SECTION 2 STRUCTURE AND FUNCTION

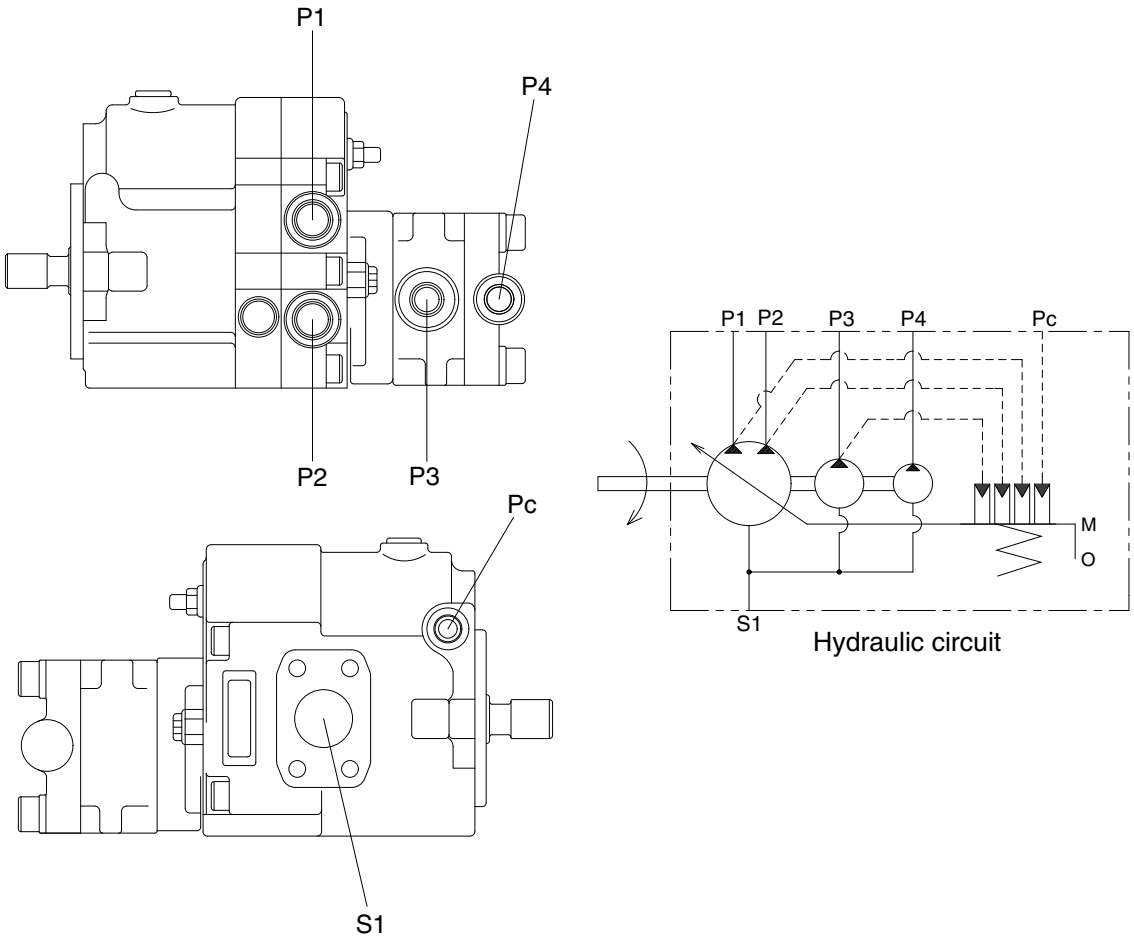
GROUP 1 HYDRAULIC PUMP

1. GENERAL

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

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

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



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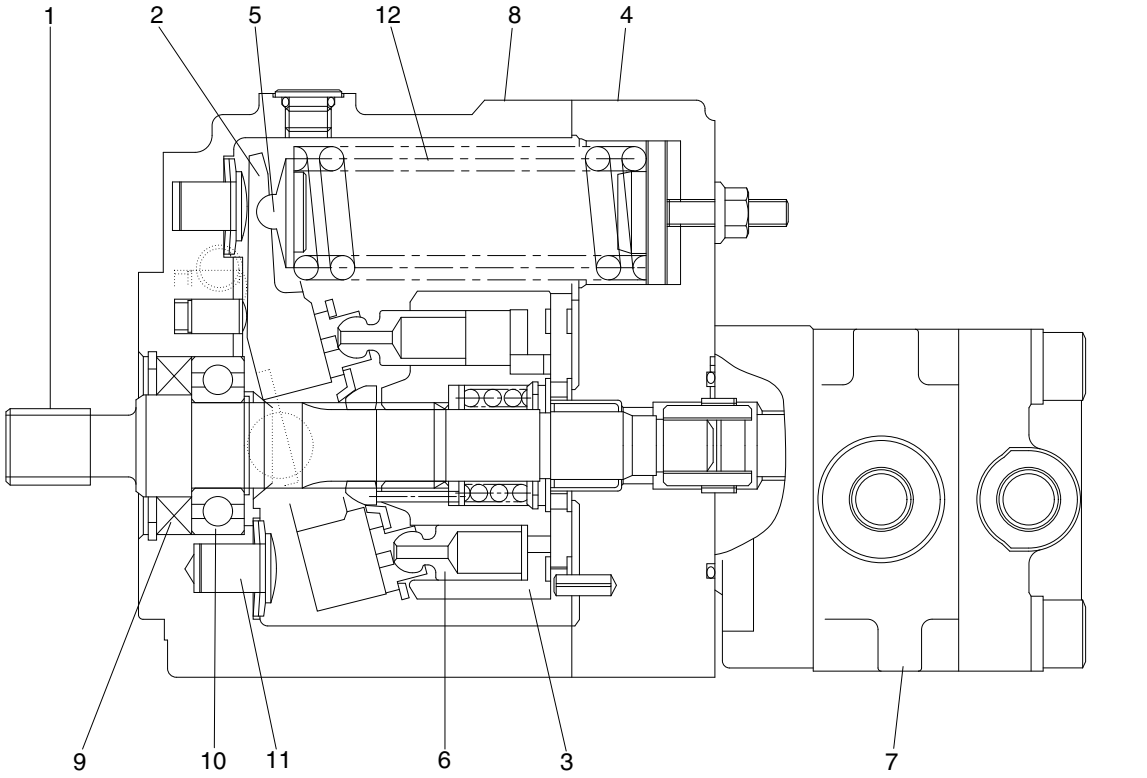
Description of the ports

Port	Port name	Port size
S1	Suction port	SAE 1 1/4
P1, P2, P3	Discharge port	PF 1/2
P4	Discharge port	PF 3/8
Pc	Pilot port	PF 1/4

2. MAJOR COMPONENTS AND FUNCTIONS



1	Drive shaft assembly	7	Gear pump
2	Swash plate assembly	8	Housing
3	Cylinder barrel	9	Oil seal
4	Port plate assembly	10	Bearing
5	Spring seat assembly	11	Stopper assembly
6	Piston	12	Spring

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

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

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

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

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

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

1) PRINCIPLE OF OPERATION

(1) Function of pump

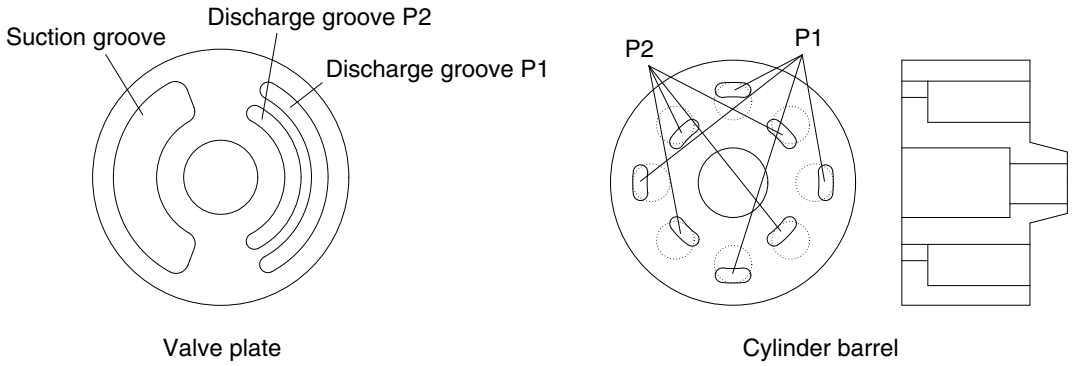


Figure 1 Working principle of PVD pump

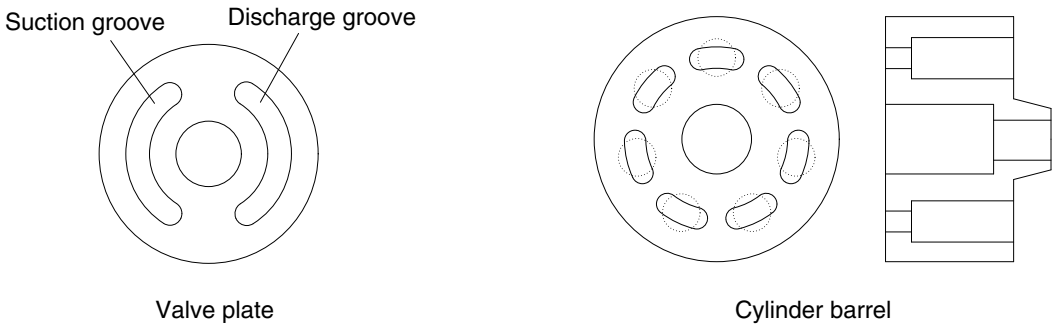


Figure 2 Working principle of Conventional type

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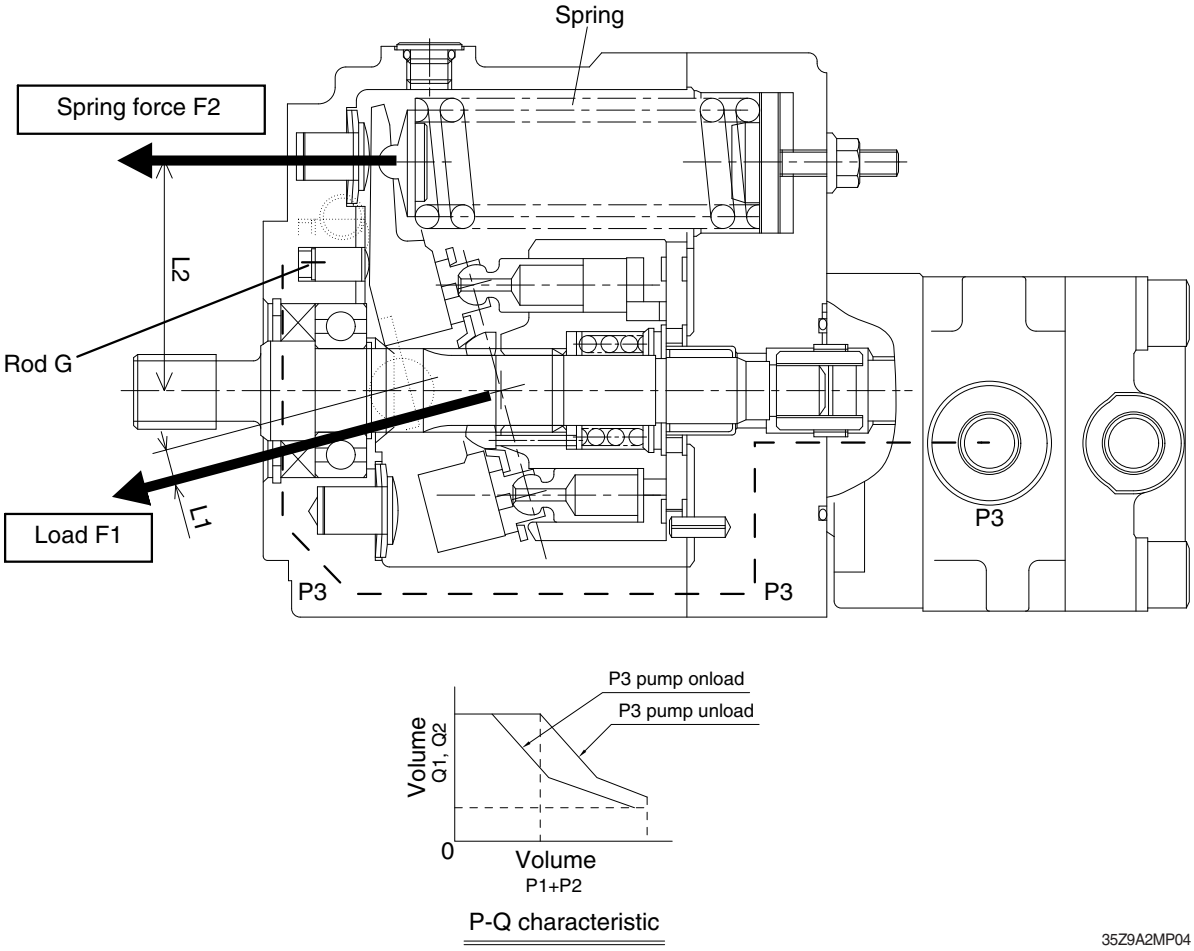
This pump adopts a new method using even numbered pistons to make functions of two same volume pumps available in one casing of a swash plate type variable volume piston pump.

Conventional valve plate has one suction groove and one discharge groove respectively as shown in figure 2. But this method adopts one common suction groove and two discharge grooves on the outer side (P1) and the inner side (P2) as shown in figure 1, the piston room in the cylinder barrel opens to either the outer side (P1) or the inner side (P2) discharge groove of the valve plate alternately, and the discharges are performed independently on the inner side and the outer side.

Since this model has even numbered pistons, same No of pistons open to the outer side and the inner side of the valve plate. All pistons are of same swash plate, so the discharges from the outer side (P1) and the inner side (P2) are equal.

Also, since only one swash plate is used, the discharges from P1 and P2 ports changes equally when the swash plate angle of rake changes in variable controls. So, there is no difference between the two discharges.

2) CONTROL FUNCTIONS



(1) Constant horse power variable structure

The pump output flow rate is variable depending on an angle of the swash plate which is controlled according to the pump output pressure. This control enables the pump consumption horse power to be sustained at the maximum. The tilt point of the swash plate is the balls located behind the swash plate. The load F1 from the pistons is in the direction shown in the illustration and generates a clockwise moment against the swash plate. Against this force the spring (force F2) is located in the opposite direction to keep the horse power constant and set at the appointed load. As the pressure increases, the above clockwise moment increases, and when it overcomes the counter-clockwise moment created by the spring force, the spring is sagged and the swash plate angle gets smaller. Then the output flow rate is reduced to keep the horse power constant.
This prevents engine stall and the engine horse power can be utilized at the maximum.

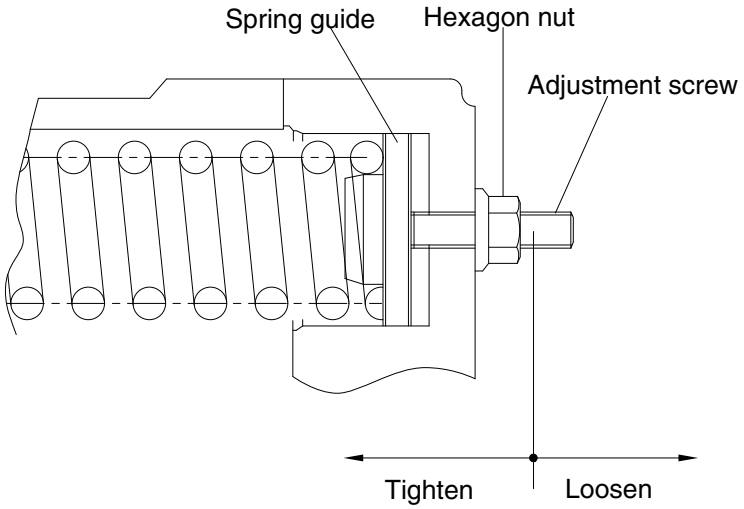
(2) Power shift mode (Reduced horse power control by P3 pressure)

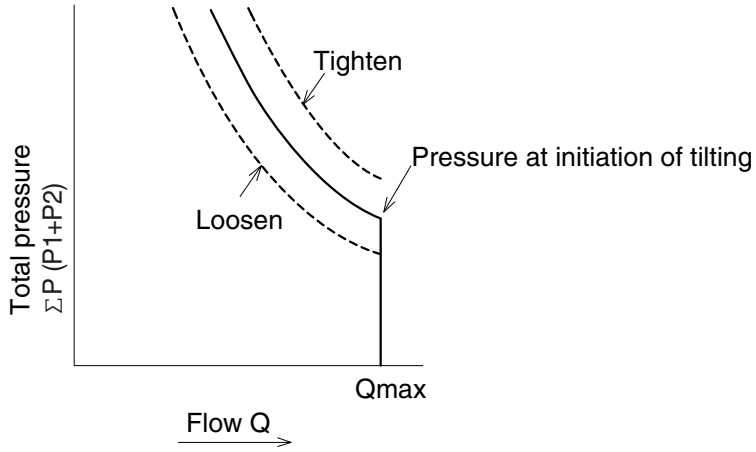
This control keeps the maximum value of the pump consumption horse power including the third pump (gear pump) constant. When the P3 (gear pump) pressure acts on the rod G, a clockwise moment proportion to the pressure acts on the swash plate and the P-Q characteristic shifts so that the total pump consumption horse power including the gear pump horse power is kept constant.

3) CONTROL / ADJUSTMENT PROCEDURE

(1) Loosen the hexagonal nut.

(2) Tighten or loosen the adjusting screw to set the power shifting line.





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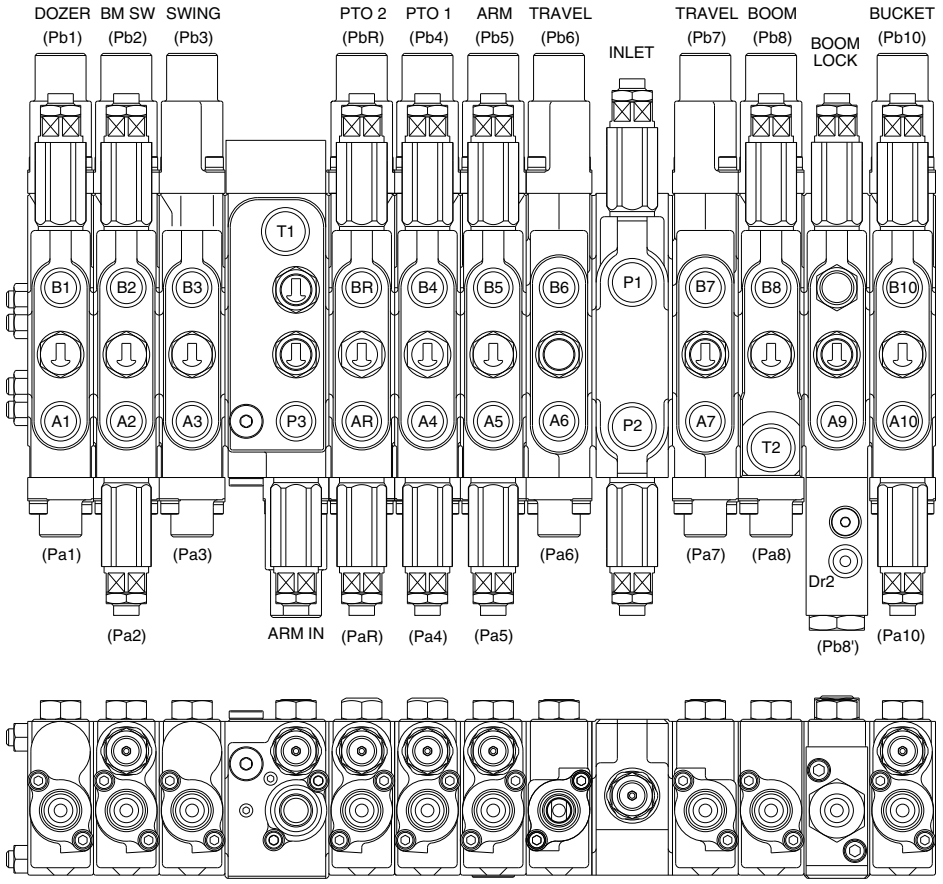
GROUP 2 MAIN CONTROL VALVE

1. OUTLINE



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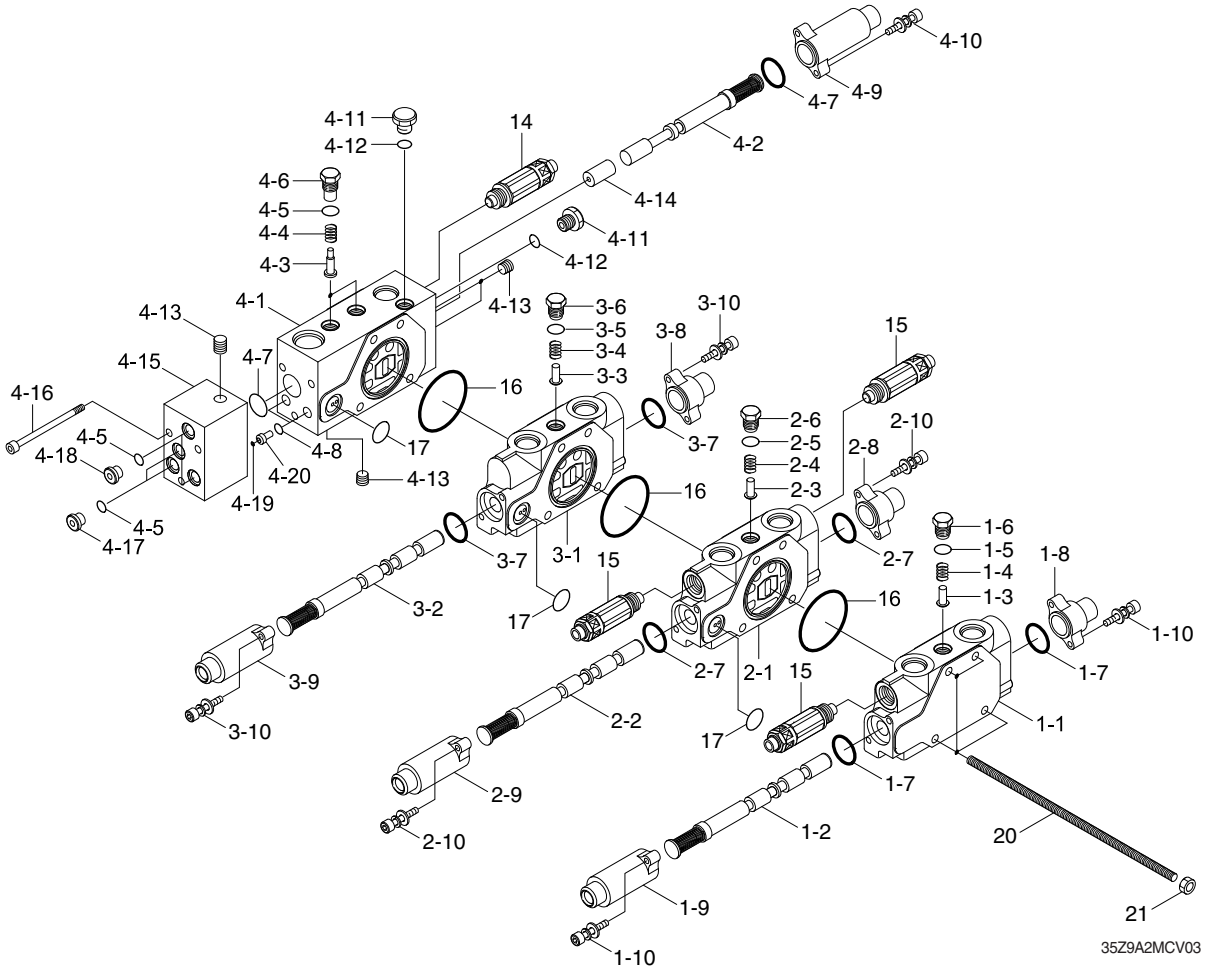
Mark	Port name	Port size	Tightening torque
P1	P1 pump port	PF 1/2	6.0~7.0 kgf · m (43.4~50.6 lbf · ft)
P2	P2 pump port		
T1	Tank return port		
T2	Tank return port		
P3	P3 pump port	PF 3/8	4.0~5.0 kgf · m (28.9~36.2 lbf · ft)
A1	Dozer		
B1	Dozer		
A2	Boom swing (RH) port		
B2	Boom swing (LH) port		
A3	Swing (LH) port		
B3	Swing (RH) port		
AR/A4	Option port		
BR/B4	Option port		
A5	Arm out port		
B5	Arm in port		
A6	Travel [LH/RR] port		
B6	Travel [LH/FW] port		
A7	Travel [RH/RR] port		
B7	Travel [RH/FW] port		
A9	Boom up port		
B8	Boom down port		

