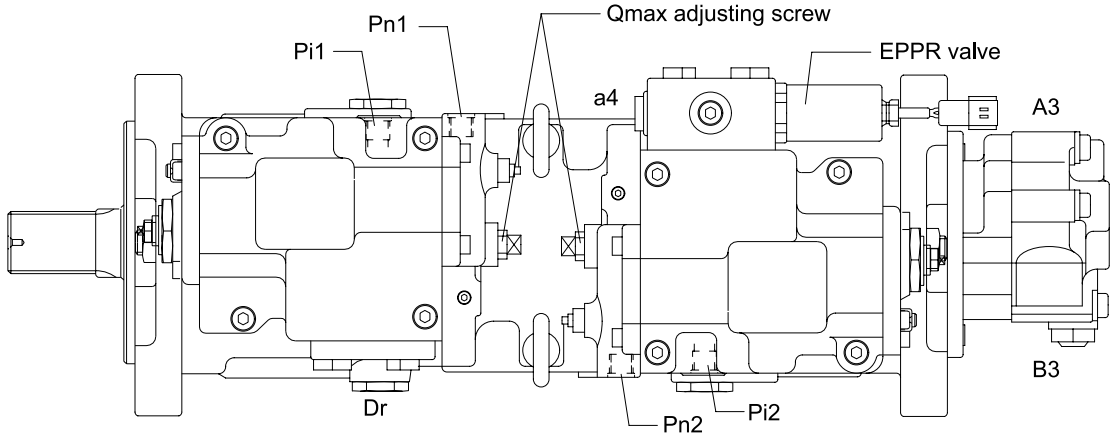
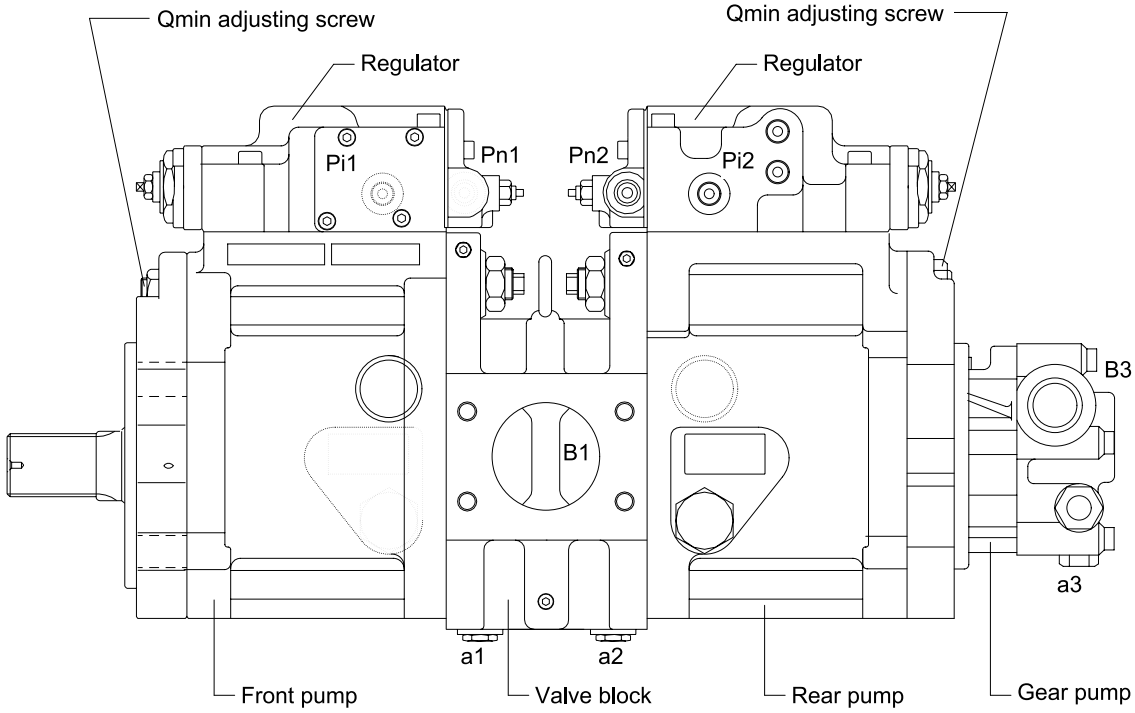
SECTION 2 STRUCTURE AND FUNCTION

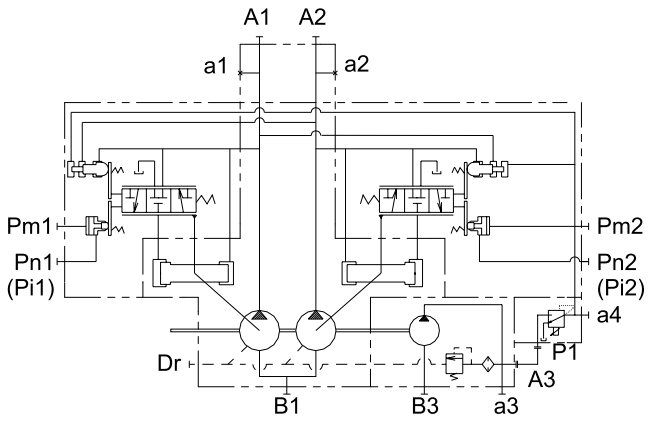
GROUP 1 PUMP DEVICE

1. STRUCTURE

The pump device consists of main pump, regulator and gear pump.



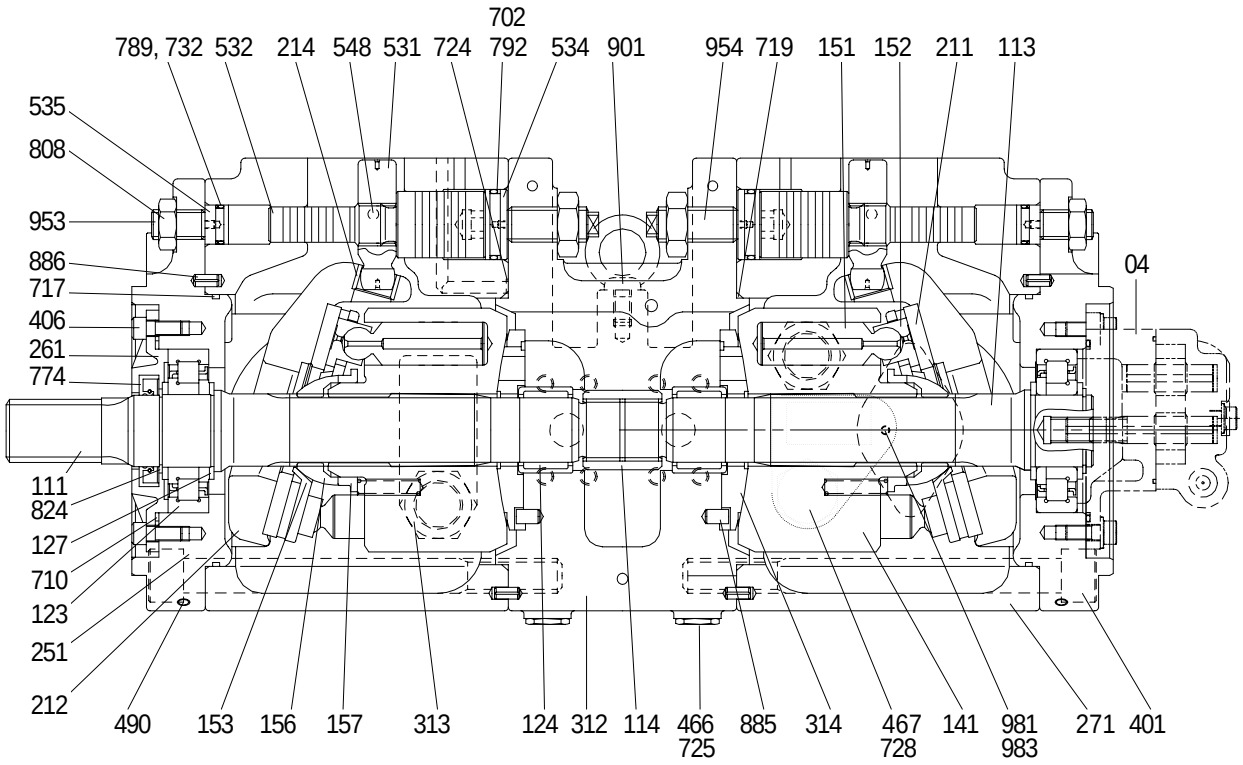




Port	Port name	Port size
A1,2	Delivery port	SAE6000psi 3/4"
B1	Suction port	SAE2500psi 2 1/2"
Dr	Drain port	PF 1/2 - 19
Pn1,n2	Pilot port	PF 1/4 - 15
Pm1,Pm2	Qmax cut port	PF 1/4 - 15
P1	EPPR port	PF 1/4 - 13
a1,2	Gauge port	PF 1/4 - 15
a3	Gauge port	PF 1/4 - 14
a4	Gauge port	PF 1/4 - 13
A3	Gear pump delivery port	PF 1/2 - 19
B3	Gear pump suction port	PF 3/4 - 20

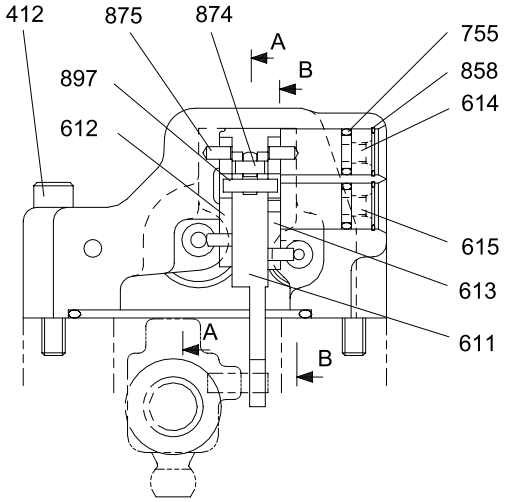
1) MAIN PUMP(1/2)

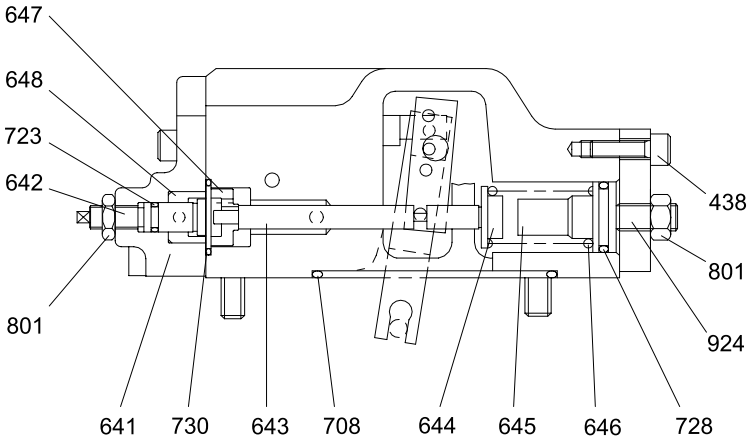
The main pump consists of two piston pumps(front & rear) and valve block.



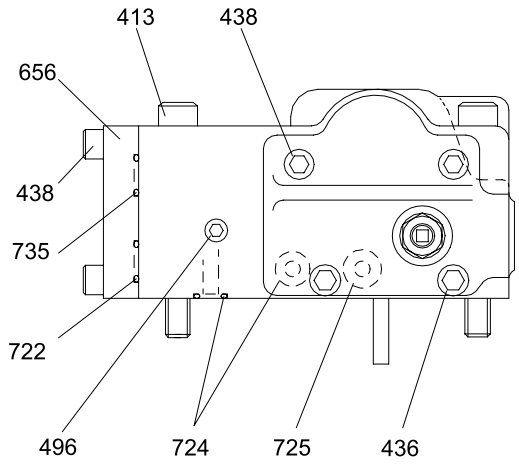
04	Gear pump	261	Seal cover(F)	717	O-ring
111	Drive shaft(F)	271	Pump casing	719	O-ring
113	Drive shaft(R)	312	Valve block	724	O-ring
114	Spline couping	313	Valve plate(R)	725	O-ring
123	Roller bearing	314	Valve plate(L)	728	O-ring
124	Needle bearing	401	Hexagon socket bolt	732	O-ring
127	Bearing spacer	406	Hexagon socket bolt	774	Oil seal
141	Cylinder block	466	VP Plug	789	Back up ring
151	Piston	467	VP Plug	792	Back up ring
152	Shoe	490	Plug	808	Hexagon head nut
153	Set plate	531	tilting pin	824	Snap ring
156	Bushing	532	Servo piston	885	Pin
157	Cylinder spring	534	Stopper(L)	886	Spring pin
211	Shoe plate	535	Stopper(S)	901	Eye bolt
212	Swash plate	548	Pin	953	Set screw
214	Bushing	702	O-ring	981	Plate
251	Support	710	O-ring	983	Pin

2) REGULATOR(1/2)

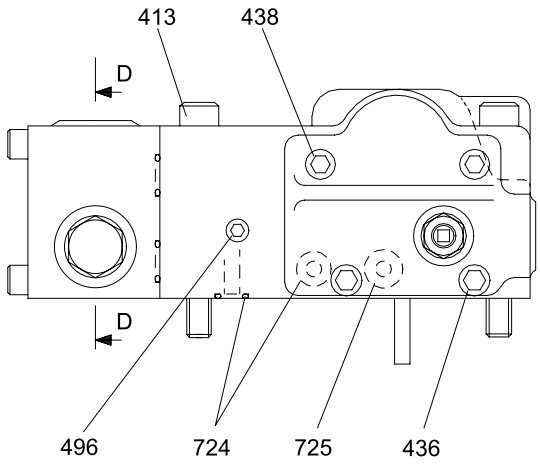




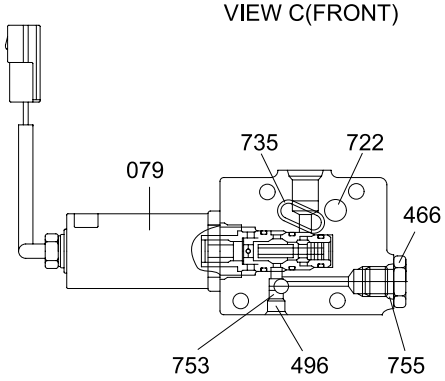
SECTION B-B



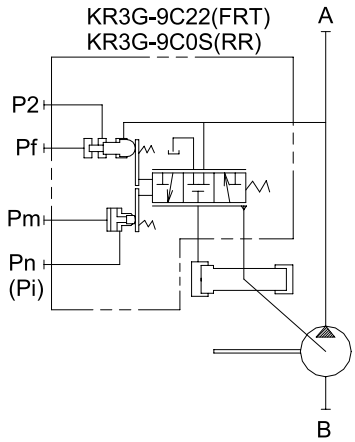
VIEW C(FRONT)



VIEW C(REAR)

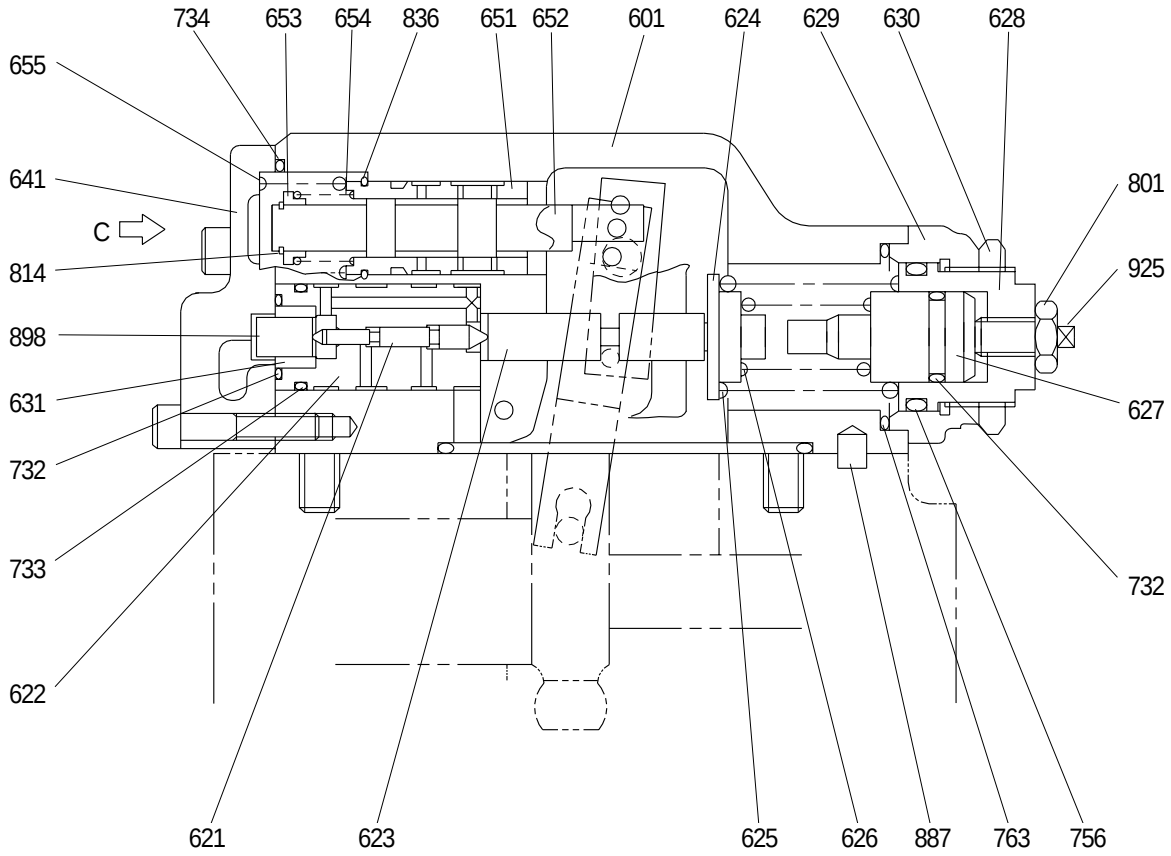


SECTION D-D



Port	Port name	port size
A	Delivery port	3/4"
B	Suction port	2 1/2"
Pn	Pilot port	PF 1/4-15
Pm	Qmax cut port	PF 1/4-15

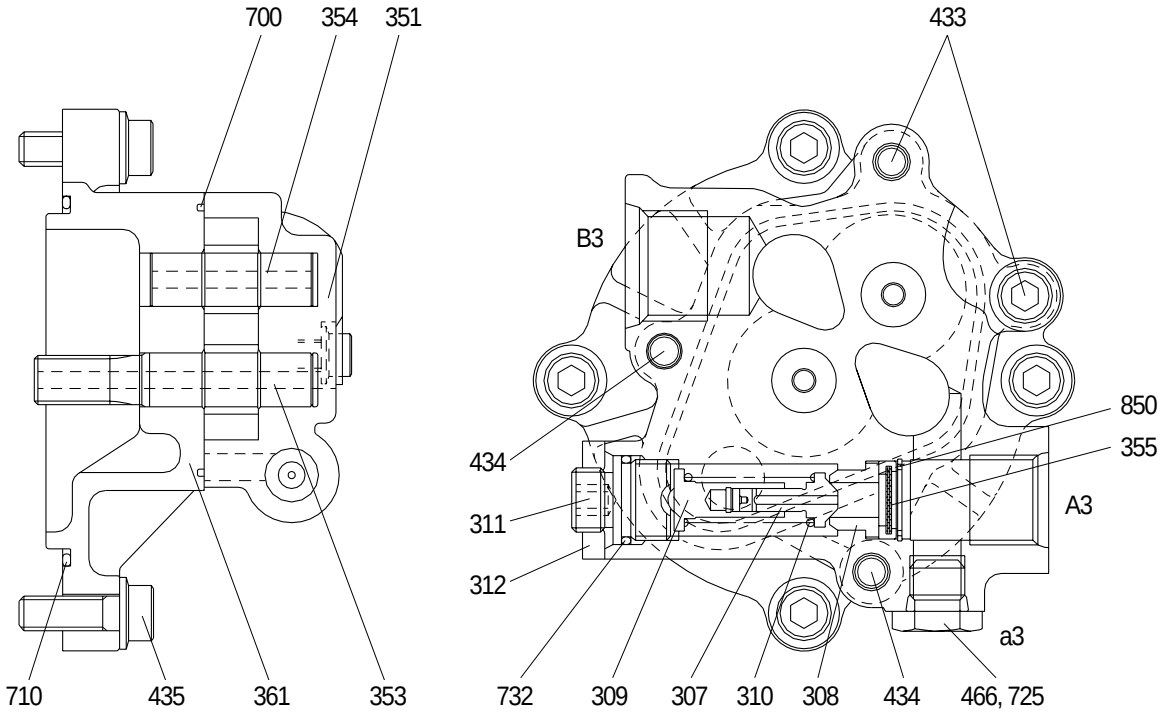
REGULATOR(2/2)



SECTION A-A

412	Hexagon socket screw	631	Sleeve, pf	730	O-ring
413	Hexagon socket screw	641	Pilot cover	732	O-ring
436	Hexagon socket screw	642	Pilot cover(QMC)	733	O-ring
438	Hexagon socket screw	643	Pilot piston	734	O-ring
496	Plug	644	Spring seat(Q)	735	O-ring
601	Casing	645	Adjust stem(Q)	755	O-ring
611	Feed back lever	646	Pilot spring	756	O-ring
612	Lever(1)	647	Stopper	763	O-ring
613	Lever(2)	648	Piston(QMC)	801	Nut
614	Fulcrum plug	651	Sleeve	814	Snap ring
615	Adjust plug	652	Spool	836	Snap ring
621	Compensator piston	653	Spring seat	858	Snap ring
622	Piston case	654	Return spring	874	Pin
623	Compensator rod	655	Set spring	875	Pin
624	Spring seat(C)	656	Block cover	887	Pin
625	Outer spring	708	O-ring	897	Pin
626	Inner spring	722	O-ring	898	Pin
627	Adjust stem(C)	723	O-ring	924	Set screw
628	Adjust screw(C)	724	O-ring	925	Adjust screw(QI)
629	Cover(C)	725	O-ring		
630	Lock nut	728	O-ring		

3) GEAR PUMP



307	Poppet	353	Drive gear	466	Plug
308	Seat	354	Driven gear	700	Ring
309	Spring seat	355	Filter	710	O-ring
310	Spring	361	Front case	725	O-ring
311	Screw	433	Flange socket	732	O-ring
312	Nut	434	Flange socket	850	Snap ring
351	Gear case	435	Flange socket		

2. FUNCTION

1) MAIN PUMP

The pumps may classified roughly into the rotary group performing a rotary motion and working as the major part of the whole pump function: the swash plate group that varies the delivery rates: and the valve cover group that changes over oil suction and discharge.

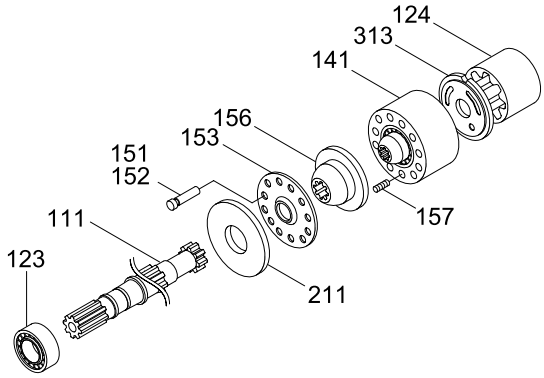
(1) Rotary group

The rotary group consists of drive shaft (F)(111), cylinder block(141), piston shoes(151,152), set plate(153), spherical bush(156) and cylinder spring(157).

The drive shaft is supported by bearing (123,124) at its both ends.

The shoe is caulked to the piston to from a spherical coupling. It has a pocket to relieve thrust force generated by loading pressure and the take hydraulic balance so that it slides lightly over the shoe plate(211). The sub group composed by a piston and a shoe is pressed against the shoe plate by the action of the cylinder spring via a retainer and a spherical bush.

Similarly, the cylinder block is pressed against valve plate(313) by the action of the cylinder spring.

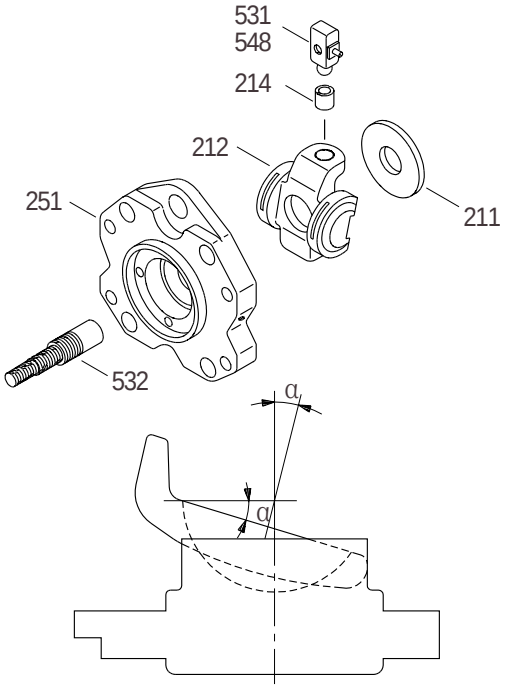


(2) Swash plate group

The swash plate group consists of swash plate(212), shoe plate(211), swash plate support(251), tilting bush(214), tilting pin(531) and servo piston(532).

The swash plate is a cylindrical part formed on the opposite side of the sliding surface of the shoe and is supported by the swash support.

If the servo piston moves to the right and left as hydraulic force controlled by the regulator is admitted to hydraulic chamber located on both sides of the servo piston, the swash plate slides over the swash plate support via the spherical part of the tilting pin to change the tilting angle(α).



(3) Valve block group

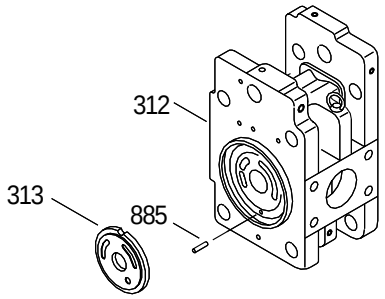
The valve block group consists of valve block(312), valve plate(313) and valve plate pin(885).

The valve plate having two melon-shaped ports is fixed to the valve block and feeds and collects oil to and from the cylinder block.

The oil changed over by the valve plate is connected to an external pipeline by way of the valve block.

Now, if the drive shaft is driven by a prime mover(electric motor, engine, etc), it rotates the cylinder block via a spline linkage at the same time. If the swash plate is tilted as in Fig(previous page) the pistons arranged in the cylinder block make a reciprocating motion with respect to the cylinder block, while they revolve with the cylinder block.

If you pay attention to a single piston, it performs a motion away from the valve plate(oil sucking process) within 180 degrees, and makes a motion towards the valve plate(or oil discharging process) in the rest of 180 degrees. When the swash plate has a tilting angle of zero, the piston makes no stroke and discharges no oil.



2) REGULATOR

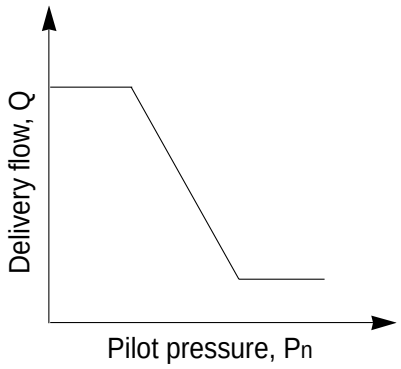
Regulator consists of the negative flow control, total horse power control and power shift control function.

(1) Negative flow control

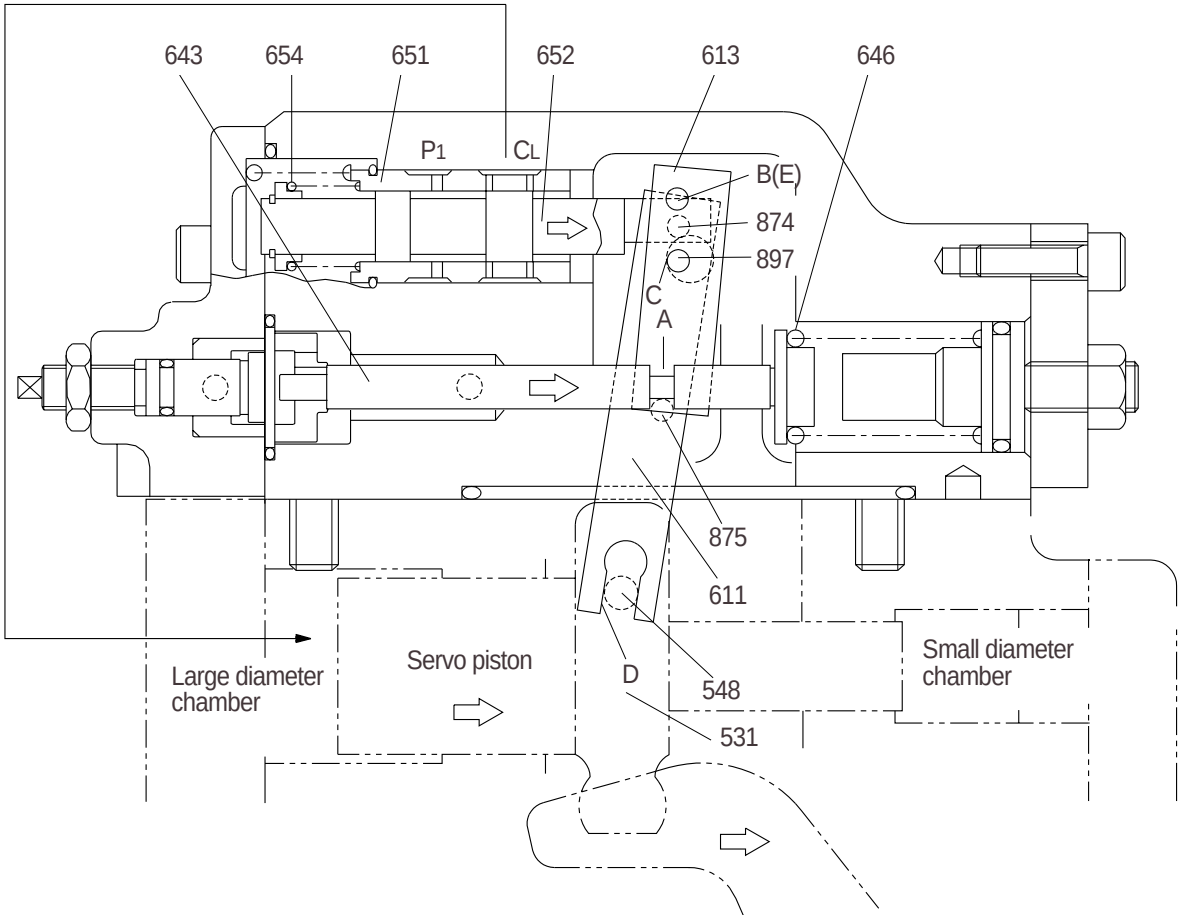
By changing the pilot pressure Pn, the pump tilting angle(delivery flow) is regulated arbitrarily, as shown in the figure.

This regulator is of the negative flow control in which the delivery flow Q decreases as the pilot pressure Pn rises.

With this mechanism, when the pilot pressure corresponding to the flow required for the work is commanded, the pump discharges the required flow only, and so it does not consume the power uselessly.



① **Flow reducing function**



As the pilot pressure Pn rises, the pilot piston(643) moves to the right to a position where the force of the pilot spring(646) balances with the hydraulic force.

The groove(A) in the pilot piston is fitted with the pin(875) that is fixed to lever 2(613). Therefore, when the pilot piston moves, lever 2 rotates around the fulcrum of point B [fixed by the fulcrum plug(614) and pin(875)]. Since the large hole section(C) of lever 2 contains a protruding pin(897) fixed to the feedback lever(611), the pin(897) moves to the right as lever 2 rotates. Since the opposing-flat section(D) of the feedback lever is fitted with the pin(548) fixed by the tilting pin(531) that swings the swash plate, the feedback lever rotates around the fulcrum of point D, as the pin(897) moves.

