REDUCTION GEAR



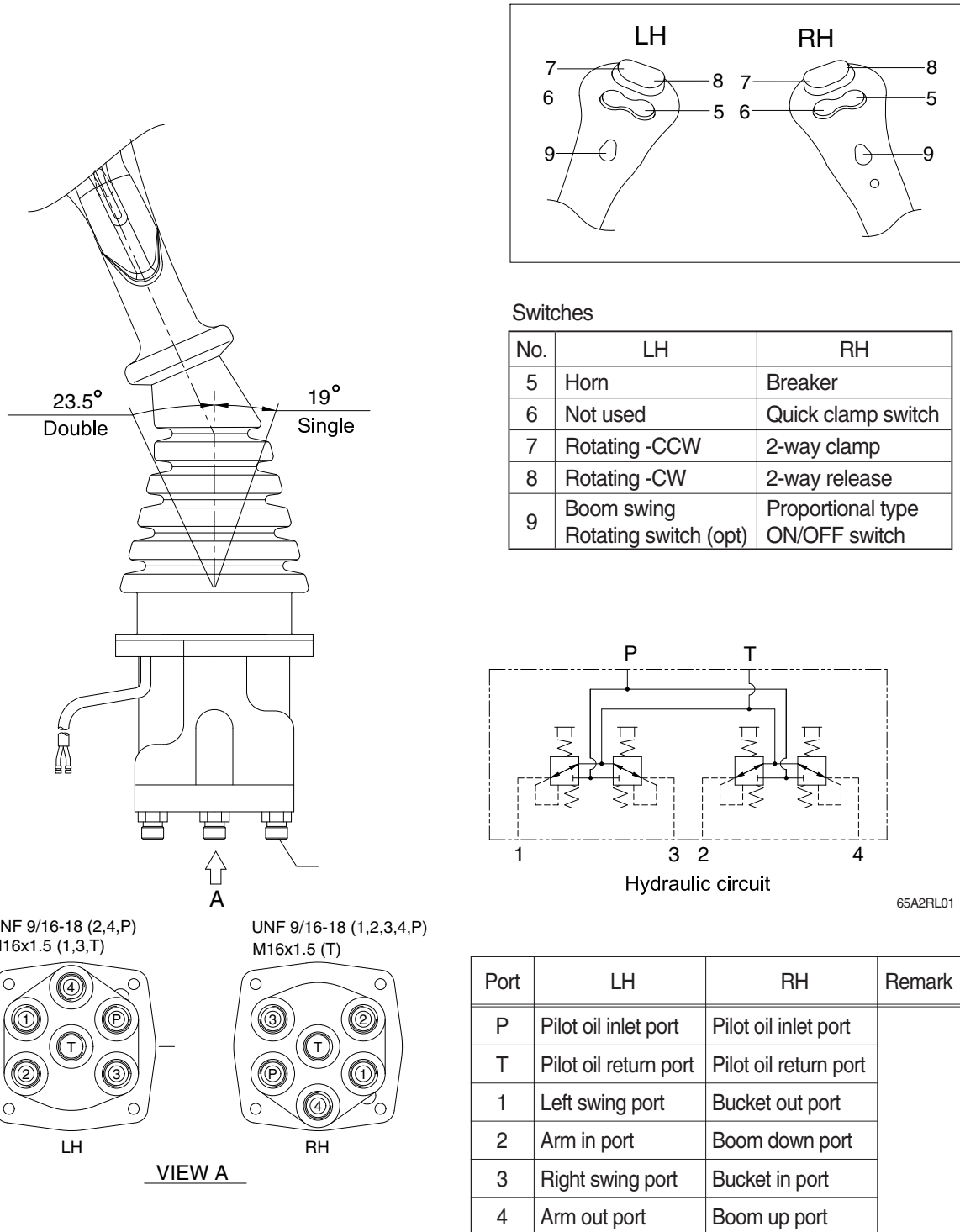
559A2TM63

- (1) Refer to the section drawing for the basic construction.
- (2) The reduction gear consists of two stage planetary gears.
- (3) The reduction ratio is determined by the number of teeth of the gear, and the reduction ratio is 42.439.  
In other words, the number of revolutions of the hydraulic motor is transmitted to the output shaft at 1 / reduction ratio.
- (4) The direction of rotation of the input and output shafts is opposite.