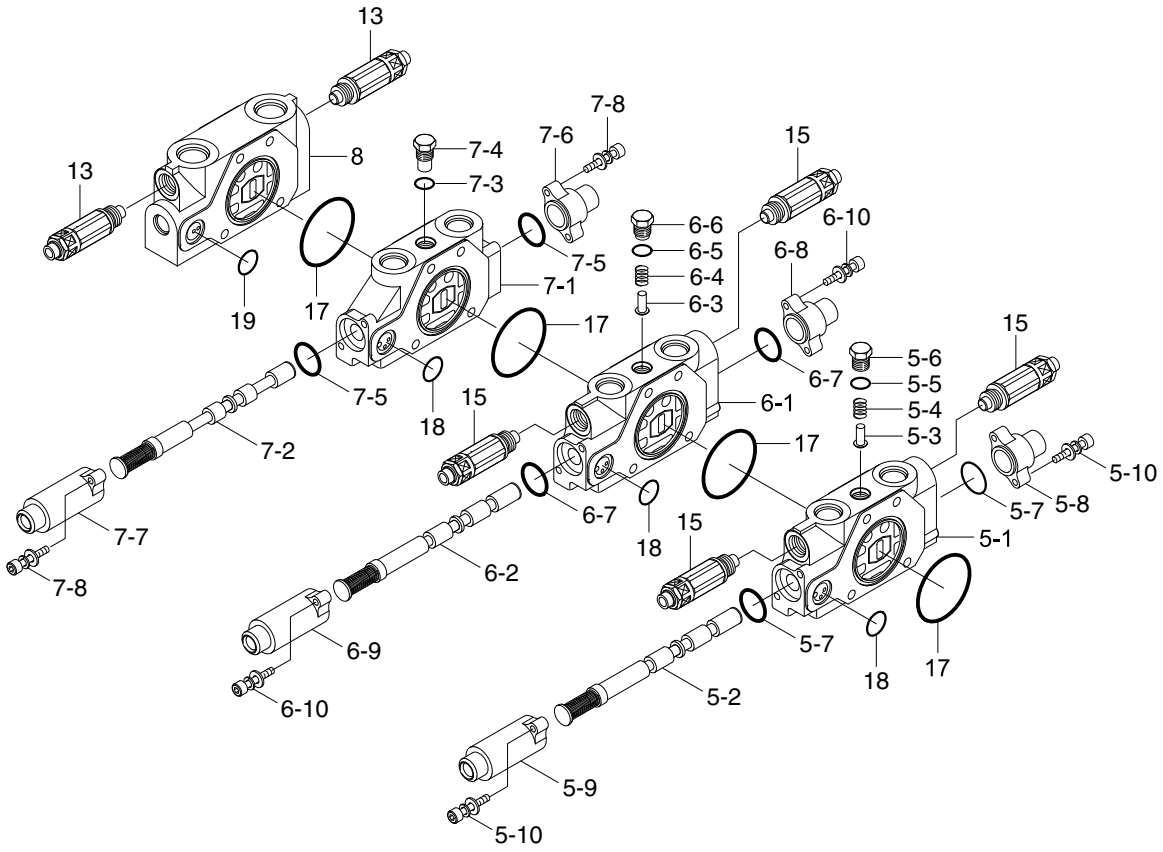
Mark	Port name	Port size	Tightening torque
A10	Bucket out port	PF 3/8	4.0~5.0 kgf · m
B10	Bucket in port		
Pa1	Dozer down pilot port	PF 1/4	2.5~3.0 kgf · m (18.1~21.7 lbf · ft)
Pb1	Dozer up pilot port		
Pa2	Boom swing (RH) pilot port		
Pb2	Boom swing (LH) pilot port		
Pa3	Swing (RH) pilot port		
Pb3	Swing (LH) pilot port		
Pa5	Arm out pilot port		
Pb5	Arm in pilot port		
Pa6	Travel [LH/RR] pilot port		
Pb6	Travel [LH/FW] pilot port		
Pa7	Travel [RH/RR] pilot port		
Pb7	Travel [RH/FW] pilot port		
Pa8	Boom up pilot port		
Pb8	Boom down pilot port		
Pa10	Bucket out pilot port		
Pb10	Bucket in pilot port		
Dr1, 2	Drain port		
PaR/Pa4	Option pilot port		
PbR/Pb4	Option pilot port		

2. STRUCTURE (1/3)



1	Dozer work block	2-9	Cover-pilot	4-7	O-ring
1-1	Body-work	2-10	Bolt-soc head w/washer	4-8	O-ring
1-2	Spool assy	3	Swing work block	4-9	Cover-pilot
1-3	Poppet	3-1	Body-work	4-10	Bolt-soc head w/washer
1-4	Spring	3-2	Spool assy	4-11	Plug
1-5	O-ring	3-3	Poppet	4-12	O-ring
1-6	Plug	3-4	Spring	4-13	Plug
1-7	O-ring	3-5	O-ring	4-14	Piston
1-8	Cover-pilot	3-6	Plug	4-15	Body-pilot
1-9	Cover-pilot	3-7	O-ring	4-16	Bolt-soc head w/washer
1-10	Bolt-soc head w/washer	3-8	Cover-pilot	4-17	Plug
2	Boom swing work block	3-9	Cover-pilot	4-18	Plug
2-1	Body-work	3-10	Bolt-soc head w/washer	4-19	Filter-coin type
2-2	Spool assy	4	Conflux block	4-20	Orifice
2-3	Poppet	4-1	Body-work	14	Relief valve
2-4	Spring	4-2	Spool assy	15	Overload relief valve
2-5	O-ring	4-3	Poppet	16	O-ring
2-6	Plug	4-4	Spring	17	O-ring
2-7	O-ring	4-5	O-ring	20	Bolt-tie
2-8	Cover-pilot	4-6	Plug	21	Nut-hex

STRUCTURE (2/3)



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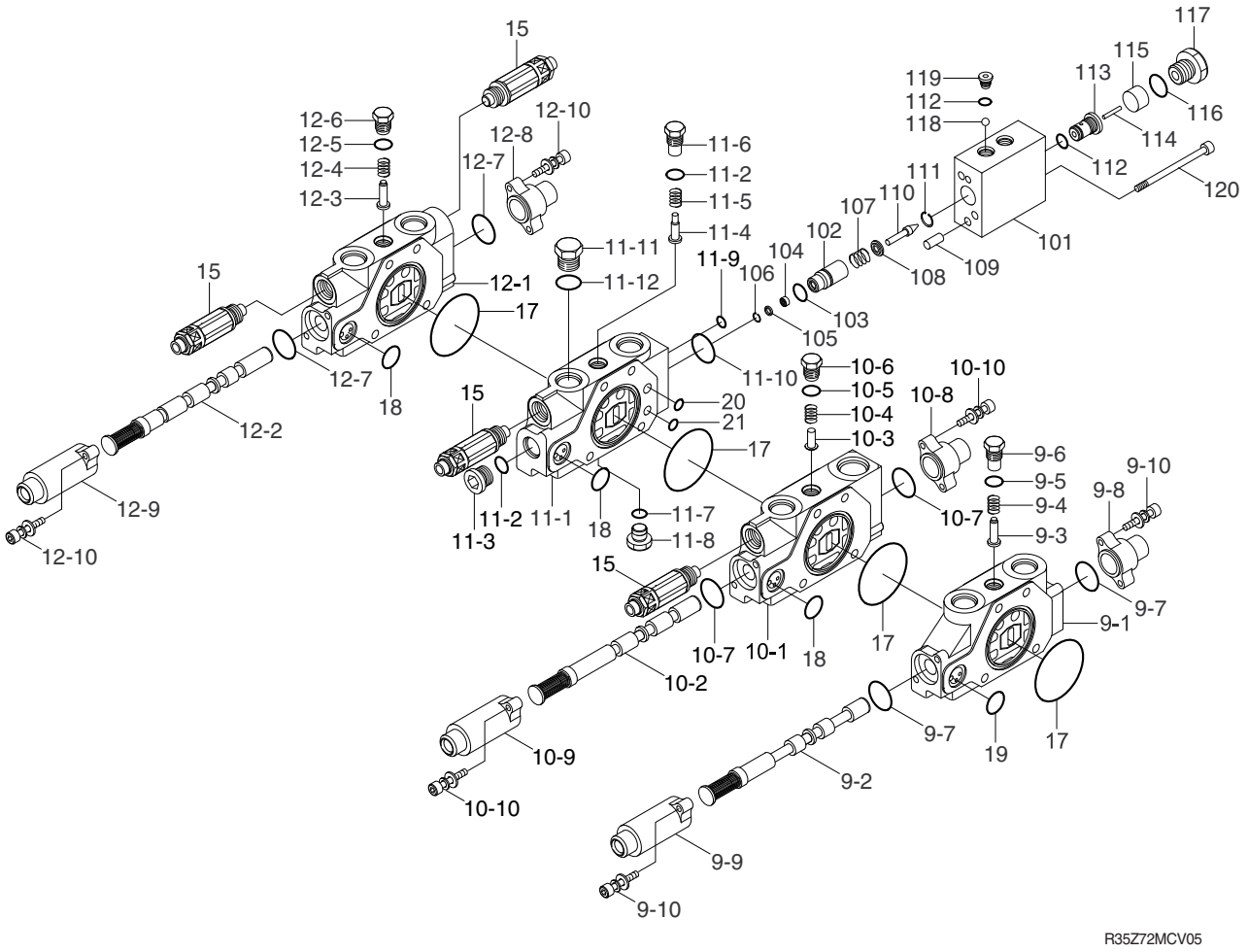
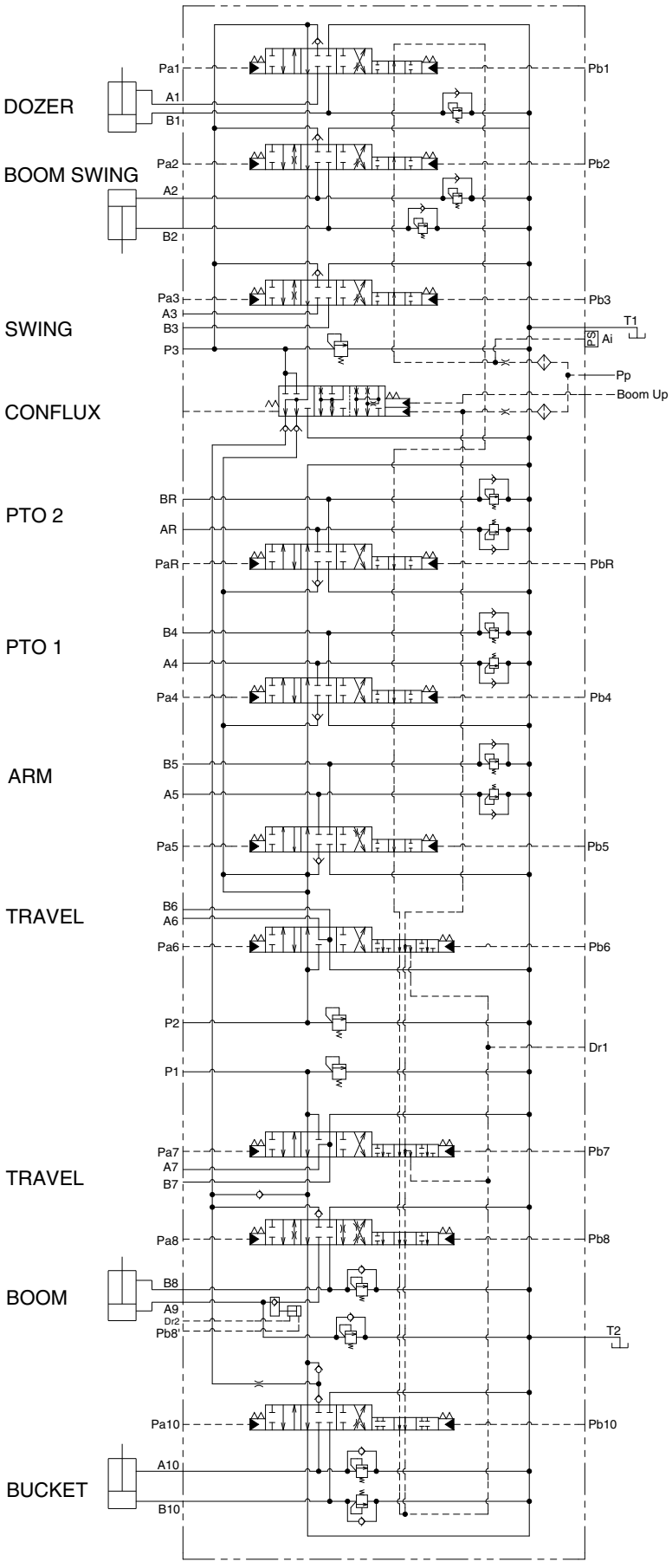
5	PTO work block	6-2	Spool assy	7-4	Plug
5-1	Body-work	6-3	Poppet	7-5	O-ring
5-2	Spool assy	6-4	Spring	7-6	Cover-pilot
5-3	Poppet	6-5	O-ring	7-7	Cover-pilot
5-4	Spring	6-6	Plug	7-8	Bolt-soc head w/washer
5-5	O-ring	6-7	O-ring	8	Inlet work block
5-6	Plug	6-8	Cover-pilot	13	Relief valve
5-7	O-ring	6-9	Cover-pilot	15	Overload relief valve
5-8	Cover-pilot	6-10	Bolt-soc head w/washer	17	O-ring
5-9	Cover-pilot	7	Travel work block	18	O-ring
5-10	Bolt-soc head w/washer	7-1	Body work	19	O-ring
6	Arm work block	7-2	Spool assy		
6-1	Body-work	7-3	O-ring		

STRUCTURE (3/3)



9	Travel work block	10-7	O-ring	12-1	Body-work	103	Seal
9-1	Body-work	10-8	Cover-pilot	12-2	Spool assy	104	Filter
9-2	Spool assy	10-9	Cover-pilot	12-3	Poppet	105	Spacer
9-3	Poppet	10-10	Bolt-soc head w/washer	12-4	Spring	106	Ring-retaining
9-4	Spring	11	Boom lock block	12-5	O-ring	107	Spring A-lock valve
9-5	O-ring	11-1	Body-work	12-6	Plug	108	Spring seat
9-6	Plug	11-2	O-ring	12-7	O-ring	109	Pin
9-7	O-ring	11-3	Plug	12-8	Cover-pilot	110	Poppet
9-8	Cover-pilot	11-4	Poppet	12-9	Cover-pilot	111	Ring-retaining
9-9	Cover-pilot	11-5	Spring	12-10	Bolt-soc head w/washer	112	O-ring
9-10	Bolt-soc head w/washer	11-6	Plug	15	Overload relief block	113	Guide-piston
10	Boom work block	11-7	O-ring	17	O-ring	114	Piston A1
10-1	Body-work	11-8	Plug	18	O-ring	115	Piston B
10-2	Spool assy	11-9	O-ring	19	O-ring	116	O-ring
10-3	Poppet	11-10	O-ring	20	O-ring	117	Connector
10-4	Spring	11-11	Plug	21	O-ring	118	Ball-steel
10-5	O-ring	11-12	O-ring	101	Cover-lock valve	119	Plug
10-6	Plug	12	Bucket work block	102	Lock valve	120	Bolt-socket head

3. HYDRAULIC CIRCUIT



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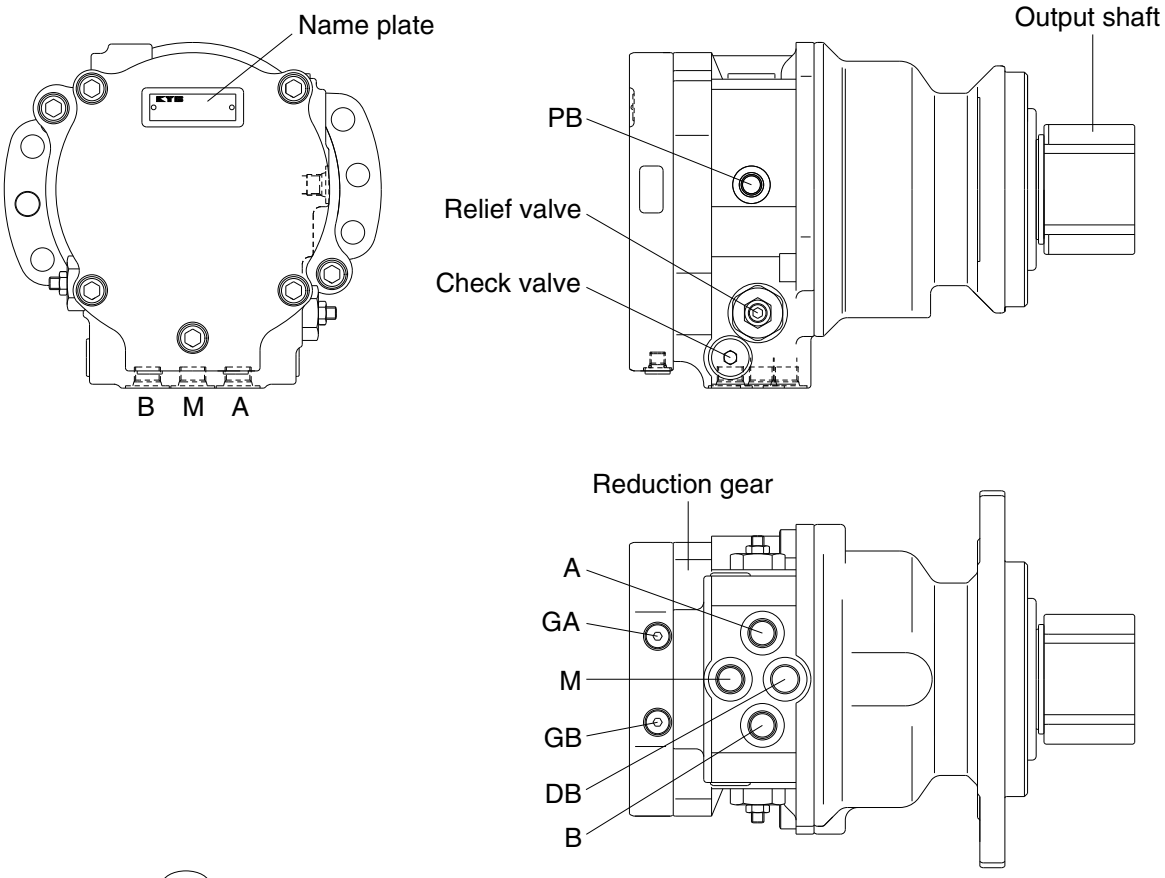
GROUP 3 SWING DEVICE

1. STRUCTURE

Swing device consists swing motor and swing reduction gear.