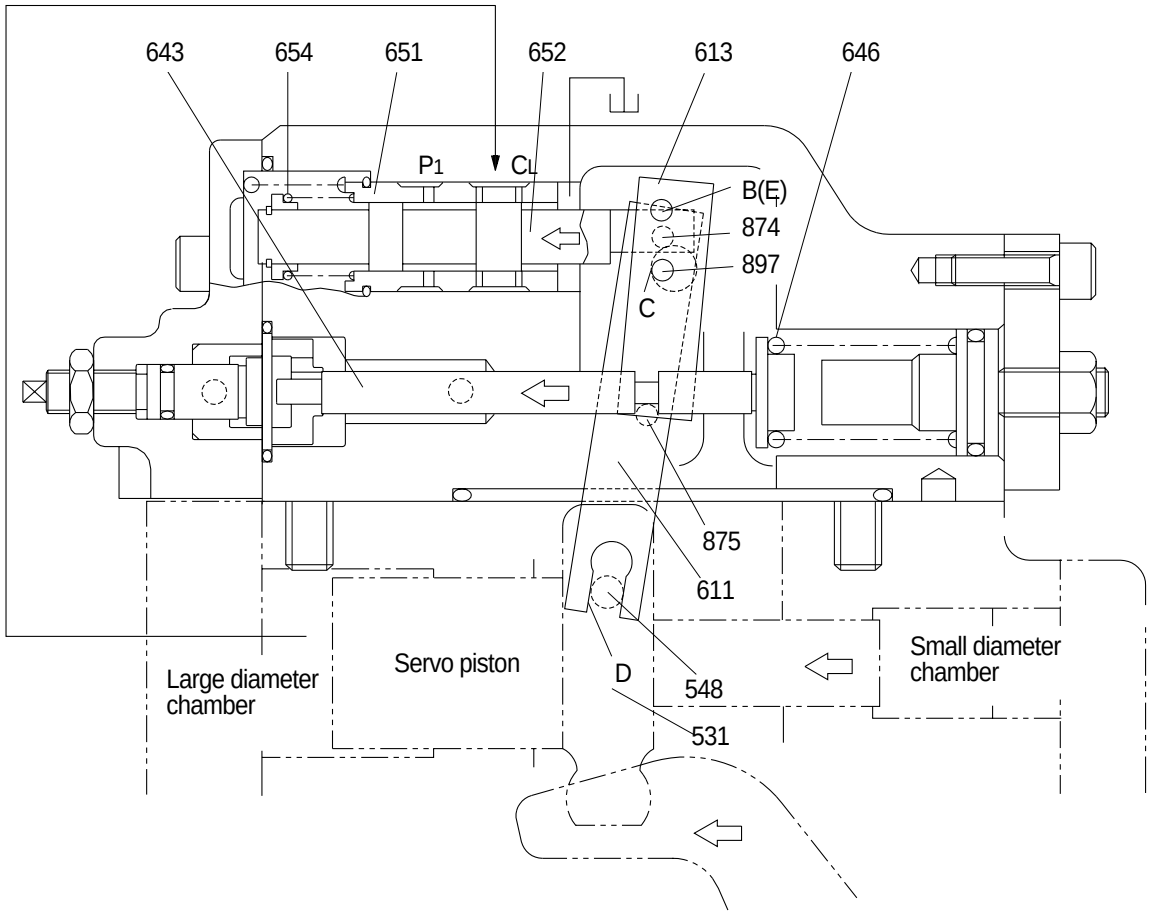
Since the feedback lever is connected with the spool(652) via the pin(874), the spool moves to the right.

The movement of the spool causes the delivery pressure P1 to connect to port CL through the spool and to be admitted to the large diameter section of the servo piston. The delivery pressure P1 that is constantly admitted to the small diameter section of the servo piston moves the servo piston to the right due to the area difference, resulting in decrease of the tilting angle.

When the servo piston moves to the right, point D also moves to the right. The spool is fitted with the return spring(654) and is tensioned to the left at all times, and so the pin(897) is pressed against the large hole section(C) of lever 2.

Therefore, as point D moves, the feedback lever rotates around the fulcrum of point C, and the spool is shifted to the left. This causes the opening between the sleeve(651) and spool(652) to close slowly, and the servo piston comes to a complete stop when it closes completely.

② **Flow increasing function**

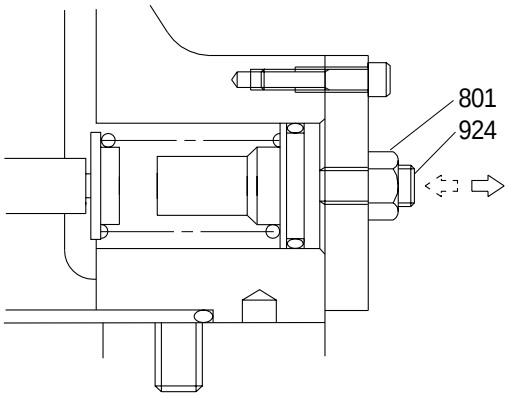


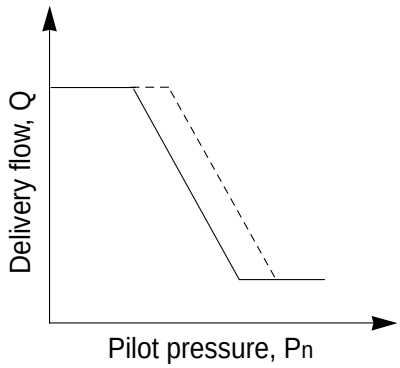
As the pilot pressure Pn decreases, the pilot piston(643) moves to the left by the action of the pilot spring(646) and causes lever 2(613) to rotate around the fulcrum of point B. Since the pin(897) is pressed against the large hole section(C) of lever 2 by the action of the return spring(654) via the spool(652), pin(874), and feedback lever(611), the feedback lever rotates around the fulcrum of point D as lever 2 rotates, and shifts the spool to the left. Port CL opens a way to the tank port as the spool moves. This deprives the large diameter section of the servo piston of pressure, and shifts the servo piston to the left by the discharge pressure P1 in the small diameter section, resulting in an increase in the flow rate.

As the servo piston moves, point D also moves to the left, the feedback lever rotates around the fulcrum of point C, and the spool moves to the right till the opening between the spool and sleeve is closed.

③ Adjustment of flow control characteristic

The flow control characteristic can be adjusted with the adjusting screw.
Adjust it by loosening the hexagon nut(801) and by tightening(or loosening) the hexagonal socket head screw(924).
Tightening the screw shifts the control chart to the right as shown in the figure.





※ Adjusting values are shown in table.

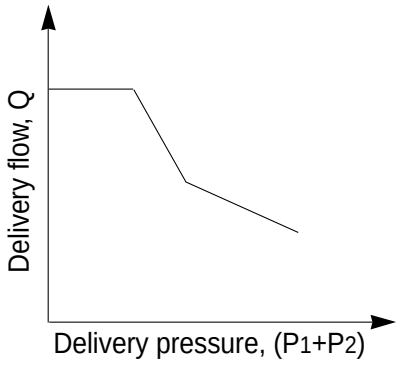
Speed	Adjustment of flow control characteristic		
	Tightening amount of adjusting screw(924)	Flow control starting pressure change amount	Flow change amount
(min $^{-1}$)	(Turn)	(kgf/cm^2)	(ℓ /min)
2100	+1/4	+1.5	+7.9

(2) Total horsepower control

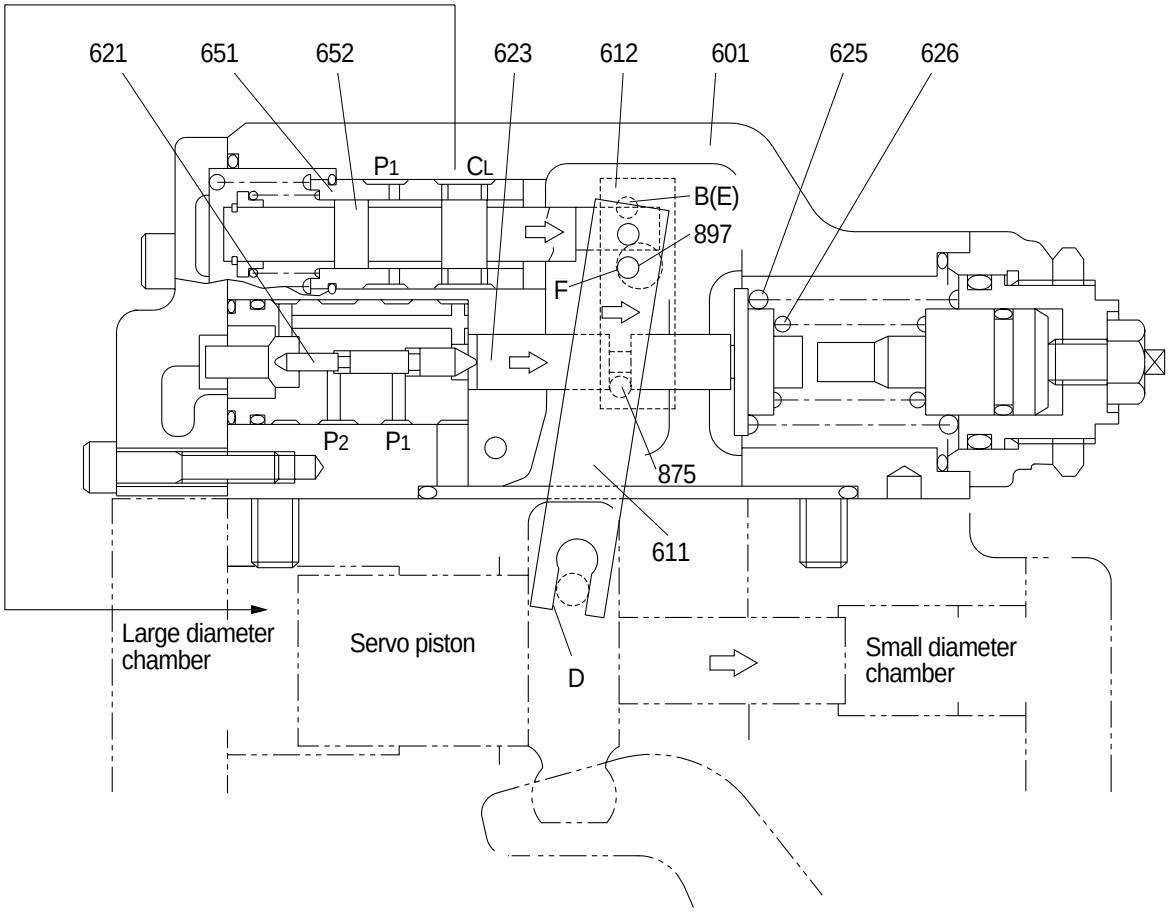
The regulator decreases the pump tilting angle(delivery flow) automatically to limit the input torque within a certain value with a rise in the delivery pressure P1 of the self pump and the delivery pressure P2 of the companion pump.
(The input horsepower is constant when the speed is constant.)
Since the regulator is of the simultaneous total horsepower type that operates by the sum of load pressures of the two pumps in the tandem double-pump system, the prime mover is automatically prevented from being overloaded, irrespective of the load condition of the two pumps, when horsepower control is under way.
Since this regulator is of the simultaneous total horsepower type, it controls the tilting angles(displacement volumes) of the two pumps to the same value as represented by the following equation :

$$Tin = P1 \times q/2\pi + P2 \times q/2\pi$$
$$= (P1+P2) \times q/2\pi$$

The horsepower control function is the same as the flow control function and is summarized in the following.(For detailed behaviors of respective parts, refer to the section of flow control).

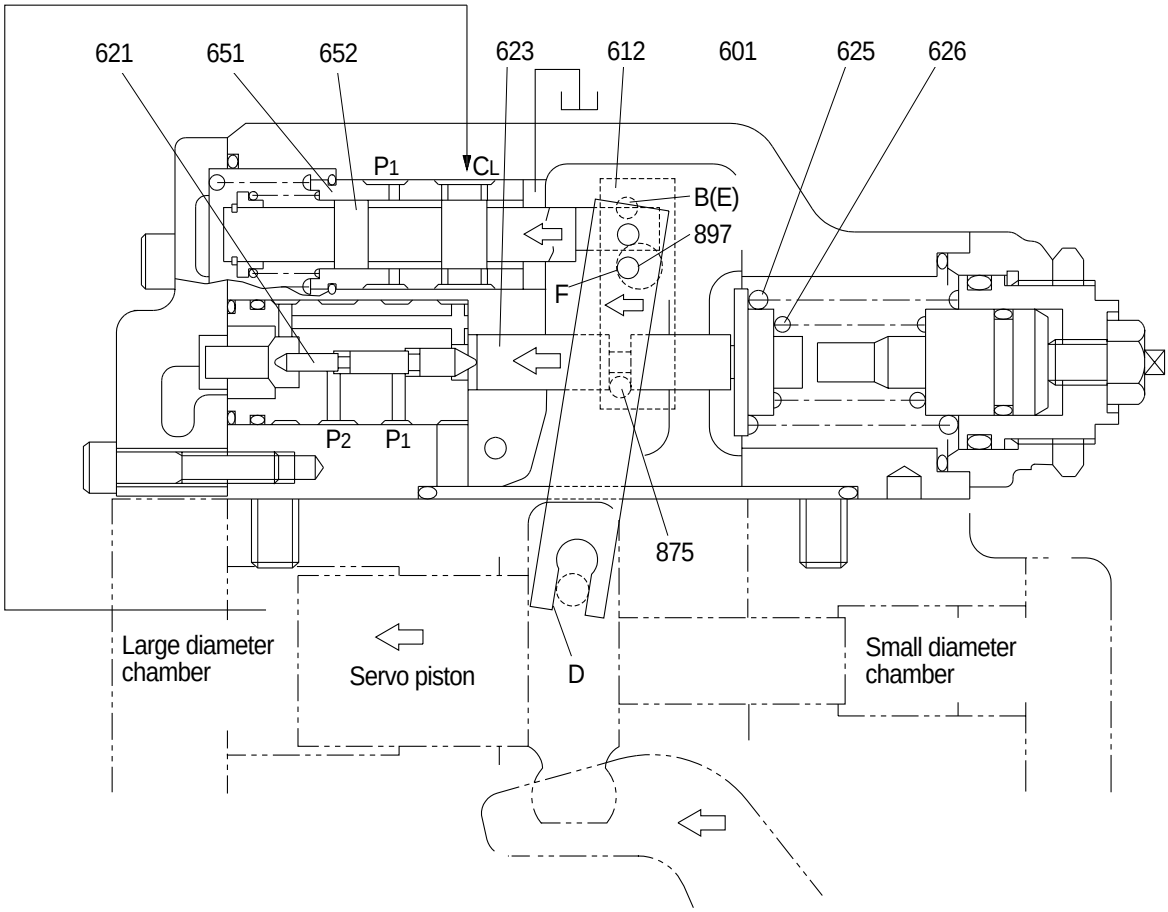


① **Overload preventive function**



When the self pump delivery pressure P1 or the companion pump delivery pressure P2 rises, it acts on the stepped part of the compensating piston(621). It presses the compensating rod(623) to the right till the force of the outer spring(625) and inner spring(626) balances with the hydraulic force. The movement of the compensating rod is transmitted to lever 1(612) via pin(875).
Lever 1 rotates around the pin(875) (E) fixed to the casing(601).
Since the large hole section(F) of lever 1 contains a protruding pin(897) fixed to the feedback lever(611), the feedback lever rotates around the fulcrum of point D as lever 1 rotates, and then the spool(652) is shifted to the right. As the spool moves, the delivery pressure P1 is admitted to the large diameter section of the servo piston via port CL, causes the servo piston move to the right, reduces the pump delivery, flow rate, and prevents the prime mover from being overloaded.
The movement of the servo piston is transmitted to the feedback lever via point D. Then the feedback lever rotates around the fulcrum of point F and the spool is shifted to the left. The spool moves till the opening between the spool(652) and sleeve(651) is closed.

② Flow reset function



As the self pump delivery pressure P1 or the companion pump delivery pressure P2 decreases, the compensating rod(623) is pushed back by the action of the springs(625 & 626) to rotate lever 1(612) around point E. Rotating of lever 1 causes the feedback lever(611) to rotate around the fulcrum of point D and then the spool(652) to move to the left. As a result, port CL opens a way to the tank port.

This causes the servo piston to move to the left and the pump's delivery rate to increase.

The movement of the servo piston is transmitted to the spool by the action of the feedback mechanism to move it till the opening between the spool and sleeve is closed.

③ **Low tilting angle(Low flow) command preferential function**

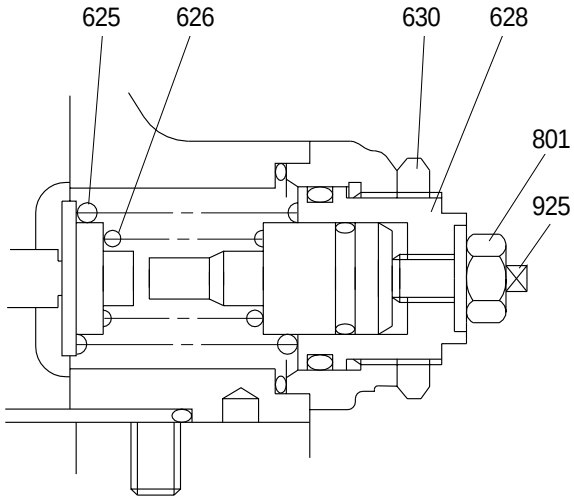
As mentioned above, flow control and horsepower control tilting angle commands are transmitted to the feedback lever and spool via the large-hole sections(C & F) of levers 1 and 2. However, since sections C and F have the pins(Ø4) protruding from the large hole(Ø8), only the lever lessening the tilting angle contacts the pin(897) ; the hole(Ø8) in the lever of a larger tilting angle command is freed without contacting the pin(897). Such a mechanical selection method permits preference of the lower tilting angle command of the flow control and horsepower control.

④ **Adjustment of input horsepower**

Since the regulator is of total cumulative horsepower type, adjust the adjusting screws of both the front and rear pumps, when changing the horsepower set values. The pressure change values by adjustment are based on two pumps pressurized at the same time, and the values will be doubled when only one pump is loaded.

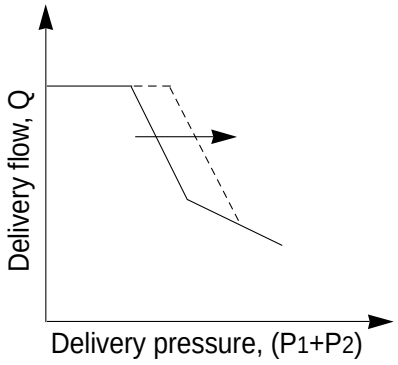
a. Adjustment of outer spring

Adjust it by loosening the hexagon nut(630) and by tightening(or loosening) the adjusting screw C(628). Tightening the screw shifts the control chart to the right and increases the input horsepower as shown in the figure. Since turning the adjusting screw C by N turns changes the setting of the inner spring(626), return the adjusting screw QI(925) by N×A turns at first.(A=2.2)



※ **Adjusting values are shown in table**

Speed	Adjustment of outer spring		
	Tightening amount of adjusting screw(C) (924)	Compens-ating control starting pressure change amount	Input torque change amount
(min $^{-1}$)	(Turn)	(kgf/cm^2)	(kgf · m)
2100	+1/4	+19.2	+2.9



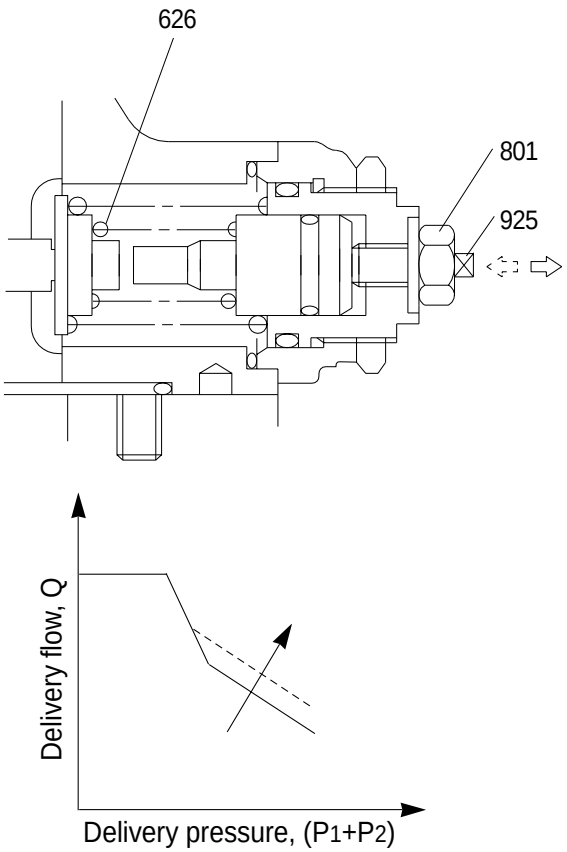
b. Adjustment of inner spring

Adjust it by loosening the hexagon nut (801) and by tightening(or loosening) the adjusting screw QI(925).

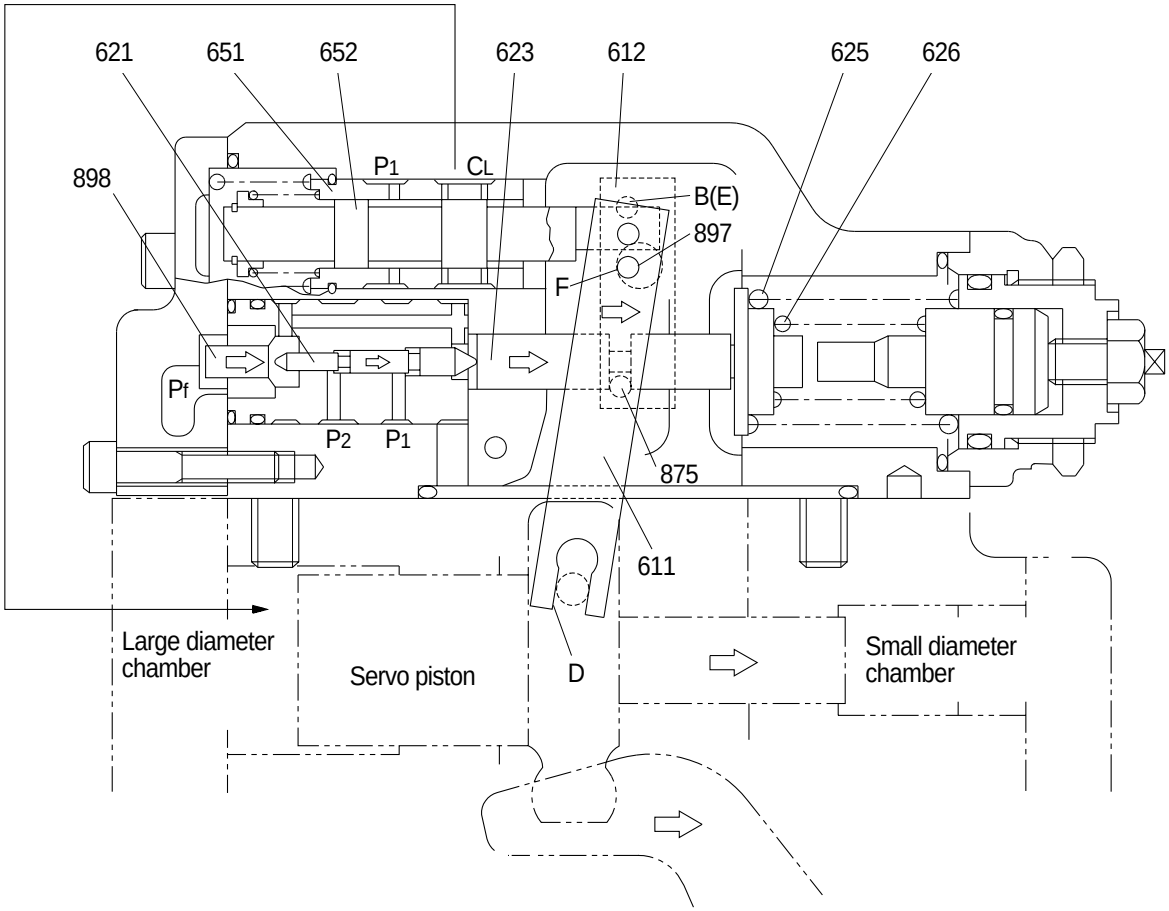
Tightening the screw increases the flow and then the input horsepower as shown in the figure.

※ **Adjusting valves are shown in table**

Speed	Adjustment of inner spring		
	Tightening amount of adjusting screw(QI) (925)	Flow change amount	Input torque change amount
(min $^{-1}$)	(Turn)	(ℓ /min)	(kgf · m)
2100	+1/4	+5.6	+2.4



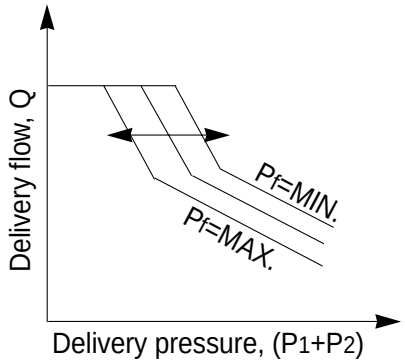
(3) Power shift control



The set horsepower valve is shifted by varying the command current level of the proportional pressure reducing valve attached to the pump.

Only one proportional pressure reducing valve is provided.

However, the secondary pressure Pf (power shift pressure) is admitted to the horsepower control section of each pump regulator through the pump's internal path to shift it to the same set horsepower level.



This function permits arbitrary setting of the pump output power, thereby providing the optimum power level according to the operating condition.

The power shift pressure Pf controls the set horsepower of the pump to a desired level, as shown in the figure.

As the power shift pressure Pf rises, the compensating rod(623) moves to the right via the pin(898) and compensating piston(621).

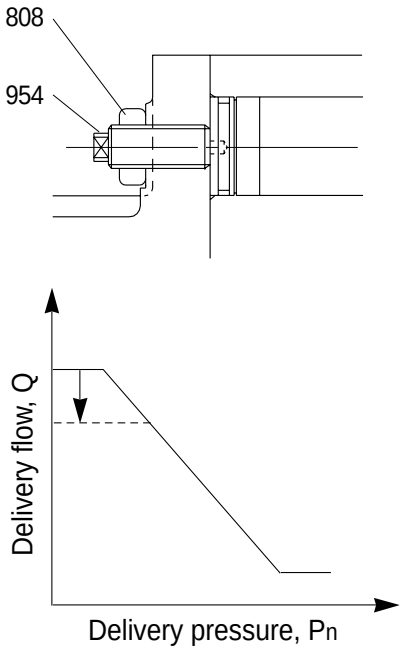
This decreases the pump tilting angle and then the set horsepower in the same way as explained in the overload preventive function of the horsepower control. On the contrary, the set horsepower rises as the power shift pressure Pf falls.

(4) Adjustment of maximum and minimum flows

① Adjust it by loosening the hexagon nut(808) and by tightening(or loosening) the set screw(954).

The maximum flow only is adjusted without changing other control characteristics.

Speed	Adjustment of min flow	
	Tightening amount of adjusting screw (954)	Flow change amount
(min $^{-1}$)	(Turn)	(ℓ /min)
2100	+1/4	-3.4

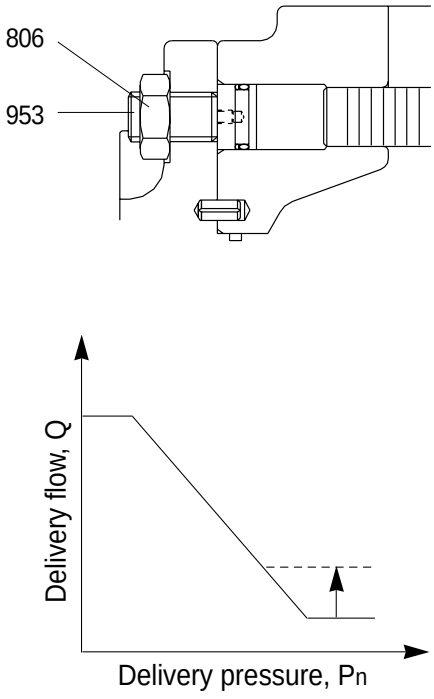


② **Adjustment of minimum flow**

Adjust it by loosening the hexagon nut(808) and by tightening(or loosening) the hexagonal socket head set screw (953). Similarly to the adjustment of the maximum flow, other characteristics are not changed.

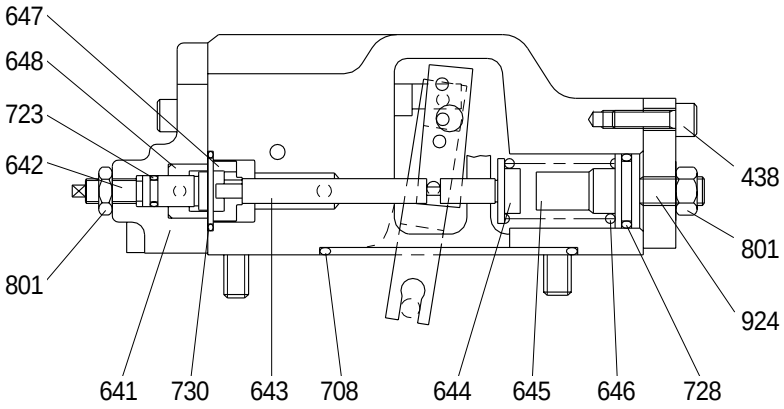
However, remember that, if tightened too much, the required horsepower during the maximum delivery pressure(or during relieving) may increase.

Speed	Adjustment of min flow	
	Tightening amount of adjusting screw (953)	Flow change amount
(min $^{-1}$)	(Turn)	(ℓ /min)
2100	+1/4	+3.4



(5) Qmax cut control

The regulator regulates the maximum delivery flow by inputting the pilot pressure Pm. Since this is a 2-position control method, the maximum delivery flow may be switched in two steps by turning on/off the pilot pressure Pm.(The maximum control flow cannot be controlled in intermediate level.)

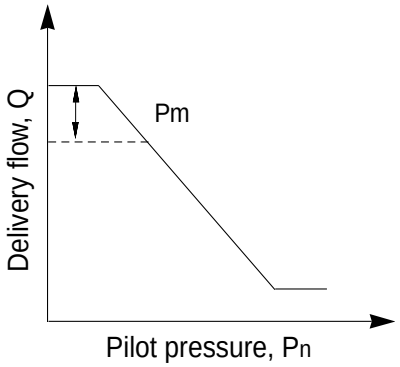


① Functional explanation

As shown in the figure, the pilot pressure Pm switches the maximum flow in two steps.

When the pilot pressure Pm is given, it is admitted to the lefthand side of the piston QMC(648). The piston QMC moves the stopper(647) and pilot piston(643) to the right, overcoming the force of the pilot spring(646), thereby reducing the delivery flow of the pump.

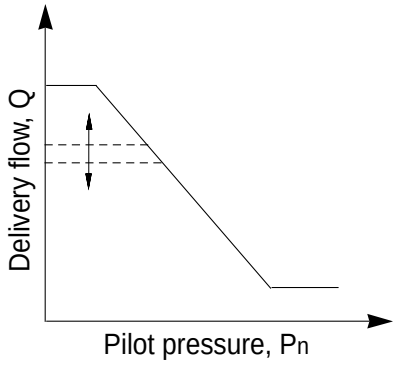
Since the adjusting screw QMC(642) is provided with a flange, the piston QMC stops upon contact with the flange, and the position of the pilot piston at this time determines the maximum flow of the pump.



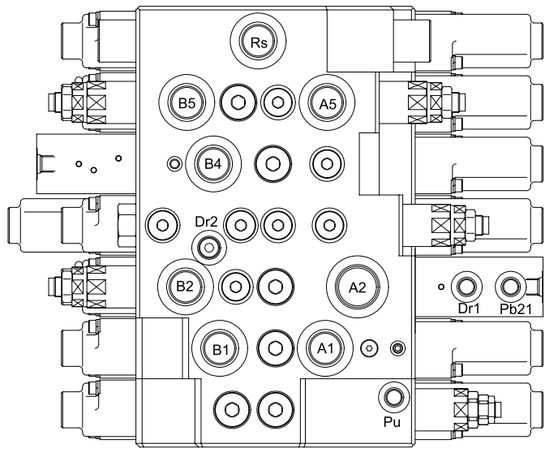
② Adjustment of Qmax cut flow

Adjust it by loosening the hexagon nut(801) and by tightening(or loosening) the adjusting screw QMC(642).

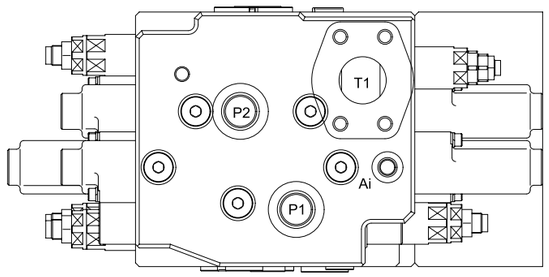
Tightening the screw decreases the Qmax cut flow as shown in the figure.