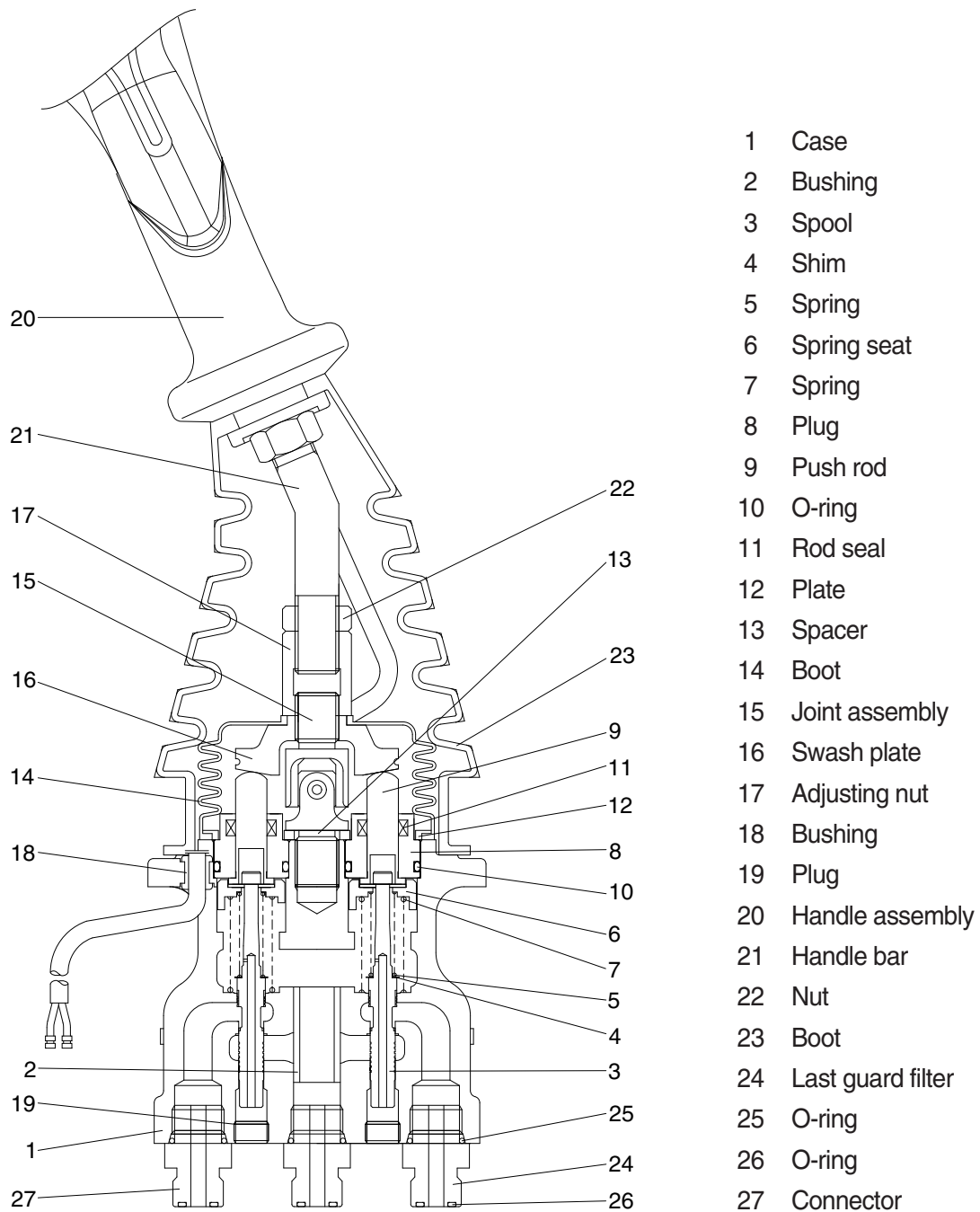
## GROUP 5 RCV LEVER

### 1. STRUCTURE

The casing has the oil inlet port P (primary pressure) and the oil outlet port T (tank). In addition the secondary pressure is taken out through ports 1, 2, 3 and 4 provided at the bottom face.