1) SWING MOTOR

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



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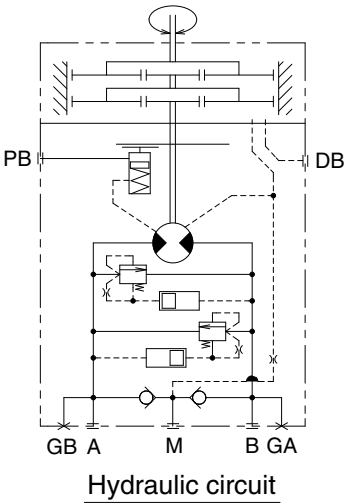
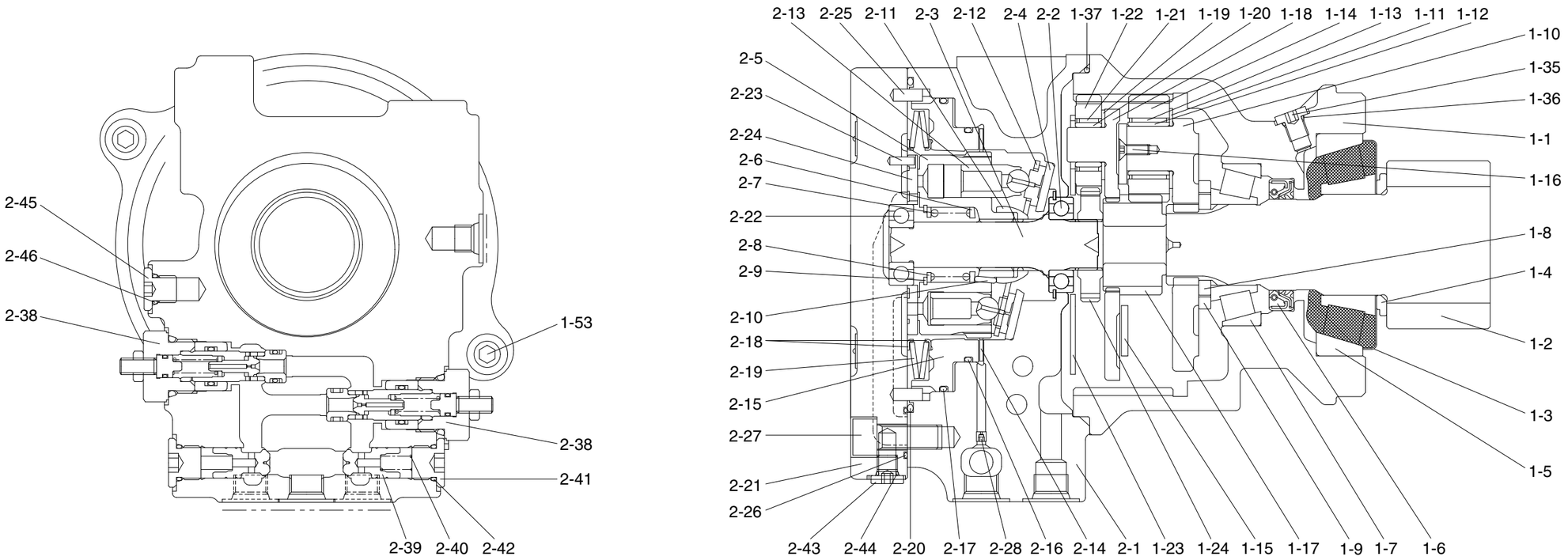


Hydraulic circuit

Port	Port name	Port size
A	Main port	PF 3/8
B	Main port	PF 3/8
DB	Drain port	PF 3/8
M	Make up port	PF 3/8
PB	Brake release port	PF 1/4
GA,GB	Gage port	PF 1/8

2) COMPONENTS



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1	Gear box	1-11	Thrust washer	1-22	Planetary gear	2-5	Cylinder block
1-1	Housing	1-12	Inner race	1-23	Thrust plate	2-6	Collar
1-2	Pinion shaft	1-13	Needle bearing	1-24	Drive gear	2-7	Spring
1-3	Plate	1-14	Planetary gear B	1-35	Plug	2-8	Washer
1-4	Collar	1-15	Thrust plate	1-36	O-ring	2-9	Ring-snap
1-5	Tapper roller bearing	1-16	Screw	1-37	O-ring	2-10	Pin
1-6	Oil seal	1-17	Sun gear B	1-53	Socket bolt	2-11	Retainer holder
1-7	Tapper roller bearing	1-18	Holder	2	Axial piston motor	2-12	Retainer plate
1-8	Plate	1-19	Thrust washer	2-1	Case	2-13	Piston assy
1-9	Collar	1-20	Inner race	2-2	Ball bearing	2-14	Disc
1-10	Holder	1-21	Needle bearing	2-3	Shaft	2-15	Brake piston
				2-4	Thrust plate		

2-16	O-ring	2-27	Socket head bolt
2-17	O-ring	2-28	Orifice
2-18	Spring seat	2-38	Relief valve assy
2-19	Spring	2-39	Check valve
2-20	O-ring	2-40	Spring
2-21	Cover	2-41	Plug
2-22	Ball bearing	2-42	O-ring
2-23	Pin	2-43	Plug
2-24	Valve plate	2-44	O-ring
2-25	Pin	2-45	Plug
2-26	O-ring	2-46	O-ring

2. DESCRIPTION OF FUNCTION AND OPERATION

1) SWASH PLATE MOTOR

The cylinder block incorporates nine pistons. The end face of the cylinder block is in contact with the valve plate having two woodruff ports B and C (distributing valve to change over between high and low pressure).

Principle of generation torque

When high pressure oil (pressure P) is introduced to the B port, the inclined surface is pushed by a force of "F = P×A, A : Piston sectional area" per piston and the piston receives a reaction force from the inclined surface. The piston that is restricted in the moving direction by the cylinder block due to the reaction force generates a rotating force. The total of rotating force by the reaction force of the high pressure side pistons works on the cylinder block. The generated rotating force is transmitted as a torque to the shaft via the spline to turn the shaft.

On the other hand, if the high pressure oil is introduced to the C port, the opposite rotation is caused.

The output torque and the revolution are calculated as follows :

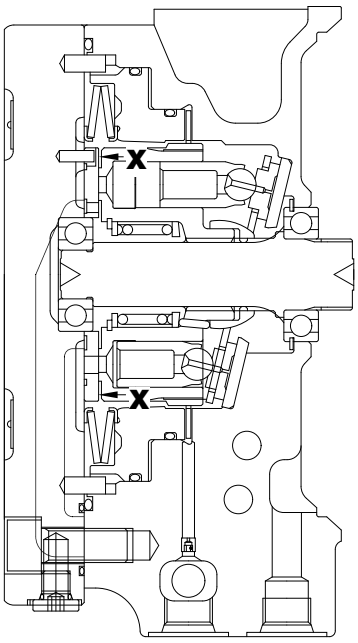
· Output torque (T)

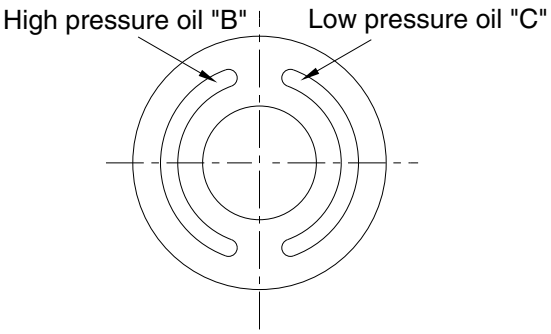
$$T = \frac{P \times D \times i \times \eta m \times \eta G}{2 \times \pi \times 100}$$

· Revolution (N)

$$N = \frac{Q \times 1000 \times \eta v}{D \times i}$$

D : Displacement (cm^3/rev)
P : Effective drive pressure (MPa)
Q : Inflow (L/min)
η m : Mechanical efficiency (motor) (% × 10^{-2})
η v : Volumetric efficiency (motor) (% × 10^{-2})
i : Speed ratio of reduction gear
η G : Efficiency of reduction gear (% × 10^{-2})





View X-X of valve plate(Outline)

R35Z72SM02

2) PARKING BRAKE

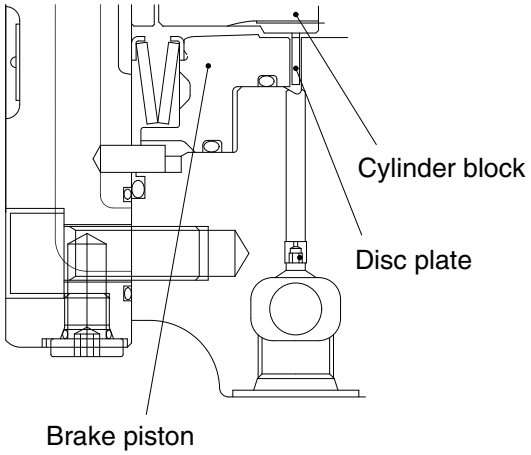
The parking brake is of wet type multi-plate construction of hydraulic release type and has a shaft lock mechanism that changes between ON and OFF of the brake by external signal pressures.

① Parking brake ON

When the hydraulic pressure for brake release is shut, the disc coupled to the periphery of the cylinder block via the spline is pushed by the spring force against the brake piston (pinned to the case so that it will not rotate) and the cylinder block and the case secured by the frictional force. Thus the shaft is locked.

② Parking brake OFF

When the brake release pressure is introduced to the brake cylinder chamber (C) via the "PB" port, the brake piston is operated by the release pressure in opposition to the spring force to eliminate the force of friction with the disc, thus allowing the shaft to rotate freely.



"PB" (Brake releasing pressure) OFF

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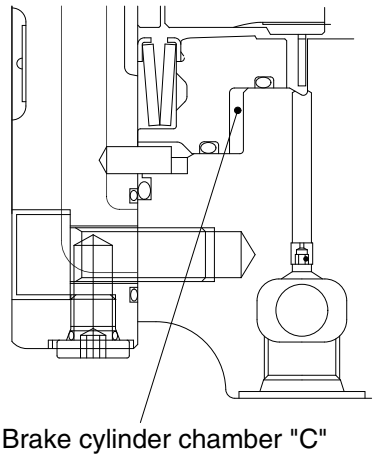


"PB" (Brake releasing pressure) ON

R35Z72SM04

3) RELIEF VALVE

The relief valves determine the drive force and the brake force for hydraulic shovel swing and are installed in the main port A and B lines. The circuit is configured to return the relief valve return oil to the counterpart main low pressure line.

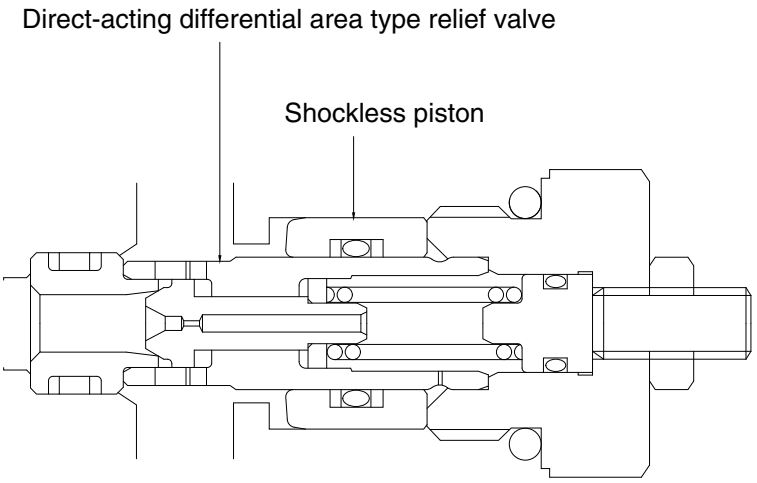
A shockless function is also incorporated to reduce shock produced at the start of both acceleration and deceleration.

(1) Construction of the relief valve

① A direct-acting differential area type relief valve

② A shockless piston

The installation of a shockless type relief valve helps reduce shock and stress produced in the strength members.



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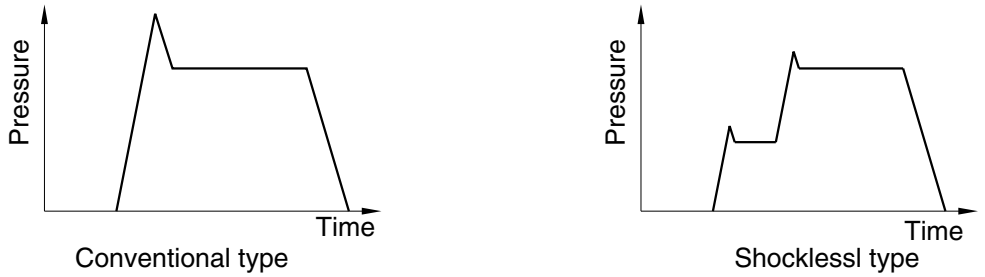


Comparison of pressure wave forms

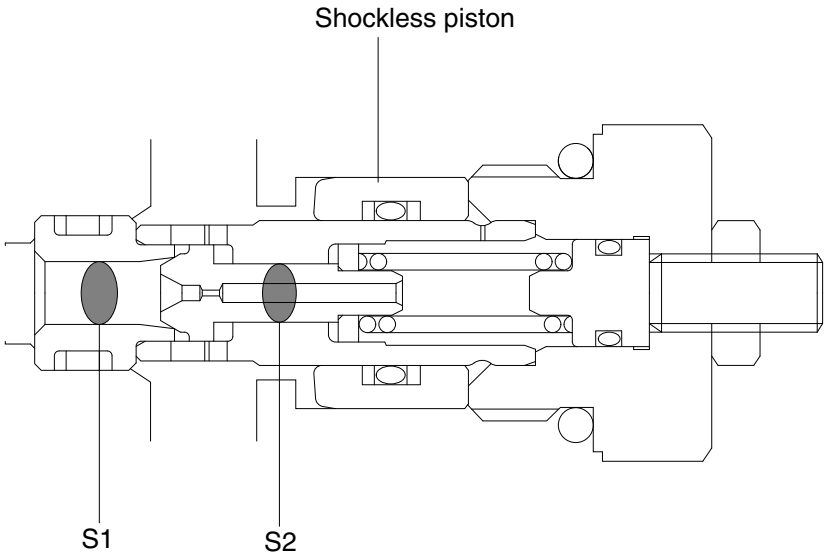
R35Z72SM08

(2) Relief valve operation

① First stage

At the start of operation, the shockless piston moves to maintain the spring chamber at a low pressure. Thus, the pressure receiving area of the poppet becomes the poppet seat area (S1), a considerably larger area than the pressure receiving area (S1-S2) at the specified relief setting. For this reason, the relief operating pressure is kept at a low pressure until the shockless piston completes its movement.

The low pressure holding time depends on the poppet orifice diameter, the free piston pressure receiving area and the free piston stroke.



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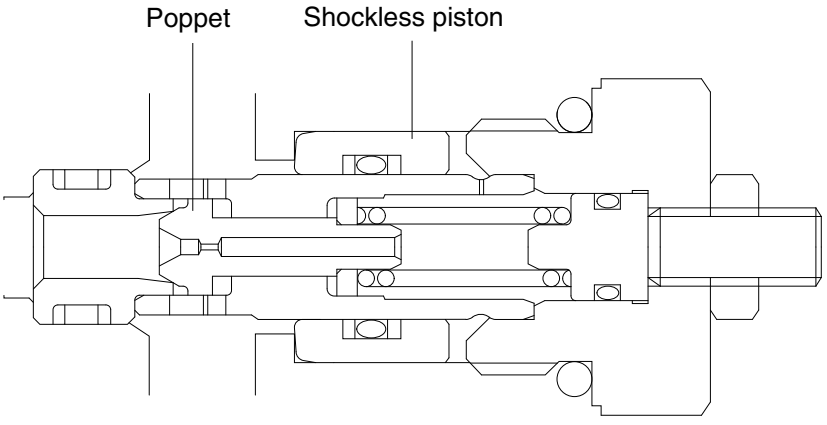
② Second stage

When the shockless piston completes its movement, the pressure inside the spring chamber increases to make the pressures before and after the poppet equal. Then the relief valve operates at the specified set pressure.



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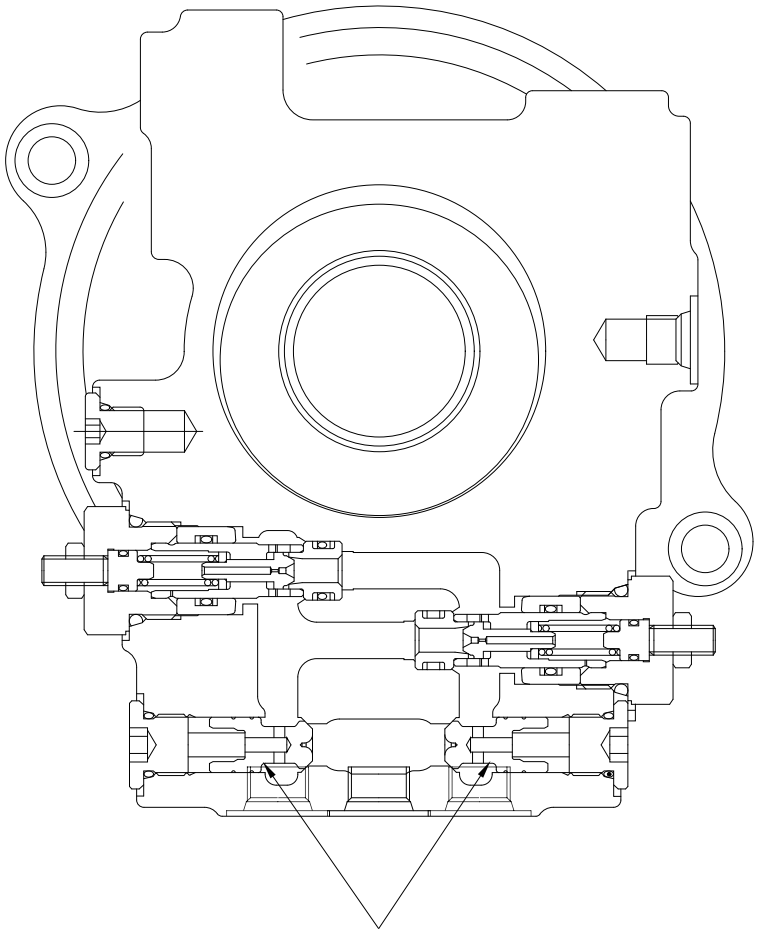
4) MAKE-UP VALVE

The make-up valve has the following two functions.

One is to prevent cavitation produced by overrun of the piston motor in order to prevent the overrun of the upper body. When the motor is turned by the inertia of the upper body to cause the pumping action, which then causes the motor revolution to rise above the revolution equivalent to the amount of oil supplied to the motor, the amount of oil equivalent to the shortage is supplied to the motor main circuit via the make-up valve from outside to prevent occurrence of vacuum inside the circuit.

The other is a function to add the amount of motor drain and valve leak via the make-up valve to prevent vacuum inside the circuit to provide the braking capability in the normal circuit status when a closed circuit is formed between the control valve and the motor as when braking.

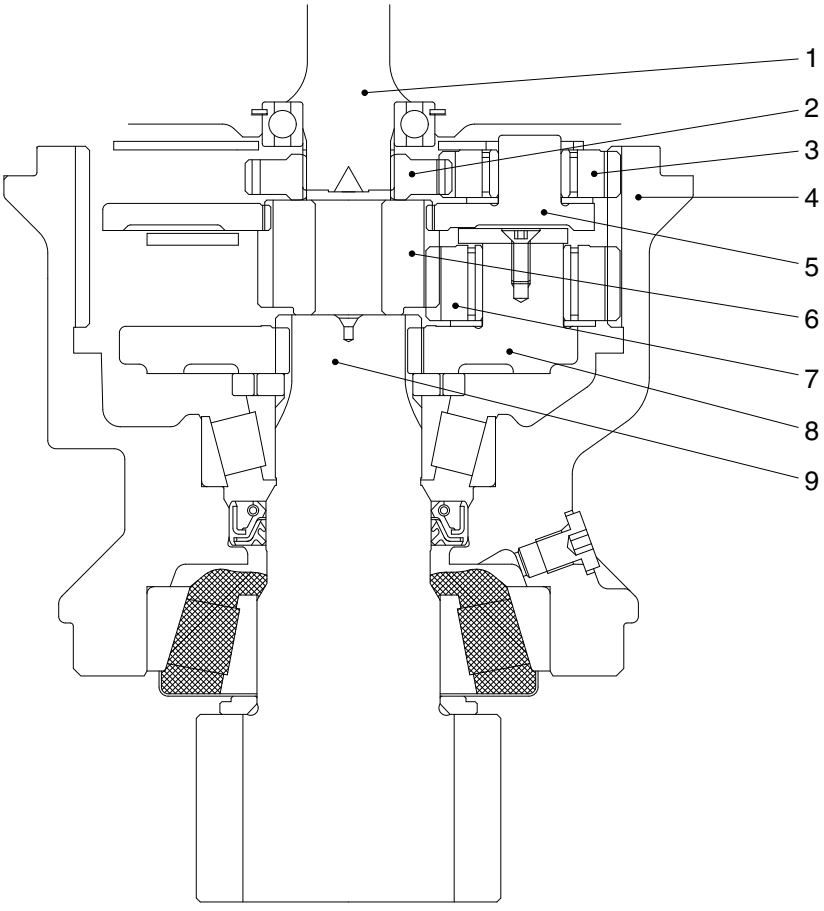


R35Z72SM09

5) **REDUCTION GEAR** (planetary two-stage)

Refer to the cross section.

The motor shaft (1) is coupled to the drive gear (2) via a spline. The drive force of the hydraulic motor is transmitted from the drive gear (2) to the engaged planetary gear (3). The planetary gear (3) is meshed with the ring gear of the reduction gear housing (4). Thus, while rotating, it revolves around the ring gear. The planetary gear (3) is held by the holder (5) via the bearing and the holder transmits the revolving motion of the planetary gear (3) to the sun gear (6) coupled via the spline. The sun gear (6) meshes with the planetary gear (7) and as with the first stage, transmits the rotary motion to the planetary gear (7). Since the planetary gear (7) is meshed with the ring gear of the housing (4), it revolves while rotating. Since the planetary gear (7) is held by the holder (8) via the bearing, the holder (8) transmits the revolving motion of the planetary gear (7) to the pinion shaft (9) coupled via the spline.



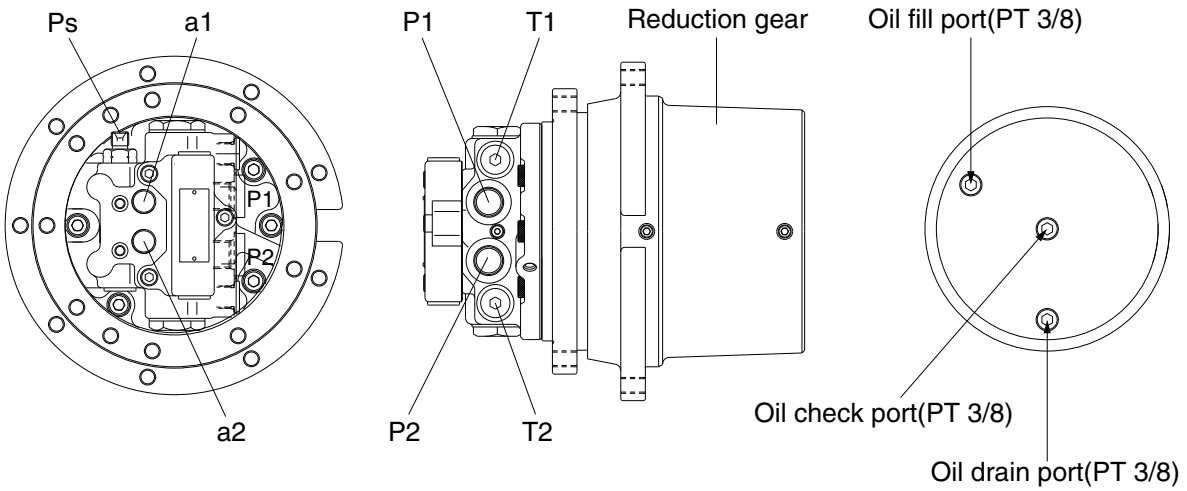
R35Z72SM10

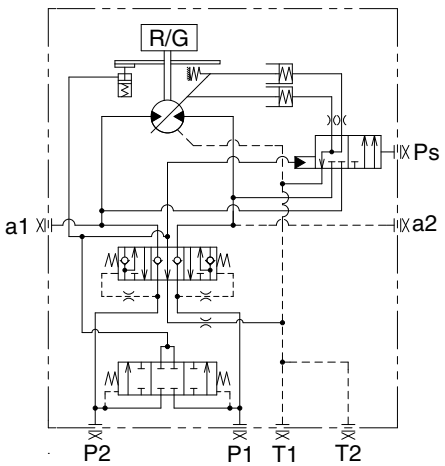
GROUP 4 TRAVEL DEVICE

1. CONSTRUCTION

Travel device consists travel motor and gear box.