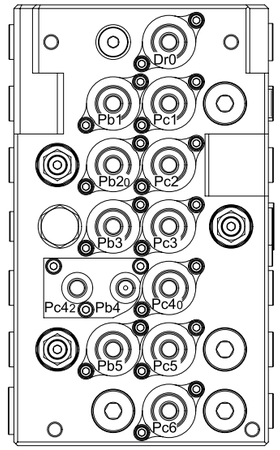
1. STRUCTURE

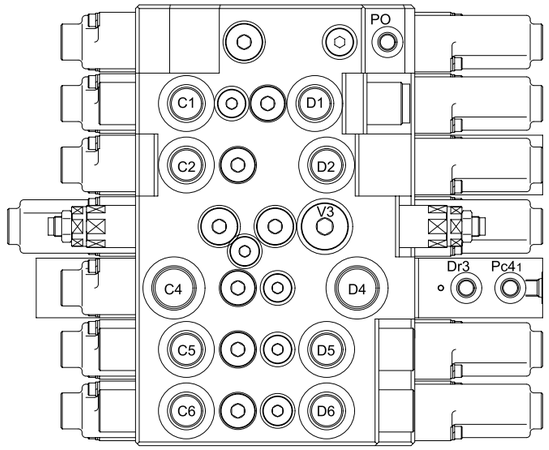


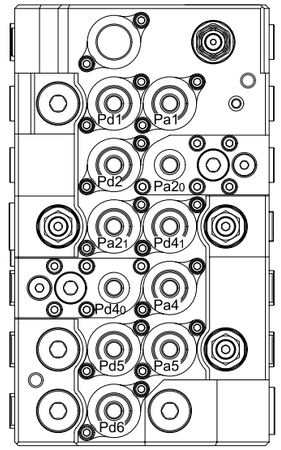
VIEW A

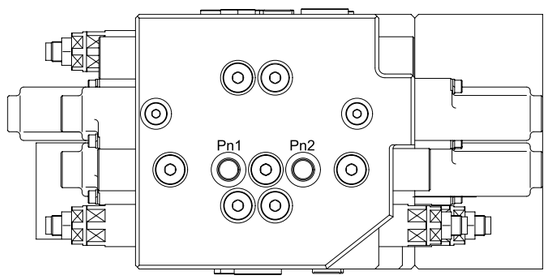


A →

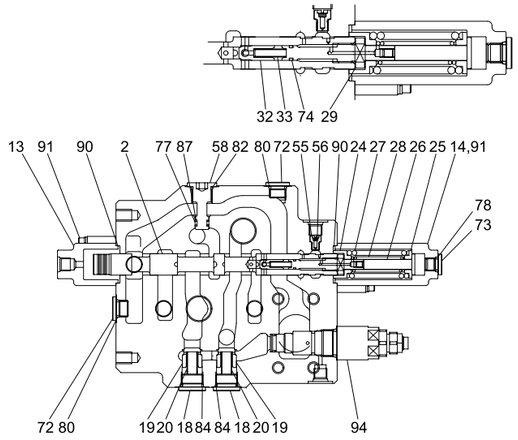




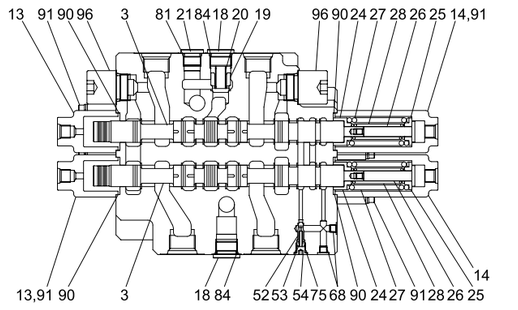




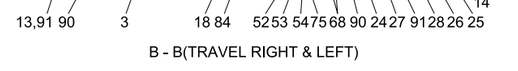
Mark	Port name	Port size	Tightening torque
Rs Pa1 Pb1 Pc1 Pd1 Pa20 Pa21 Pb20 Pb21 Pc2 Pd2 Pb3 Pc3 Pa4 Pb4 Pc40 Pc41 Pc42 Pd40 Pd41 Pa5 Pb5 Pc5 Pd5 Pc6 Pd6 PO Pu Ai Dr0 Dr1 Dr2 Dr3 Pn1 Pn2	Make up for swing motor Travel left pilot port(FW) Travel left pilot port(BW) Travel right pilot port(BW) Travel right pilot port(FW) Boom up pilot port Boom up confluence pilot port Boom down pilot port Lock valve pilot port(Boom) Swing pilot port(RH) Swing pilot port(LH) Arm in confluence pilot port Swing priority pilot port Option A pilot port(Breaker) Arm in regeneration cut port Arm in pilot port Lock valve pilot port(Arm) Arm in regen-cut signal selector port Arm out pilot port Arm out confluence pilot port Bucket in pilot port Bucket out pilot port Option B pilot port Option B pilot port Option C pilot port Option C pilot port Pilot pressure port Main relief pressure up Auto idle signal port Drain port(Travel straight) Drain port(Boom holding valve) Drain port(Boom2 & swing priority) Drain port(Arm holding valve) Negative control signal port(P1 port side) Negative control signal port(P2 port side)	G1/4	3.5~3.9kgf · m (25.3~28.2lbf · ft)
A1 B1 C1 D1 B2 C2 D2 B4 A5 B5 C5 D5 C6 D6 P1 P2	Travel motor left side port(FW) Travel motor left side port(BW) Travel motor right side port(BW) Travel motor right side port(FW) Boom rod side port Swing motor port(LH) Swing motor port(RH) Option A port(Breaker) Bucket head side port Bucket rod side port Option B port Option B port Option C port Option C port Pump port(P1 side) Pump port(P2 side)	G3/4	15~18kgf · m (109~130lbf · ft)
A2 C4 D4	Boom head side port Arm head side port Arm rod side port	G1	20~25kgf · m (115~180lbf · ft)
T1	Return port	SAE3000, 1 1/2 (M12)	8.5~11.5kgf · m (61.5~83.1lbf · ft)



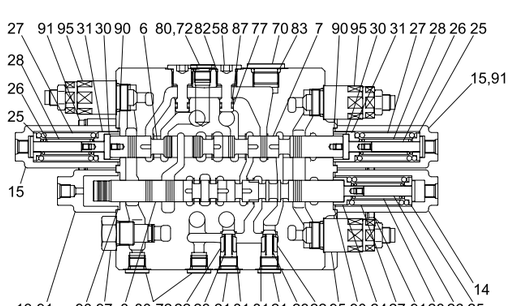
A - A(STRAIGHT-TRAVEL & SUPPLY)

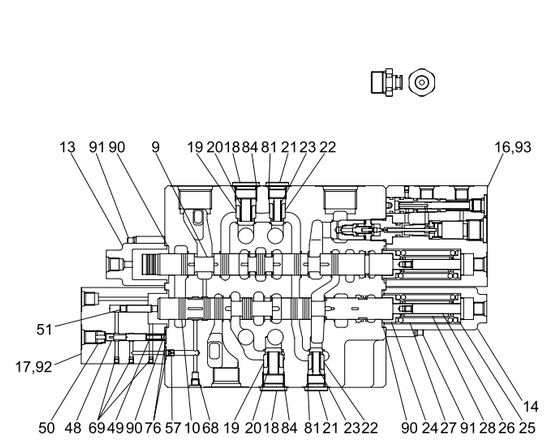


B - B(TRAVEL RIGHT & LEFT)

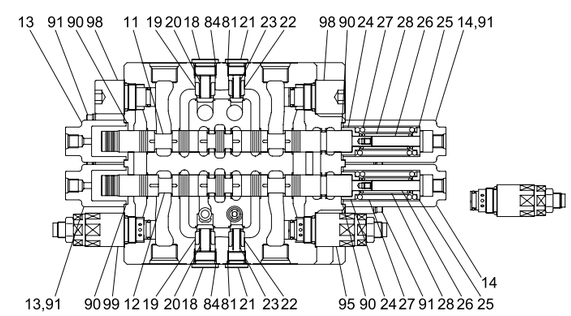


C - C(SWING & BOOM)

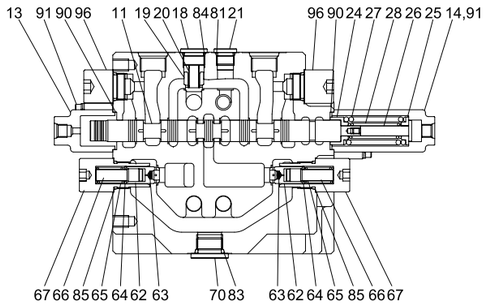




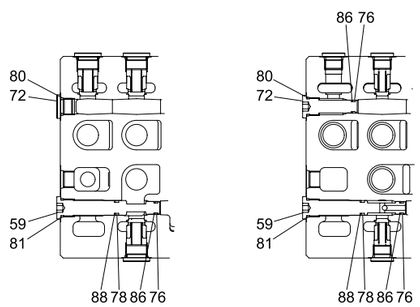
E - E(ARM & ARM REGENERATION /BREAKER)

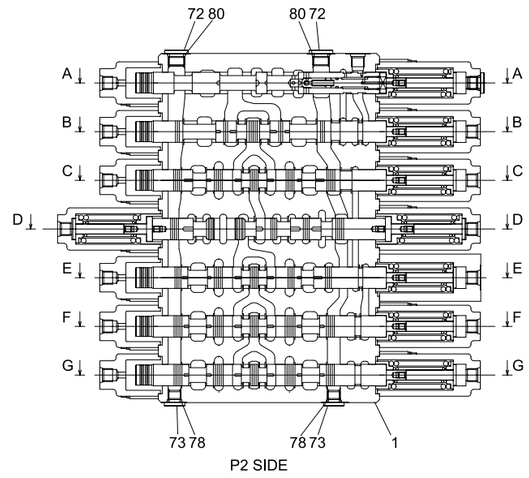


F - F(OPTION & BUCKET)

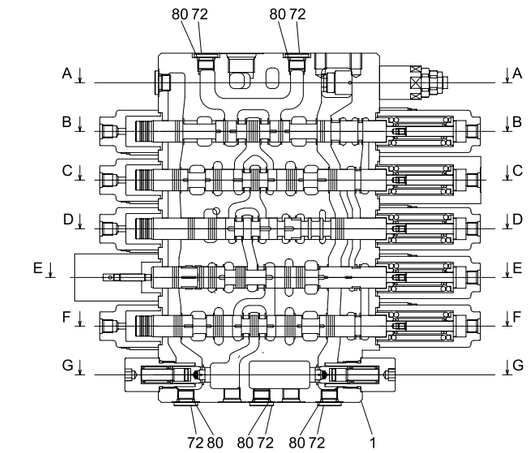


G - G(OPTION & NEGATIVE CONTROL)

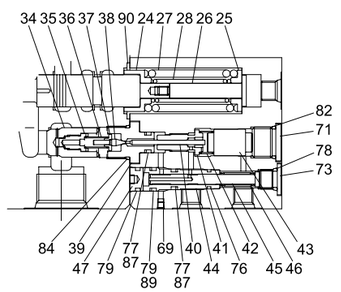




P2 SIDE



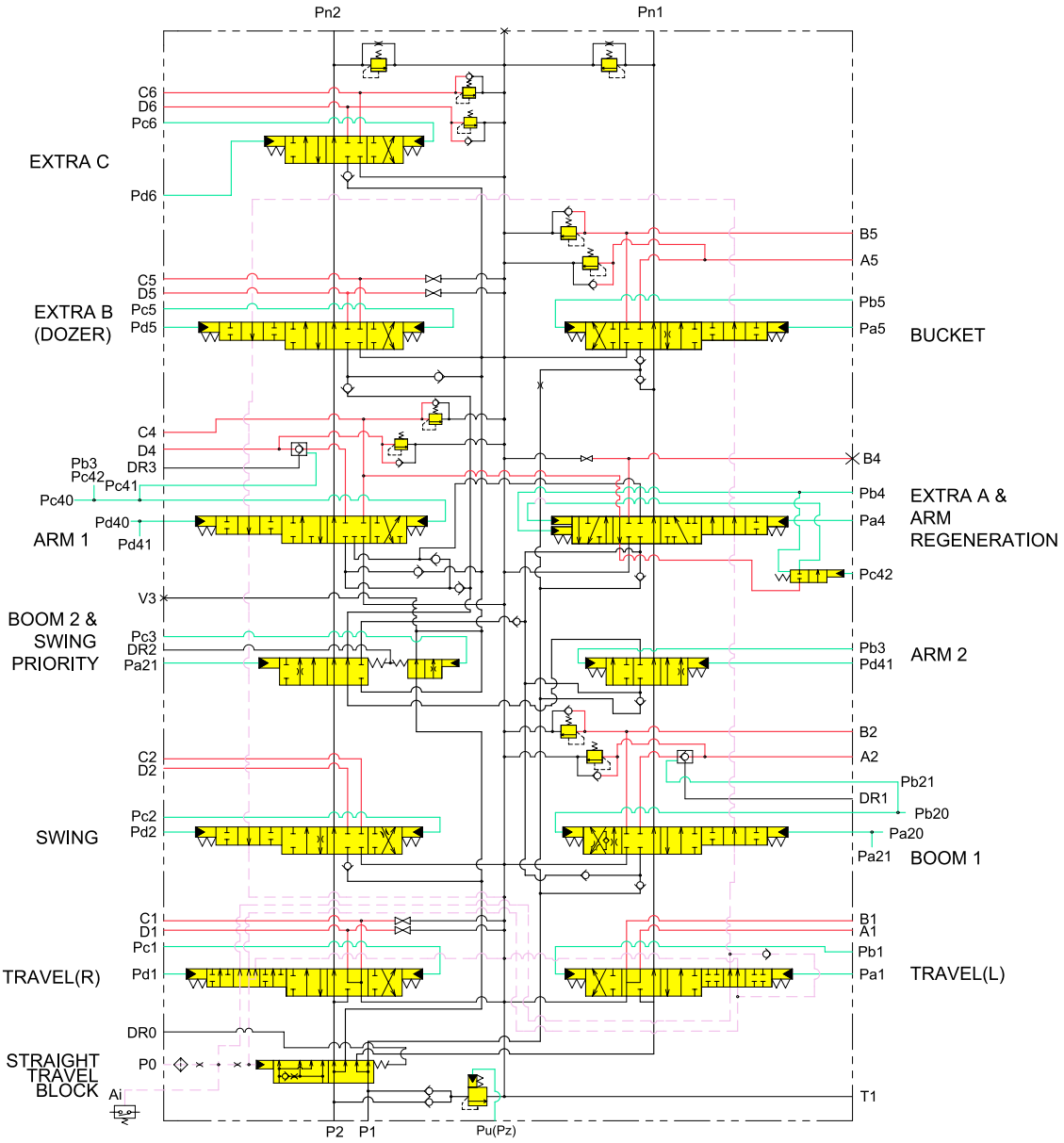
P1 SIDE



DETAIL OF LOCK VALVE(BOOM & ARM)

1	Body	50	Stopper-regeneration
2	Spool-straight travel	51	Piston-cut off
3	Spool-travel	52	Poppet-signal
4	Spool-swing	53	Spring-signal
5	Spool-boom	54	Plug
6	Spool-swing priority	55	Orifice-signal
7	Spool-boom2	56	Coin type filter
8	Spool-arm2	57	Orifice-plug
9	Spool-arm	58	Plug
10	Spool-arm regeneration & breaker	59	Plug
		60	Plug
11	Spool-option	61	Plug-orifice
12	Spool-bucket	62	Poppet-negative control
13	Cover-pilot A	63	Coin type filter
14	Cover-pilot B1	64	Spring seat
15	Cover-Pilot B2	65	Spring-negative control
16	Block-holding	66	Piston-negative control
17	Block-regeneration	67	Socket-negative control
18	Plug	68	Plug
19	Poppet1-check valve	69	Plug
20	Spring-check valve	70	Plug
21	Plug	71	Plug
22	Poppet2-check valve	72	Plug
23	Spring-check valve	73	Plug
24	Spring seat1	74	O-ring
25	Spring seat3	75	O-ring
26	Spacer bolt	76	O-ring
27	Spring-return(L)	77	O-ring
28	Spring-return(S)	78	O-ring
29	Stopper1-TS	79	O-ring
30	Stopper2-priority	80	O-ring
31	Spring seat2	81	O-ring
32	Poppet-TS check valve	82	O-ring
33	Spring-TS check valve	83	O-ring
34	Poppet-lock valve	84	O-ring
35	Restrictor-lock valve	85	O-ring
36	Spring-lock valve pilot	86	Back-up ring
37	Guide poppet	87	Back-up ring
38	Poppet-pilot	88	Back-up ring
39	Seat-poppet	89	Back-up ring
40	Piston1	90	O-ring
41	Guide-piston	91	Bolt with washer
42	Spring1-lock valve	92	Socket head bolt
43	Piston2	93	Socket head bolt
44	Socket-lock valve	94	Main relief valve
45	Spool-lock valve	95	Over load relief valve
46	Spring2-lock valve	96	Plug-relief valve
47	Stopper-lock valve	97	Plug-relief valve
48	Spool-regen selector	98	Plug-relief valve
49	Spring-regeneration	99	Over load relief valve

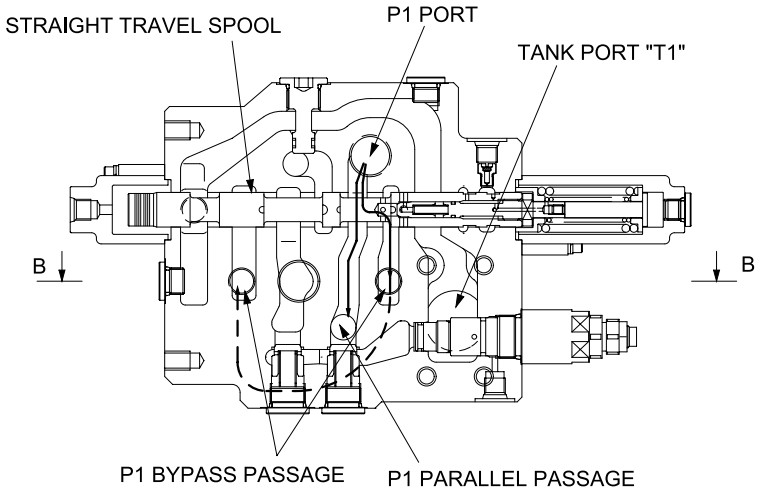
2. HYDRAULIC CIRCUIT



3. FUNCTION

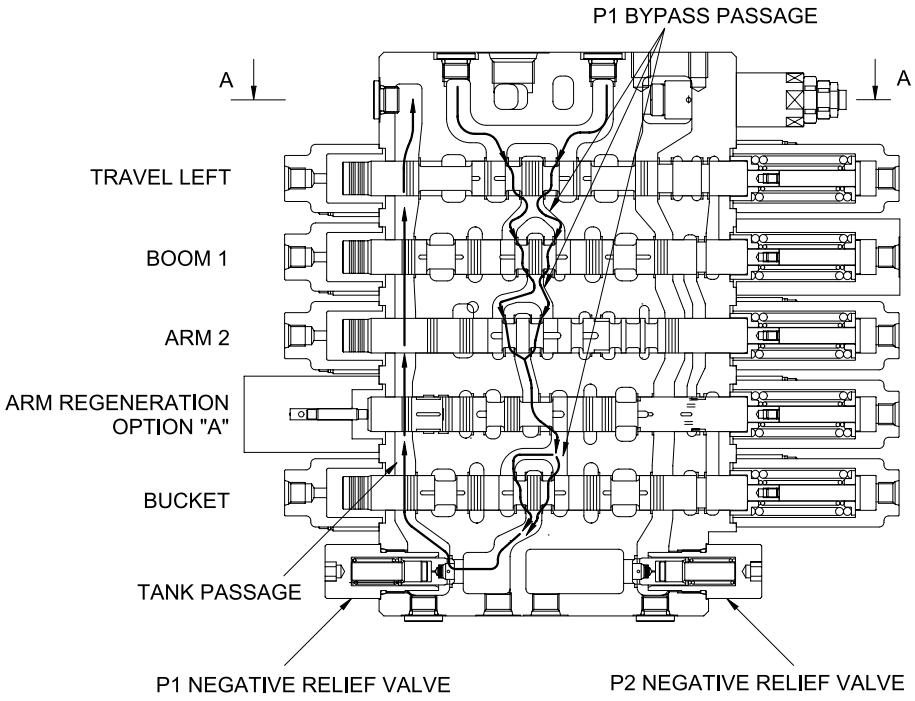
1) CONTROL IN NEUTRAL FUNCTION

(1) P1 SIDE



14072SF13

SECTION A-A



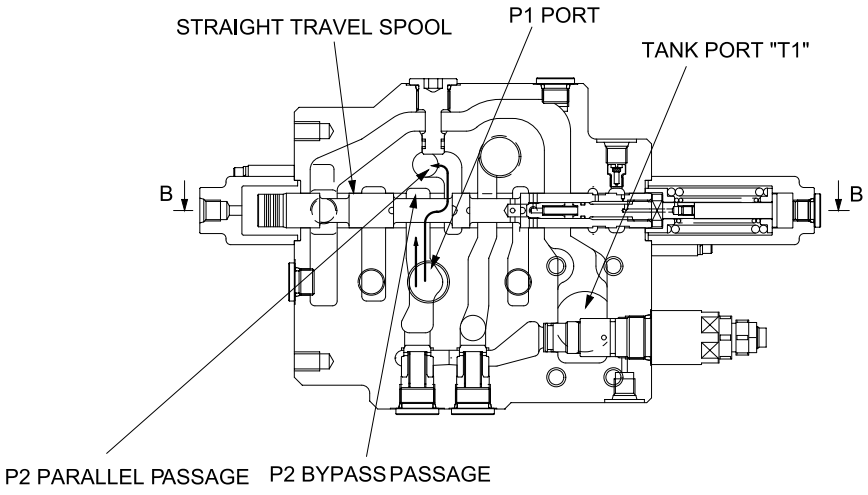
SECTION B-B

14072SF15

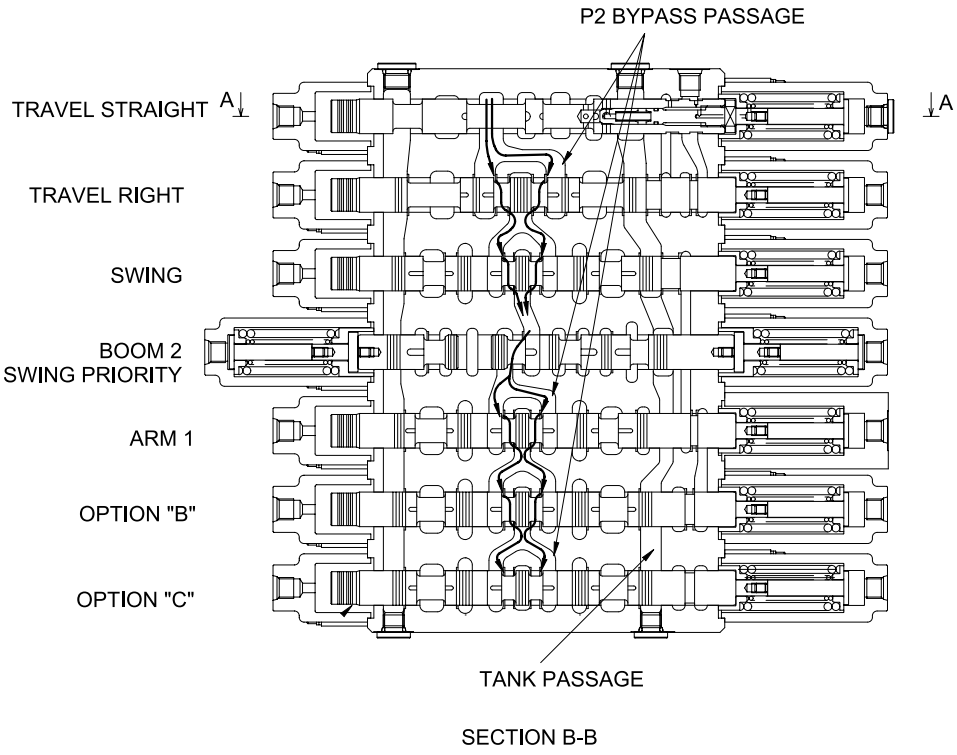
The hydraulic fluid from pump P1 flows into the main control valve through the inlet port "P1", pass the travel straight spool, into the P1 bypass passage and P1parallel passage.

The hydraulic fluid from the pump P1 is directed to the tank through the bypass passage of spools : travel left, boom1, arm2, arm regeneration & option A and bucket, the negative relief valve, tank passage, and the tank port "T1"

(2) P2 SIDE



14072SF14



14072SF16

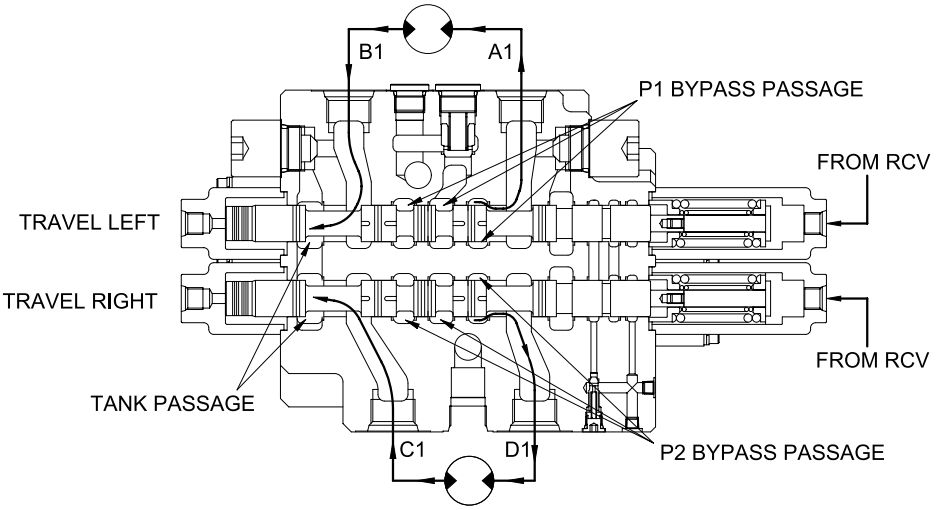
The hydraulic fluid from pump P2 flows into the main control valve through the inlet port "P2", pass the straight travel spool, into the P2 bypass passage and P2 parallel passage.

The hydraulic fluid from the pump P2 is directed to the tank through the bypass passage of spools : travel right, swing, boom2 & swing priority, arm1, option "B" and option "C", and the negative relief valve with the tank passage.

2) EACH SPOOL OPERATION

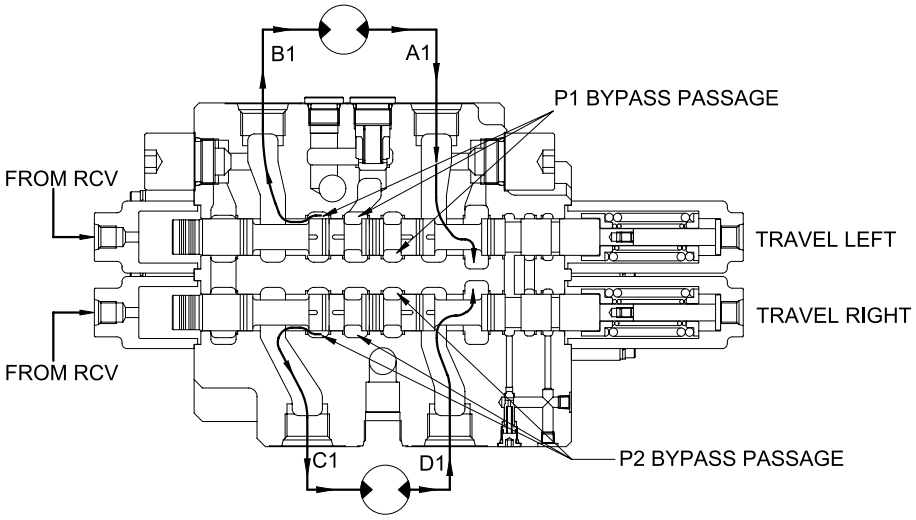
(1) TRAVEL OPERATION

① Travel forward operation



14072SF17

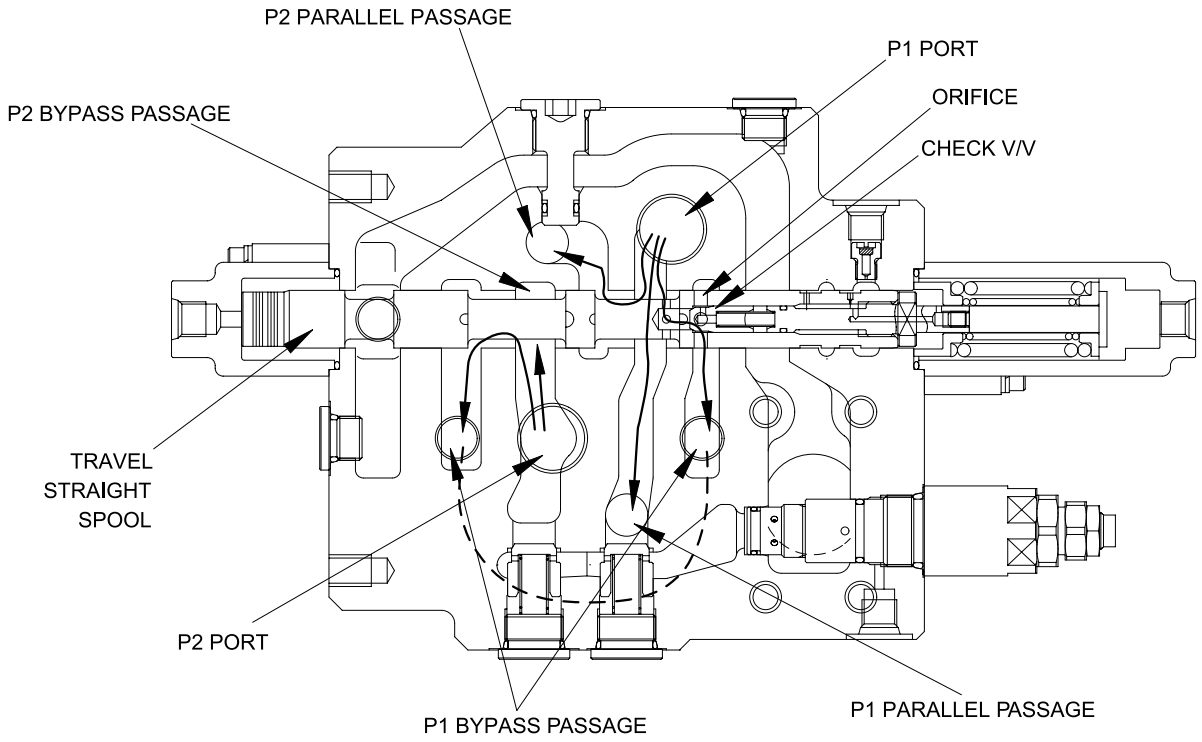
② Travel backward operation



14072SF18

During the travel operation, the hydraulic fluid of the pump P1 is supplied to the travel motor and the hydraulic fluid of the pump P2 is supplied to the other travel motor.
The pilot pressure from the pilot control valve is supplied to the spring side of pilot port (pa1, pd1).
And it shifts travel right and left spools in the left direction against springs. Hydraulic fluid from the pump P1 flow into the travel left spool through the bypass passage and hydraulic fluid from the pump P2 flow into the travel right spool through the bypass passage.
Then they are directed to the each travel motor through port A1 and D1. As a result, the travel motors turn and hydraulic fluid returns to the tank passage through the travel spools.
In case of the opposite operation, the operation is similar.

(2) TRAVEL STRAIGHT FUNCTION



This function keeps straight travel in case of simultaneous operation of other actuators(boom, arm, bucket, swing) 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.

The hydraulic fluid from pump P1 is supplied actuator through P1 and P2 parallel pass and travel motors through orifice at side of straight travel spool.