## CROSS SECTION



- 1 Case
- 2 Bushing
- 3 Spool
- 4 Shim
- 5 Spring
- 6 Spring seat
- 7 Spring
- 8 Plug
- 9 Push rod
- 10 O-ring
- 11 Rod seal
- 12 Plate
- 13 Spacer
- 14 Boot
- 15 Joint assembly
- 16 Swash plate
- 17 Adjusting nut
- 18 Bushing
- 19 Plug
- 20 Handle assembly
- 21 Handle bar
- 22 Nut
- 23 Boot
- 24 Last guard filter
- 25 O-ring
- 26 O-ring
- 27 Connector

300L2RL06K

The construction of the pilot valve is shown in the attached cross section drawing. The casing has vertical holes in which reducing valves are assembled.

The pressure reducing section is composed of the spool (3), spring (5) for setting secondary pressure, return spring (7), spring seat (6) and shim (4). The spring for setting the secondary pressure has been generally so preset that the secondary pressure is 5 to 20.5 kgf/cm<sup>2</sup> (depending on the type). The spool is pushed against the push rod (9) by the return spring.

When the push rod is pushed down by tilting the handle, the spring seat comes down simultaneously and changes setting of the secondary pressure spring.

## 2. FUNCTIONS

### 1) FUNDAMENTAL FUNCTIONS

The pilot valve is a valve that controls the spool stroke, direction, etc of a main control valve. This function is carried out by providing the spring at one end of the main control valve spool and applying the output pressure (secondary pressure) of the pilot valve to the other end.

For this function to be carried out satisfactorily, the pilot valve is composed of the following elements.

- (1) Inlet port (P) where oil is supplied from hydraulic pump.
- (2) Output ports (1, 2, 3 & 4) to apply pressure supplied from inlet port to ends of control valve spools.
- (3) Tank port (T) necessary to control the above output pressure.
- (4) Spool to connect output port to inlet port or tank port.
- (5) Mechanical means to control output pressure, including springs that work on the above spools.

### 2) FUNCTIONS OF MAJOR SECTIONS

**Item numbers are based on the type L1.**

The functions of the spool (3) are to receive the supply oil pressure from the hydraulic pump at its port P, and to change over oil paths to determine whether the pressure oil of port P is led to output ports 1, 2, 3 & 4 or the output port pressure oil to tank port T.

The spring (5) works on this spool to determine the output pressure.

The change the deflection of this spring, the push rod (9) is inserted and can slide in the plug (8).

For the purpose of changing the displacement of the push rod through the swash plate (16) and adjusting nut (17) are provided the handle assy (20) that can be tilted in any direction around the fulcrum of the universal joint (15) center.

The spring (7) works on the case (1) and spring seat (6) and tries to return the push rod (9) to the zero-displacement position irrespective of the output pressure, securing its resetting to the center position.

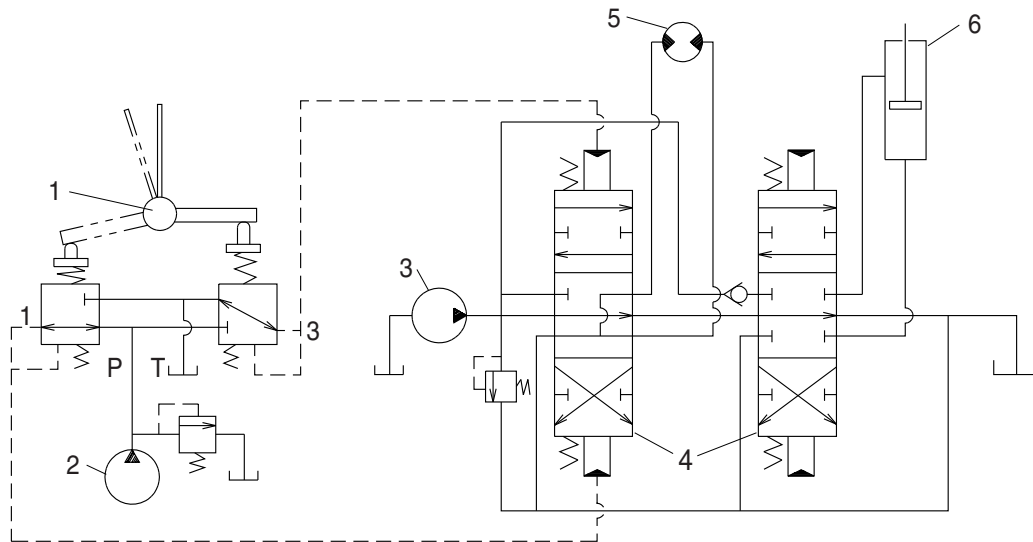
This also has the effect of a reaction spring to give appropriate control feeling to the operator.