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



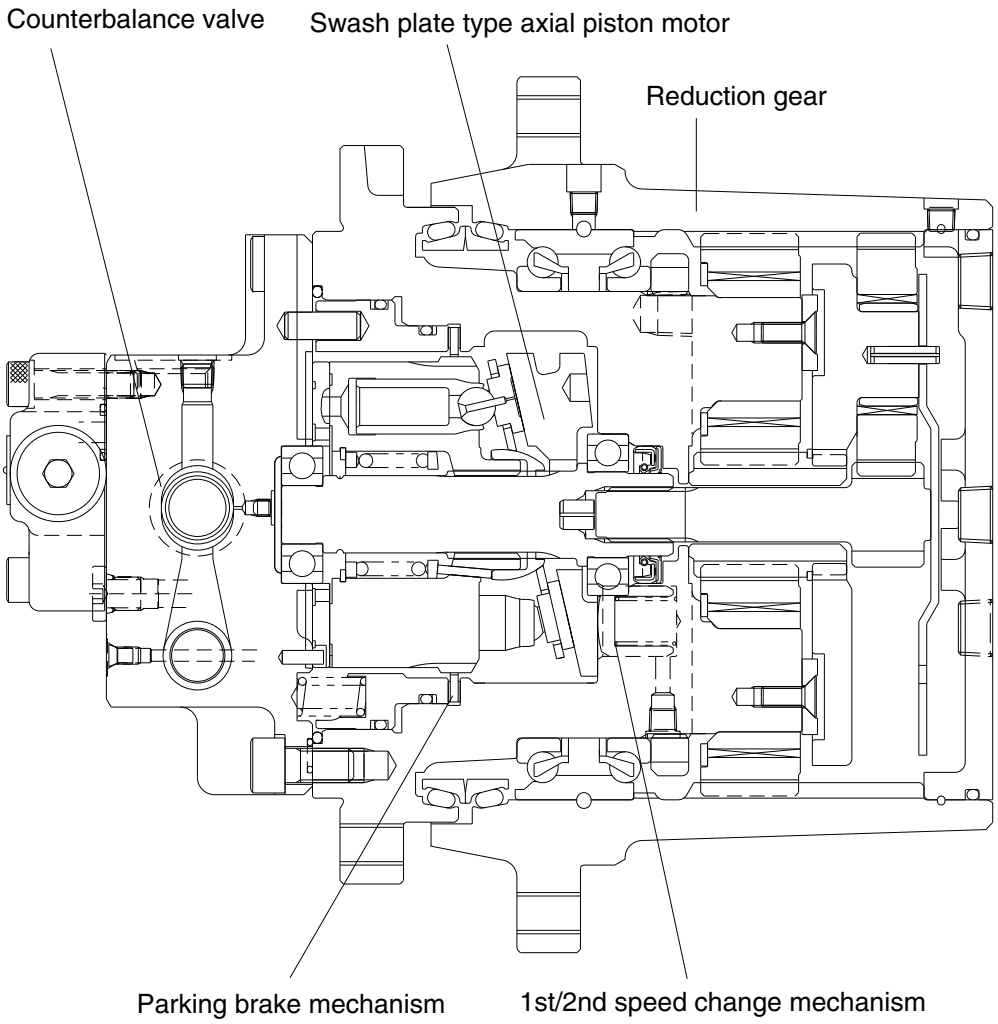


Hydraulic circuit

35Z9A2TM20

Port	Port name	Port size
P1	Main port	PF 1/2
P2	Main port	PF 1/2
a1,a2	Gauge port	PF 1/8
T1,T2	Drain port	PF 3/8
Ps	2 speed control port	9/16-18 UNF

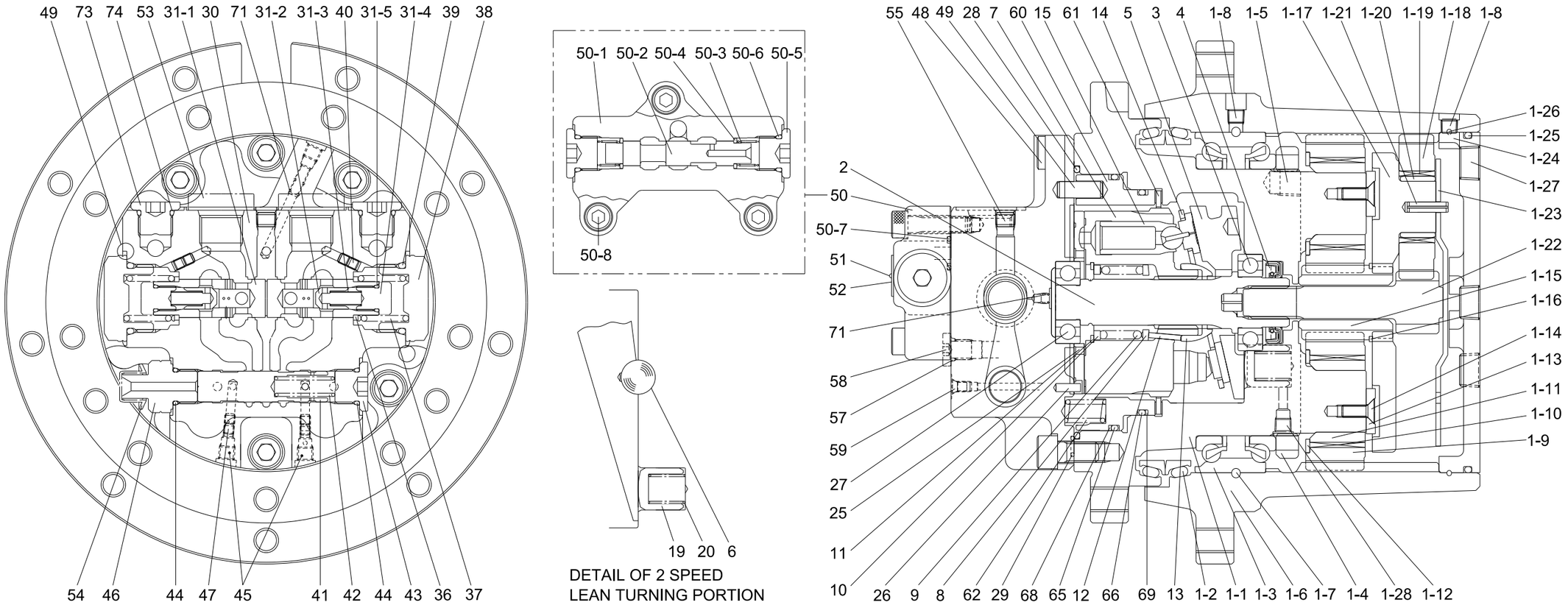
1) STRUCTURE (1/2)



R35Z72TM02

The travel motor is constituted with swash plate type axial piston motor, counterbalance valve, 2 speed change mechanism, parking brake, anti-cavitation valve and reduction gear unit.

STRUCTURE (2/2)



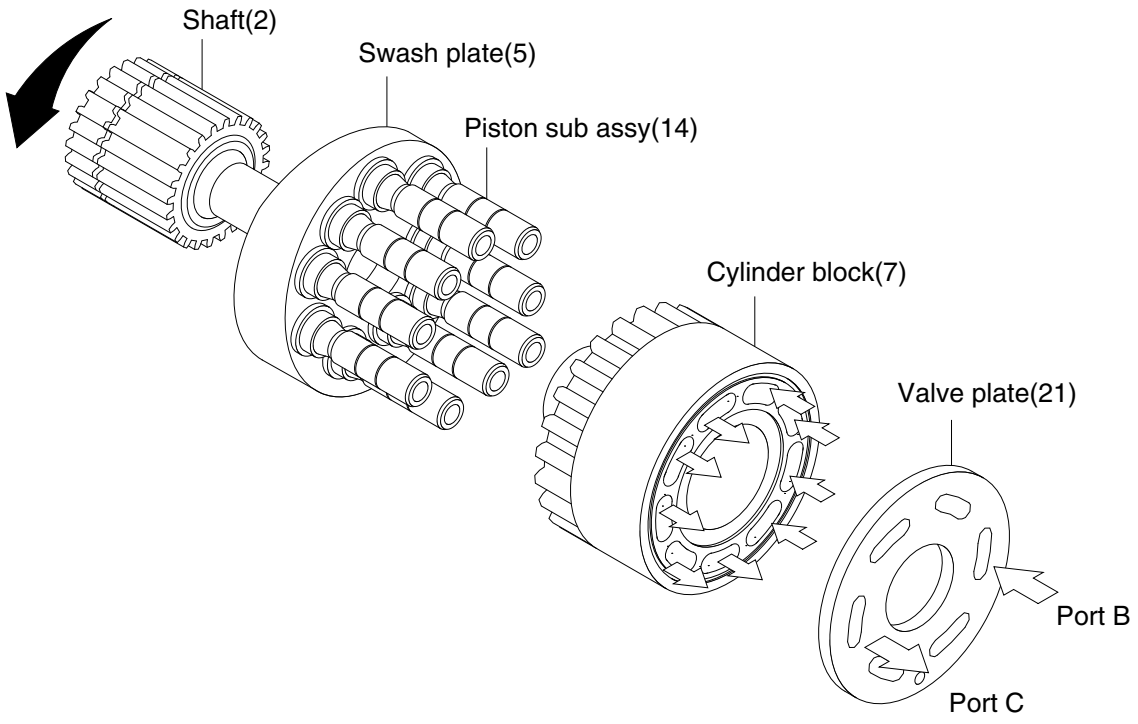
35Z9A2TM01

1	Gear box	1-17	Holder	5	Swash plate	29	O-ring
1-1	Flange holder	1-18	Planetary gear (A)	6	Steel ball	30	Base plate
1-2	Floating seal	1-19	Needle bearing	7	Cylinder block	31	Plunger assy
1-3	Angular bearing	1-20	Inner race	8	Color	31-1	Plunger
1-4	Ring nut	1-21	Spring pin	9	Spring	31-2	Check valve
1-5	Plug	1-22	Drive gear	10	Washer	31-3	Spring
1-6	Housing	1-23	Thrust plate (T = 1.8)	11	Snap ring	31-4	Plug
1-7	Steel ball	1-23	Thrust plate (T = 2.3)	12	Pin	31-5	O-ring
1-8	Plug	1-23	Thrust plate (T = 2.8)	13	Holder	36	Spring seat
1-9	Planetary gear B	1-24	Cover	14	Retainer plate	37	Spring
1-10	Needle bearing	1-25	O-ring	15	Piston assy	38	Cap
1-11	Collar	1-26	Wire	19	Piston assy	39	O-ring
1-12	Thrust washer	1-27	Plug	20	Spring	40	Orifice
1-13	Thrust plate	1-28	Plug	25	Valve plate	41	Spool
1-14	Screw	2	Shaft sub assy	26	Pin	42	Spring
1-15	Sun gear	3	Ball bearing	27	Ball bearing	43	Plug
1-16	Snap ring	4	Oil seal	28	O-ring	44	O-ring

45	Plug	57	O-ring	68	Backup ring
46	Plug	58	Plug	69	Backup ring
47	Orifice	59	Plug	71	Spring
48	Socket head bolt	60	Brake piston	73	Plug
49	Pin	61	Disc	74	O-ring
50	Valve assy	62	Spring		
50-1	Valve body	65	O-ring		
50-2	Spool	66	O-ring		
50-3	Spring				
50-4	Spring seat				
50-5	Plug				
50-6	O-ring				
50-7	O-ring				
50-8	Socket head bolt				
51	Name plate				
52	Drive screw				
55	Plug				

2. FUNCTION

1) HYDRAULIC MOTOR



R35Z72TM03

Nine piston sub assemblies (14) are assembled in cylinder block (7). The end face of cylinder block (7) is in contact with valve plate (21) having two crescent shaped ports, B and C (high and low pressure ports).

When supplying pressure fluid (pressure P) to B port, a swash plate (5) is pushed by the force of piston sub assemblies having F = P · A (A : piston pressure area). Piston sub assemblies receive the reaction force against it, and produce the reaction force (Ft) in rotating direction. The total force of high pressure side piston sub assemblies in rotating direction produces a rotating force in the cylinder block, and the torque is transmitted to shaft (2) through the spline resulting in the rotation of the shaft.

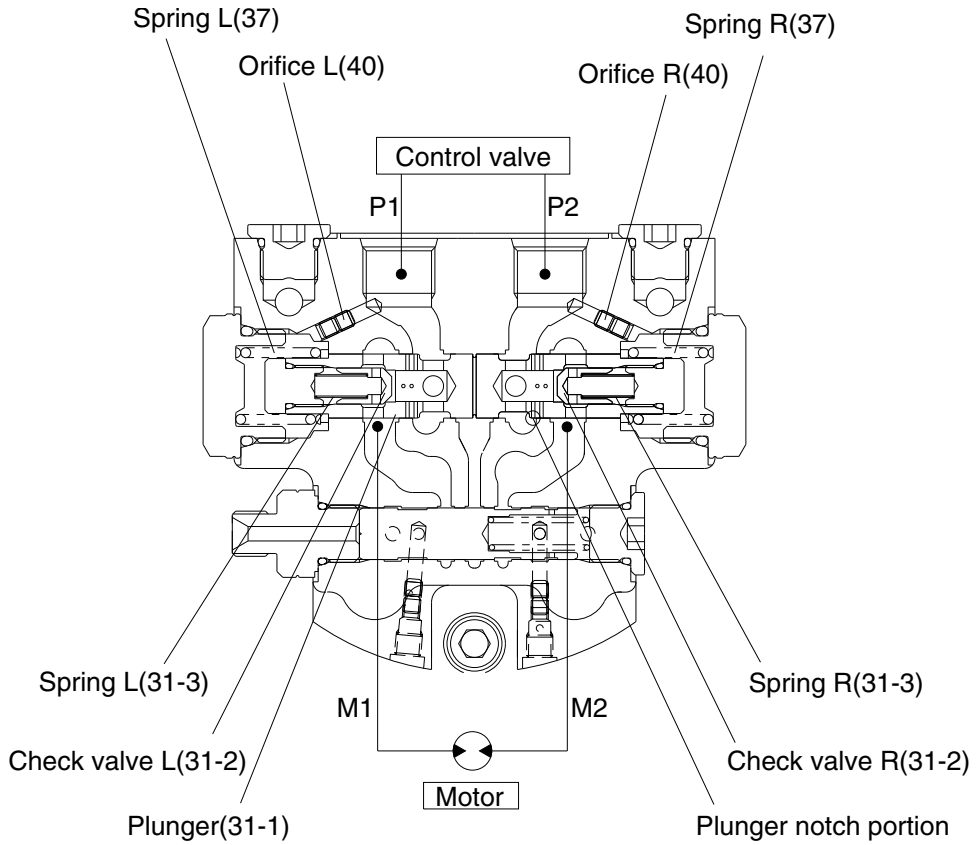
According to the above working principle, the output torque and rotating speed of the piston motor are determined by supply pressure (P) and flow rate (Q), and are calculated by the following equation.

$$T = \frac{P \times D \times \eta m}{2^{*} \pi}$$

$$N = \frac{Q \times 10^{3} \times \eta v}{D}$$

T : Output torque [N · m]
N : Speed of rotation [rpm]
P : Working pressure [MPa]
Q : Flow rate [L/min]
D : Theoretical displacement [cm³/rev]
η m : Mechanical efficiency
η v : Volumetric efficiency

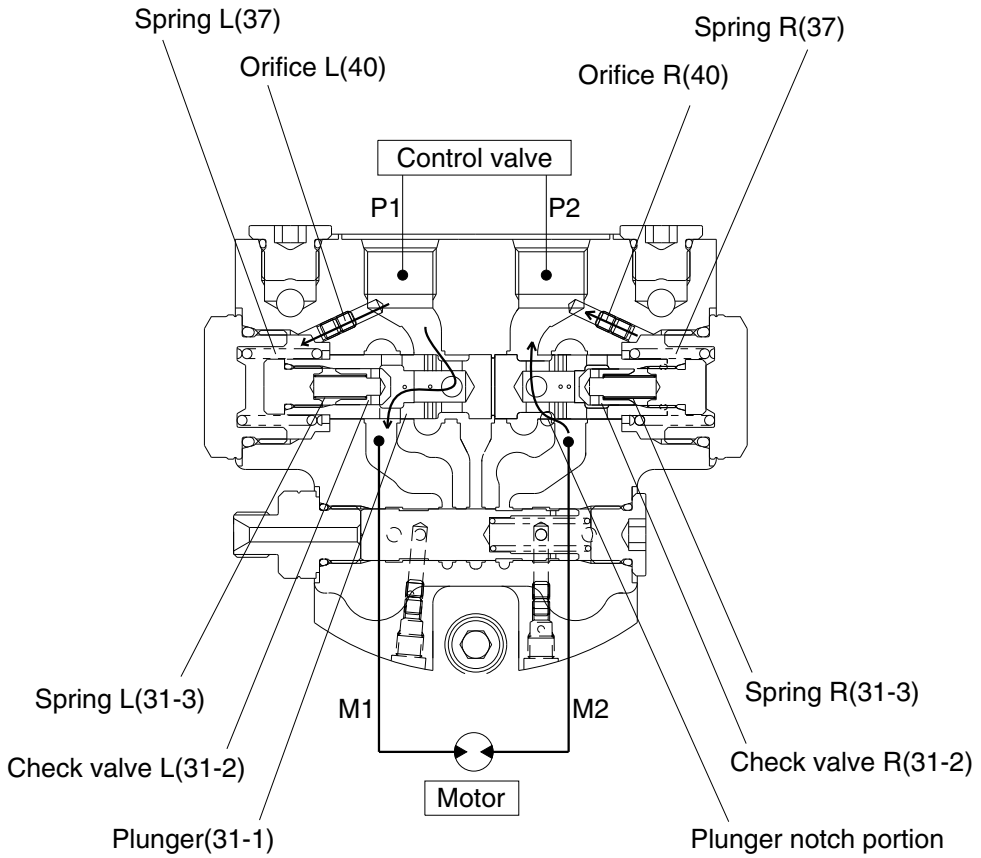
2) COUNTER BALANCE VALVE



R35Z72TM04

The counter balance valve is provided to stop the axial piston motor and to prevent overrunning. When the control valve is set to the neutral position, there is no pressure in the ports P1 and P2, and ports M1 and M2 are blocked by plunger (31-1) and check valve (31-2), consequently the motor does not start rotating.

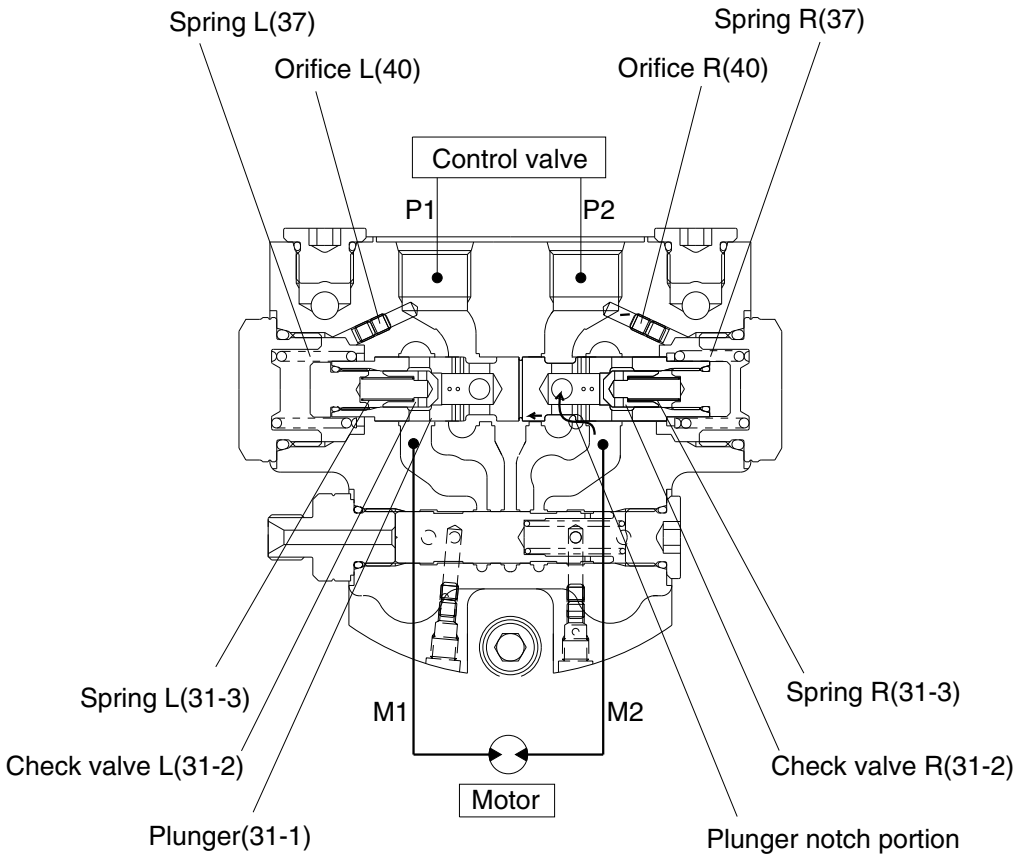
(1) Counter balance valve work



R35Z72TM05

When the fluid is supplied from pump to counter balance valve port P1 through control valve, the fluid flows into piston motor through check valve L (31-2), and rotate the piston motor.
On the other hand, the return fluid from the piston motor flows into the counterbalance valve through port M2, but the fluid is interrupted by check valve R (31-2), and consequently the pump delivery pressure will increase.
The high pressure oil at port P1 passes through orifice L (40), pushes the end of face of plunger (31-1) and pushes the plunger rightward against spring R (37) on the opposite side with the force proportional to the pressure.
When the hydraulic pressure rises to a certain pressure, plunger (31-1) starts moving rightward, and the fluid in port M2 passes through the notch machined outer circular of plunger (31-1) and flows into the port P2, producing a back pressure on the port M2, finally returning into the tank through a control valve.
And when the pump delivery pressure rises, the throttling aperture of notch in plunger (31-1) becomes larger, and consequently the back pressure of the port M2 becomes lower.
This way, the throttling aperture of the notch in plunger (31-1) automatically adjusts the area of a return side passage in order to rotate the piston motor with the appropriate speed for port P1 side flow rate (inlet flow).

(2) Brake work



R35Z72TM06

Then, when the control valve returns to the neutral position, the pressurized oil from the pump is shut off and the pressures of the ports P1 and P2 become equal. A plunger (31-1) tries to be returned to neutral position by force of spring R (37). When plunger (31-1) moves, the throttle opening of plunger becomes small.

Piston motor tries to rotate with inertia energy (motor-pumping-action) and the pressure rises on port M2.

With the movement of plunger (31-1), the oil of spring L room flows out through orifice L (40) and control the speed of plunger (31-1), By this movement, the shock pressure due to the inertia energy on the port M2 is absorbed, simultaneously preventing the cavitation on the port M1.

3) TWO SPEED CHANGE MECHANISM

(1) When running at 1st speed (low speed)

Swash plate (5) has three faces, from "a" to "c", as shown below in the figure and installed in the flange holder with two steel balls (6) in the condition where it can be tilted.