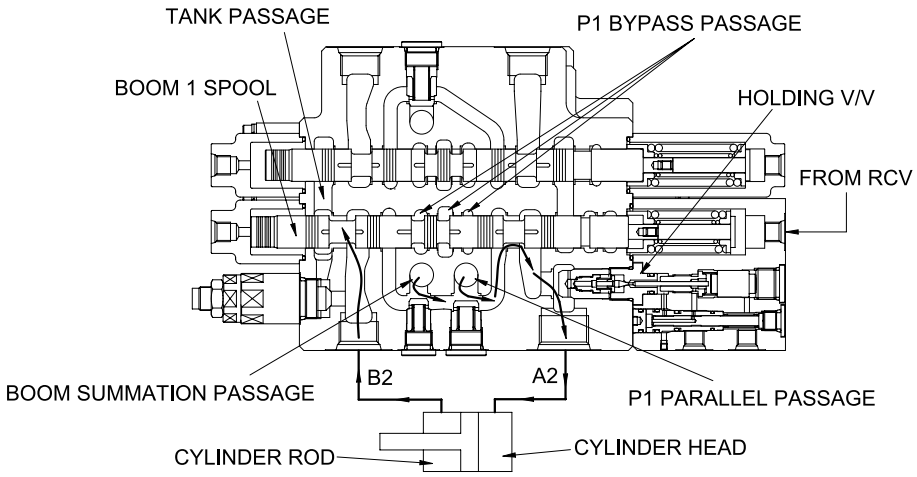
The hydraulic oil fluid from pump P2 is supplied to travel motors(left/right).

Therefore, the other actuator operation with straight travel operation, hydraulic oil fluid from pump P1 is mainly supplied to actuator, and the hydraulic oil fluid form pump P2 is mainly supplied to travel motors(left/right).

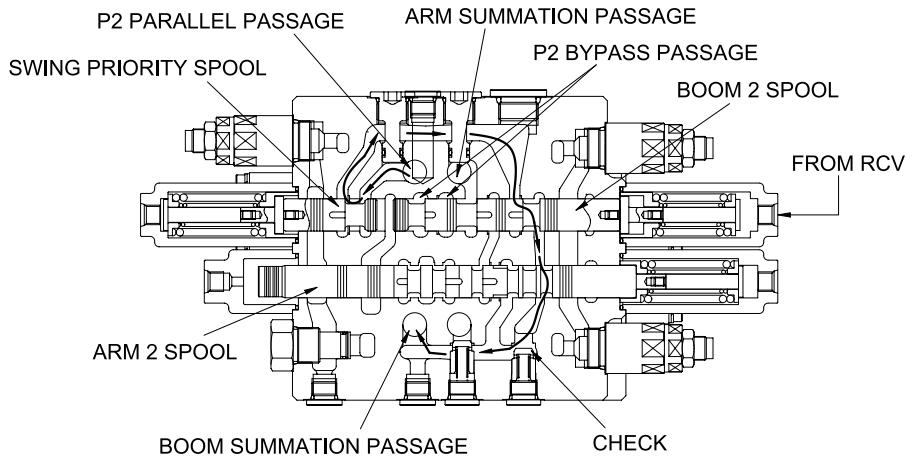
Then the machine keeps straight travel.

(3) BOOM OPERATION

① Boom up operation



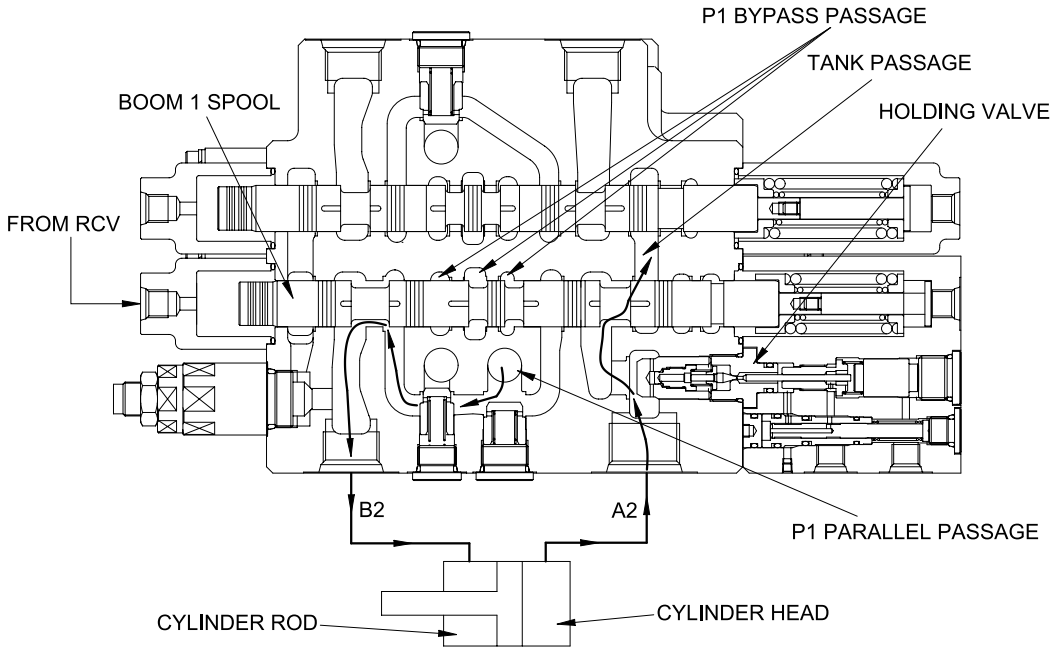
14072SF24



14072SF25

During boom up operation, the pilot pressure from RCV is supplied into the port Pa20 and shift the boom1 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 and boom holding valve then flows into the port A2.
Following this it flows into the head side of the boom cylinder.
(In this case, the boom holding valve is free flow condition)
At the same time the pilot pressure through the port Pa21 shifts the boom2 spool. The hydraulic oil fluid from pump P2 entered boom summation passage via the P2 parallel passage, the swing priority spool, the boom2 spool, arm1 spool and the check. The flows combine in passage and are directed to port A2 and head side of boom cylinder.
The flow from rod side of the boom cylinder return to the boom1 spool through the port B2. There after it is directed to the hydraulic oil tank through the tank passage.

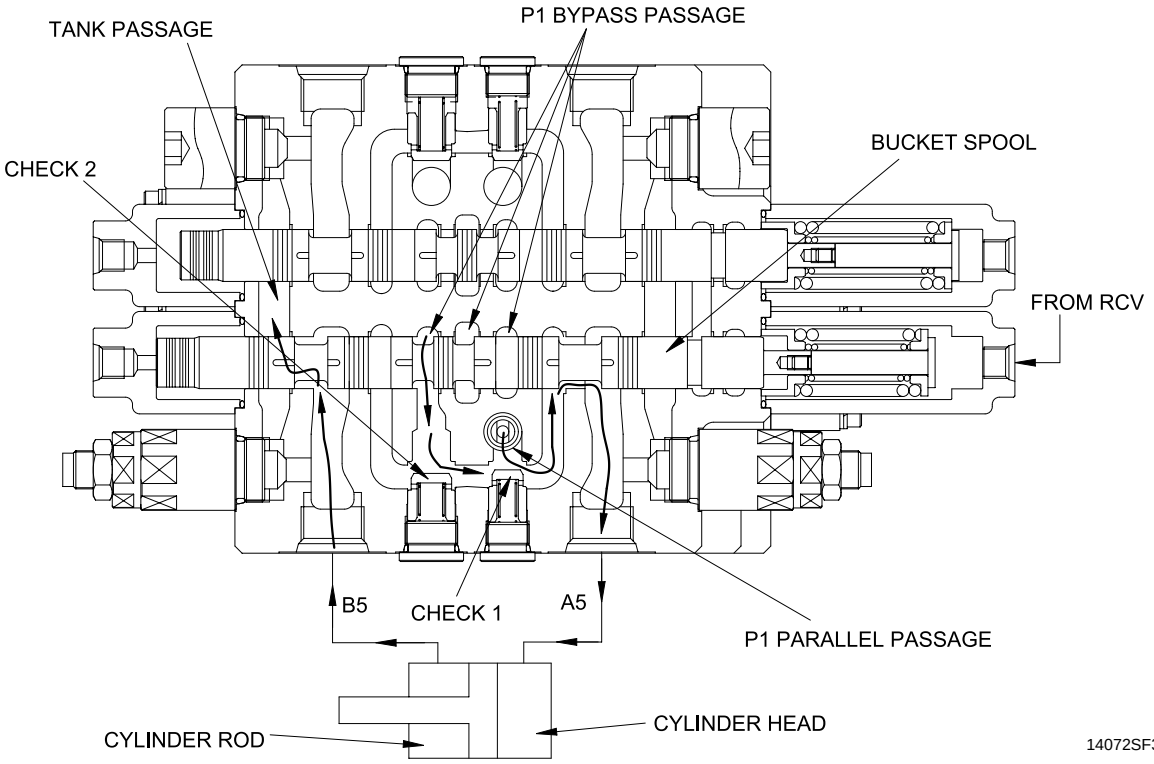
② **Boom down operation**



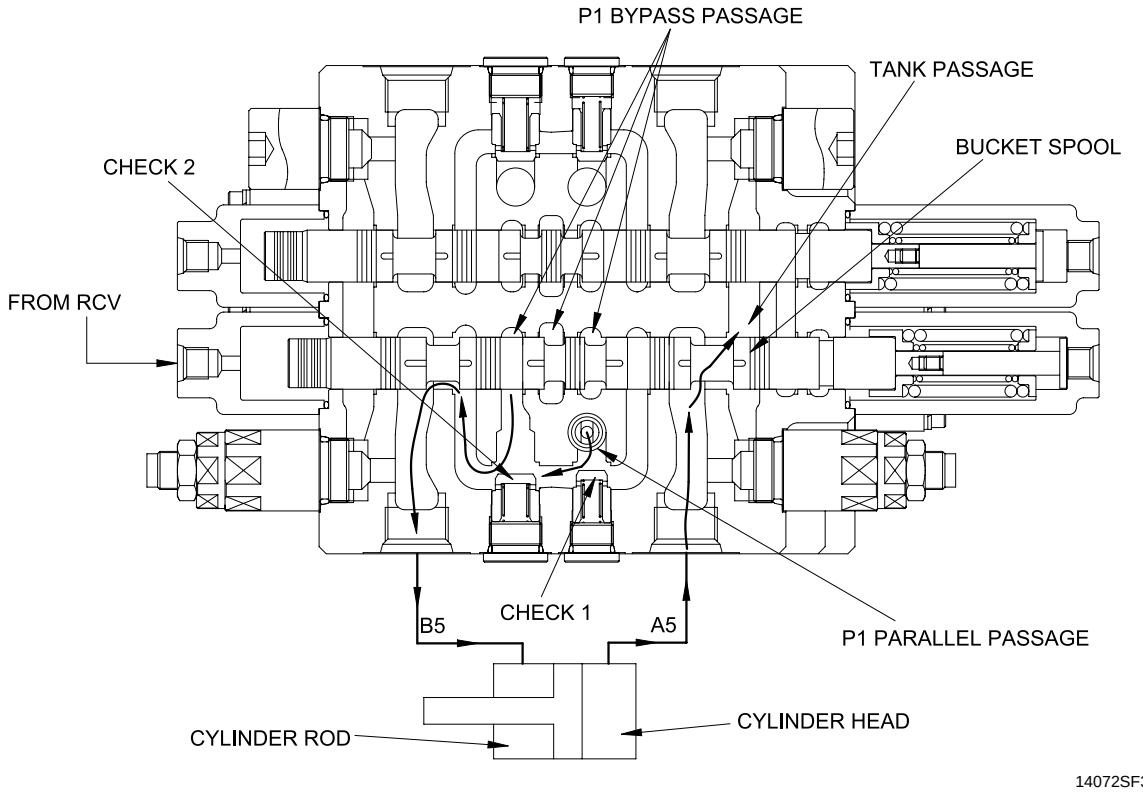
During the boom lowing operation, the pilot pressure from RCV is supplied to the port Pb20 and shift the boom1 spool in the right direction.
The hydraulic fluid from the pump P1 enters the parallel passage and is directed to the port B2 through the load check valve. Following this, it flows into the rod side of the boom cylinder.
The return flow from the head side of the boom cylinder returns to the boom1 spool through the port A2 and boom holding valve. Thereafter it is directed to the hydraulic oil tank through tank passage.
For details of the boom holding valve, see page 2-36.

(4) BUCKET OPERATION

① Bucket roll in operation



② Bucket roll out operation



① Bucket roll in operation

During the bucket roll in operation, the pilot pressure from RCV is supplied to port Pa5 and shift the bucket spool in the left direction.

The hydraulic fluid from pump P1 entered P1 parallel passage and is directed to the port A5 through the check1.

At the same time, the hydraulic fluid from P1 bypass passage is directed to the port A5 through the check2.

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 B5. Thereafter it is directed to the hydraulic oil tank through the tank passage.

② Bucket roll out operation

In case of the bucket roll out operation, the operation is similar

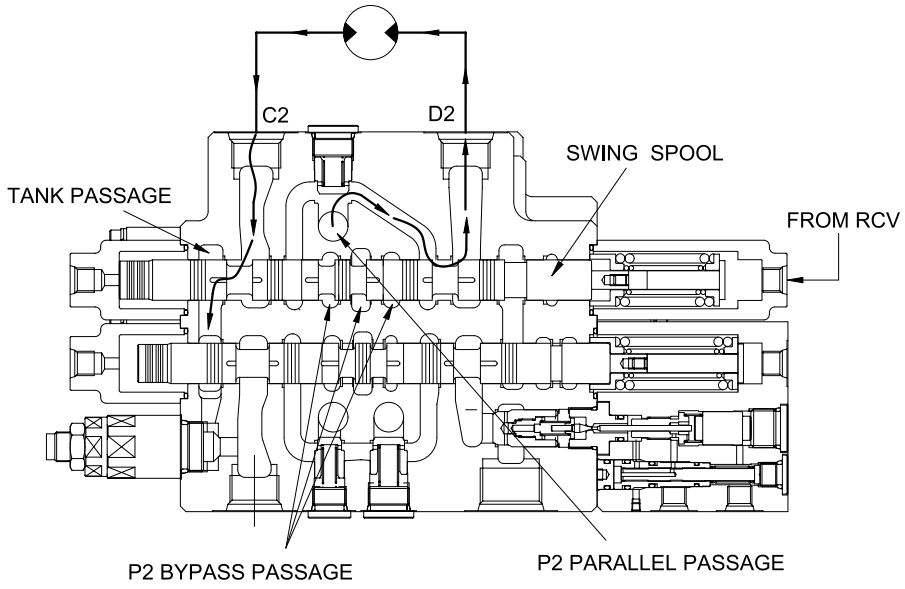
③ Bucket operation with arm or boom operation

When combined operation, mostly same as above but the fluid from bypass passage is empty.

So only the fluid from parallel passage is supplied to the bucket cylinder. Also, parallel passage is installed the orifice for supplying the fluid from pump to the boom or the arm operation prior to the bucket operation.

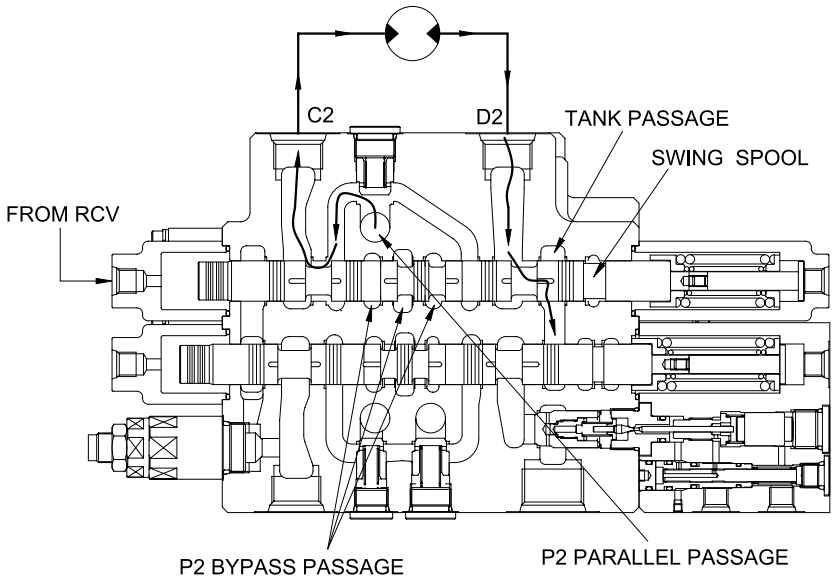
(5) SWING OPERATION

① Swing left operation



14072SF32

② Swing right operation

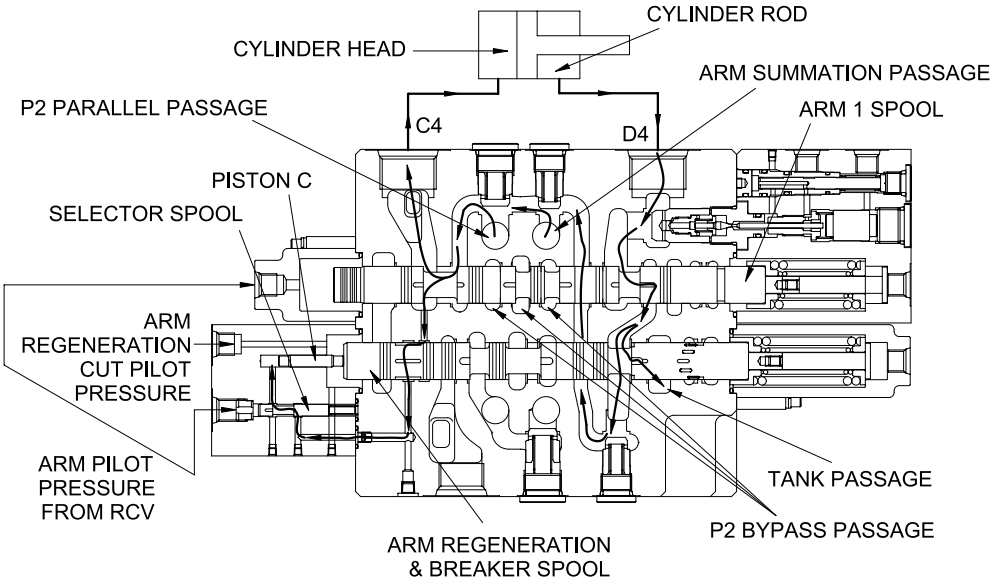


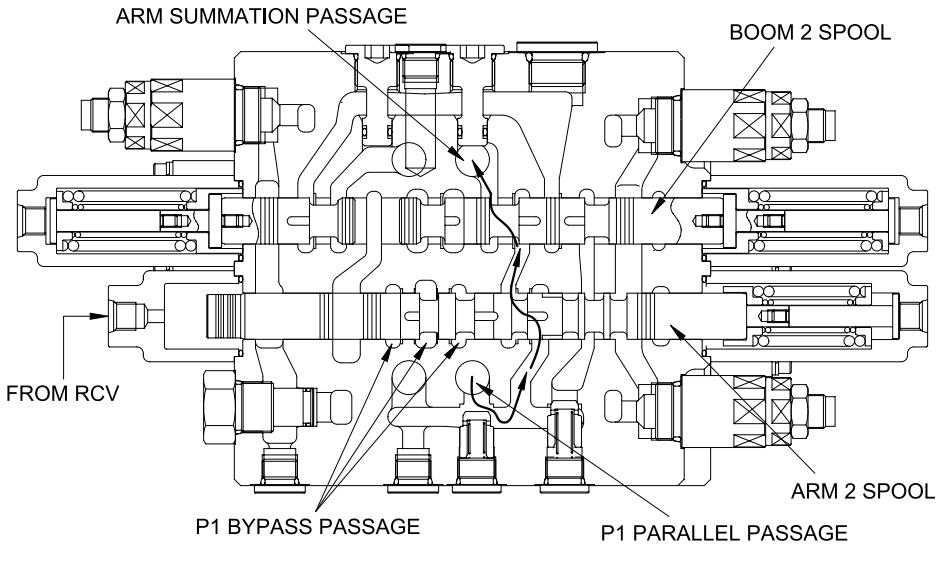
14072SF33

The pilot pressure from the RCV is supplied to the Pd2 and shift the swing spool in left direction. The hydraulic fluid from pump P2 flows into swing spool through the parallel passage. Then it is directed to swing motor through the port D2. As the result, swing motor turns and flow from the swing motor returns to the hydraulic oil tank through the port C2, swing spool and the tank passage .
In case of swing right operation, the operation is similar.

(6) ARM OPERATION

① Arm roll in operation





· **Arm roll in operation :**

During arm roll in operation the pilot pressure from the RCV is supplied to the port Pc4o and Pb3 and shifts arm1 spool and arm2 spool in the right 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 C4.

At same time, the hydraulic fluid from the pump P1 flows into the arm summation passage through parallel passage, the check valve, the arm2 spool and the boom2 spool. Then it entered the arm cylinder head side with hydraulic fluid from arm1 spool.

- **Arm regeneration :**

The return flow from the arm cylinder rod side is pressurized by self weight of arm and so, returns to port D4. The pressurized oil returning to port D4 enters the arm regeneration & breaker spool through the arm holding valve and the arm1 spool. It is suppled the arm cylinder head through internal passage. This is called the arm regeneration function.

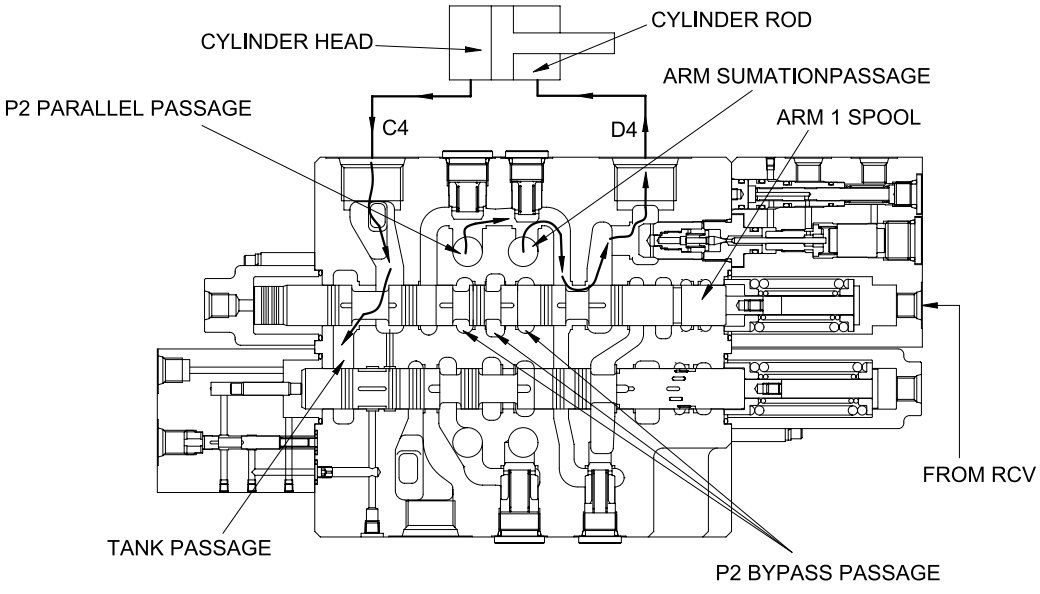
The amount of regeneration fluid are changed by movement of the arm regeneration & breaker spool.

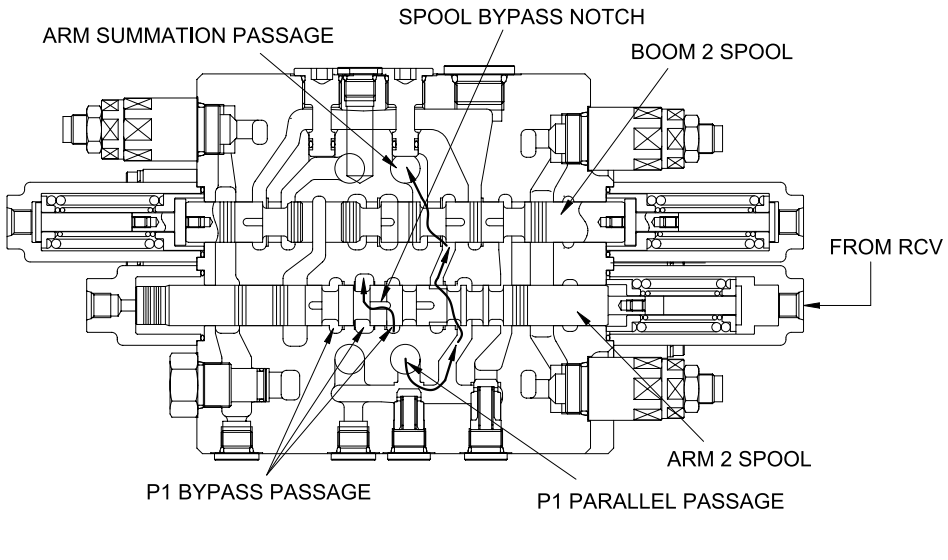
A few fluid after P2 parallel passage is push piston "C" through the notch of arm regeneration spool and selector spool. At this time, the selector spool is opened by pilot pressure from RCV.

Then, the arm regeneration spool shift to right side and flow to tank pass increases and regeneration flow decreases. Therefore, pressure of arm cylinder head increases, then, arm regeneration flow decreases.

Furthermore, the arm regeneration cut pressure is supplied to port and arm regeneration spool is move into the right direction fully. The flow from the arm cylinder rod is returned to the hydraulic oil tank and regeneration function is not activated.

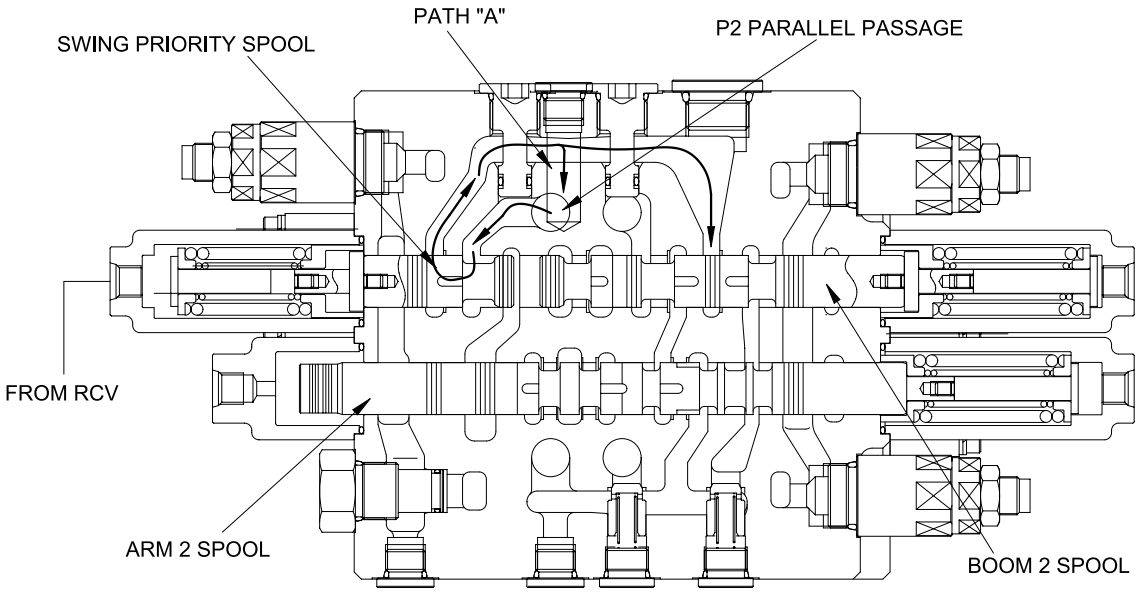
② Arm roll out operation





During arm roll out operation the pilot pressure from RCV is supplied to the port Pd40 and the Pd41 and shifts arm1 spool and arm2 spool in the right direction.
The hydraulic fluid from pump P2 flows into arm1 spool through the parallel passage. Then it enters into the arm cylinder rod side through the load check valve, bridge passage, arm holding valve and the port D4.
Some of the hydraulic fluid from pump P2 bypassed through bypass notch.
The rest of hydraulic fluid from pump P2 flows into the arm summation passage through P1 parallel passage the check valve arm2 spool and boom2 spool.
Then it enters into the arm cylinder rod side with the fluid from the arm1 spool.
The return flow from the arm cylinder head side returns to the hydraulic tank through the port C4 the arm1 spool and tank passage.

(7) SWING PRIORITY FUNCTION

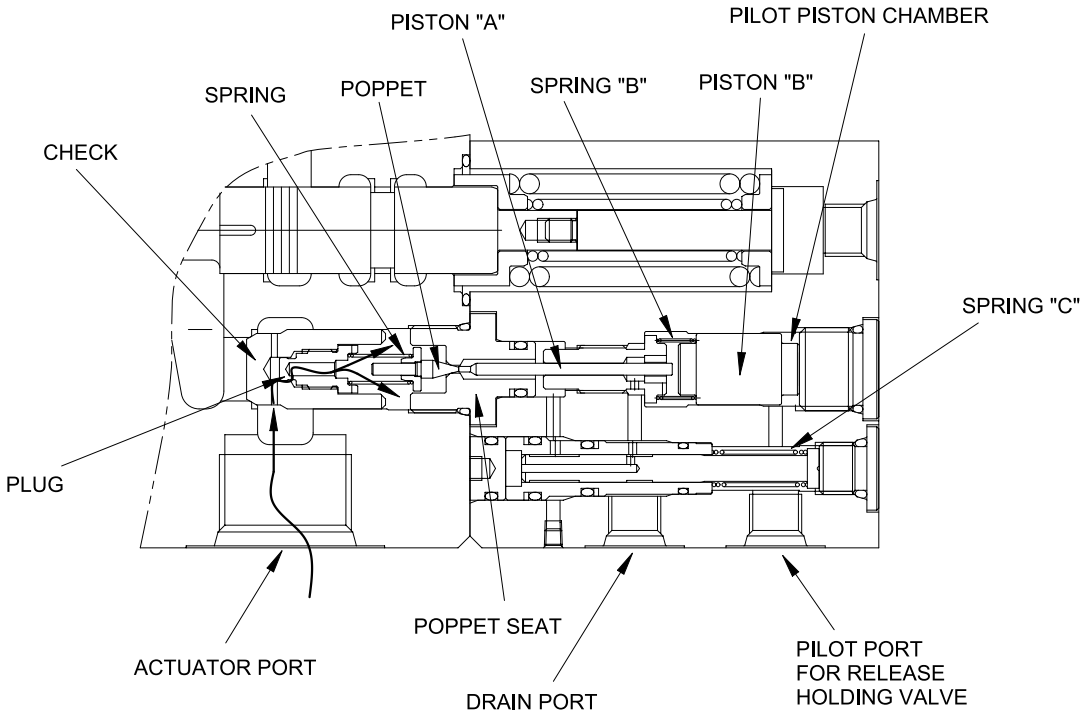


14072SF27

During swing priority operation, the pilot pressure is supplied to the port Pc3 and shift swing priority spool in the right direction.
The hydraulic fluid from P2 parallel passage flows into the parallel passage of arm1 side through swing priority spool and the passage "A" and also flows into the boom2 spool.
Due to shifting of the swing priority spool, the fluid from pump P2 flows to swing side more then next spools to make the swing operation most preferential.