### 3) OPERATION

The operation of the pilot valve will be described on the basis of the hydraulic circuit diagram shown below and the attached operation explanation drawing.

The diagram shown below is the typical application example of the pilot valve.



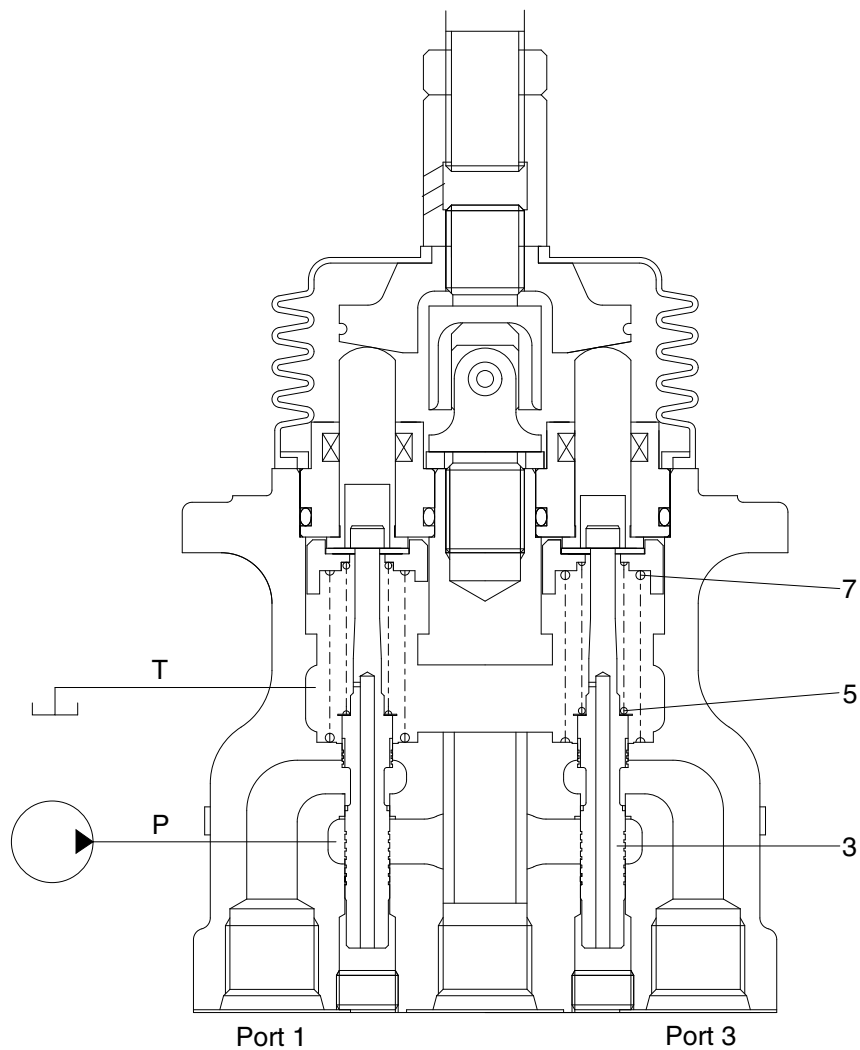
2-70

1 Pilot valve  
2 Pilot pump

3 Main pump  
4 Main control valve

5 Hydraulic motor  
6 Hydraulic cylinder

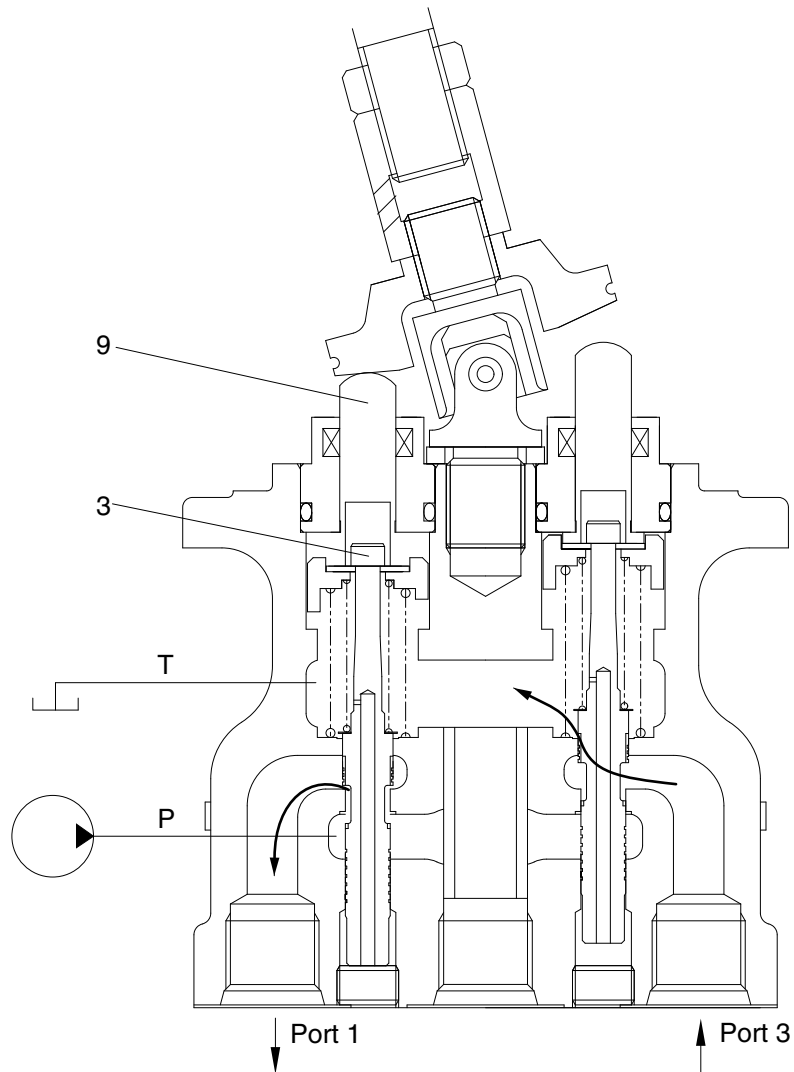
(1) Case where handle is in neutral position



300L2RL03

The force of the spring (5) that determines the output pressure of the pilot valve is not applied to the spool (3). Therefore, the spool is pushed up by the spring (7) to the position of port (1, 3) in the operation explanation drawing. Then, since the output port is connected to tank port T only, the output port pressure becomes equal to tank pressure.

**(2) Case where handle is tilted**



300L2RL04

When the push rod (9) is stroked, the spool (3) moves downwards.

Then port P is connected with port (1) and the oil supplied from the pilot pump flows through port (1) to generate the pressure.

When the pressure at port (1) increases to the value corresponding to the spring force set by tilting the handle, the hydraulic pressure force balances with the spring force. If the pressure at port (1) increases higher than the set pressure, port P is disconnected from port (1) and port T is connected with port (1). If it decreases lower than the set pressure, port P is connected with port (1) and port T is disconnected from port 1.

In this manner the secondary pressure is kept at the constant value.

Besides, in some type, when the handle is tilted more than a certain angle, the upper end of the spool contacts with the inside bottom of the push rod and the output pressure is left to be connected with port P.