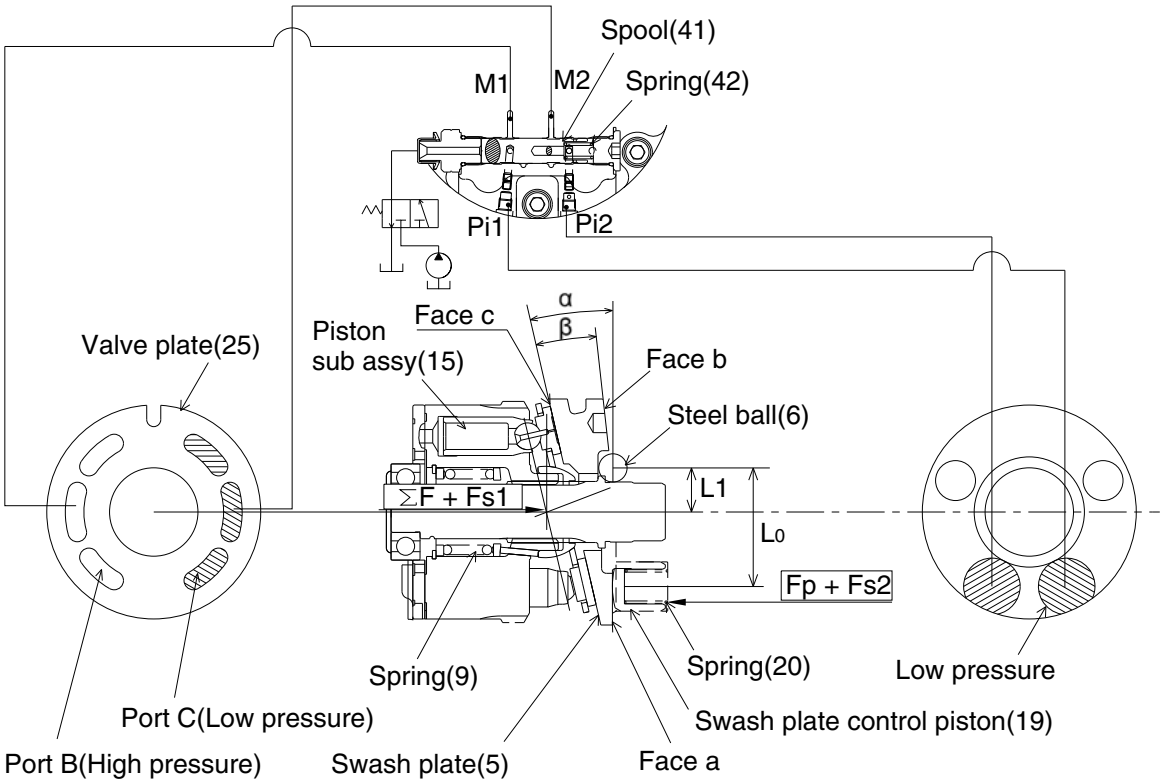
When the control valve is set to the 1st speed position, spool (41) is placed in the position shown below in the figure by the force of spring (42), and the passage of swash plate control piston (19) passes across the Pi1 and Pi2 port positions and led to the tank port. Therefore, the force pushing up the swash plate (5) does not act on the swash plate control piston (19).

$Fp = (Ap \times P) = 0$

Fp : Swash plate control piston thrust
Ap : Swash plate control piston pressure receiving area
P : Pressure

When steel ball (6) is placed on the tilting center, the balance of moment acting on swash plate (5) is in the condition of $(\sum F + Fs1) \times L1 > (Fp + Fs2) \times Lo$ depending on the total $\sum F$ of driving force of piston sub assy (15) and the force of spring (9) Fs1 and Fs2, then swash plate (5) stables at the face a and the swash plate angel is α, and consequently the motor speed corresponding to the 1st speed, low speed, is obtained.

$(\sum F + Fs1) \times L1 > (Fp + Fs2) \times Lo$



At 1st speed(low speed)

R35Z72TM08

(2) When running at 2nd speed (high speed)

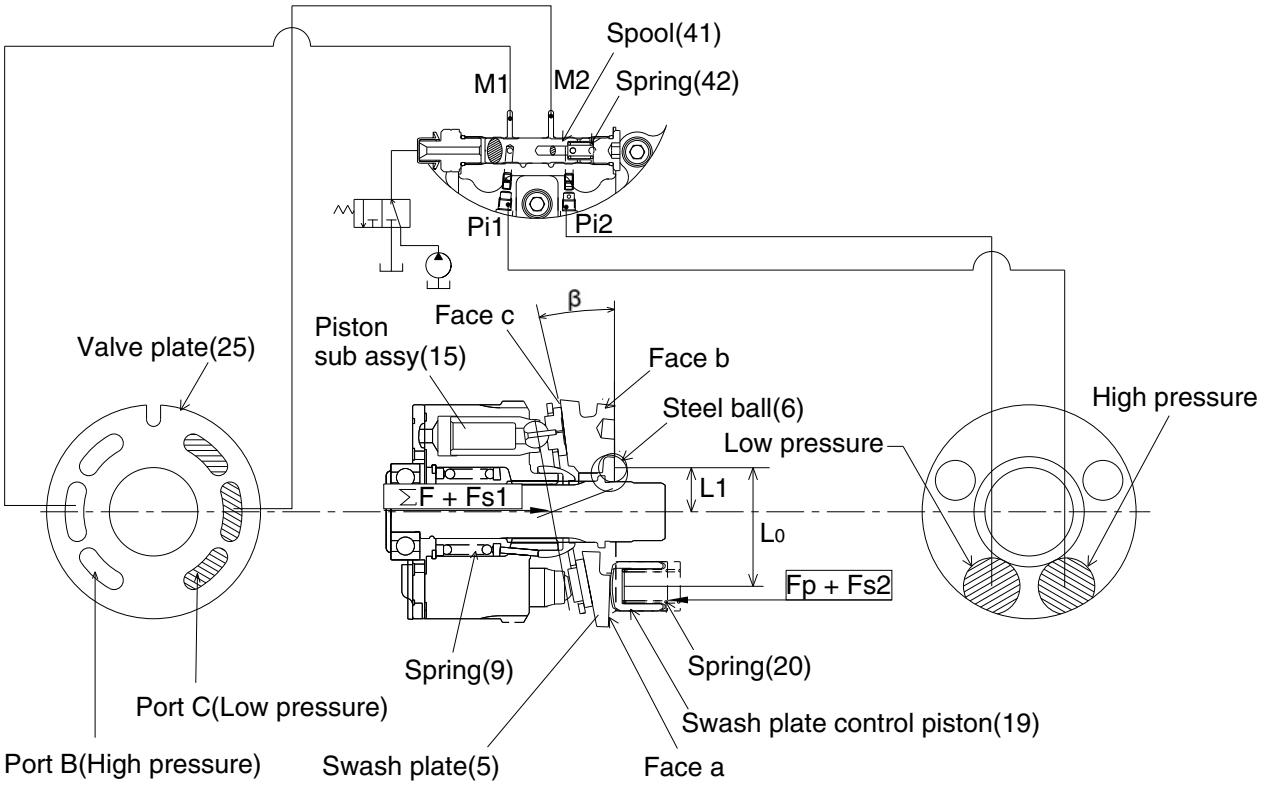
When control valve is set to the 2nd speed position, the pressure oil delivered by the pump is led to spool (41) and spool (41) is switched to the position shown below in the figure. And the pressurized oil flows into each ports Pi1 and Pi2 through ports M1 and M2 and the motor driving pressure (P1 : high pressure and P2 : low pressure) is led to each swash plate control piston (19). Therefore the force pushing up the swash plate acts on swash plate control piston (19).

$Fp1 = Ap \times P1$ $Fp2 = Ap \times P2$

When steel ball (6) is placed on the tilting center, the balance of moment acting on swash plate (5) is in the condition of $(\sum F+Fs1) \times L1 < (Fp+Fs2) \times Lo$ depending on the total $\sum F$ of driving force of piston sub assy (15).

The face "b" of swash plate (5) stabilizes and the swash plate angle become β, consequently the motor speed is the 2nd speed (high speed).

While the engine is stopped, spool (41) is returned to the 1st speed position by the force of spring (9) since pressurized oil does not flow. When steel ball (6) is placed on the tilting center, the balance of moment acting on swash plate (5) is in the condition of $Fs \times L1 > Fp \times Lo$, the face "a" of swash plate (5) stabilizes and the swash plate angle become α, consequently the motor speed at starting is always the 1st speed.



At 2nd speed(high speed)

R35Z72TM21

4) AUTO TWO SPEED CHANGE MECHANISM

Auto two speed control mechanism consists of two spools and spring. This valve automatically changes motor displacement in portion to motor pressure. This valve works while the pilot port Ps is pressurized.

(1) Motor pressure is low

The motor displacement is small (high speed displacement) as shown in the figure.

When the two speed spool is on the right position, motor pressure PM1 and PM2 are connected to each side of chamber of two speed piston. So swash plate is moved to high speed position by two speed piston and motor displacement is kept on high speed position.

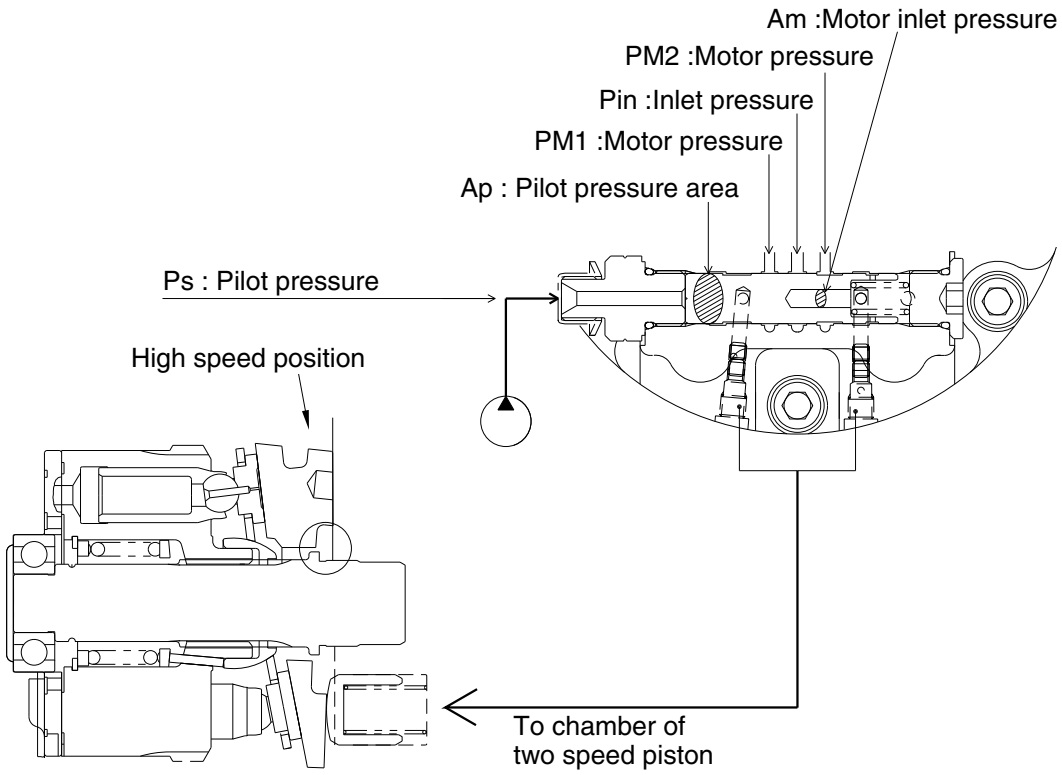
Pilot pressure is applied on the area Ap when Ps port is pressurized. Then the pressure of Ps pushes the spool to the right direction on the figure. At the same time, motor inlet pressure is applied on the area Am. So, the spool is also applied to the left direction by Am pressure.

According to above, if the motor pressure is lower and keep the following condition, the spool stay on the right position.

$$Ps \times Dp > Am \times Pin + Kx$$

Kx : the force of spring

Motor pressure is low : $(Ap \times Ps) > (Am \times Pin + Kx)$



Automatic two speed (Motor pressure is low)

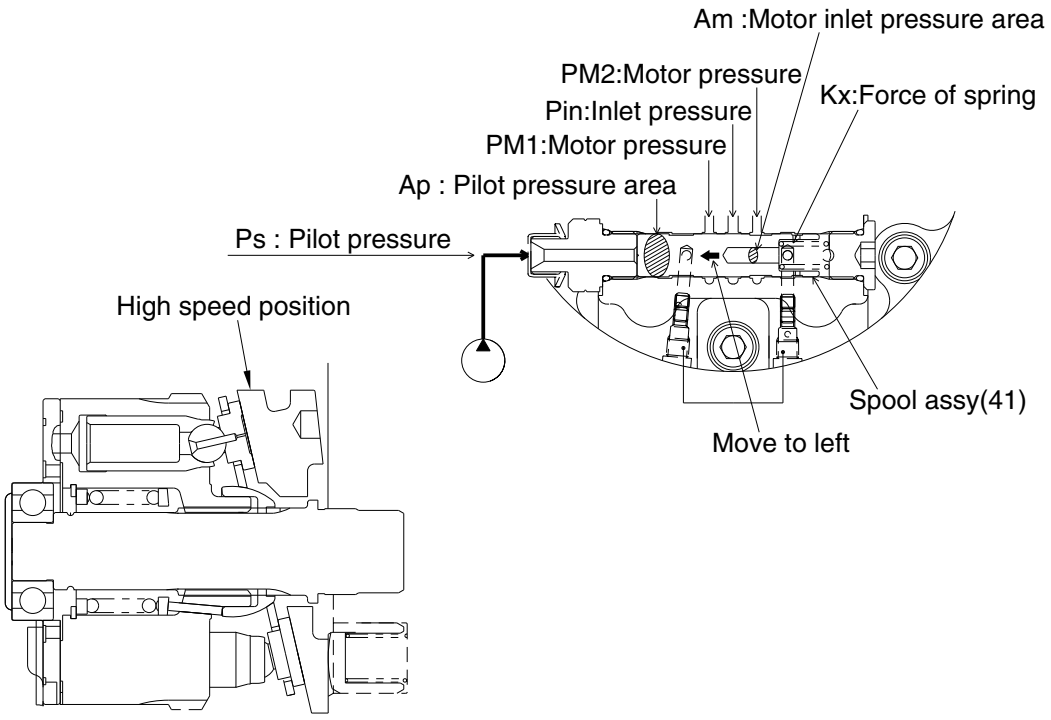
R35Z72TM11

(2) Motor pressure is high

The motor displacement is large (low speed displacement) as shown in the figure.

The two speed spool is on the left position if Pin pressure is high. Then, PM1 and PM2 are shutted by the spool. If the motor pressure is higher and keep the following condition, the spool stay on the left position.

$$Ps \times Dp < Am \times Pin + Kx$$



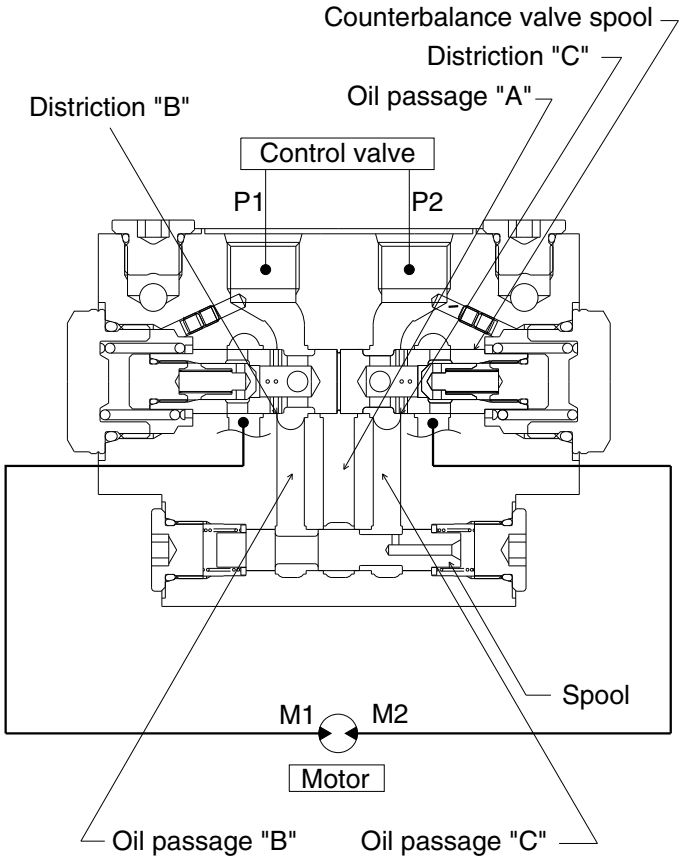
Automatic two speed (Motor pressure is high)

R35Z72TM09A

5) ANTI CAVITATION VALVE (with parking brake)

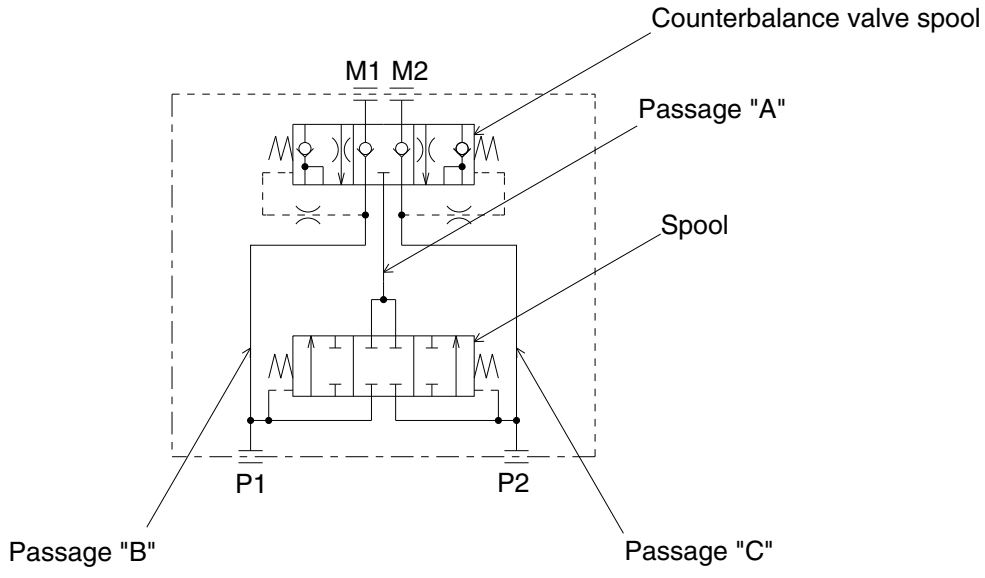
Anti cavitation valve is always working with counter balance valve.

This system consists of oil passage "A", "B", "C" and spool in addition to traditional counter balance valve.



Anti cavitation valve system

R35Z72TM12

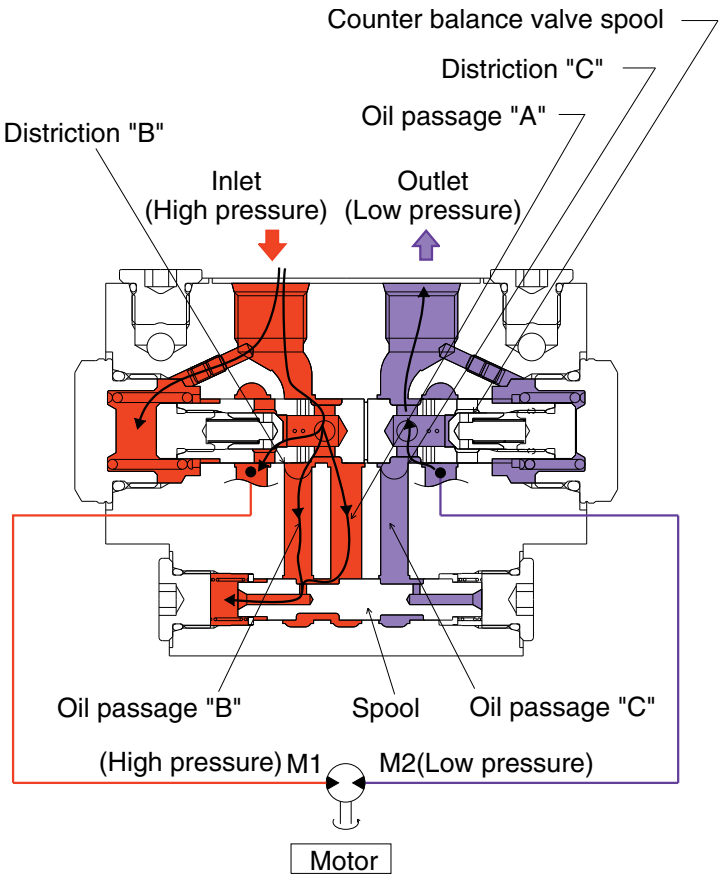


Hydraulic circuit

R35Z72TM17

(1) From stopping to starting

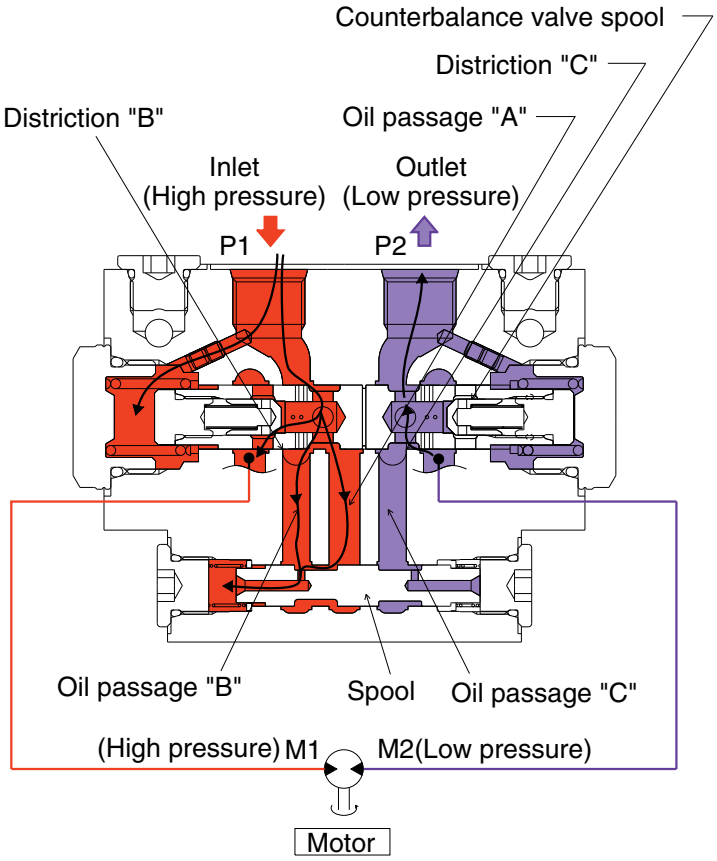
Counterbalance valve spool is moved to right position by the force of spring when port P1 is pressurized. According as the movement of spool, P1 connects to M1 and M2 connects to P2. Consequently the motor work. At the same time, oil passage A is selected high pressure, however, there is no oil flow to oil passage C because of the movement of spool.