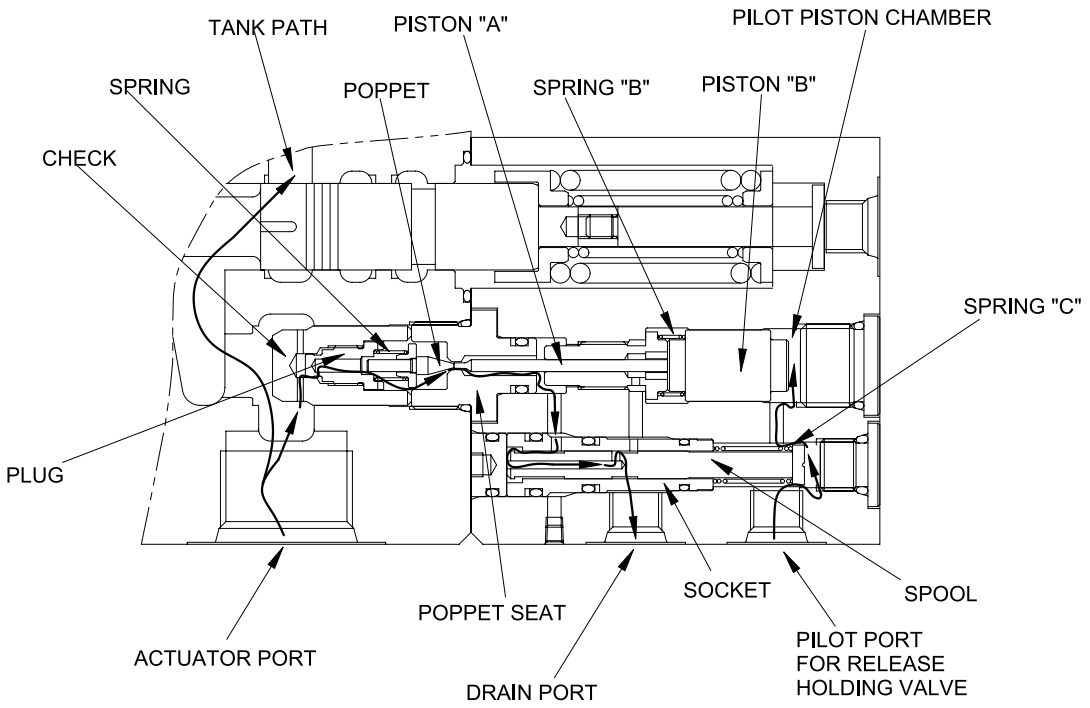
(8) HOLDING VALVE OPERATION

① Holding operation



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" and 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**

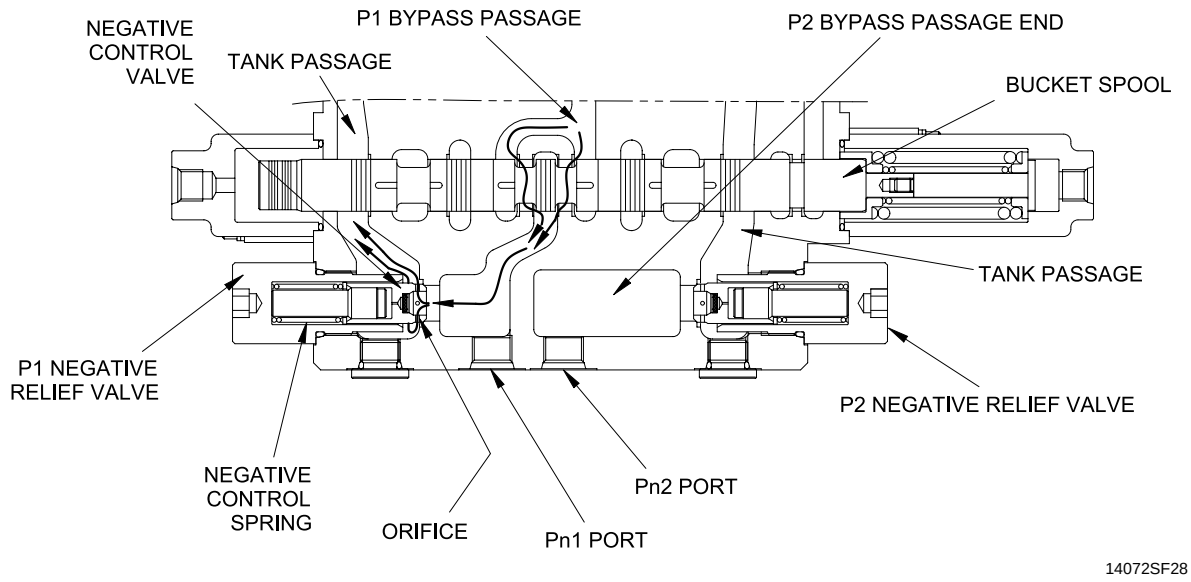


The pilot pressure is supplied to the pilot port for release holding valve and shifts the piston "B" in the left direction against the spring "B", and shifts the poppet in the left direction through piston "B" and piston "A" against spring "B" and shifts the spool in the left side.

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 the socket and spool and inside 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.

(9) NEGATIVE CONTROL



When no function is being actuated on P1 side, the hydraulic fluid from the pump P1, flows into the tank passage through the bypass passage and orifice. The restriction caused by this orifice thereby pressurizes. This pressure is transferred as the negative control signal pressure Pn1 to the pump P1 regulator.

It controls the pump regulator so as to minimize the discharge of the pump P1.

The bypass passage is shut off when the shifting of one or more spools and the flow through bypass passage became zero. The pressure of negative control signal become zero and the discharge of the pump P1 become maximum.

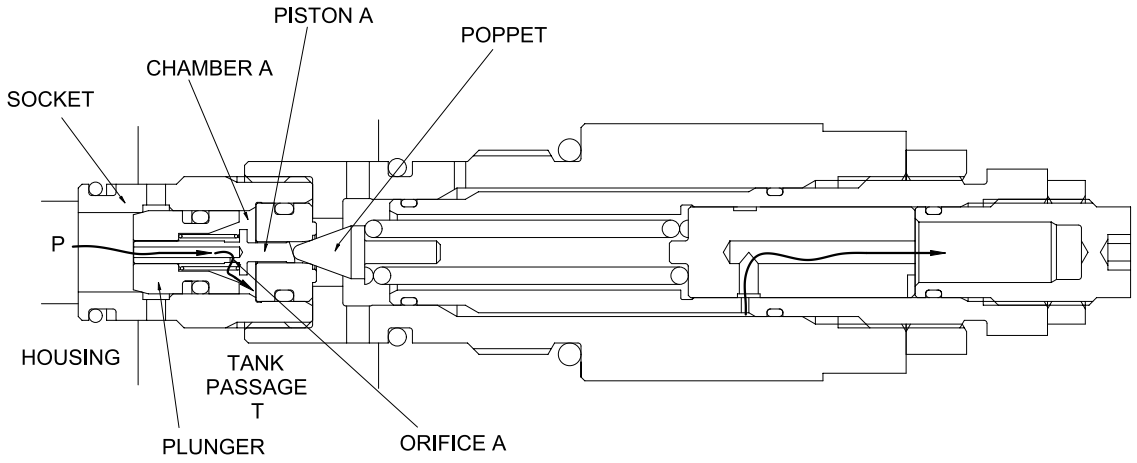
The negative control pressure reaches to the set level, the hydraulic fluid in the passage pushes open negative control valve and escapes into the return passage.

For the pump P2 the same negative control principle.

(10) OPERATION OF MAIN RELIEF VALVE

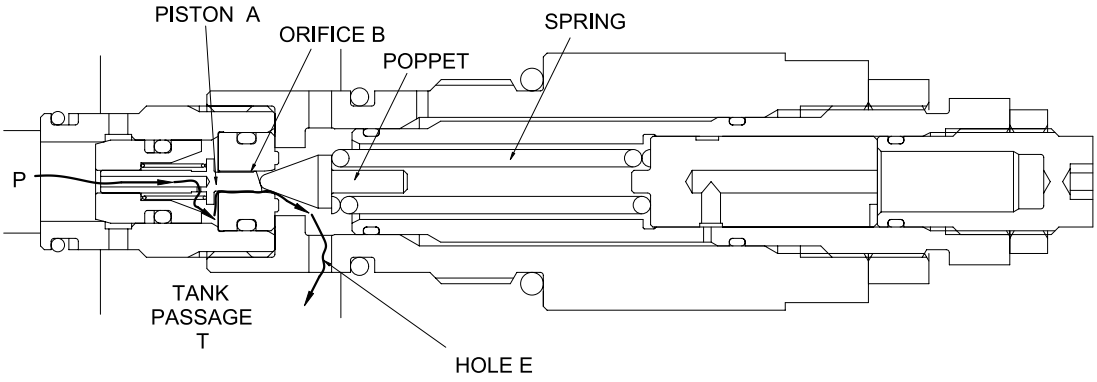
The main relief valve is fitted to the straight travel valve block and functions as follows :

① The pressurized oil passes through the orifice (A) of the plunger is filled up in chamber A of the inside space, and seats the plunger against the housing securely.



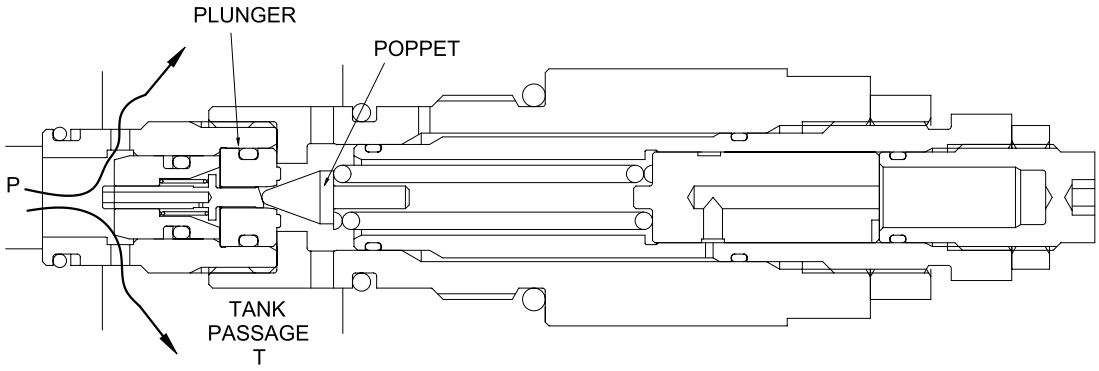
14072SF36

② When the pressure at (P) becomes equal to the set pressure of the spring the hydraulic oil passes through the piston (A) pushes open the poppet and flows to tank passage (T) through the hole (E).



14072SF37

③ Opening the poppet causes the pressure in chamber A to fall and the plunger to open. As the result the pressurized oil at port P runs into tank passage (T)

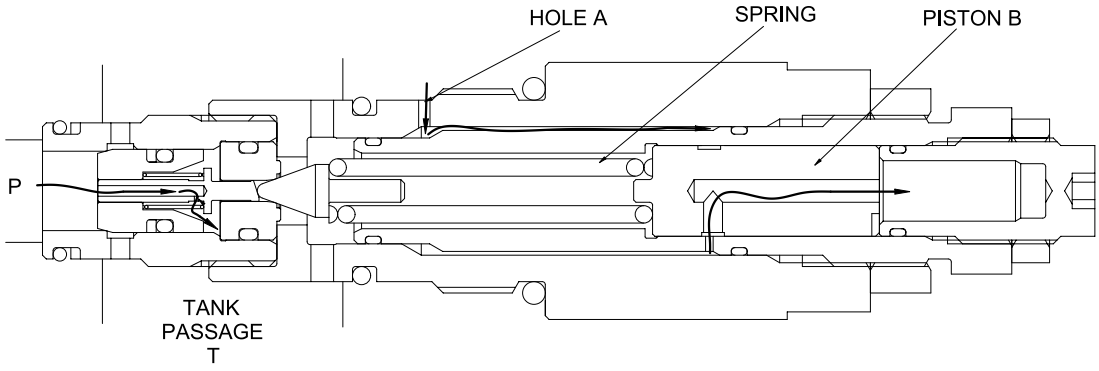


14072SF38

④ High pressure setting pilot signal(Pu) : ON

When the power boost switch is ON, the pilot pressure enters through hole A.

It pushes the piston(B) in the left direction to increase the force of the spring and change the relief set pressure to the high pressure.

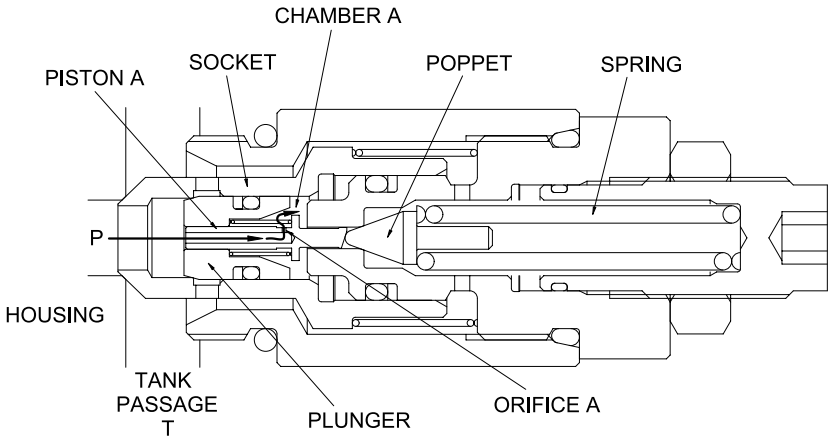


14072SF36

(11) OPERATION OF PORT RELIEF VALVE

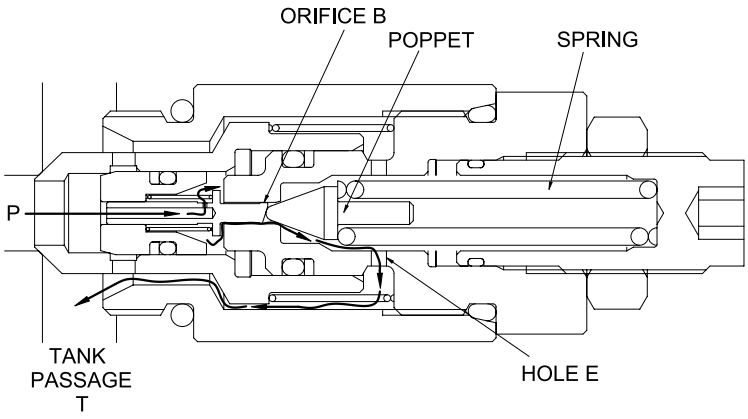
① Function as relief valve

ⓐ The pressurized oil passes through the piston A and orifice is filled up in chamber A of the inside space and seat the plunger against the socket and the socket against the housing securely.



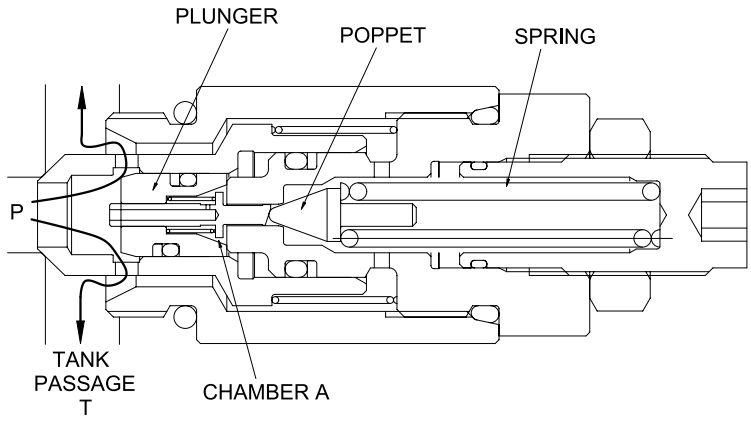
14072SF39

ⓑ When the pressure at port P becomes equal to the set pressure of the spring, the pressurized oil pushes open the poppet flows to tank passage (T) through hole E.



14072SF40

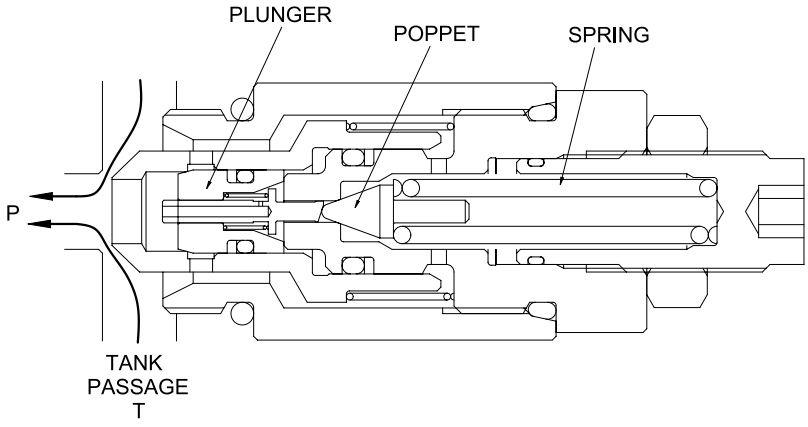
ⓒ Opening of the poppet causes the pressure in chamber A to fall and the plunger to open. As the result the pressurized oil at port P runs into tank passage (T).



14072SF41

② **Make-up function**

When negative pressure exists at port P, the oil is supplied through tank passage (T). When the pressure at tank passage (T) becomes higher than that at port P, the socket moves in the right direction. Then, sufficient oil passes around the socket from tank passage (T) to port P and fills up the space.



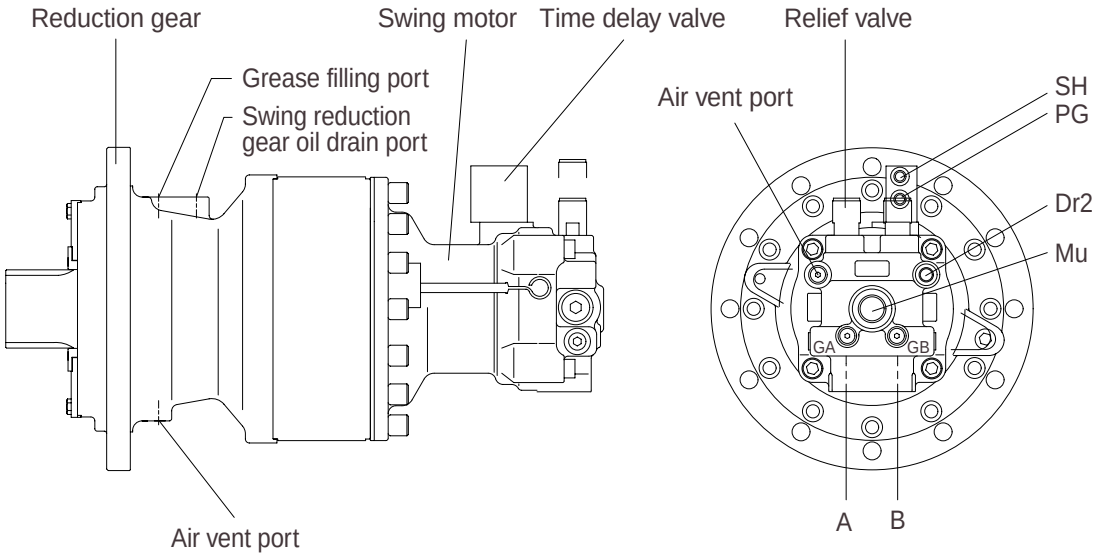
14072SF42

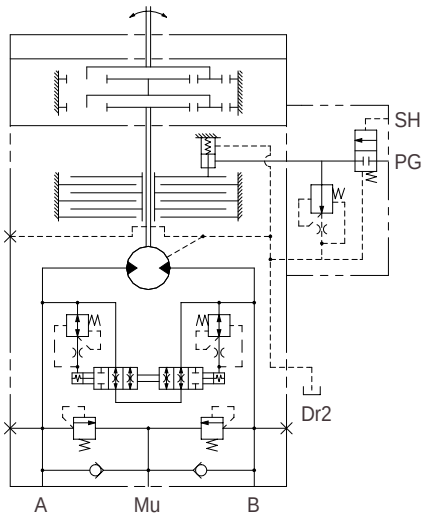
GROUP 3 SWING DEVICE

1. STRUCTURE

Swing device consists swing motor, swing reduction gear.

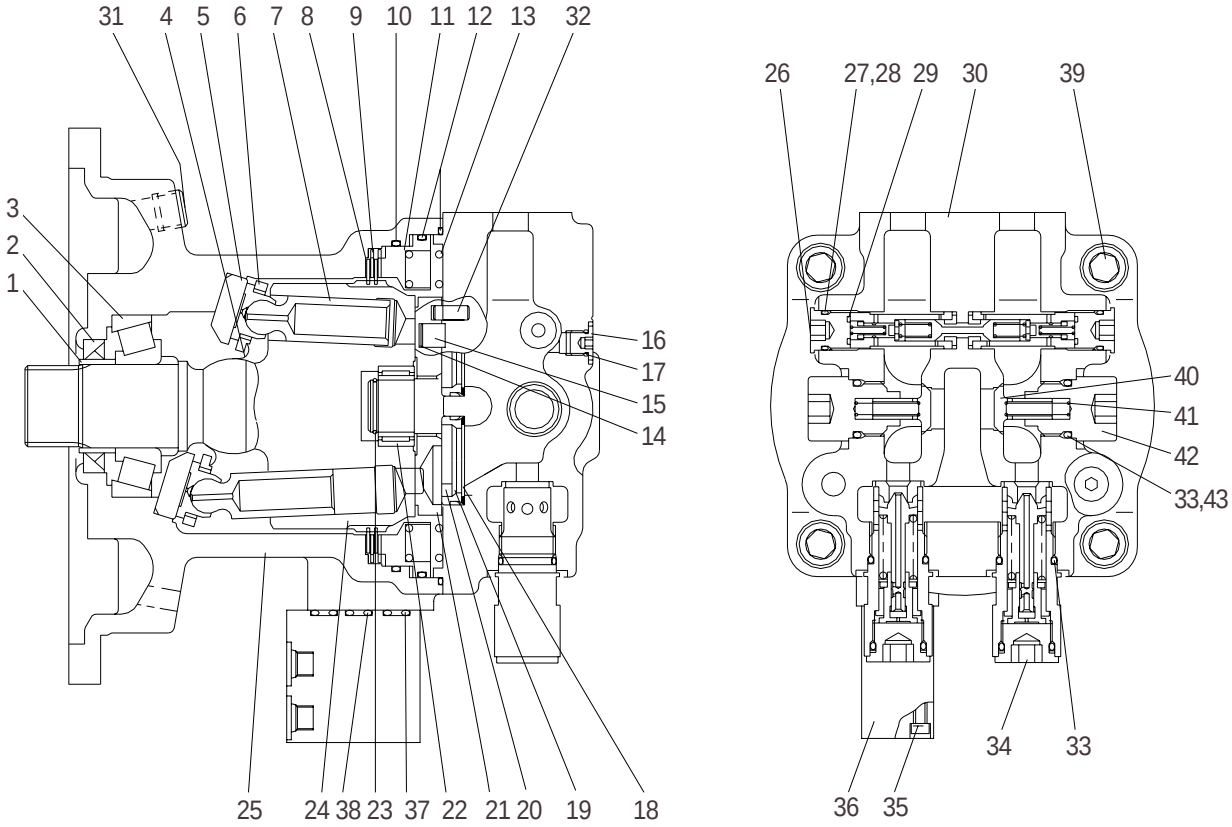
Swing motor include mechanical parking valve, relief valve, make up valve and time delay valve.





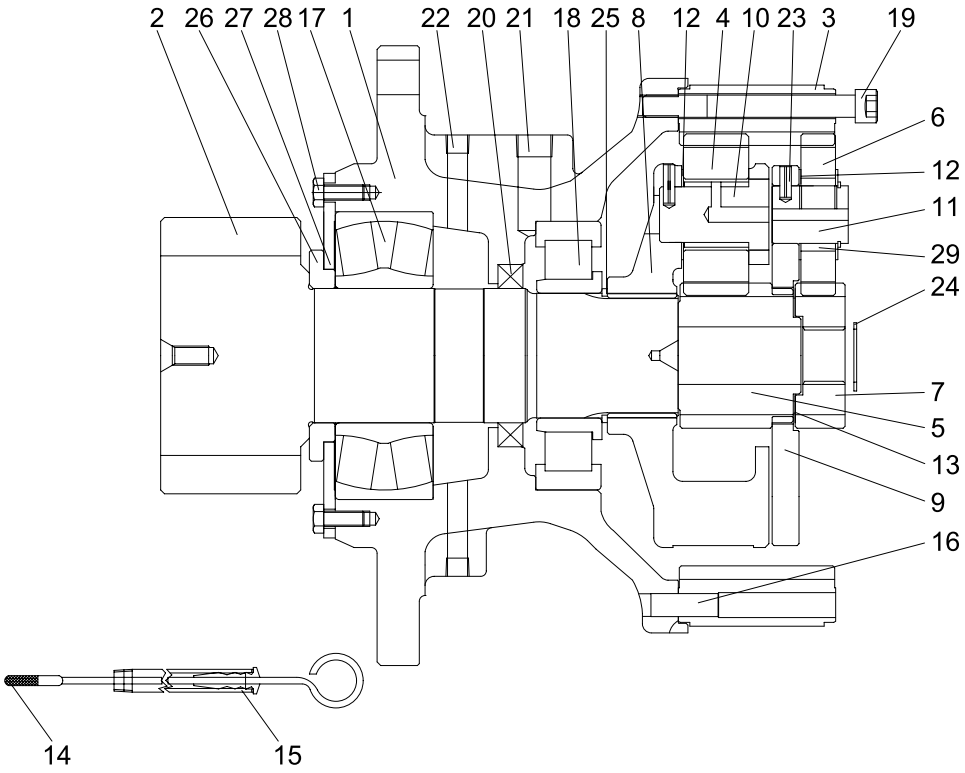
Port	Port name	Port size
A	Main port	PF 3/4
B	Main port	PF 3/4
Dr2	Drain port	PF 3/8
Mu	Make up port	PF 1
SH	Brake release port	PF 1/4
PG	Stand by port	PF 1/4
GA, GB	Gage port	PF 1/4

1) SWING MOTOR



1	Inner ring	15	Piston	29	O-ring
2	Oil seal	16	Cap	30	Cover
3	Tappered roller bearing	17	O-ring	31	Plug
4	Backing spring	18	Scrowave	32	Parallel pin
5	Cam plate	19	Teflon ring	33	O-ring
6	Return plate	20	Bush	34	Relief valve
7	Piston assembly	21	Balance plate	35	Bolt
8	Lining plate	22	Needle bearing	36	Time delay valve
9	Plate	23	Snap ring	37	O-ring
10	O-ring	24	Cylinder assembly	38	O-ring
11	Piston	25	Housing	39	Bolt
12	O-ring	26	Bypass valve assy	40	Check
13	Spring	27	Back-up ring	41	Spring
14	Teflon ring	28	O-ring	42	Cap
				43	Back-up ring

2) REDUCTION GEAR



1	Casing	10	Pin No.2 assembly	20	Oil seal
2	Drive shaft	11	Pin No.1	21	Plug(B)
3	Ring gear	12	Thrust washer(B)	22	Plug(A)
4	Planet gear No.2	13	Thrust washer(A)	23	Spring pin
5	Sun gear No.2	14	Gage bar	24	Stop ring
6	Planet gear No.1	15	Gage pipe	25	Stop ring
7	Sun gear No.1	16	Knock pin	26	Spacer
8	Carrier No.2	17	Sph roller bearing	27	Cover plate
9	Carrier No.1	18	Cyl roller bearing	28	Bolt
		19	Bolt	29	Needle cage

2. FUNCTION

1) ROTARY PART

When high pressurized oil enters a cylinder through port(a), which is the inlet of balance plate(1), hydraulic pressure acting on the piston causes axial force F. The pressure force F works via the piston(2) upon the return plate(3) which acts upon the swash plate(4) via an hydrostatic bearing. Force F1 perpendicular to swash plate(4) and force F2 perpendicular to cylinder center.

Being transferred to the cylinder block(5) 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.

$$T = \frac{p \times q}{2\pi}, \quad q = Z \cdot A \cdot PCD \cdot \tan\theta, \quad F1 = \frac{F}{\cos\theta}, \quad F_2 = F \tan\theta, \quad S = PCD \times \tan\theta$$

Where p : Effective difference of pressure(kgf/cm^2)

q : Displacement(cc/rev)

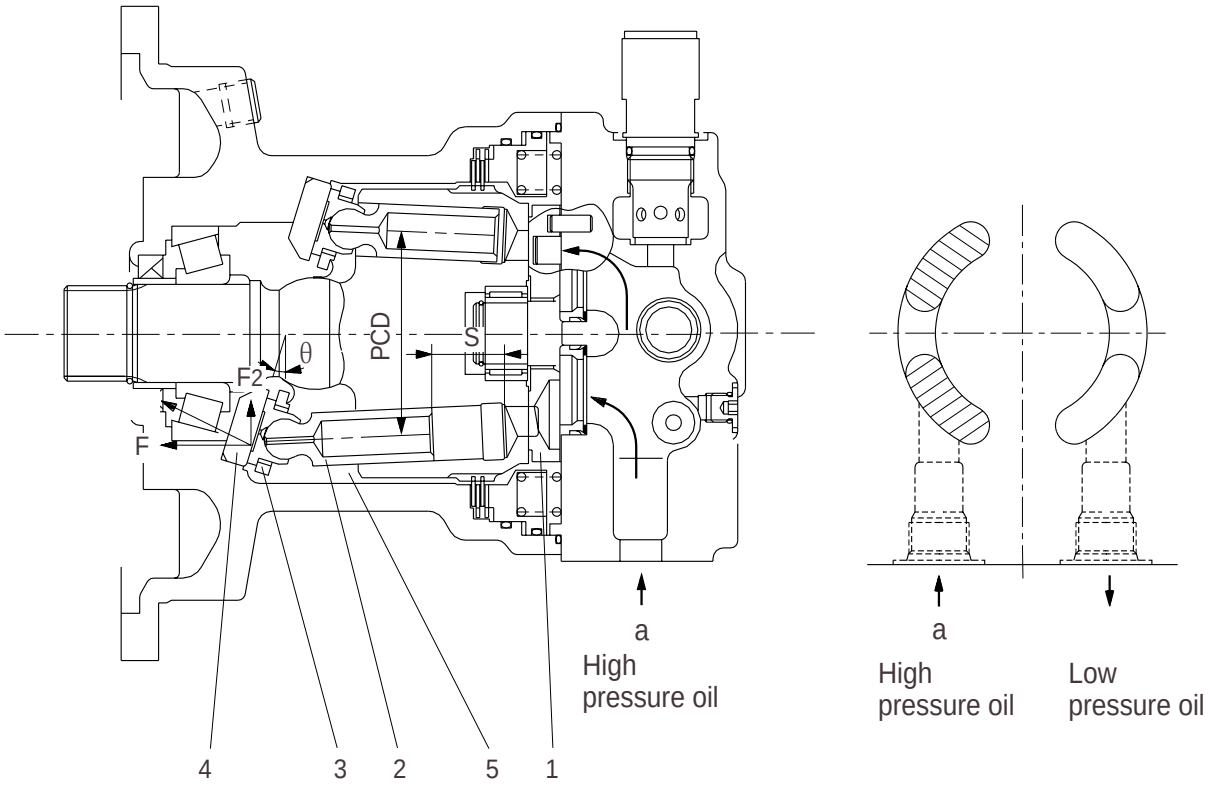
T : Output torque(kgf · cm)

Z : Piston number(9EA)

A : Piston area(cm^2)

θ: Tilting angle of swash plate(degree)

S : Piston stroke(cm)



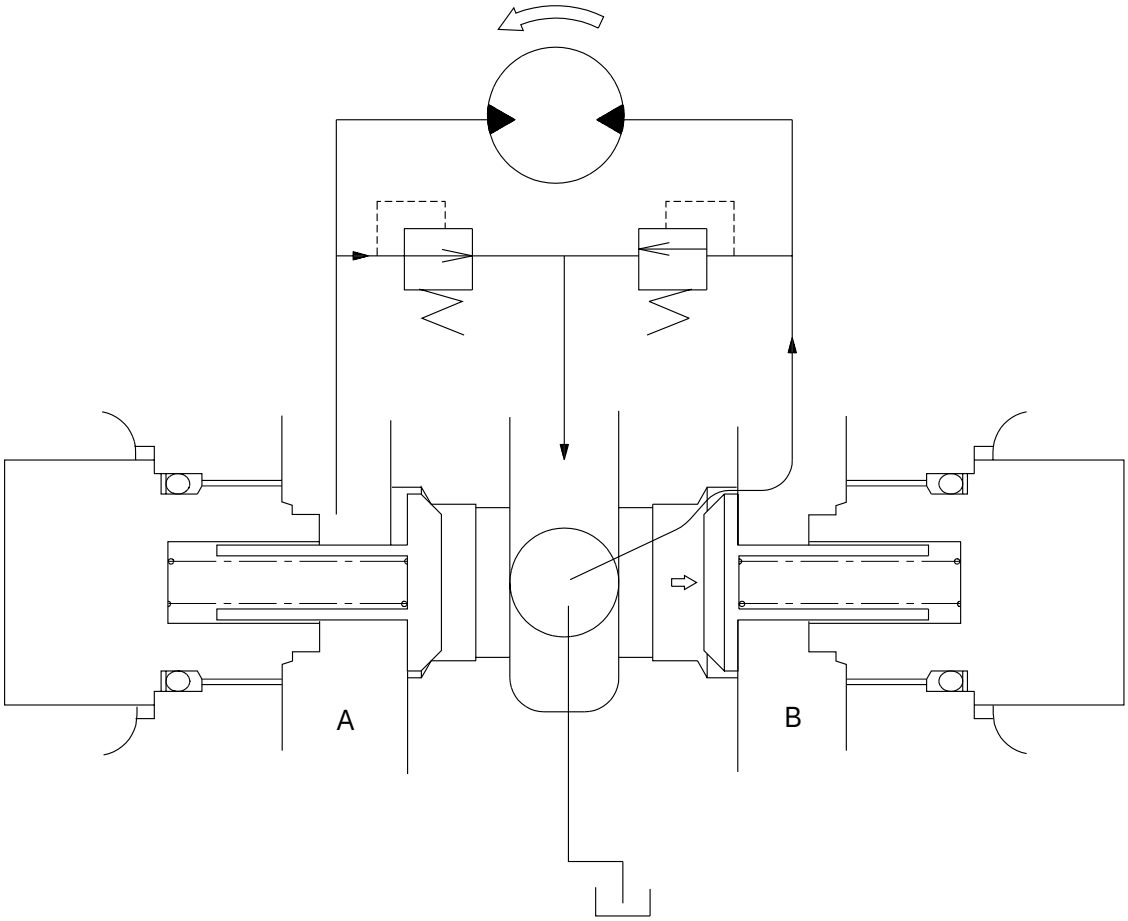
2) MAKE UP VALVE

In the system using this type of motor, there is no counter balance functioning valve and there happens the case of revolution exceeding hydraulic supply of motor. To prevent the cavitation caused by insufficient oil flow there is a make up valve to fill up the oil insufficiency.

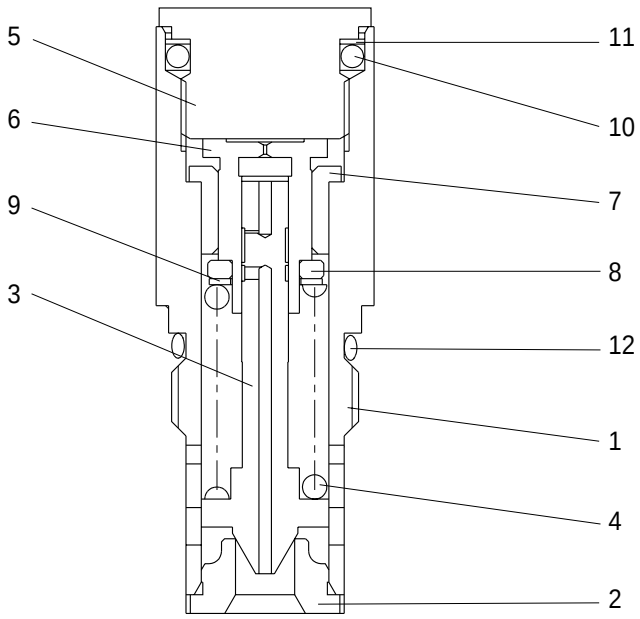
A make up valve is provided immediately before the port leading to the hydraulic oil tank to secure feed pressure required when the hydraulic motor makes a pumping action. The boost pressure acts on the hydraulic motor's feed port via the make up valve.

Pressurized oil into the port B, the motor rotate counterclockwise.

If the plunger of MCV moves neutral position, the oil in the motor is drain via left relief valve, the drain oil run into motor via right make up valve, which prevent the cavitation of motor.



3) RELIEF VALVE



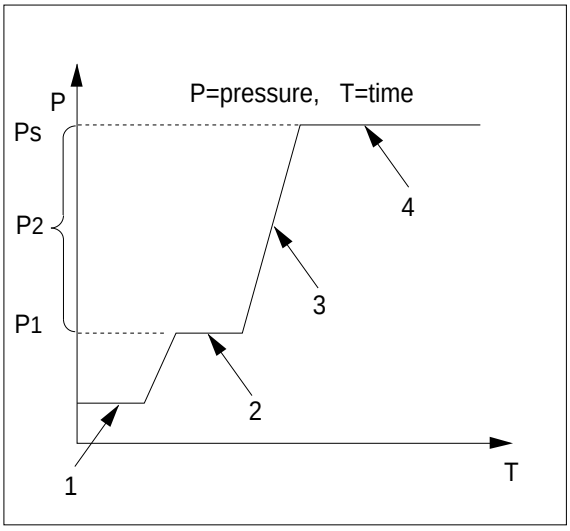
1	Body
2	Seat
3	Plunger
4	Spring
5	Adjusting screw
6	Piston
7	Bushing
8	Spring seat
9	Shim
10	O-ring
11	Back up ring
12	O-ring

(1) Construction of relief valve

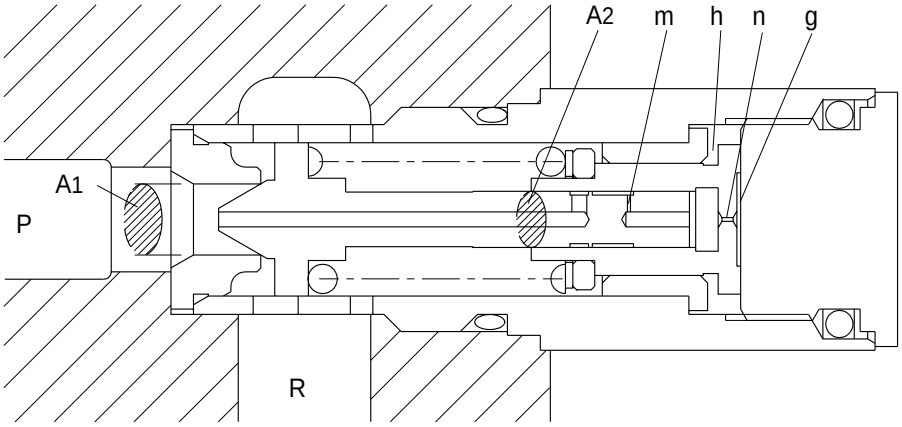
The valve casing contains two cartridge type relief valves that stop the regular and reverse rotations of the hydraulic motor. The relief valves relieve high pressure at start or at stop of swing motion and can control the relief pressure in two steps, high and low, in order to insure smooth operation.

(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.



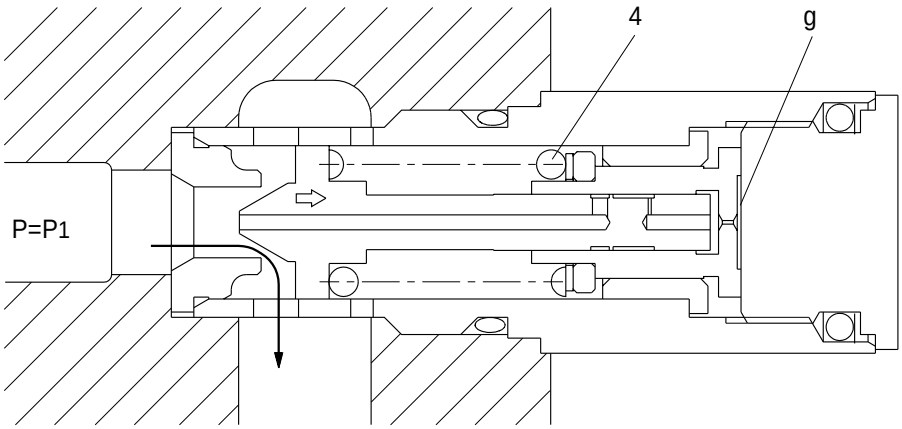
① Ports (P,R) at tank pressure.



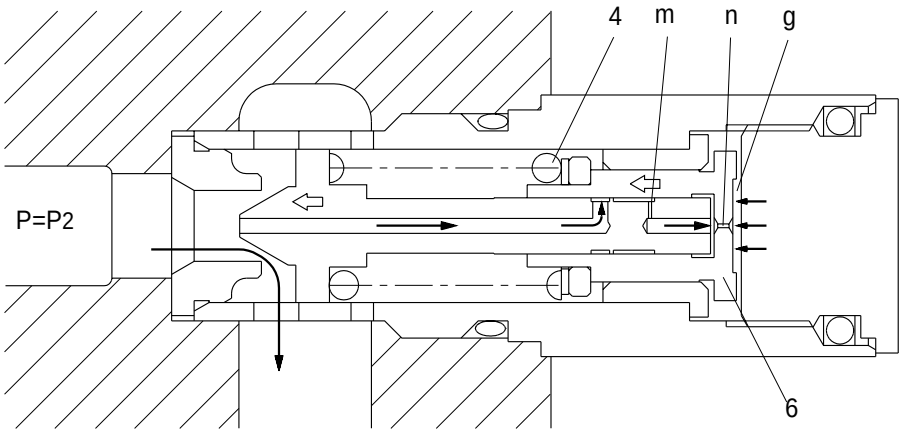
② When hydraulic oil pressure($P \times A_1$) reaches the preset force(F_{SP}) of spring(4), the plunger(3) moves to the right as shown.

$P_1 \times A_1 = Fsp + Pg \times A_2$

$$P_1 = \frac{Fsp + Pg \times A_2}{A_1}$$



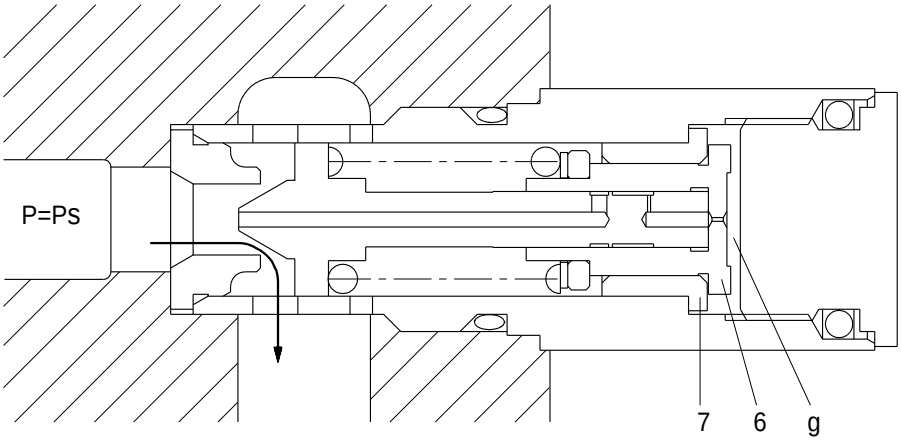
③ The oil flow chamber g via orifice m and n. When the pressure of chamber g reaches the preset force(F_{SP}) of spring(4), the piston(6) moves left and stop the piston(6) hits the bottom of bushing(7).



④ When piston(6) hits the bottom of bushing(7), it stops moving to the left any further. As the result, the pressure in chamber(g) equals(P_s).

$P_s \times A_1 = F_{sp} + P_s \times A_2$

$$P_s = \frac{F_{sp}}{A_1 - A_2}$$

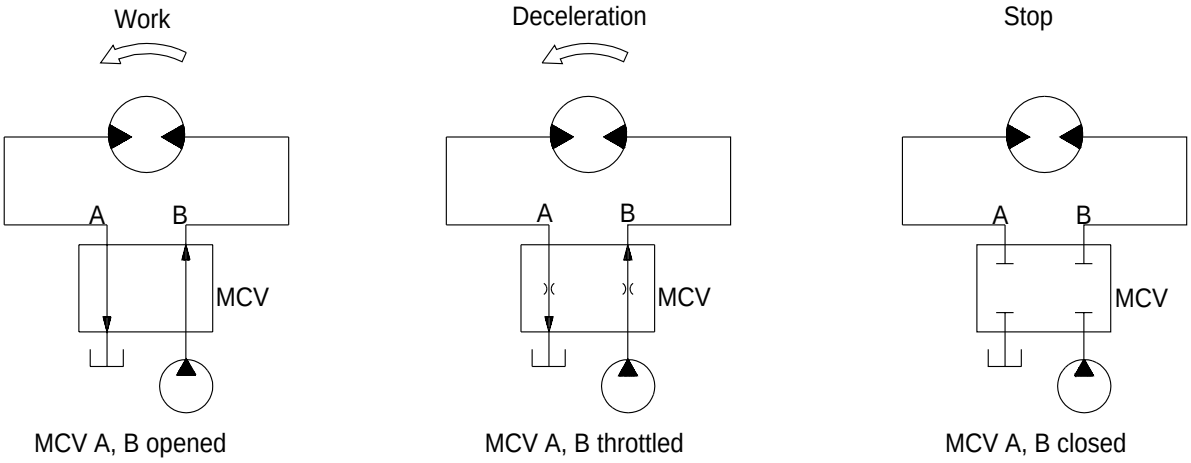


4) BRAKE SYSTEM

(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.



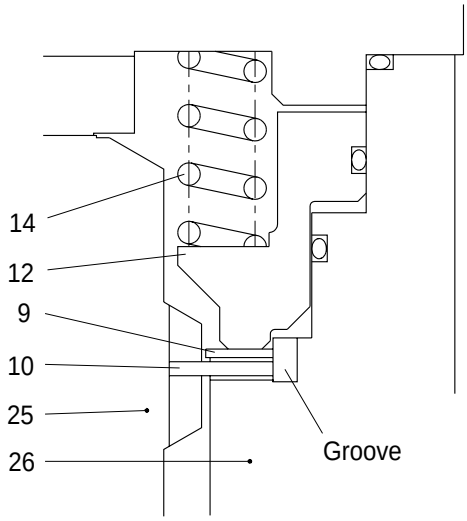
(2) Mechanical swing parking brake system

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 slop, work can be done more easily and safely.

① **Brake assembly**

Circumferential rotation of separate plate(9) is constrained by the groove located at housing(26). When housing is pressed down by brake spring(16) through lining plate(10), separate plate(9) and brake piston(12), friction force occurs there.

Cylinder(25) is constrained by this friction force and brake acts, while brake releases when hydraulic force exceeds spring force.

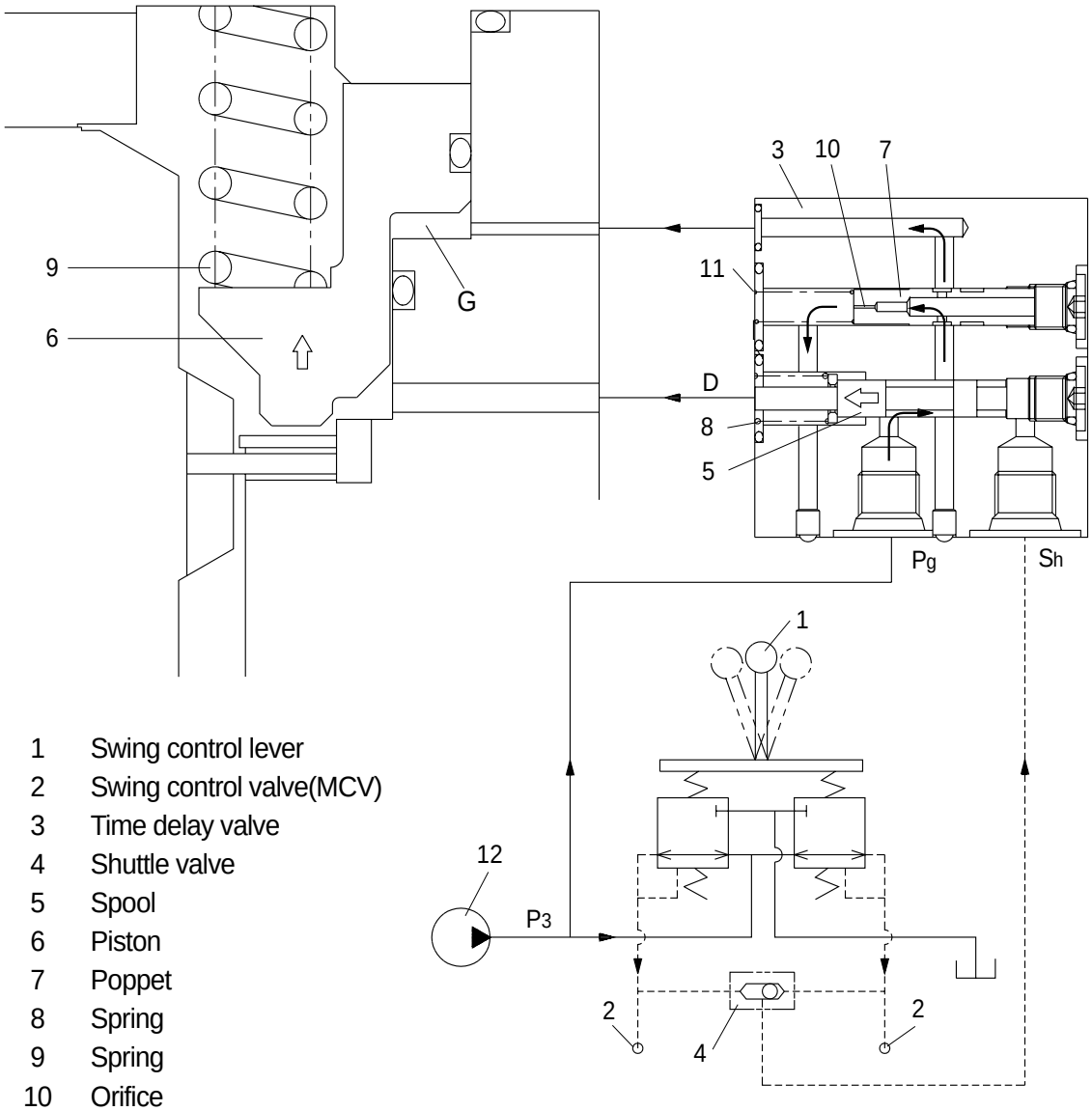


9	Separate plate	14	Spring
10	Lining plate	25	Cylinder
12	Brake piston	26	Housing

② Operating principle

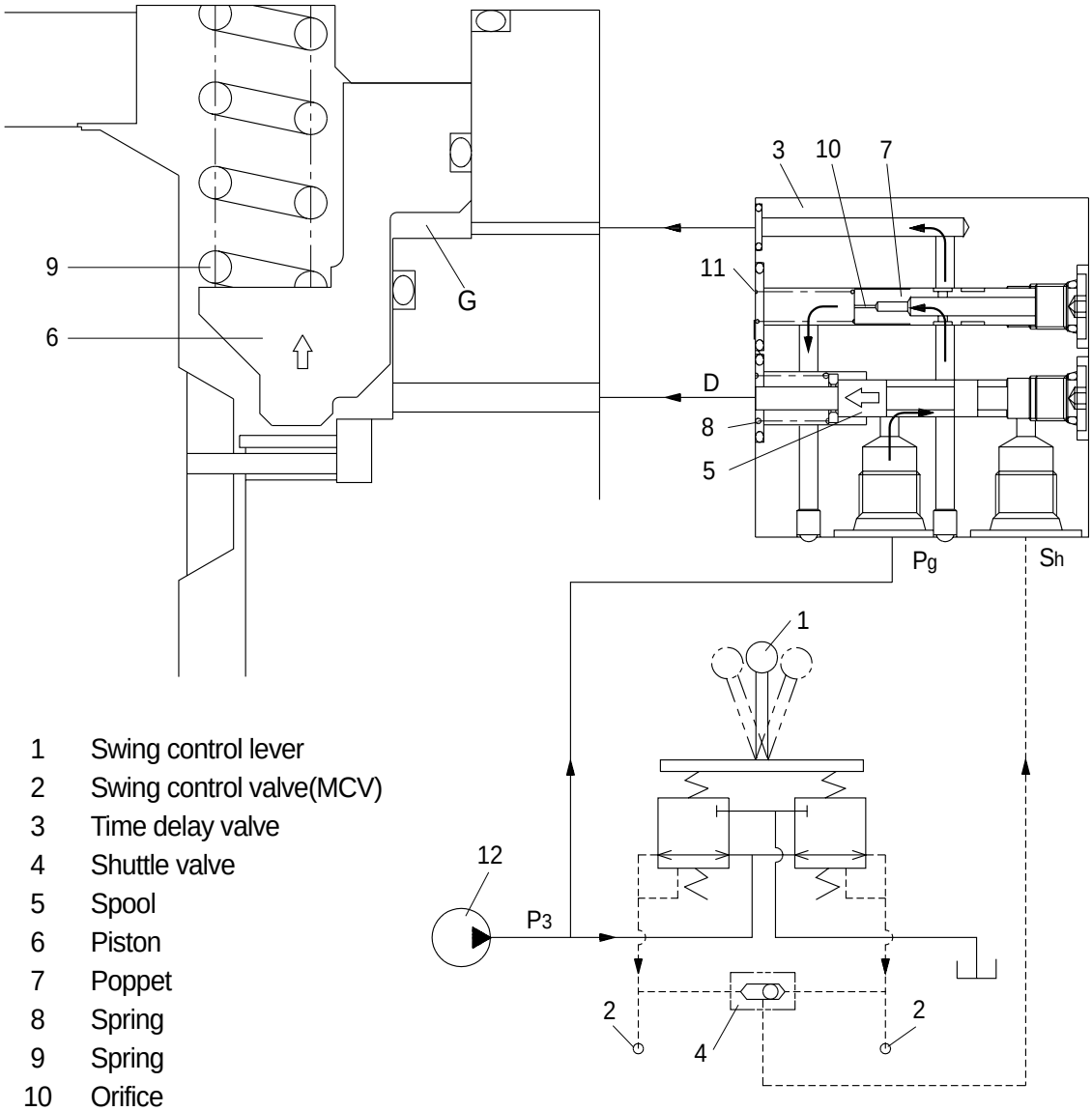
a. When the swing control lever(1) is set to the swing position, the pilot oil go to the swing control valve(2) and to S_h of the time delay valve(3) via the shuttle valve(4), this pressure move spool(5) to the leftward against the force of the spring(8), so pilot pump charged oil(P_3) goes to the chamber G.

This pressure is applied to move the piston(6) to the upward against the force of the spring(9). Thus, it releases the brake force.



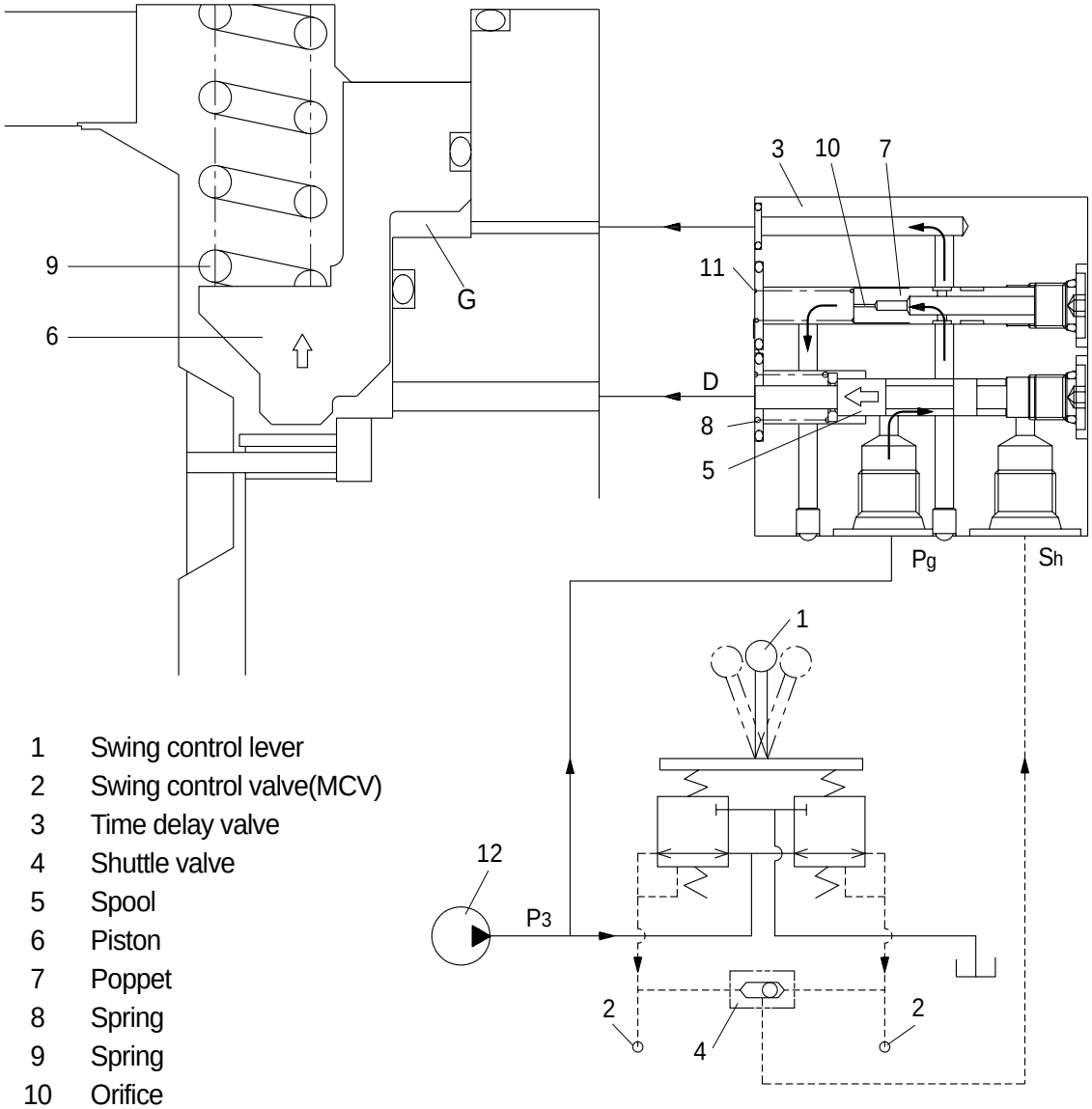
1 Swing control lever
2 Swing control valve(MCV)
3 Time delay valve
4 Shuttle valve
5 Spool
6 Piston
7 Poppet
8 Spring
9 Spring
10 Orifice
11 Spring
12 Pilot pump

b. Meantime, the oil pressure of port D balance with the preset force of spring(11), the pressure of chamber G keeps constant pressure.



1 Swing control lever
2 Swing control valve(MCV)
3 Time delay valve
4 Shuttle valve
5 Spool
6 Piston
7 Poppet
8 Spring
9 Spring
10 Orifice
11 Spring
12 Pilot pump

c. When the swing control(1) lever is set the neutral position, the spool(5) returns right in the time delay valve(3).
Then, the piston(6) is moved lower by spring force and the return oil from the chamber G flows back to D-port through orifice(10) of the poppet(7).
At this time, the poppet(7) works to make a time lag for 5 seconds.



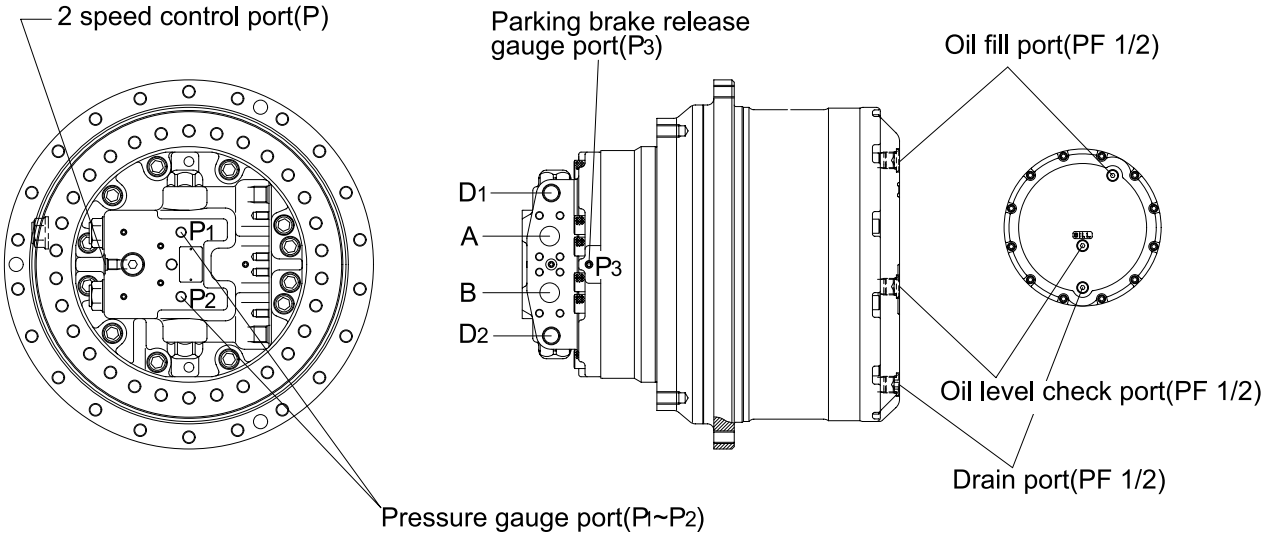
1 Swing control lever
2 Swing control valve(MCV)
3 Time delay valve
4 Shuttle valve
5 Spool
6 Piston
7 Poppet
8 Spring
9 Spring
10 Orifice
11 Spring
12 Pilot pump

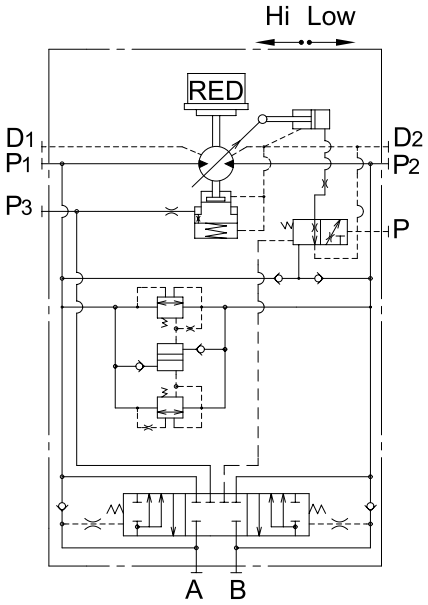
GROUP 4 TRAVEL DEVICE

1. CONSTRUCTION

Travel device consists travel motor and gear box.

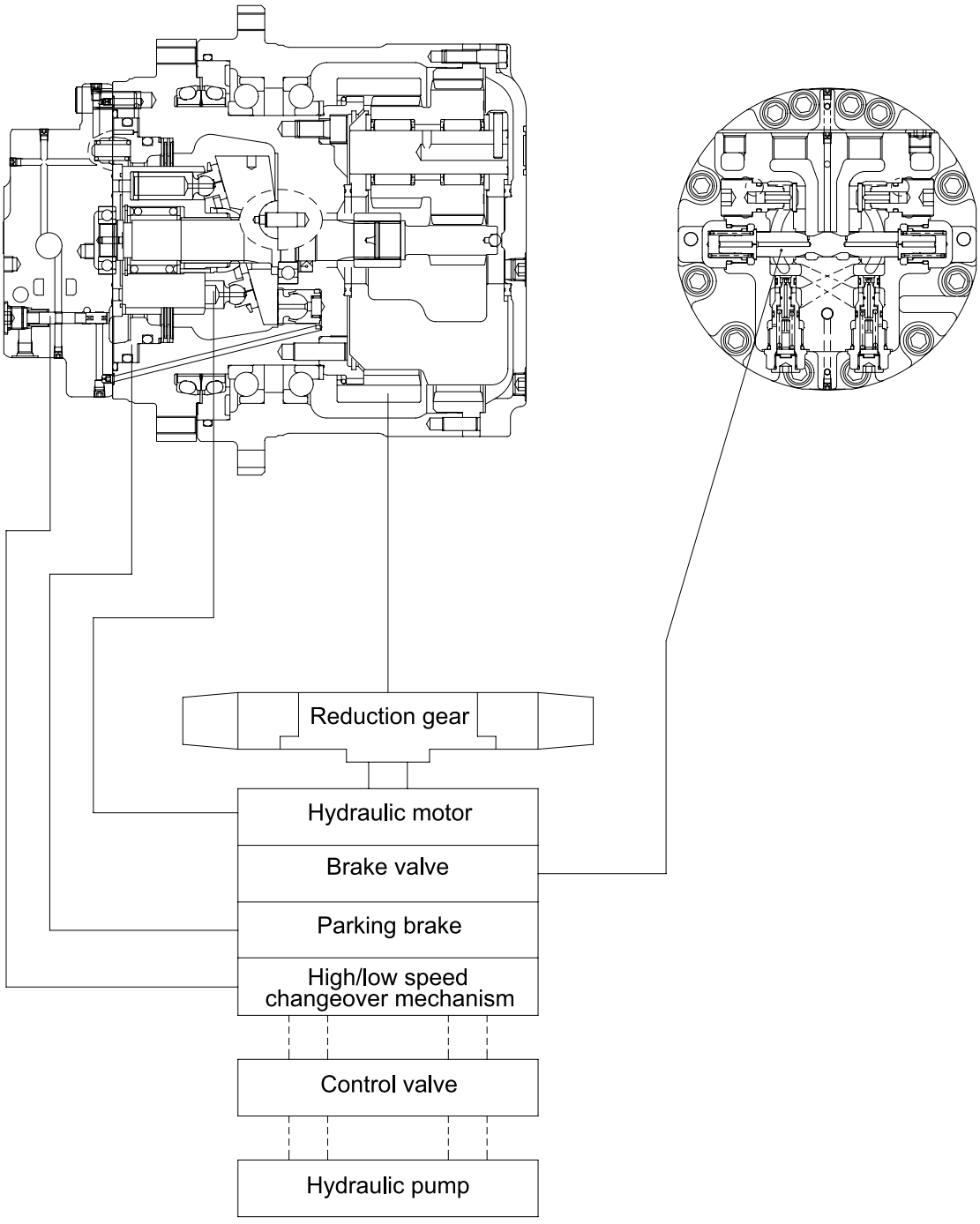
Travel motor includes brake valve, parking brake and high/low speed changeover mechanism.