R35Z72TM13

(2) Continuous rotating

At continuous rotating, high pressure is similiarly selected at oil passage A. However, there is no oil flow to oil passage C. So, anti cavitation valve has no influence during motor operation.

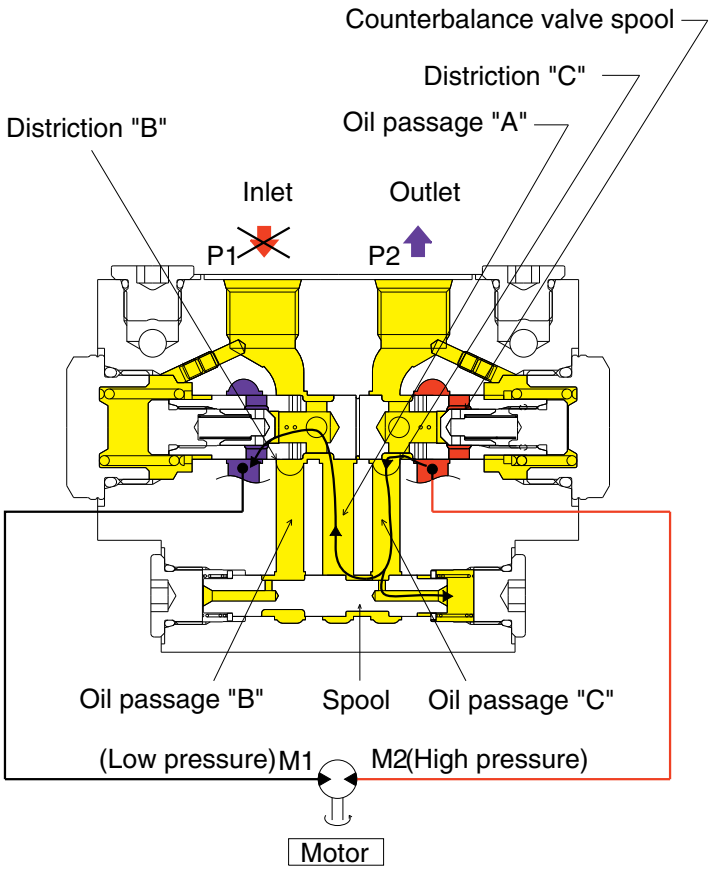


R35Z72TM14

(3) From continuous rotating to deceleration

At deceleration, the motor is still rotated by inertia. The oil flows M2 port to P2 port while counter balance valve is opened. Then, if the flow to P1 is not enough, the cavitation could be appeared in P1-M1 line.

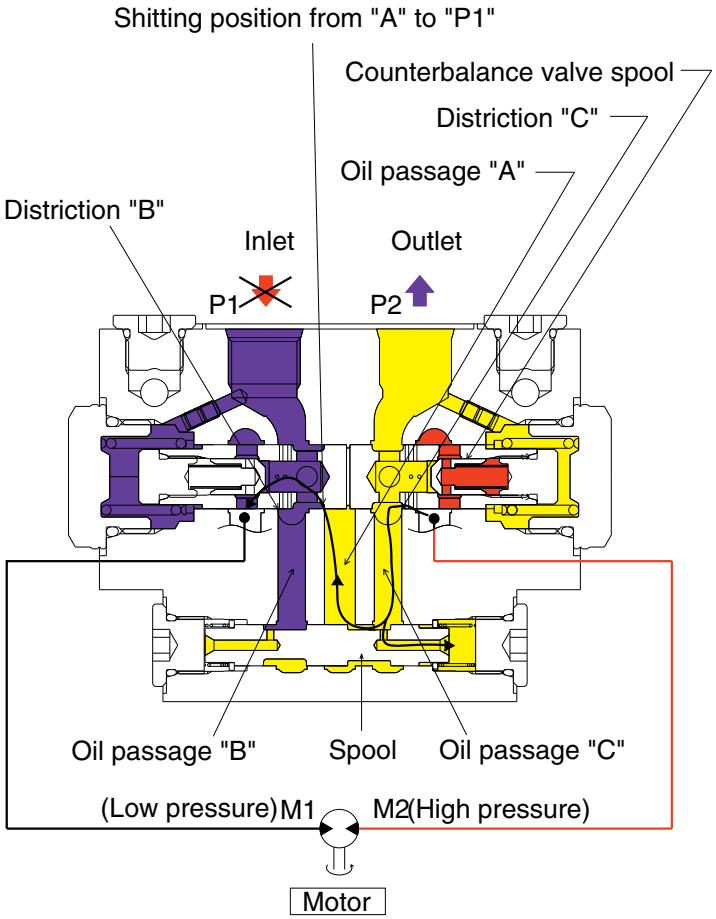
Anti cavitation valve can make a oil passage like M2 → C → spool → A → P1 → M1 and supply flow before counter balance valve spool is returned. Consequently the cavitation is reduced by the above function.



R35Z72TM15

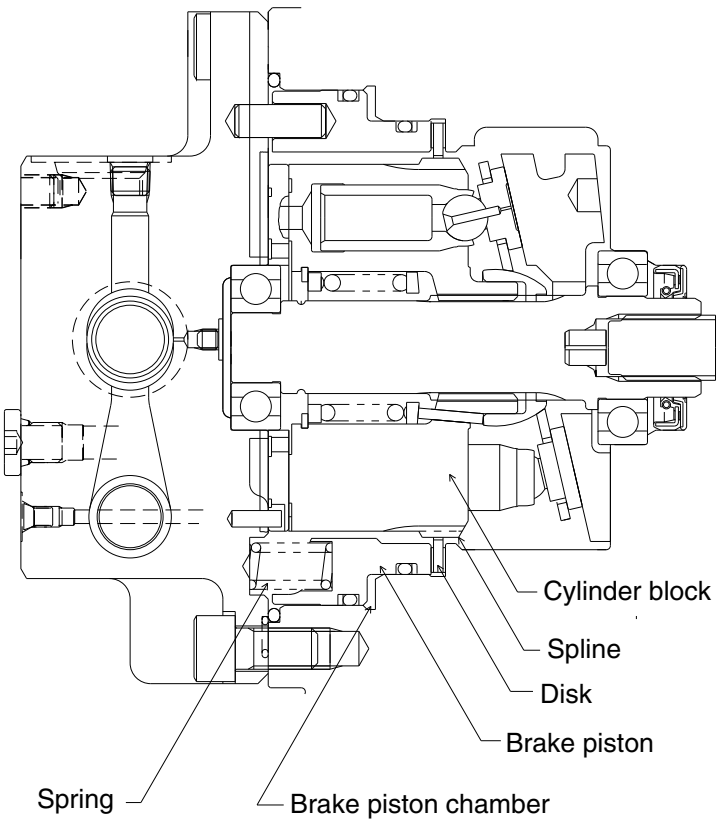
(4) From deceleration to stopping

Anti cavitation valve works until oil passage from A to P1 is shut.



R35Z72TM16

6) PARKING BRAKE

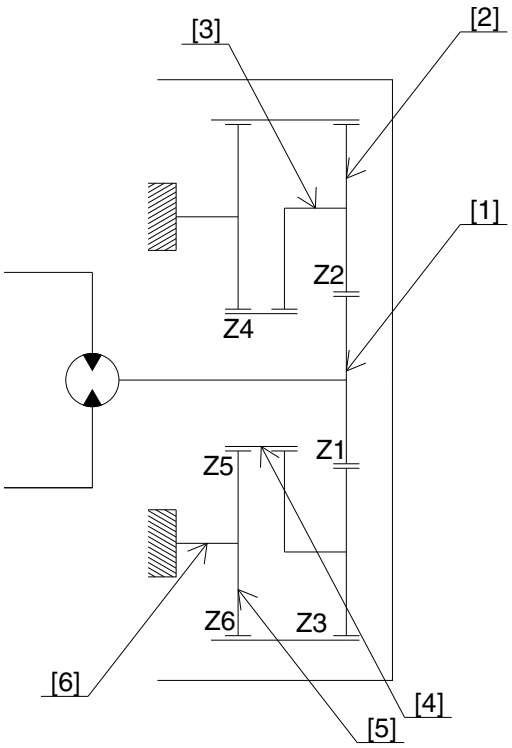


R35Z72TM18

The parking brake is a negative brake consisting of disk, brake piston and spring.
The cylinder block and the disk are combined with a spline, and friction material is bonded on both sides of disk. The disk generates frictional force between the flange holder and the brake piston by the force of spring and restricts the rotating force of the motor, achieving the best performance of the parking brake.
When the pressurized oil flows into the motor, the plunger moves and the parking brake release port is opened. After the oil flows into brake piston chamber, the thrust F is generated, corresponding to the pressure receiving area of brake piston and the thrust F becomes larger than the force of spring f, consequently the brake piston moves toward right.
Then, the disk rotates freely between the flange holder and brake piston, and parking brake is released.
When the motor is stopped, the plunger returns to the neutral position and the parking brake release port is closed. Consequently the pressurized oil in brake piston chamber flows into motor case, the parking brake acts by the force of spring.

7) REDUCTION UNIT

The reduction unit consists of double stage planetary gear mechanism.



R35Z72TM19

Drive gear[1] is engaged with the 1st planetary gear [2], 2nd stage sun gear [4] is engaged with the 2nd planetary gear [5]. The 2nd stage planetary carrier [6] is fixed machine body. Planetary gears [2], [5] are engaged with ring gear (housing).

The driving force form the piston motor is transmitted to drive gear [1], and the speed is reduced by each gear.

The reduced driving force is transmitted to ring gear through planetary gear [5] of planetary carrier [6] fixed on the machine body. (The driving force is also transferred from 1st stage planetary gear [2]). The direction of output rotation are reversed against that of input rotation.

The reduction gear ratio " i " is shown as follows.

※ Reduction gear ratio (i)

$$I = (i1 \times i2\text{-}1) = \left(\frac{Z1+Z3}{Z1} \times \frac{Z4+Z6}{Z4} \text{-}1 \right)$$

※ Output torque of reduction unit (T)

$$T = TM \times i \times \eta M$$

Z1 : Drive gear teeth number
Z2 : Ring gear teeth number
Z4 : Sun gear teeth number
Z6 : Ring gear teeth number

※ Reduction gear output rotating speed (N)

$$N = \frac{NM}{i}$$

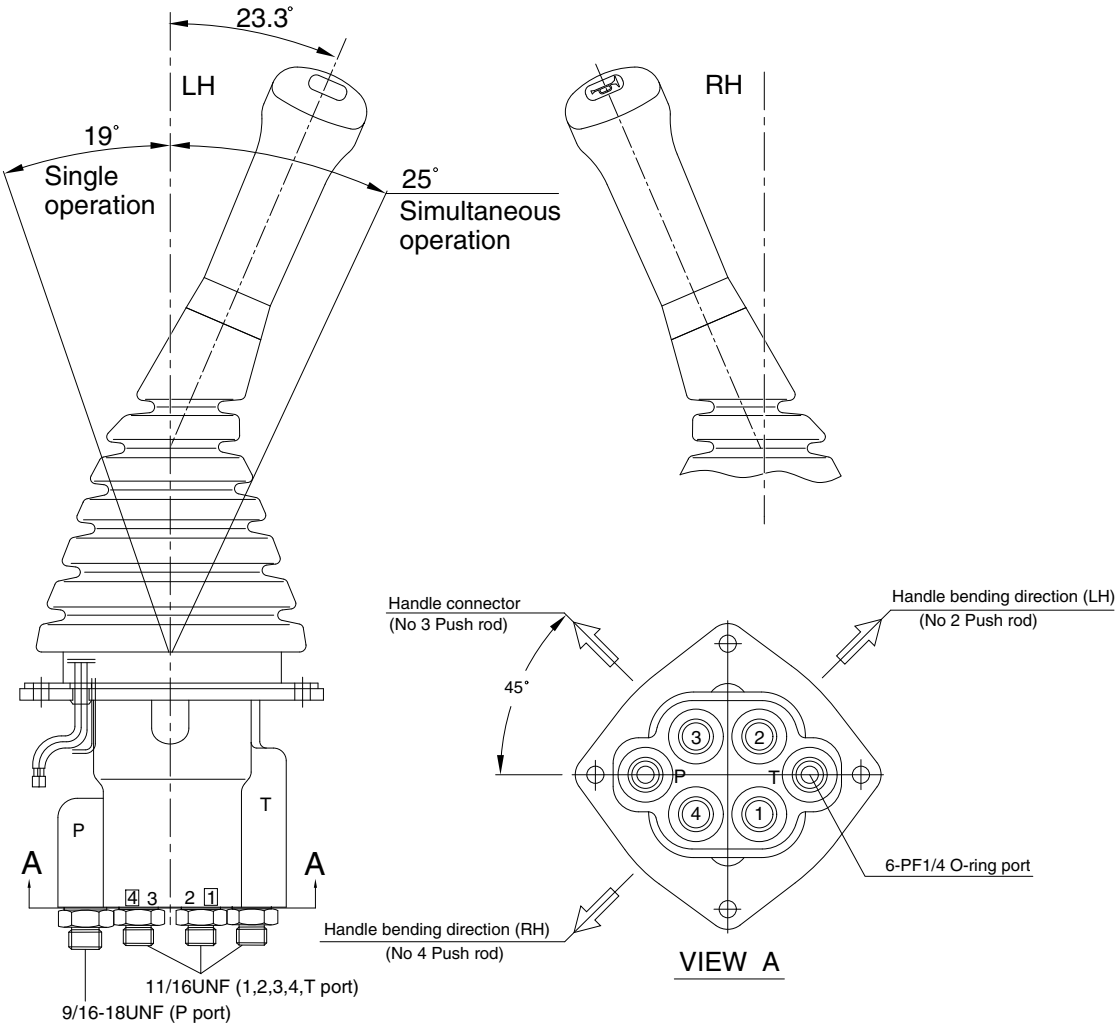
TM : Input torque (motor output torque)
i : Reduction gear ratio
η M : Mechanical efficiency
NM : Input speed of rotation (output motor speed)

GROUP 5 RCV LEVER

■ TYPE 1 (STD)

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.



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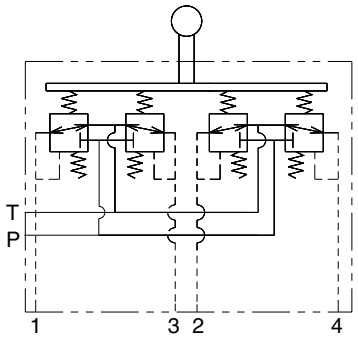


Hydraulic circuit

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 out port	Boom up port	
3	Right swing port	Bucket in port	
4	Arm in port	Boom down port	

CROSS SECTION

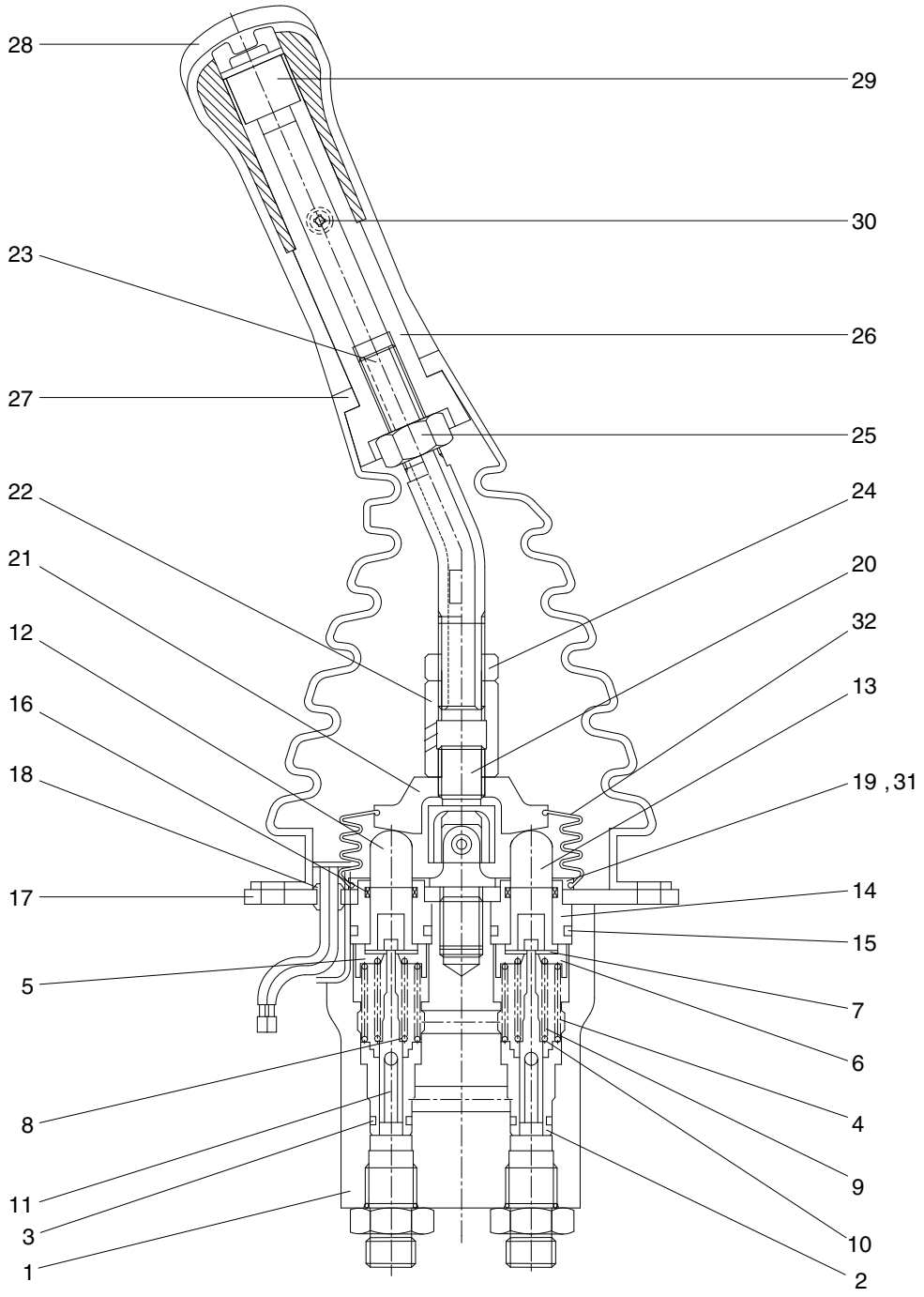
The construction of the pilot valve is shown in the attached cross section drawing. The casing has vertical holes in which reducing valves are assembled.

The pressure reducing section is composed of the spool (11), spring (8, 9) for setting secondary pressure, return spring (4), stopper (7), spring seat (5, 6) and spring seat (10). The spring for setting the secondary pressure has been generally so preset that the secondary pressure is 5 to 20.5 kgf/cm^2 (depending on the type). The spool is pushed against the push rod (12, 13) 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	12	Push rod (1, 3)	23	Connector
2	Plug	13	Push rod (2, 4)	24	Nut
3	O-ring	14	Plug	25	Nut
4	Spring	15	O-ring	26	Insert
5	Spring seat (1, 3)	16	Rod seal	27	Boot
6	Spring seat (2, 4)	17	Plate (A)	28	Handle
7	Stopper	18	Bushing	29	Switch assembly
8	Spring (1, 3)	19	Machine screw	30	Screw
9	Spring (2, 4)	20	Joint assembly	31	Plate
10	Spring seat	21	Swash plate	32	Boot
11	Spool	22	Hex nut		

CROSS SECTION



R25Z9A2RL02

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 (11) 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 (8, 9) works on this spool to determine the output pressure.

The change the deflection of this spring, the push rod (12, 13) is inserted and can slide in the plug (14).

For the purpose of changing the displacement of the push rod through the switch plate (21) and adjusting nut (22) are provided the handle (28) that can be tilted in any direction around the fulcrum of the universal joint (20) center.

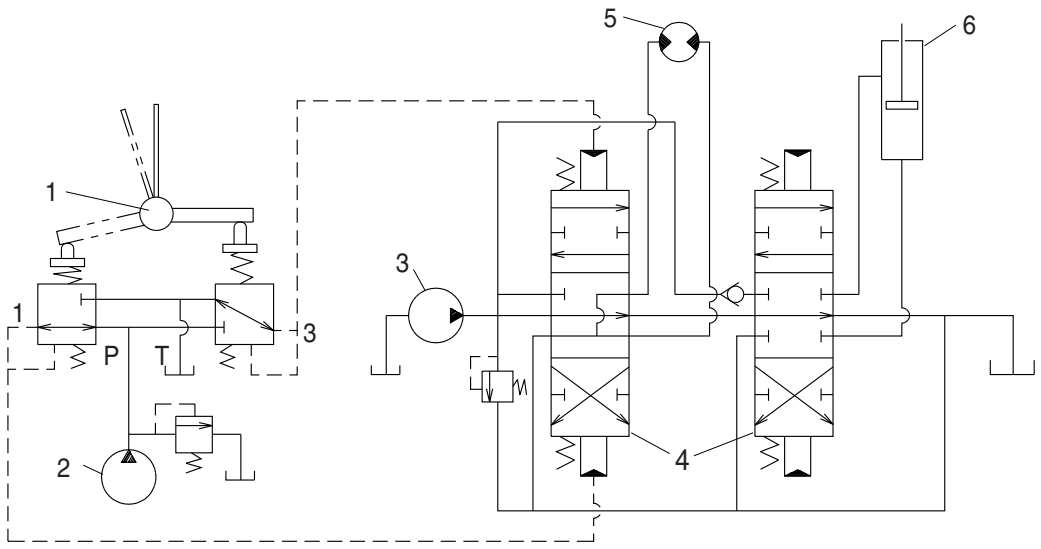
The spring (4) works on the case (1) and spring seat (5, 6) and tries to return the push rod (12, 13) to the zero-displacement position irrespective of the output pressure, securing its resetting to the center position.