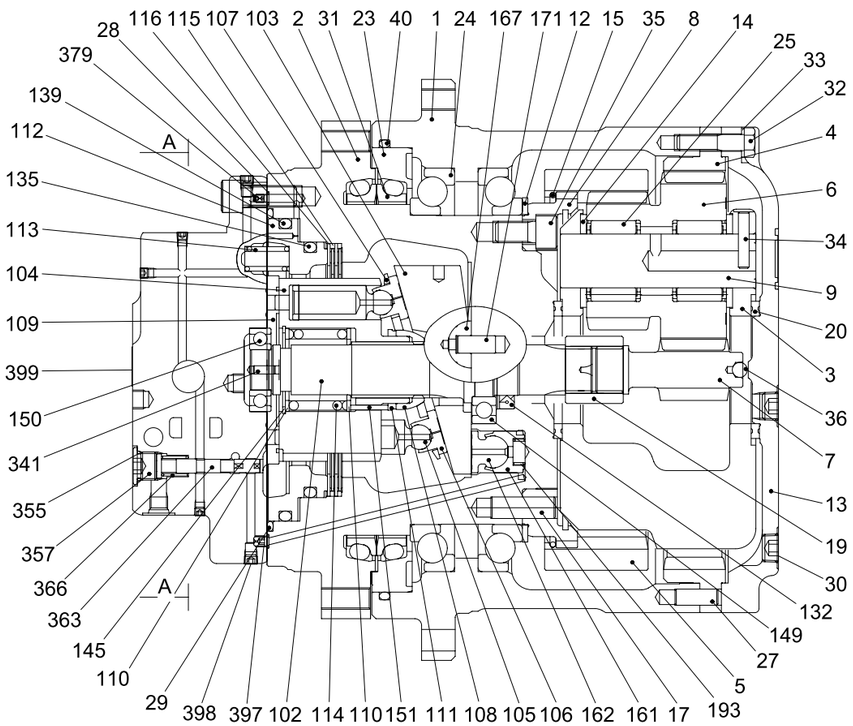


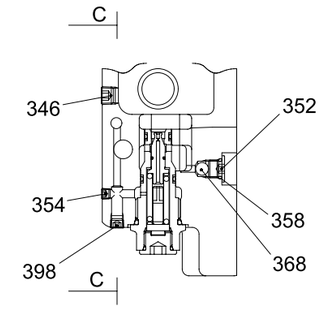


Port	Port name	Port size
A	Main port	SAE 5000psi 1"
B	Main port	SAE 5000psi 1"
P1, P2	Gauge port	PT 1/4
P3	Gauge port	PT 1/8
D1, D2	Drain port	PF 1/2
P	2 speed control port	PF 1/4

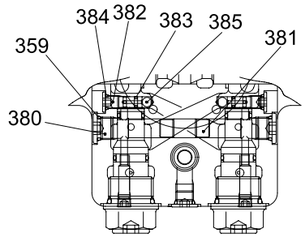
1) BASIC STRUCTURE



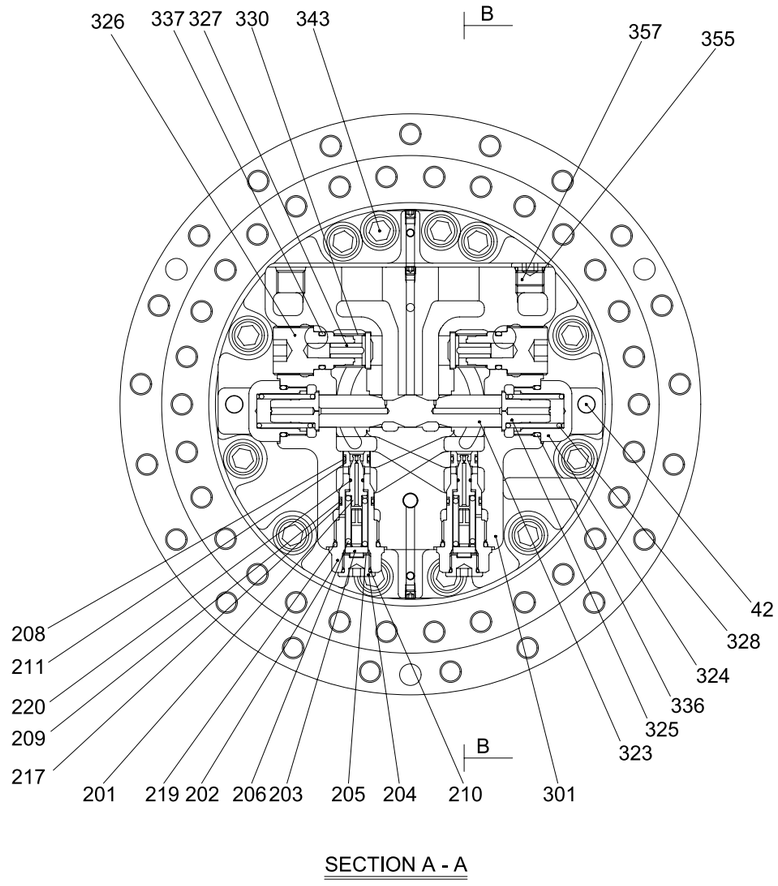




SECTION B - B



SECTION C - C



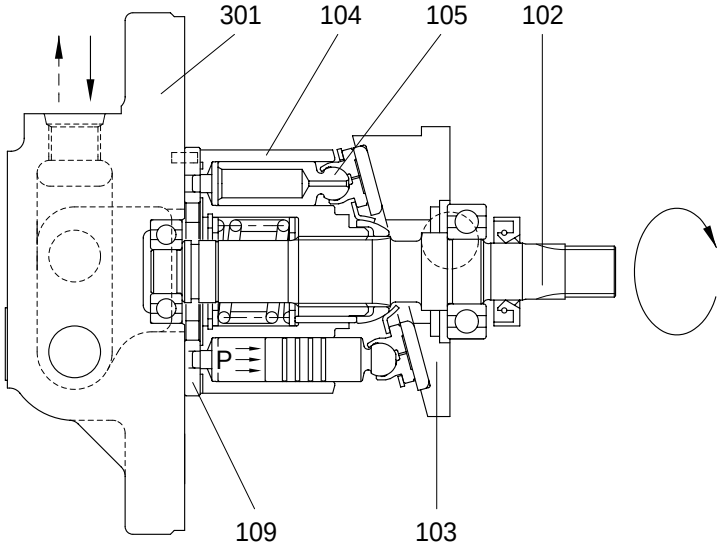
SECTION A - A

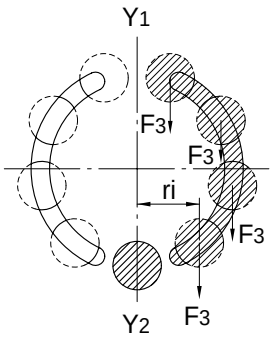
1	Hub	25	Needle bearing	106	Shoe	151	Rolling	219	O-ring	355	O-ring
2	Spindle	27	Parallel pin	107	Retainer plate	161	Piston(2)	220	Piston seal	357	RO plug
3	Carrier	28	O-ring	108	Thrust ball	162	Shoe(2)	301	Rear flange	358	O-ring
4	Ring gear A	29	O-ring	109	Timing plate	167	Pivot	323	Spool	359	O-ring
5	Ring gear B	30	PT plug	110	Washer	171	Paralell pin	324	Plug	363	Spool(2)
6	Cluster gear	31	Floating seal	111	Collar	193	Spring	325	Stopper	366	Spring
7	Sun gear	32	Socket bolt	112	Piston	201	Valve	326	Plug	368	Steel ball
8	Coupling gear	33	Spring washer	113	Spring	202	Sleeve	327	Valve	379	Filter
9	Shaft(cluster)	34	Parallel pin	114	Spring	203	Spring retainer	328	Spring	380	Plug
12	Distance piece	35	Socket bolt	115	Friction plate	204	Plug	330	Spring	381	Piston
13	Cover	36	Steel ball	116	Mating plate	205	Shim	336	O-ring	382	Plug
14	Thrust collar	40	O-ring	132	Oil seal	206	Spring	337	O-ring	383	O-ring
15	Ring	42	Parallel pin	135	O-ring	208	O-ring	341	Parallel pin	384	O-ring
17	Pin	102	Main shaft	139	O-ring	209	O-ring	343	Socket bolt	385	Steel ball
19	Coupling	103	Swash plate	145	Snap ring	210	O-ring	346	PT plug	397	Orifice
20	Thrust plate	104	Cylinder block	149	Ball bearing	211	Back-up ring	352	RO plug	398	PT plug
23	Seal ring	105	Piston	150	Ball bearing	217	Back-up ring	354	PT plug	399	Name plate
24	Ball bearing										

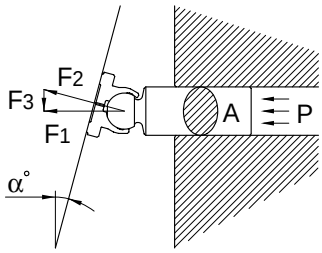
2. FUNCTION

1) HYDRAULIC MOTOR

(1) Rotary group







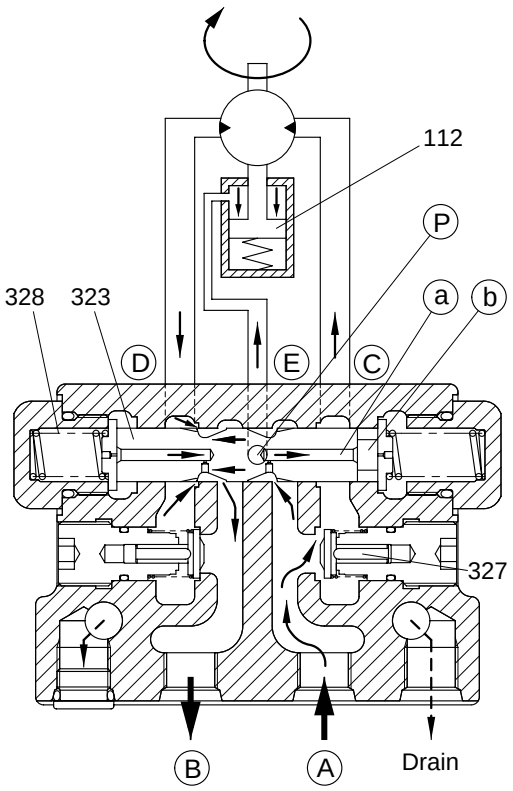
The pressurized oil delivered from the hydraulic pump flows to rear flange(301) of the motor, passes through the brake valve mechanism, and is introduced into cylinder block(104) via timing plate(109). This oil constructively introduced only to one side of Y1-Y2 connecting the upper and lower dead points of stroke of piston(105). The pressurized oil fed to one side in cylinder block(104) pushes each piston(105, four or five) and generates a force(F kg = P kg/cm^2 × A cm^2).
This force acts on swash plate(103), and is resolves into components (F2 and F3) because swash plate(103) is fixed at an angle(α) with the axis of drive shaft(102). Redial component(F3) generates respective torques(T = F3 × ri) for Y1-Y2. This residual of torque(T = F3 × ri) rotates cylinder block(104) via piston(105). Cylinder block(104) is spline-coupled with drive shaft(102). So the drive shaft(102) rotates and the torque is transmitted.

(2) Brake valve

① **Brake released**(Starting / Running)

When the pressurized oil supplied from port Ⓐ, the oil opens valve(327) and flows into port Ⓒ at the suction side of hydraulic motor to rotate motor. At the same time, the pressurized oil passes through pipe line ⓐ from a small hole in spool(323) and flows into chamber ⓑ. The oil acts on the end face of spool(323) which is put in neutral position by the force of spring(328), thus causing spool(323) to side to the left. When spool(323) slides, port Ⓓ on the passage at the return side of hydraulic motor, which is closed by the spool groove during stoppage, connected with port Ⓑ at the tank side and the return oil from the hydraulic motor runs into the tank. In consequence, the hydraulic motor rotates. Moreover, sliding of spool(323) causes the pressurized oil to flow into ports Ⓟ.

The pressurized oil admitted into port Ⓟ activates piston(112) of the parking brake to release the parking brake force. (For details, refer to description of the parking brake.) When the pressurized oil is supplied from port Ⓑ, spool(323) move reversely and the hydraulic motor also rotates reversely.



② **Brake applied**(Stopping / Stalling)

When the pressurized oil supplied from port Ⓐ is stopped during traveling, no hydraulic pressure is applied and spool(323) which has slid to the left will return on the right(Neutral) via stopper (325) by the force of spring(328).

At the same time, the hydraulic motor will rotate by the inertia even if the pressurized oil stopped, so the port D of the motor will become high pressure.

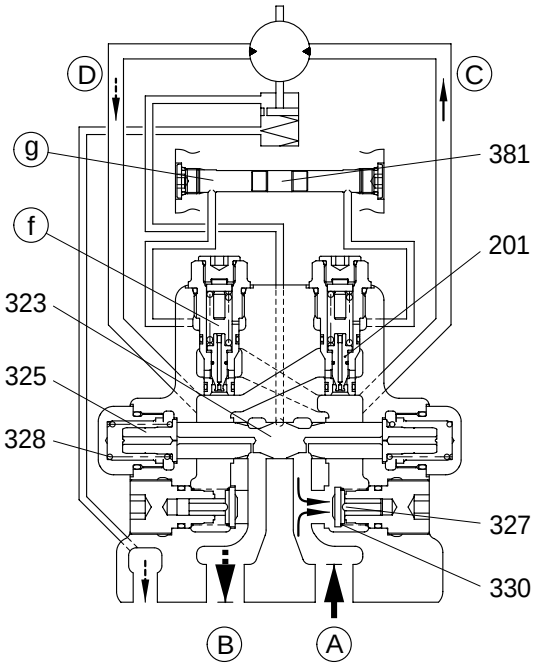
This pressurized oil goes from chamber ⓕ to chamber ⓖ through the left-hand valve(201).

When the oil enters chamber ⓖ, the piston(381) slids to the right so as not to rise the pressure, as shown in the figure. Meanwhile, the left-hand valve(201) is pushed open by the pressurized oil in port D.

Therefore, the pressurized oil in port D flows to port C at a relatively low pressure, controlling the pressure in port D and preventing cavitation in port C.

When the piston(381) reaches the stroke end, the pressure in chamber ⓖ and ⓕ increase and the left-hand valve(201) closes again, allowing the oil pressure in port D to increase further. Then, the right-hand valve(201) opens port C with pressure higher than that machine relief set pressure.

In this way, by controlling the pressure in port D in two steps, the hydraulic motor is smoothly braked and brought to a stop.



③ Braking effect on downhill travel

If the machine traveling downhill with a relatively small supply of high pressure oil to its travel motors should start coasting, the same braking effect as the one described above would automatically occur.

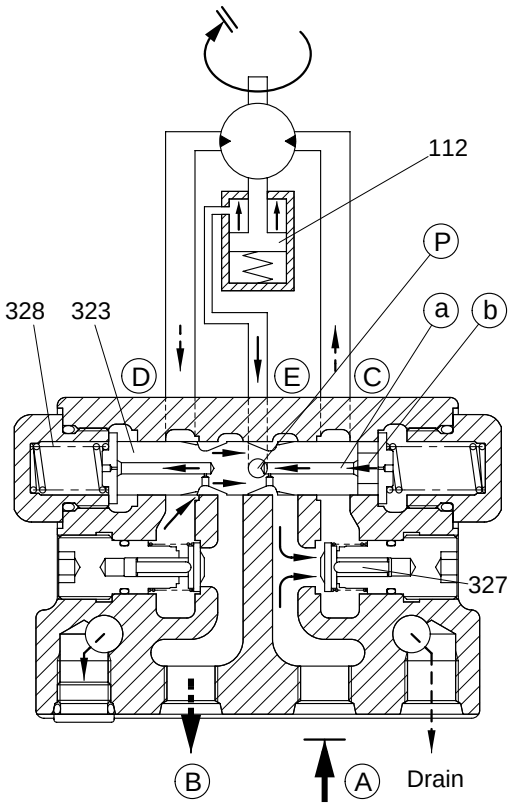
In the coasting condition, the motor is driven, instead of driving the track, from the ground and sucks high pressure oil in.

In other words, the motor tends to draw more high pressure oil than is being supplied.

Under this condition, port A goes negative to pull oil out of chamber ⓑ through oil way ⓐ, moving back the spool(323) rather rapidly.

The clearance on the left then becomes smaller to throttle the outgoing oil more than before, thereby obstructing the pumping action of the motor.

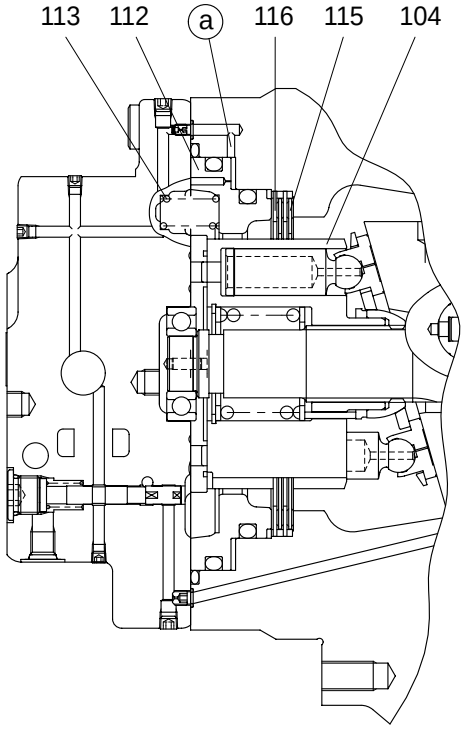
As in stopping the machine, pressure will build up in port D to make it harder to drive the motor from the ground: This is the braking action.



(3) Parking brake

① Running

When the pressurized oil is supplied from the brake valve, the spool of brake valve in the hydraulic motor assembly actuates to open the passage to the parking brake and the pressurized oil is introduced into cylinder chamber ⓐ which is composed of the spindle of reduction gear assembly and piston(112). When the hydraulic pressure reaches 6kgf/cm²(0.59Mpa) or more, it overcomes the force of spring (113) and shifts piston(112). With shift of piston(112), no pressing force is applied to mating plate(116) and friction plate (115) and the movement of friction plate (115) becomes free, whereby the brake force to the cylinder in the hydraulic motor assembly is released.



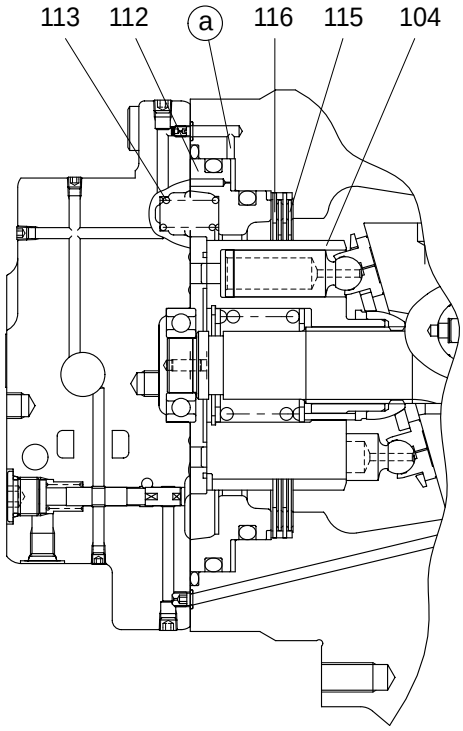
② Stopping

When the pressurized oil from the brake valve is shut off and the pressure in cylinder chamber ⓐ drops 6kgf/cm² (0.59Mpa) or less, piston(112) will return by the force of spring(113).

Piston(112) is pushed by this force of spring(113), and mating plate(116) and friction plate(115) in free condition are pressed against the spindle of reduction gear assembly.

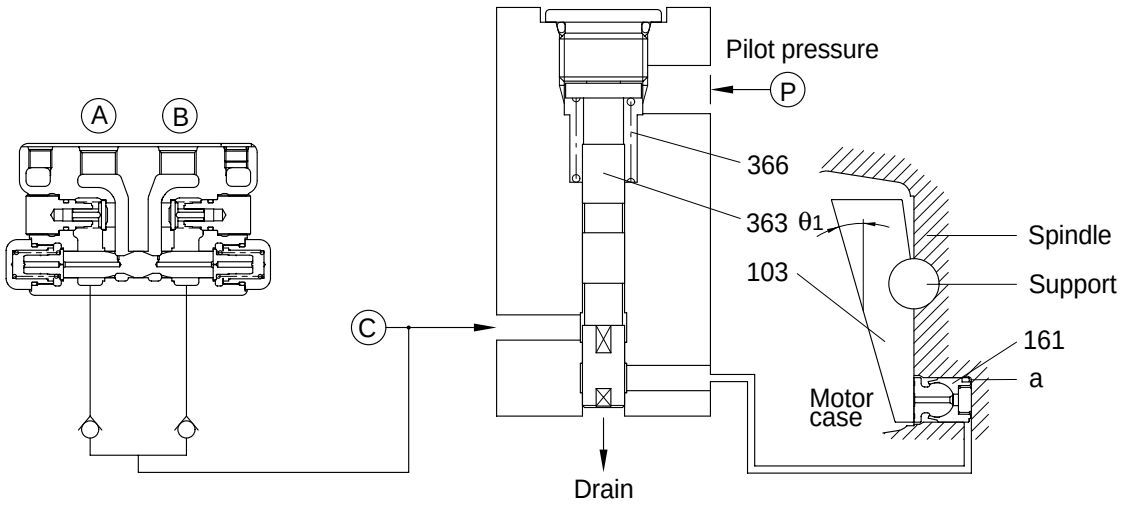
The friction force produced by this pressing stops rotation of the cylinder block(104) and gives a braking torque 40.6kgf · m(398N · m) to the hydraulic motor shaft.

Note that oil control through a proper oil passage ensures smooth operation.



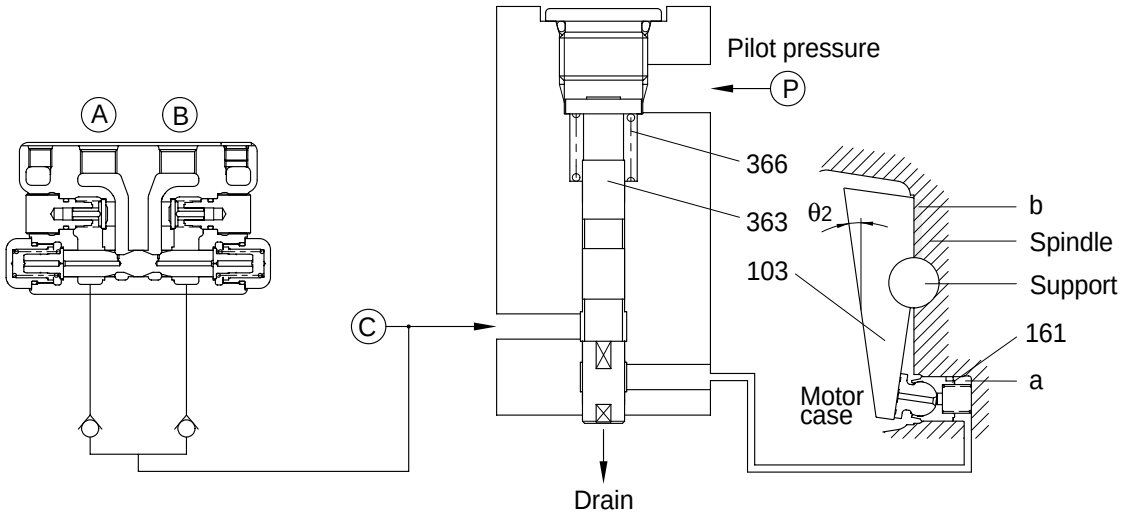
(4) High/low speed changeover mechanism

① **At low speed** - At pilot pressure of less than 20kgf/cm²(1.96Mpa)



When the pilot pressure is shut off from port Ⓟ, valve(363) is pressed upward by the force of spring(366), the pressurized oil supply port Ⓒ is shut off, and oil in chamber ⓐ is released into the motor case through the valve(363). Consequently, swash plate(103) is tilted at a maximum angle(θ_1) and the piston displacement of hydraulic motor becomes maximum, thus leading to low-speed operation.

② **At high speed** - At pilot pressure of 20kgf/cm²(1.96Mpa) or more



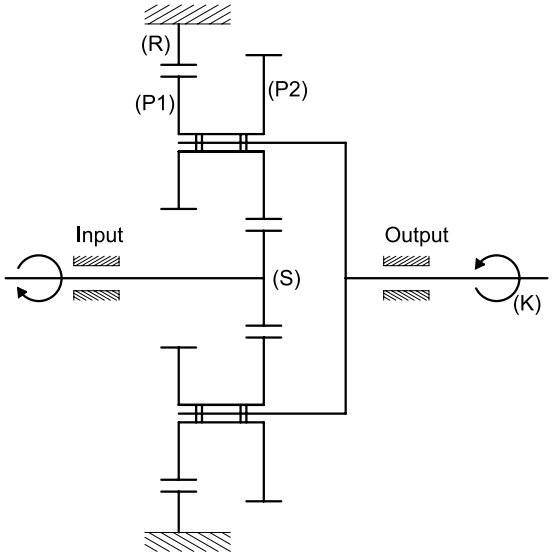
When a pilot pressure supplied from port Ⓟ(At a pressure of 20kgf/cm²(1.96Mpa) or more), the pressure overcomes the force of spring(366) and valve(363) is pressed downward. The pressurized oil supply port Ⓒ is then introduced into chamber ⓐ through the valve(363). Piston (161) pushes up swash plate(103) until it touches side ⓑ of the spindle. At this time, swash plate(103) is tilted at a minimum angle(θ_2) and the piston displacement of hydraulic motor becomes minimum, thus leading to high-speed operation.

2) REDUCTION GEAR

(1) Function

The reduction gear unit consists of a combination of simple planetary gear mechanism and differential gear mechanism. This mechanism reduce the high speed rotation from the hydraulic motor and convert it into low speed, high torque to rotate the hub(or case), which in turn rotates the sprocket.

Planetary gear mechanism



(2) Operating principle

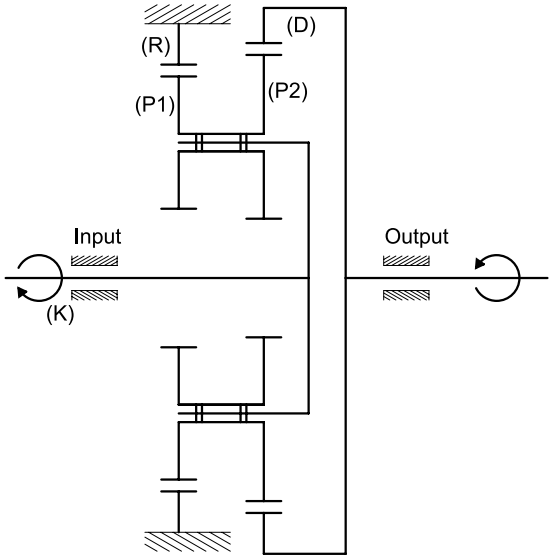
① Upon rotation of the sun gear (S) via the input shaft, the planetary gear (P) engages with the fixed ring gear (R) while rotating on its axis.
Rotation around the fixed ring gear (R) is transmitted to the carrier (K).

$$i1 = 1 + \frac{R \cdot P2}{S \cdot P1}$$

② With rotation of the carrier (K), the planetary gears (P1) and (P2) rotate around the fixed ring gear(R).
When a proper difference in number of teeth is given between (P1) and (R) and between (P1) and (P2), a difference in rotation is produced on the gear (D) because the gears (P1) and (P2) are on the same axis.

$$i2 = \frac{1}{1 - \frac{R \cdot P2}{D \cdot P1}}$$

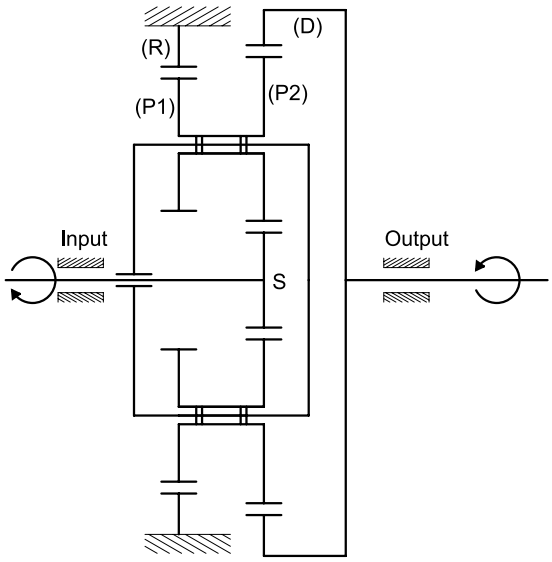
Differential gear mechanism



③ Upon rotation of the sun gear (S) via the input shaft, planetary motion is given among the gears (S), (P1) and (R) and rotation of the gear (P1) around another gear causes the carrier (K) to rotate.
This carrier rotation gives differential motion among the gears (R), (P1), (P2) and (D) to rotate the ring gear (D). The motor then rotates since the ring gear (D) is connected to the hub (case) of the motor.

$$i = i1 \times i2 = \frac{1 + \frac{R \cdot P2}{S \cdot P1}}{1 - \frac{R \cdot P2}{D \cdot P1}}$$

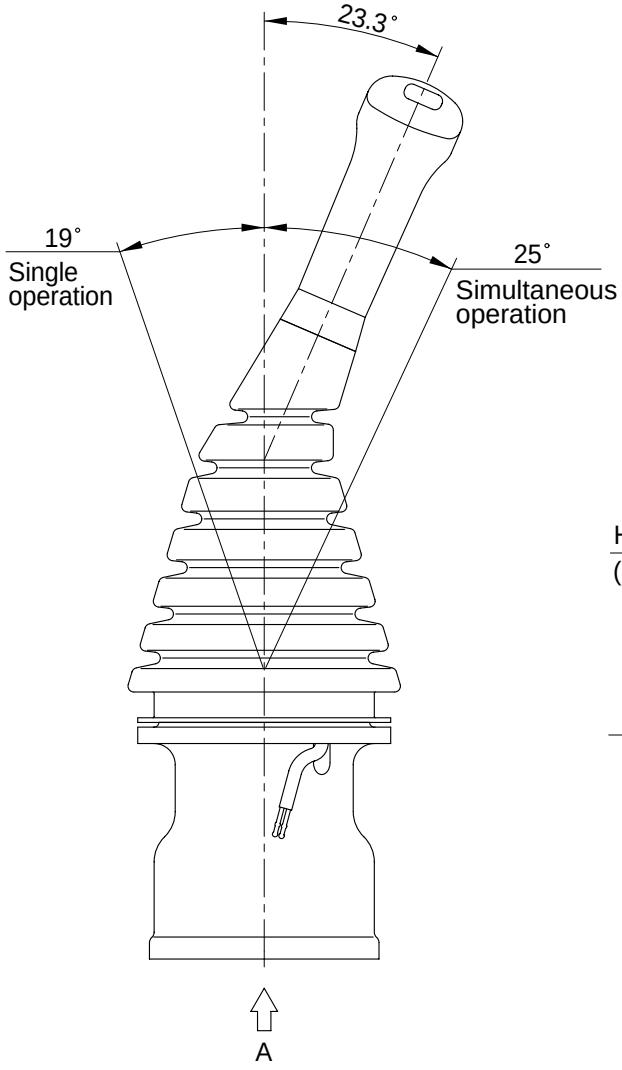
Combination of planetary gear mechanism and differential gear mechanism

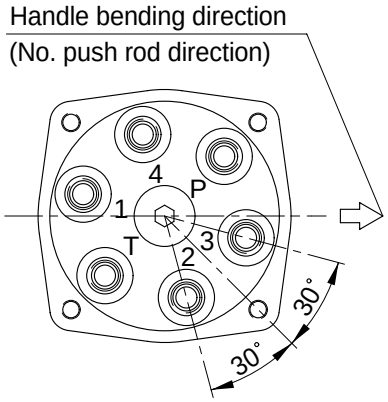


GROUP 5 RCV LEVER

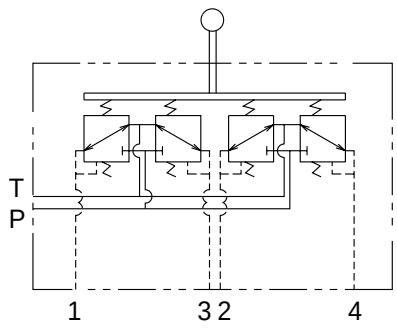
1. STRUCTURE

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.