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

3) OPERATION

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

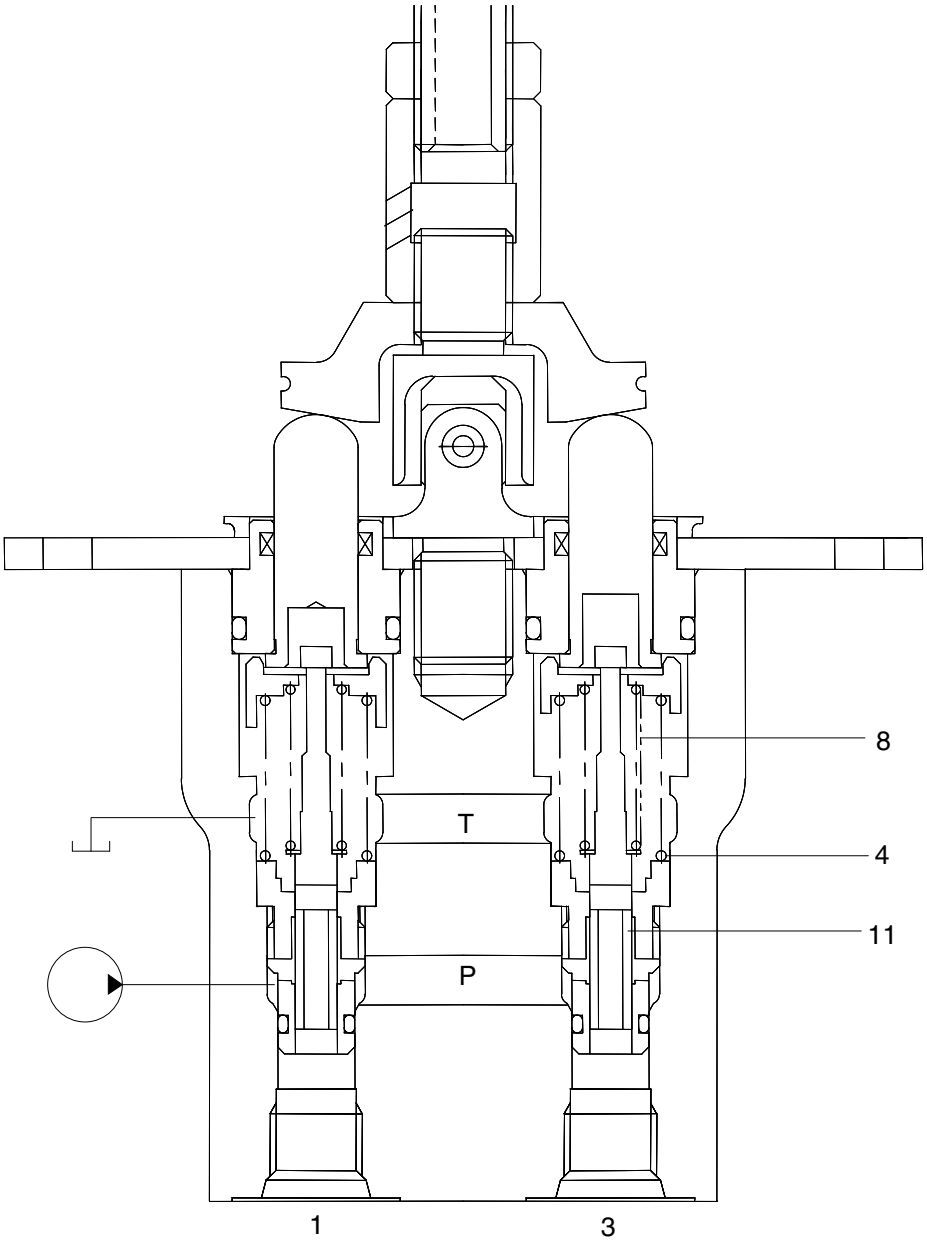
The diagram shown below is the typical application example of the pilot valve.



2-70 (140-7TIER)

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

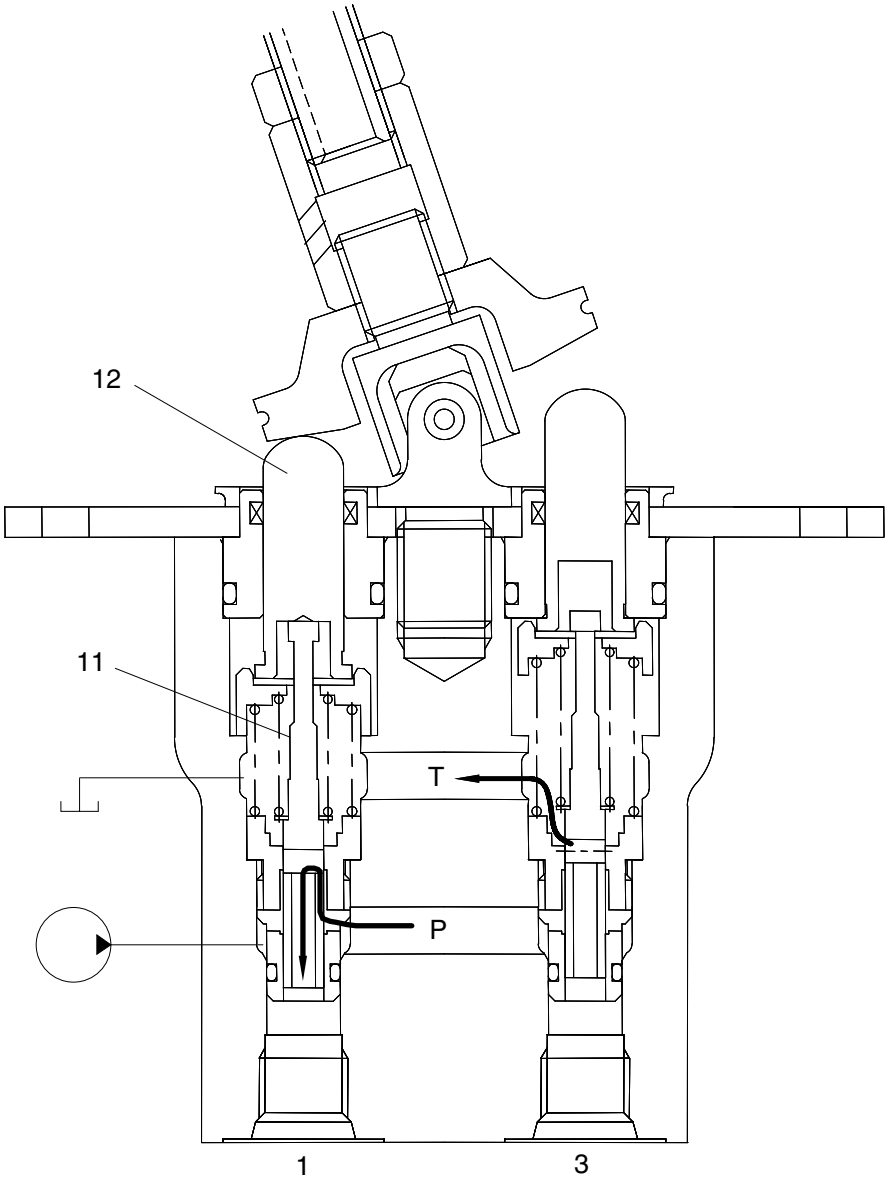
(1) Case where handle is in neutral position



R35Z72RL03

The force of the spring (8) that determines the output pressure of the pilot valve is not applied to the spool (11). Therefore, the spool is pushed up by the spring (4) 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

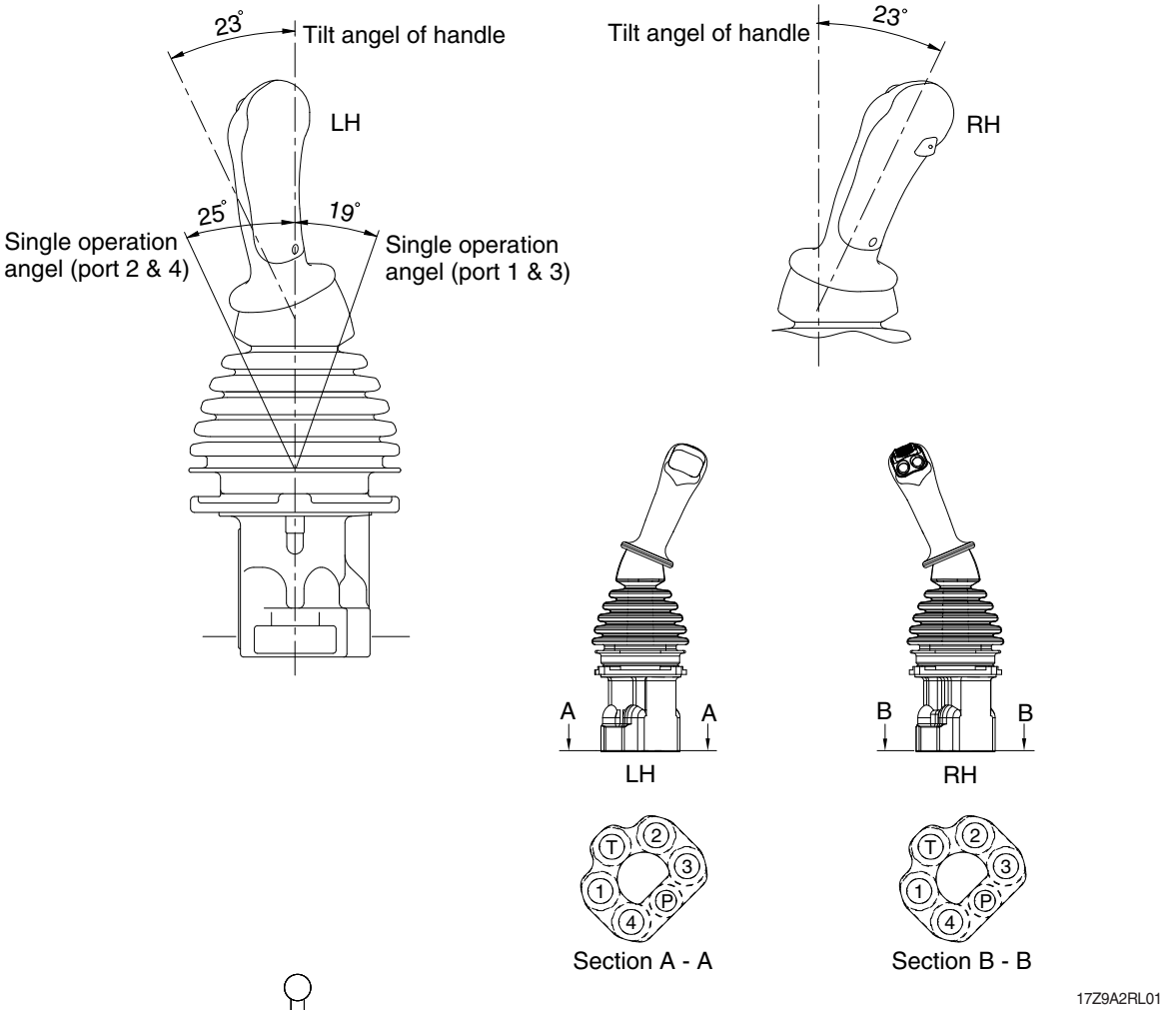


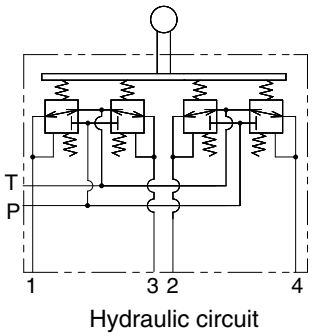
When the push rod (12) is stroked, the spool (11) moves downwards.
Then port P is connected with port (1) and the oil supplied from the pilot pump flows through port (1) to generate the pressure.
When the pressure at port (1) increases to the value corresponding to the spring force set by tilting the 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.

■ TYPE 2 (OPT)

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.

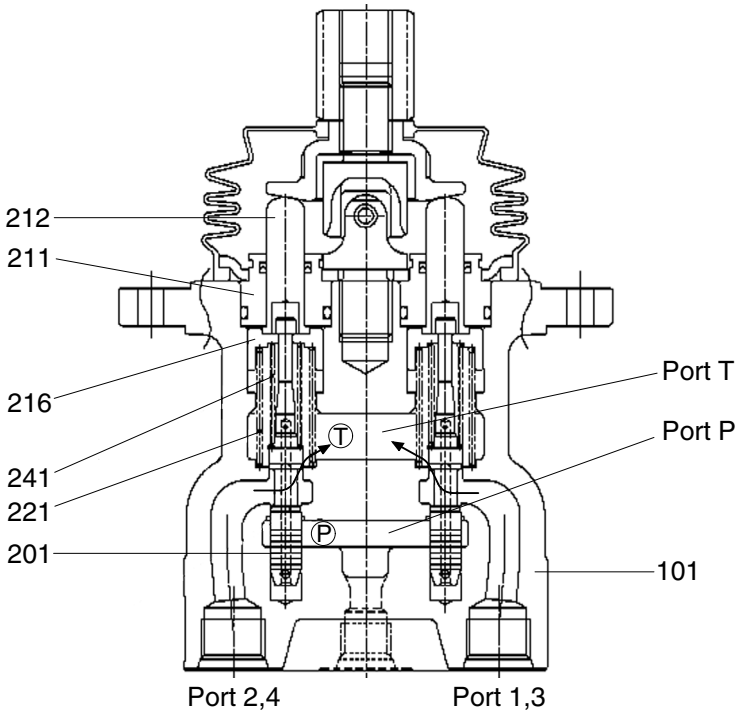




Hydraulic circuit

Port	LH	RH (with proportional)	Port size
P	Pilot oil inlet port	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	Pilot oil return port	PF 3/8
1	Left swing port	Bucket out port	
2	Arm out port	Boom down port	
3	Right swing port	Bucket in port	
4	Arm in port	Boom up port	

CROSS SECTION



17Z9A2RL02

101 Casing
201 Spool
211 Plug
212 Push rod
216 Spring seat
221 Return spring
241 Secondary pressure setting spring

The structure of the remote control valve is as shown in the assembly. There is a vertical axial hole in the casing and the reduction valves are inserted into this.

The secondary pressure setting spring (241) is set such that the secondary pressure is calculated as 5.1~10.2 kgf/cm^2. Spool (201) is pushed onto the push rod (212) by return spring (221).
Tilting the control handle pushes down push rod (212), the spring seat (216) also moves down and the setting of the secondary pressure setting spring (241) is changed.
Port P, oil inlet (primary pressure) and port T outlet (tank) are in the casing (101).

2. PERFORMANCE

1) BASIC PERFORMANCE

The remote control valve controls the stroke and direction of the control valve spools. This is achieved by the output pressure of the remote control valve acting on the tip of the control valve spool.

To achieve satisfactory performance, the remote control valve comprises the following elements :

(1) An inlet port (P) for oil fed from the hydraulic pump.

(2) Multiple output ports (1, 2, 3 and 4) to allow pressure from the inlet port to act on the spool tips of the control valve.

(3) A tank port (T) to control the output pressure.

(4) A spool to connect the output port to the inlet port or tank port.

(5) A mechanical assembly, which contains a spring which acts on the spool and controls the output pressure.

2) PERFORMANCE OF THE MAIN PARTS

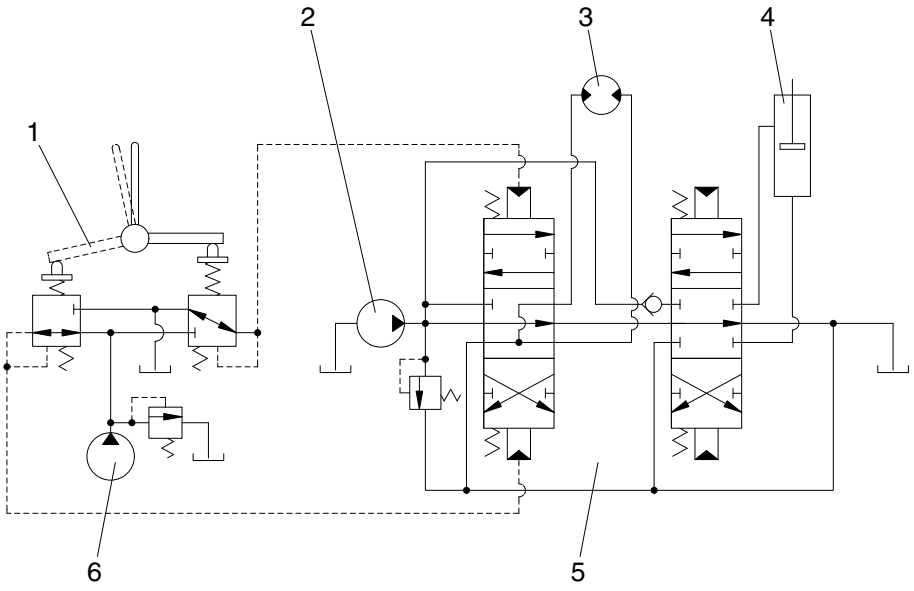
The spool (201) operates to take the supply oil pressure from the hydraulic pump. This switches the oil channel so that the port P oil pressure is directed to the output ports 1, 2, 3, 4 or to port T. The secondary pressure setting spring (241) determines the output pressure that acts on the spool (201).

The push-rod (212), which changes the strain of the secondary pressure setting spring (241), is inserted so that it can move smoothly into the plug (211).

The return spring (221) acts to return the push-rod (212) towards zero displacement without reference to the output pressure acting on the spring seat (216) and casing (101). This acts to ensure the return to neutral of the spool (201) and also acts as a resistance spring to provide the operator with an appropriate operating "feel".

3) OPERATION

The operation of the remote control valve is described in the hydraulic circuit plan and operation explanatory figures (see figures RL04, 05 and 06). The below figure shows a typical example of the use of the remote control valve.



17Z9A2RL03

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

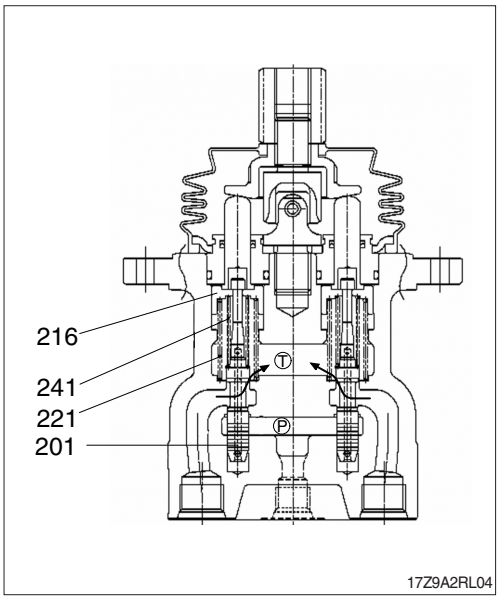
(1) Control handle neutral

The force of the secondary pressure setting spring (241) (which determines the output pressure of the pilot valve) does not act on the spool (201).

Spool (201) is pressed upward by the return spring (221) and spring seat (216) .

Output ports (2, 4) and port T are open.

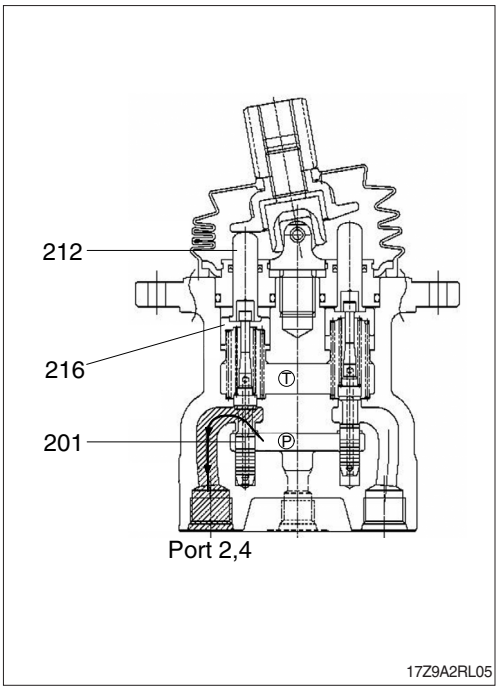
The output pressure is the same as the tank pressure.



17Z9A2RL04

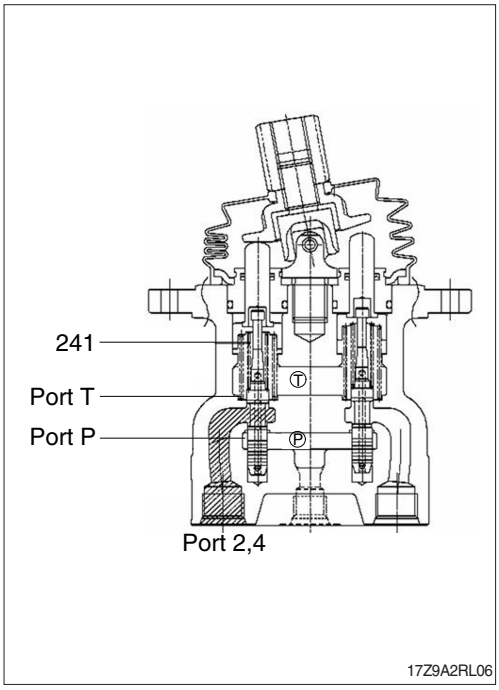
(2) Control handle tilted

The push-rod moves, (spring seat (216)), spool (201) moves downward, port P and ports (2, 4) are open and the oil fed from the pilot pump flows to ports (2, 4) and generates pressure.



(3) Control handle held

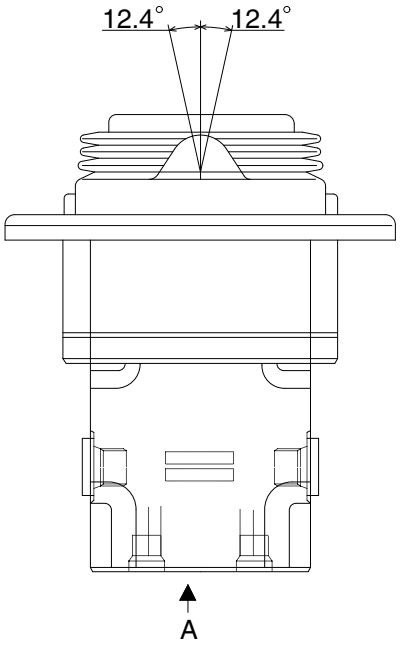
The pressure of ports (2, 4) rises to become equal to the spring (241) force; the oil pressure and spring pressures become balanced. If the pressure of ports (2, 4) exceeds the set pressure, ports (2, 4) and port P close, ports (2, 4) and port T open. If the pressure of ports (2, 4) falls below the set pressure, ports (2, 4) and port P open and ports (2, 4) and port T close. The secondary pressure is kept constant.

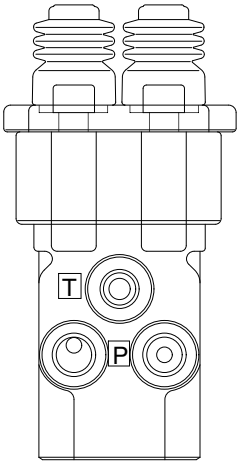


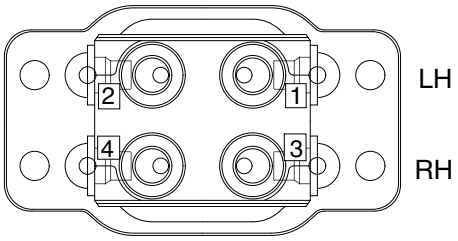
GROUP 6 RCV PEDAL

1. STRUCTURE

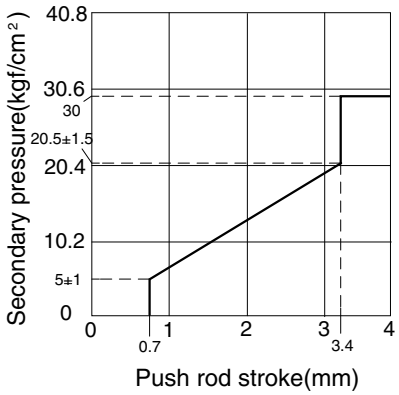
The casing has the oil inlet port P (primary pressure), and the oil outlet port T (tank). In addition the secondary pressure is taken out through ports 1, 2, 3 and 4 provided at the bottom face.