VIEW A



Hydraulic circuit

Port	LH	RH	Port size
P	Pilot oil inlet port	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	Pilot oil return port	
1	Left swing port	Bucket out port	
2	Arm in port	Boom down port	
3	Right swing port	Bucket in port	
4	Arm out port	Boom up port	

CROSS SECTION

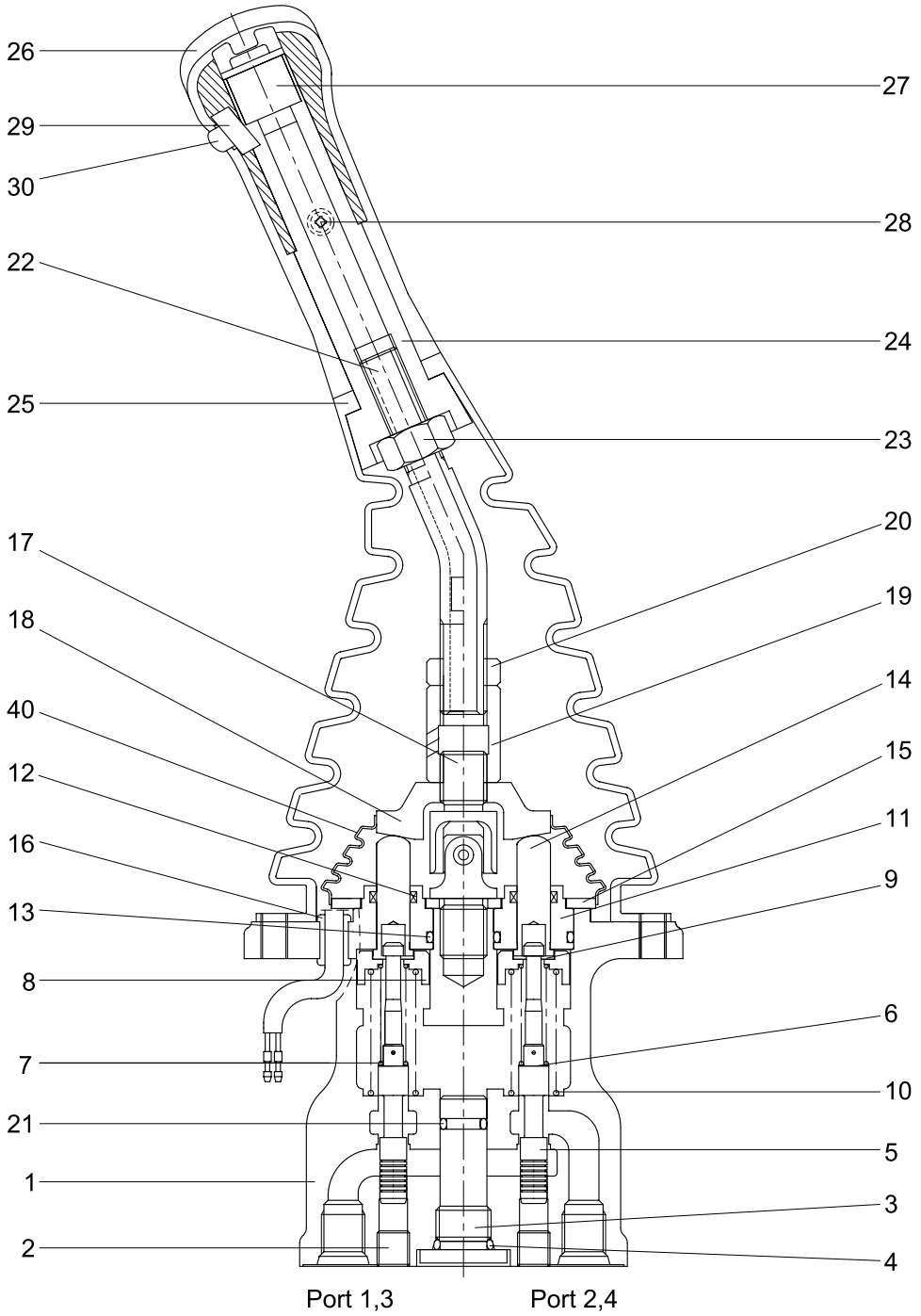
The construction of the pilot valve is shown in the attached cross section drawing. The casing has vertical holes in which reducing valves are assembled.

The pressure reducing section is composed of the spool(5), spring(7) for setting secondary pressure, return spring(10), stopper(9), spring seat(8) and shim(6). The spring for setting the secondary pressure has been generally so preset that the secondary pressure is 5 to 20.5kgf/cm^2(Depending on the type). The spool is pushed against the push rod(14) 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.

1	Case	11	Plug	21	O-ring
2	Plug	12	Rod seal	22	Handle connector
3	Plug	13	O-ring	23	Nut
4	O-ring	14	Push rod	24	Insert
5	Spool	15	Plate	25	Boot
6	Shim	16	Bushing	26	Handle
7	Spring	17	Joint assembly	27	Switch assembly
8	Spring seat	18	Swash plate	28	Screw
9	Stopper	19	Adjusting nut	29	Switch assembly
10	Spring	20	Lock nut	30	Switch cover
				40	Boot

CROSS SECTION



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

The functions of the spool(5) 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(7) works on this spool to determine the output pressure.

The change the deflection of this spring, the push rod(14) is inserted and can slide in the plug(11).

For the purpose of changing the displacement of the push rod through the switch plate(19) and adjusting nut(20) are provided the handle(27) that can be tilted in any direction around the fulcrum of the universal joint(18) center.

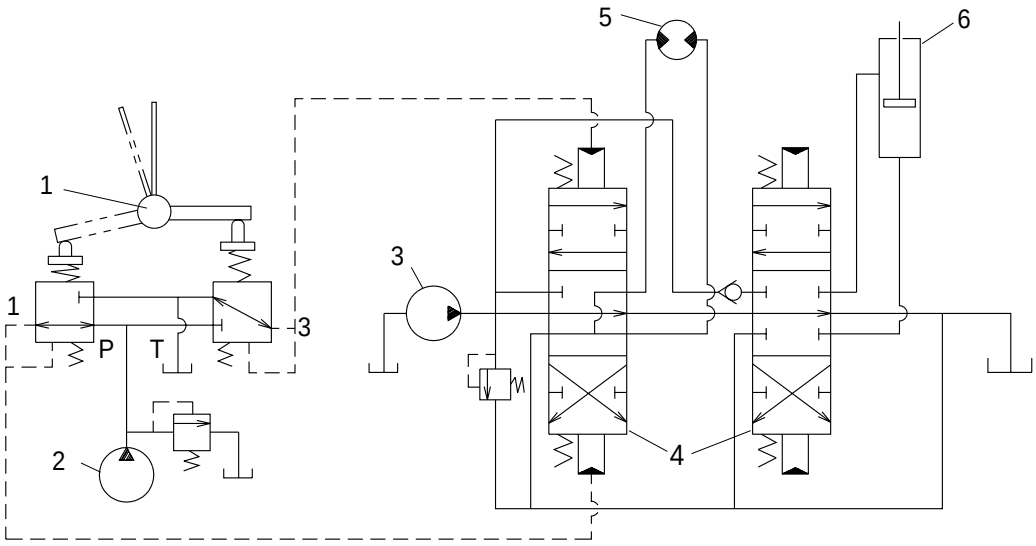
The spring(10) works on the case(1) and spring seat(8) and tries to return the push rod(14) to the zero-displacement position irrespective of the output pressure, securing its resetting to the center position.

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

3) OPERATION

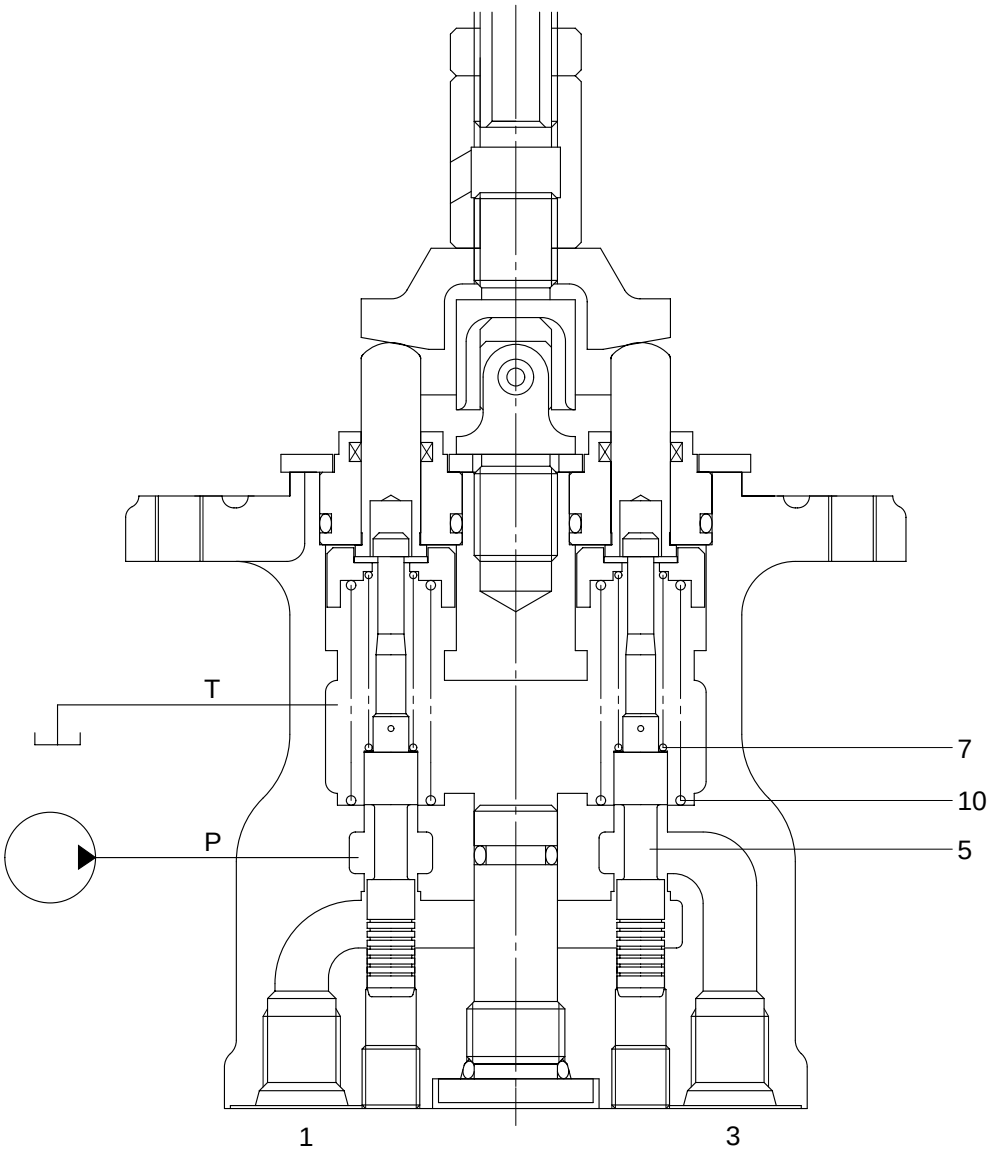
The operation of the pilot valve will be described on the basis of the hydraulic circuit diagram shown below and the attached operation explanation drawing.

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



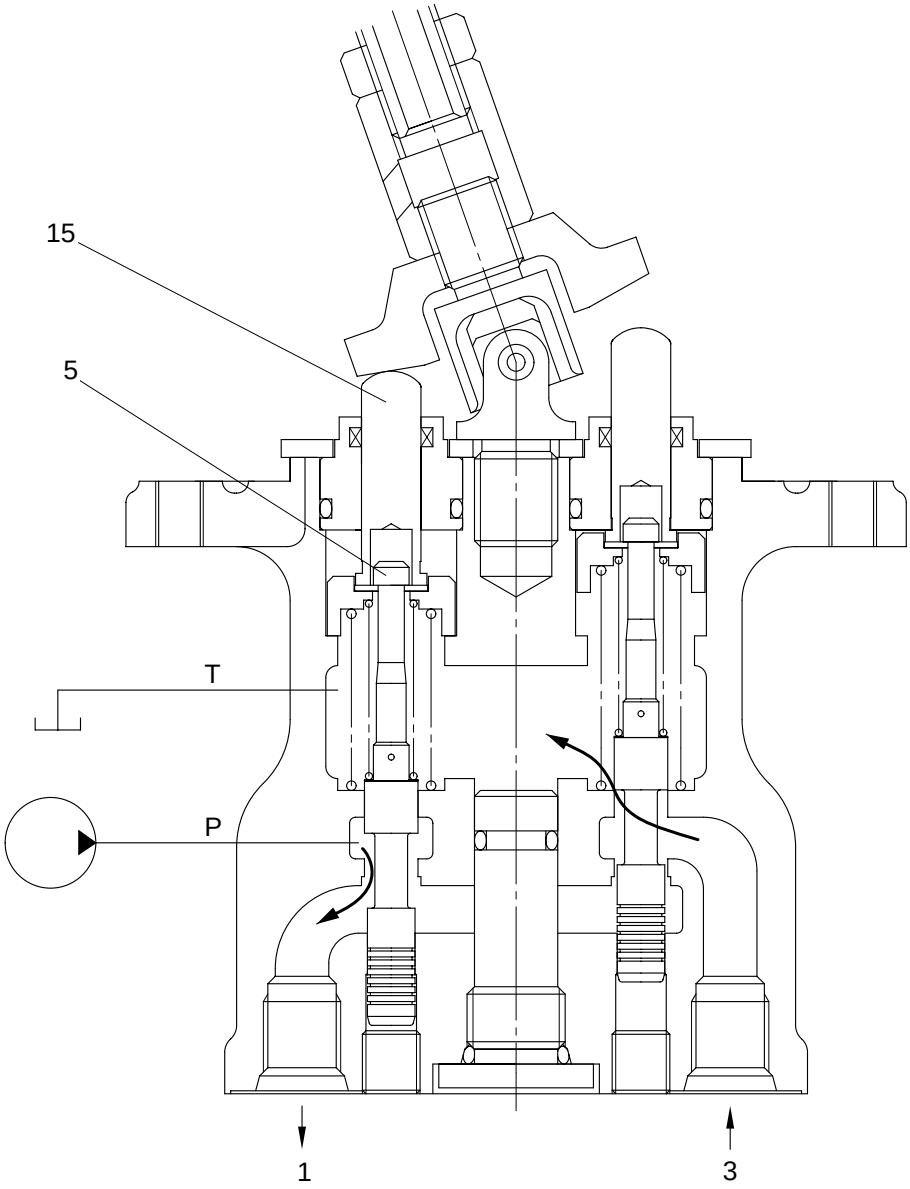
1	Pilot valve	3	Main pump	5	Hydraulic motor
2	Pilot pump	4	Main control valve	6	Hydraulic cylinder

(1) Case where handle is in neutral position



The force of the spring(7) that determines the output pressure of the pilot valve is not applied to the spool(5). Therefore, the spool is pushed up by the spring(10) 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

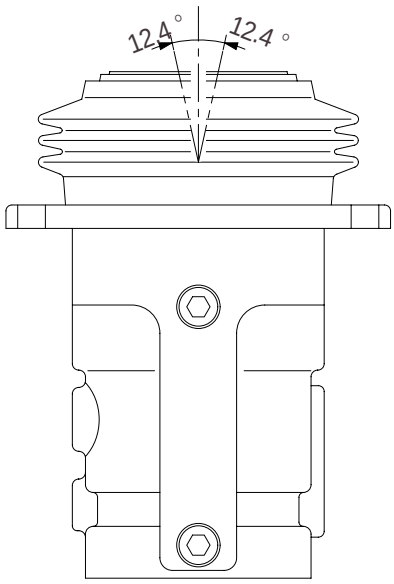


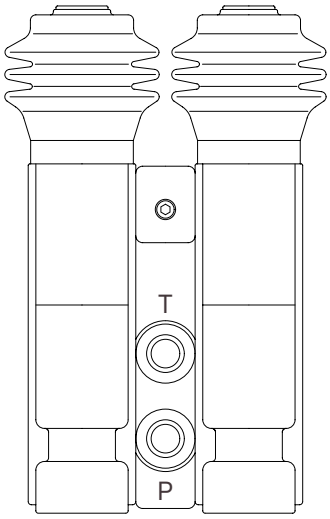
When the push rod(14) is stroked, the spool(5) moves downwards.
Then port P is connected with port(1) and the oil supplied from the pilot pump flows through port(1) to generate the pressure.
When the pressure at port(1) increases to the value corresponding to the spring force set by tilting the handle, 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.

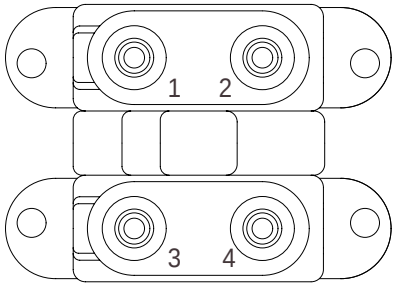
GROUP 6 RCV PEDAL

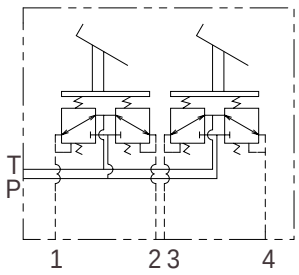
1. STRUCTURE

The casing(Spacer) 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.









Hydraulic circuit

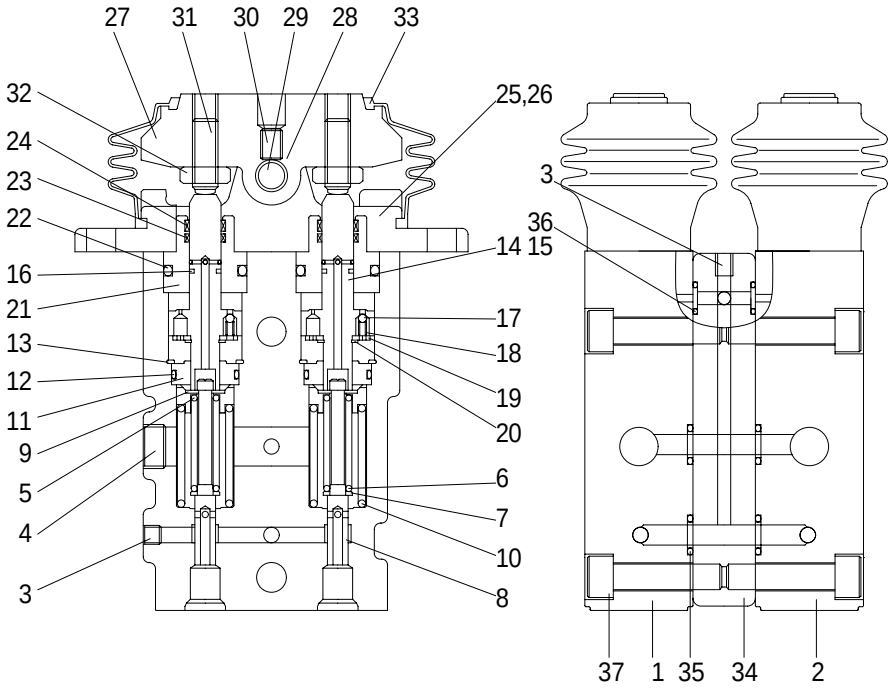
Port	Port	Port size
P	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	
1	Travel(LH, Forward)	
2	Travel(LH, Backward)	
3	Travel(RH, Forward)	
4	Travel(RH, Backward)	

CROSS SECTION

The construction of the RCV pedal is shown in the below drawing. The casing has vertical holes in which reducing valves are assembled.

The pressure reducing section is composed of the spool(8), spring(6) for setting secondary pressure, return spring(10), stopper(9), and spring seat(7). The spring for setting the secondary pressure has been generally so preset that the secondary pressure is 5 to 19 kgf/cm^2 (depending on the type). The spool is pushed against the push rod(14) by the return spring.

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



1	Body(1)	13	Snap ring	25	Cover
2	Body(2)	14	Push rod	26	Bolt
3	Plug	15	Spring pin	27	Cam
4	Plug	16	Seal	28	Bushing
5	Spring seat	17	Steel ball	29	Cam shaft
6	Spring	18	Spring	30	Set screw
7	Spring seat	19	Plate	31	Set screw
8	Spool	20	Snap ring	32	Nut
9	Stopper	21	Plug	33	Bellows
10	Spring	22	O-ring	34	Space
11	Rod guide	23	Rod seal	35	O-ring
12	O-ring	24	Dust seal	36	O-ring
				37	Bolt

2. FUNCTION

1) FUNDAMENTAL FUNCTIONS

The pilot valve is a valve 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 port(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 tank port.

(5) Mechanical means to control output pressure, including springs that work on the above spools.

2) FUNCTIONS OF MAJOR SECTIONS

The functions of the spool(8) 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 spool to determine the output pressure.

The spring(6) works on this spool to determine the output pressure.

The change the deflection of this spring, the push rod(14) is inserted and can slide in the plug(21).

For the purpose of changing th displacement of the push rod through the cam(27) and adjusting nut(32) are provided the pedal that can be tilted in any direction around the fulcrum of the cam(27) center.

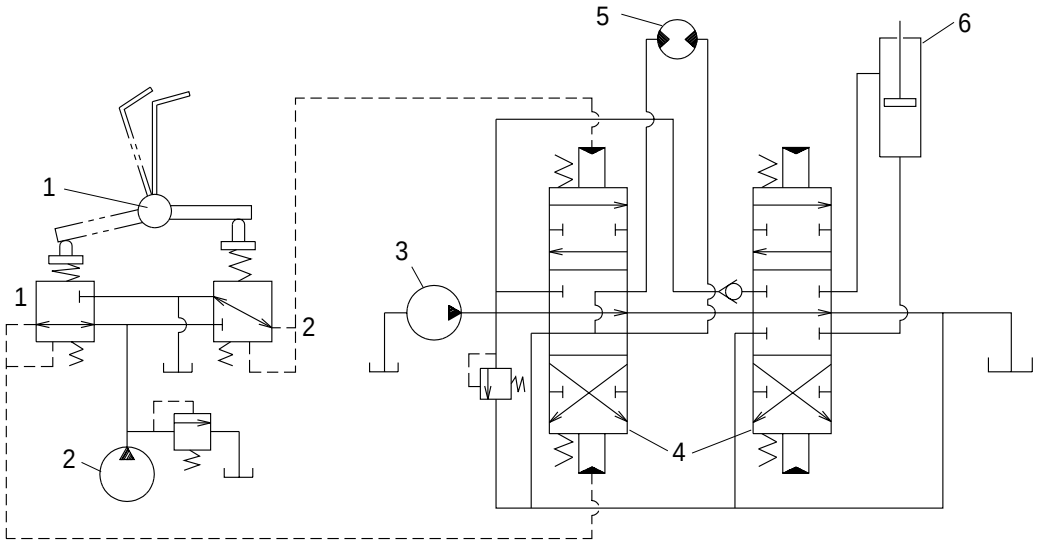
The spring(10) works on the casing(1) and spring seat(7) and tries to return the push rod(14) to the zero-displacement position irrespective of the output pressure, securing its resetting to the center position.

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

3) OPERATION

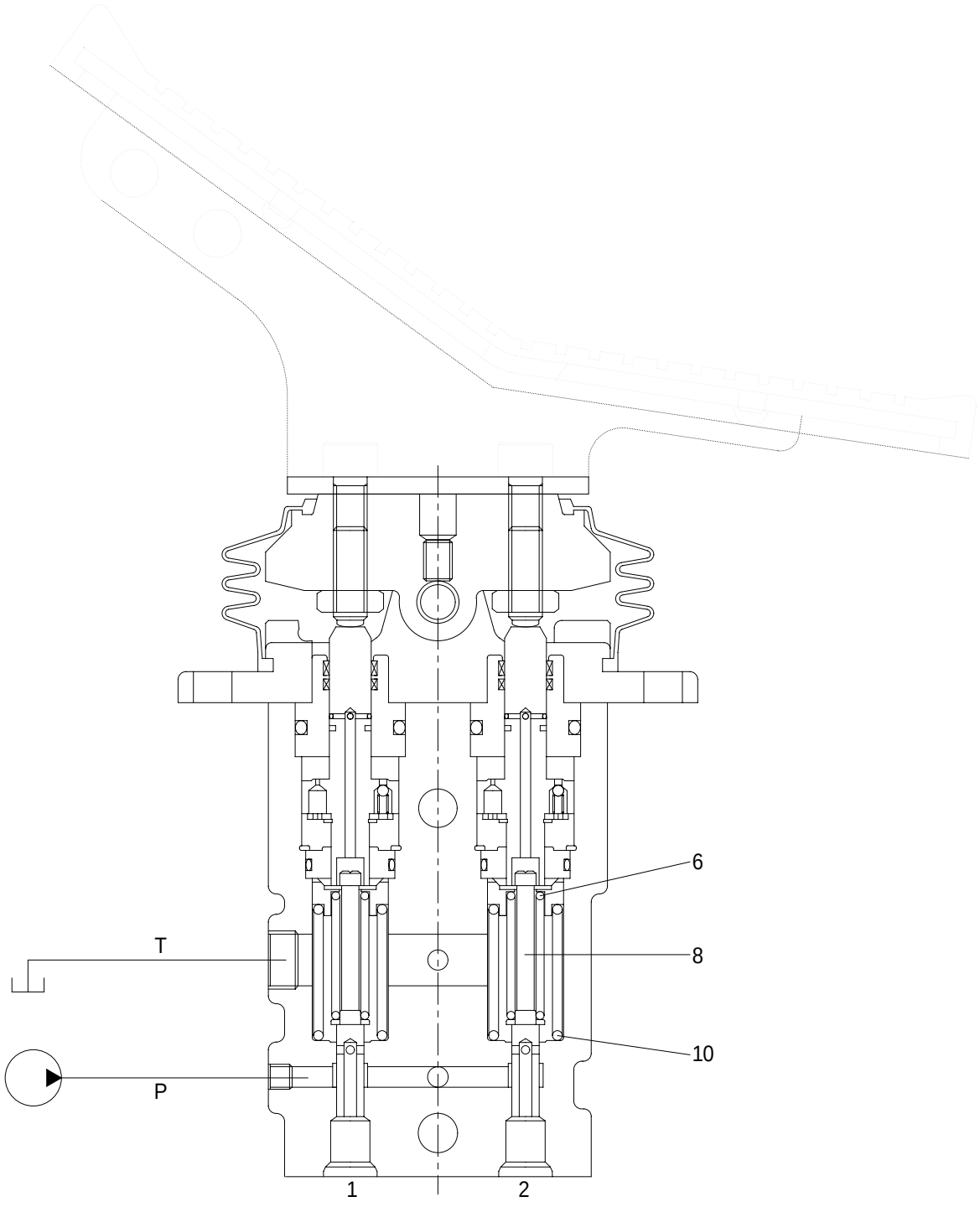
The operation of the pilot valve will be described on the basis of the hydraulic circuit diagram shown below ant the attached operation explanation drawing.

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



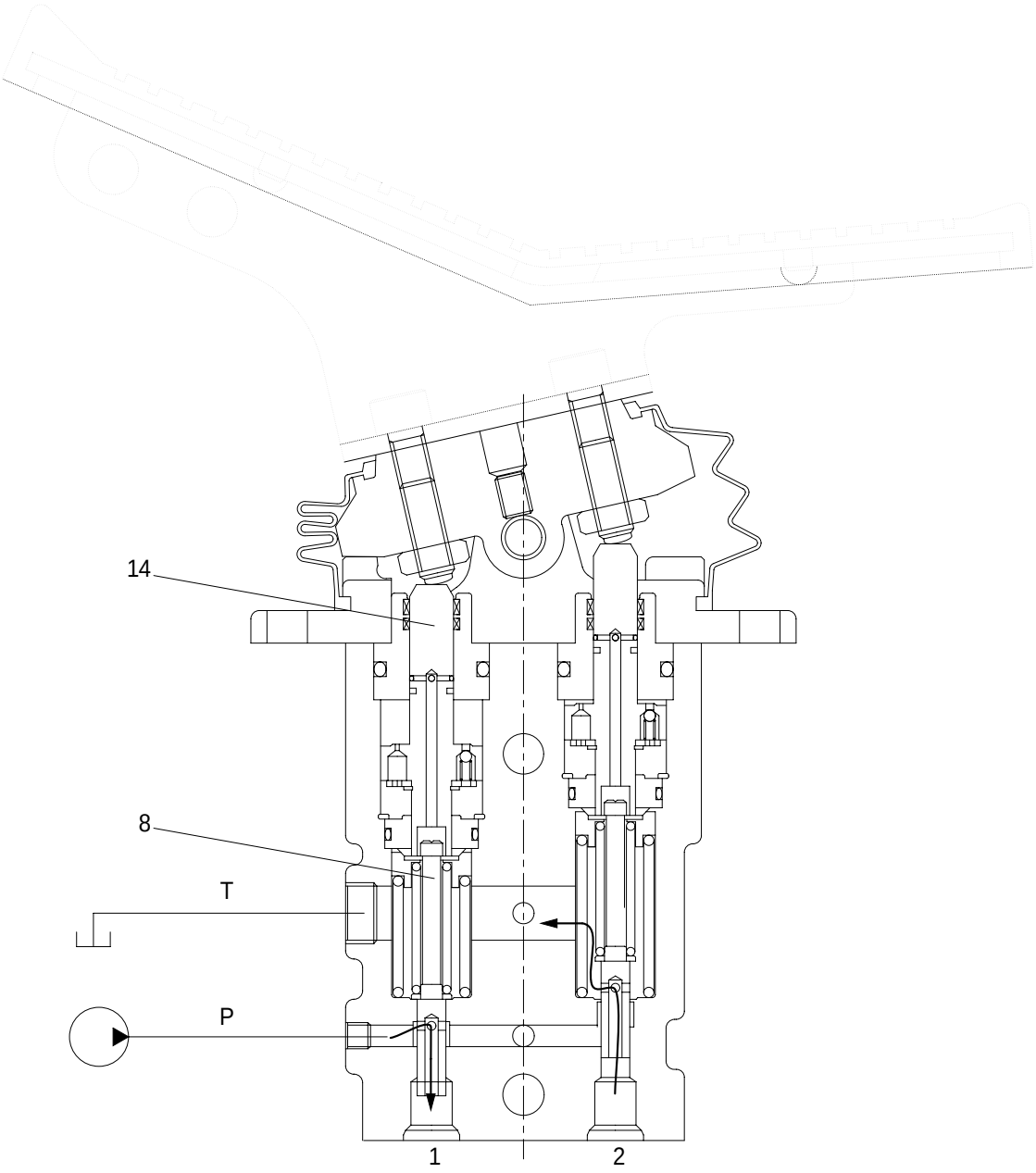
1	Pilot valve	3	Main pump	5	Hydraulic motor
2	Pilot pump	4	Main control valve	6	Hydraulic cylinder

(1) Case where pedal is in neutral position



The force of the spring(6) that determines the output pressure of the pilot valve is not applied to the spool(8). Therefore, the spool is pushed up by the spring(10) to the position of port 2 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 pedal is tilted



When the push rod(14) is stroked, the spool(8) 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 inside bottom of the push rod and the output pressure is left to be connected with port P.