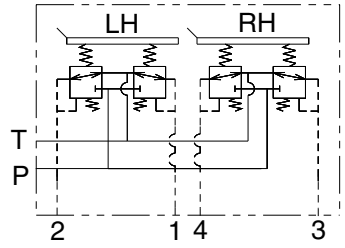




VIEW "A"



R35Z72RCP01



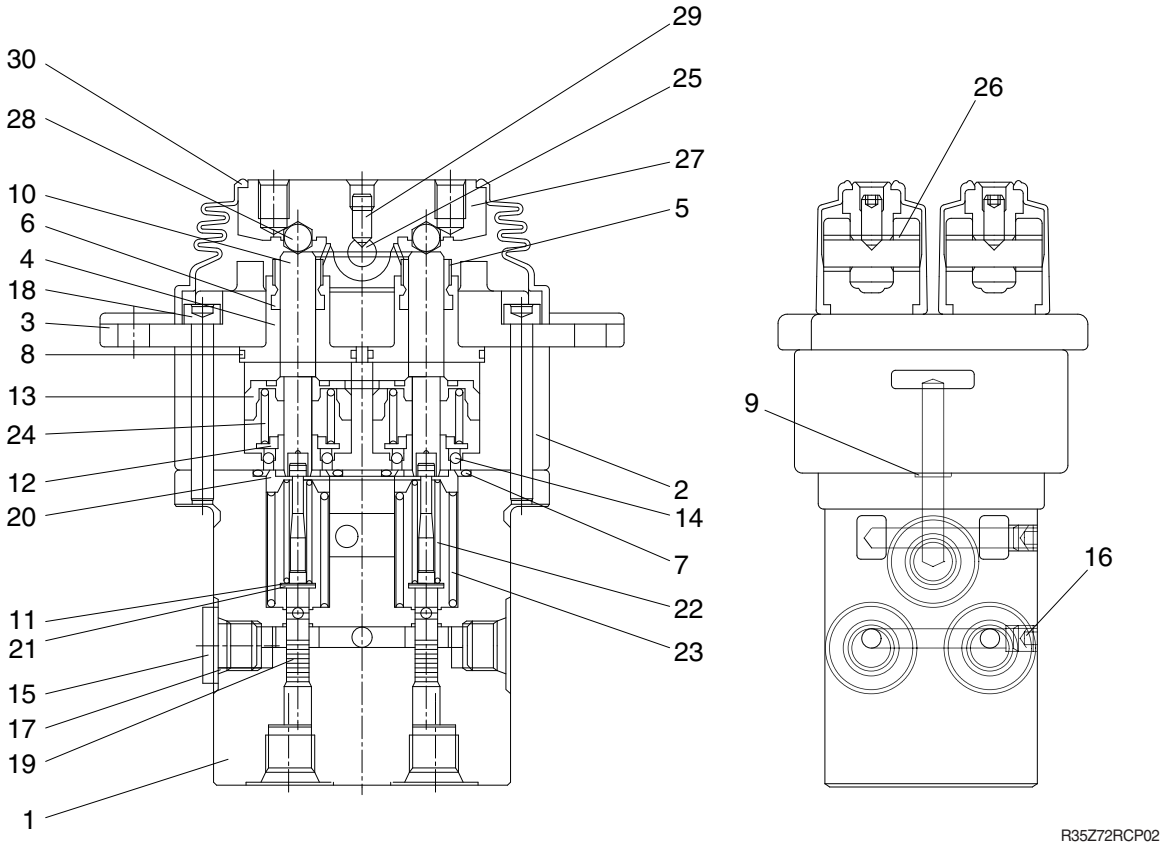
Port	Port name	Port size
P	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	
1	Travel (LH, backward)	
2	Travel (LH, forward)	
3	Travel (RH, backward)	
4	Travel (RH, forward)	

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 (19), spring (22) for setting secondary pressure, return spring (23), spring seat (20) and washer (21). 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 (10) 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.



R35Z72RCP02

1	Casing (1)	11	Shim	21	Washer
2	Casing (2)	12	Spring seat	22	Spring
3	Cover	13	Piston	23	Spring
4	Plug	14	Steel ball	24	Spring
5	Grease cap	15	Plug	25	Cam shaft
6	Packing	16	Plug	26	Bushing
7	O-ring	17	O-ring	27	Cam
8	O-ring	18	Hex soc head screw	28	Steel ball
9	O-ring	19	Spool	29	Set screw
10	Push rod	20	Spring seat	30	Bellows

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 (19) 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 (22) works on this spool to determine the output pressure.

The change the deflection of this spring, the push rod (10) is inserted and can slide in the plug (4).

For the purpose of changing th displacement of the push rod through the cam (27) and steel ball (28) are provided the pedal that can be tilted in any direction around the fulcrum of the cam (27) center.

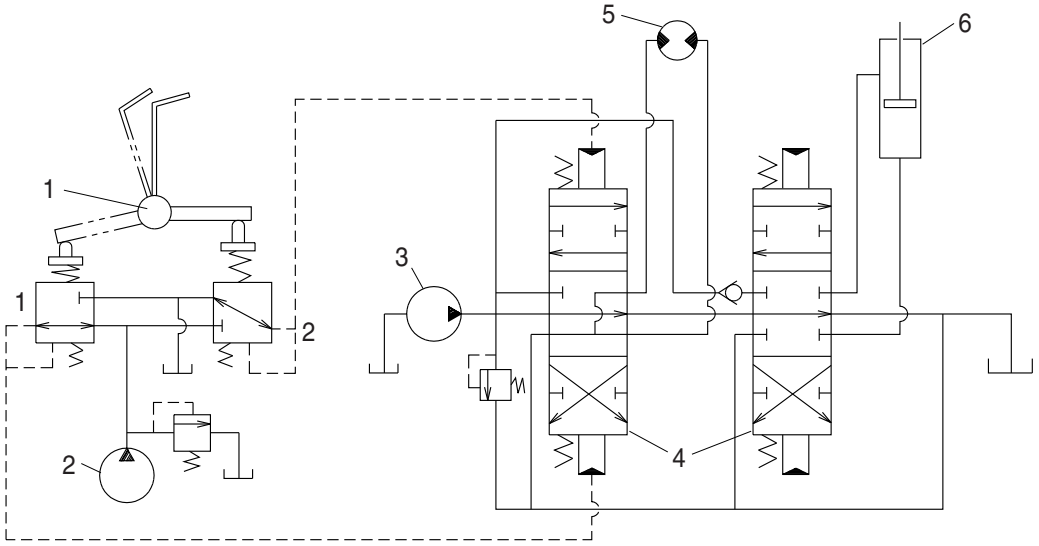
The spring (23) works on the casing (1) and washer (21) and tries to return the push rod (10) to the zero-displacement position irrespective of the output pressure, securing its resetting to the center position.

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.

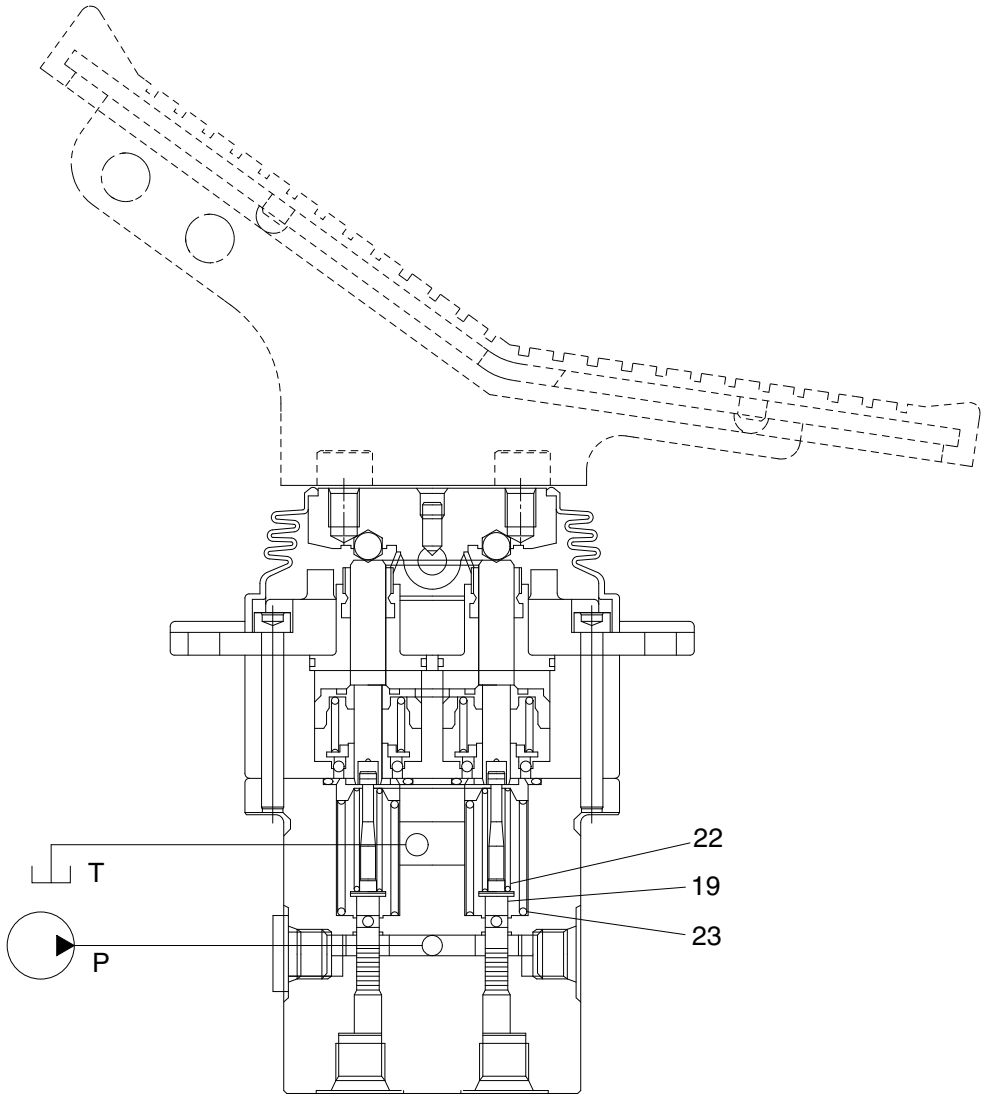
The diagram shown below is the typical application example of the pilot valve.



140LC-7 기타2-76

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

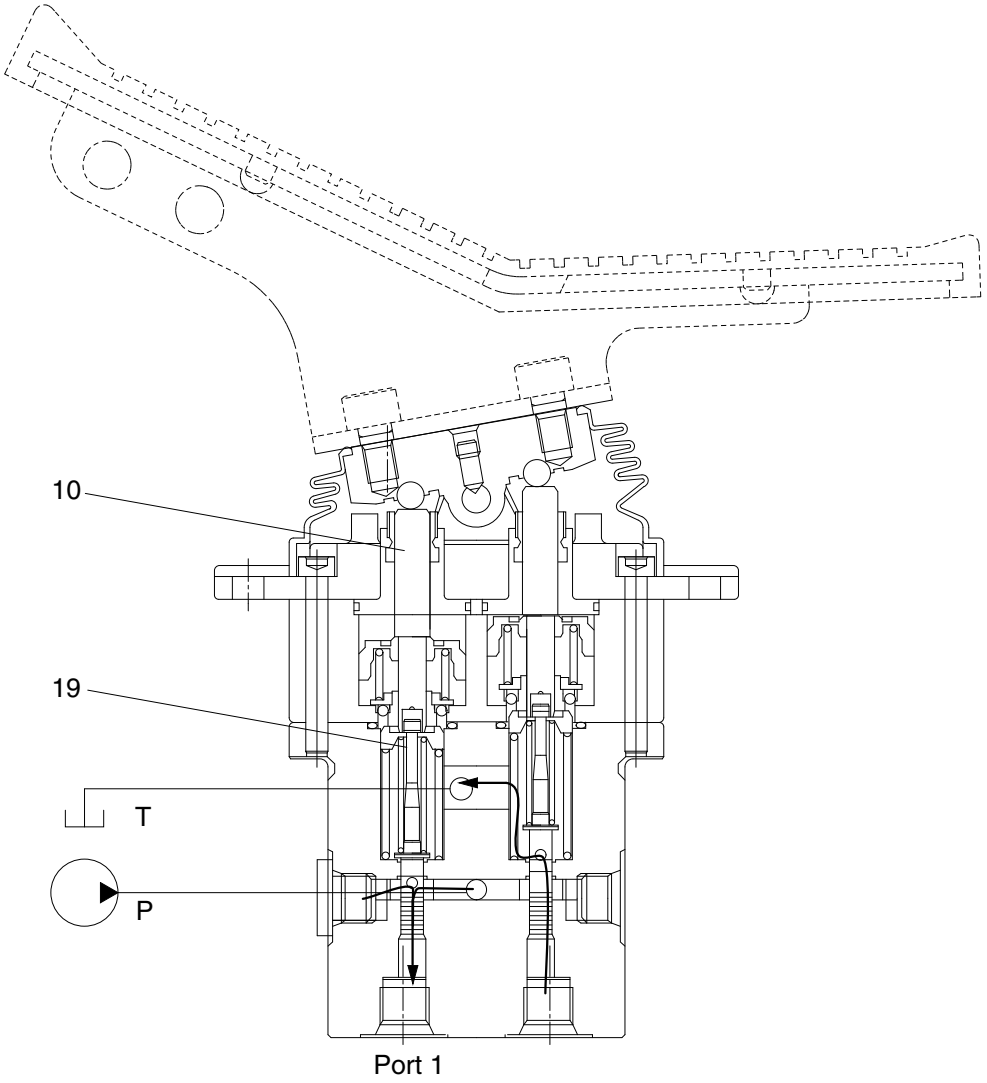
(1) Case where pedal is in neutral position



R35Z72RCP04

The force of the spring (22) that determines the output pressure of the pilot valve is not applied to the spool (19). Therefore, the spool is pushed up by the spring (23) 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



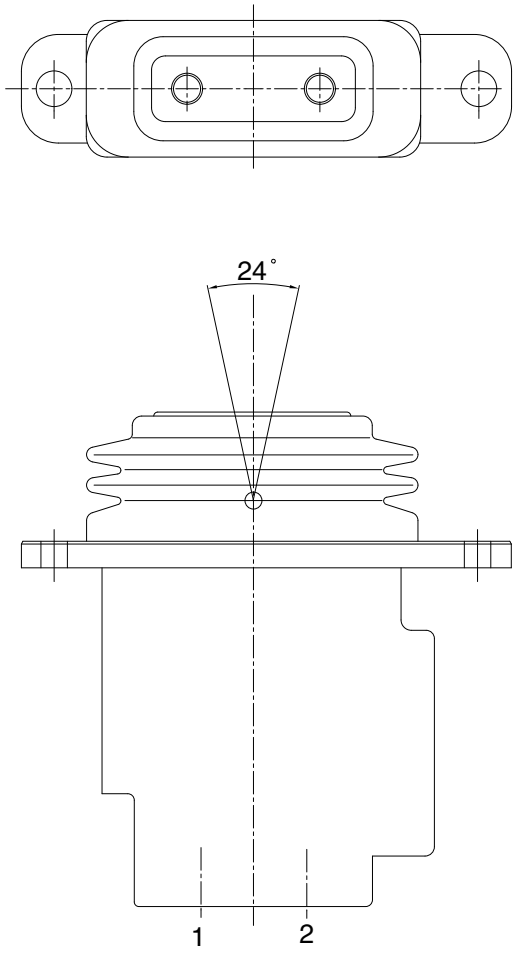
R35Z72RCP05

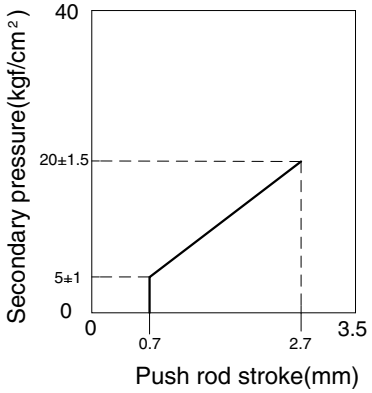
When the push rod (10) is stroked, the spool (19) moves downwards.
Then port P is connected with port 1, and the oil supplied from the pilot pump flows through port 1 to generate the pressure.
When the pressure at port 1 increases to the value corresponding to the spring force set by tilting the handle, 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.

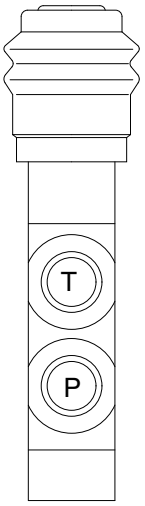
3. BOOM SWING PEDAL

1) STRUCTURE

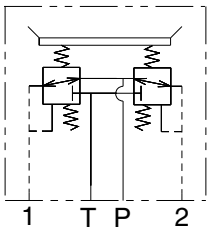
The casing has the oil inlet P (primary pressure) and the oil return port (tank).
In addition the secondary pressure is taken out through port 1 and port 2 provided at the housing bottom face.







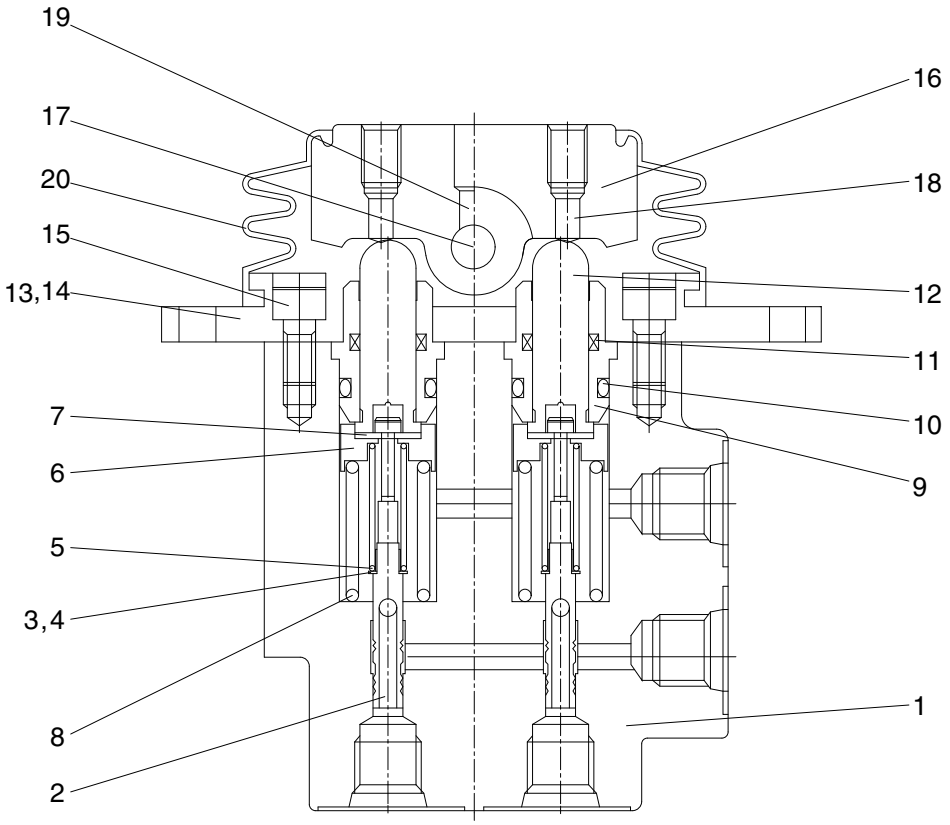
R35Z72RSP01



Hydraulic circuit

Port	Port name	Port size
P	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	
1	Boom swing (LH)	
2	Boom swing (RH)	

2) COMPONENT



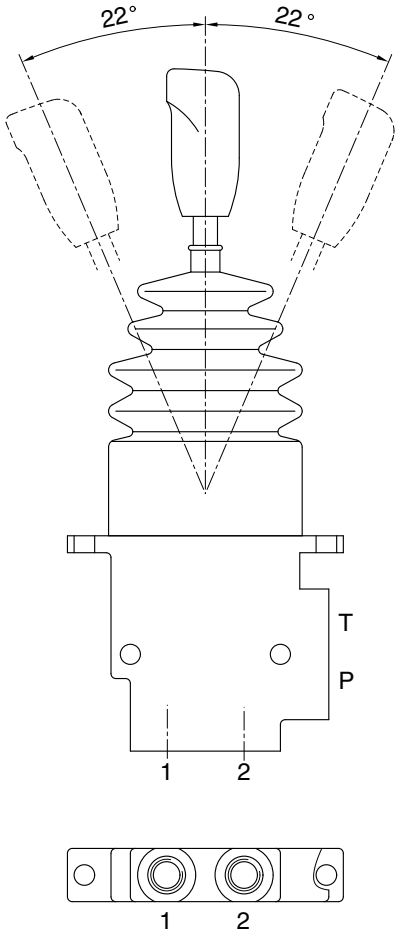
R35Z72RSP02

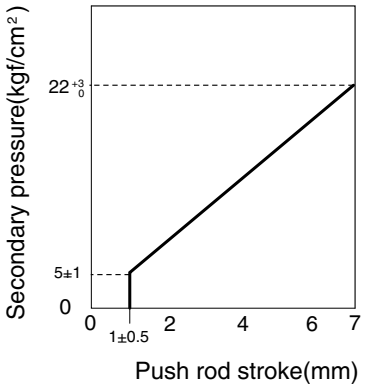
1	Body	8	Stopper	15	DU bush
2	Plug	9	Spring	16	Wrench bolt
3	O-ring	10	Plug	17	Cam
4	Spool	11	O-ring	18	Pin
5	Spring seat	12	Rod seal	19	Adjust screw
6	Spring	13	Push rod	20	Socket bolt
7	Spring seat	14	Cover	21	Bellows

4. DOZER LEVER

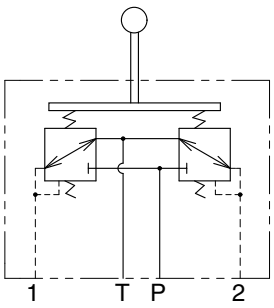
1) STRUCTURE

The casing has the oil inlet P (primary pressure) and the oil return port (tank).
In addition the secondary pressure is taken out through port 1 and port 2 provided at the housing bottom face.





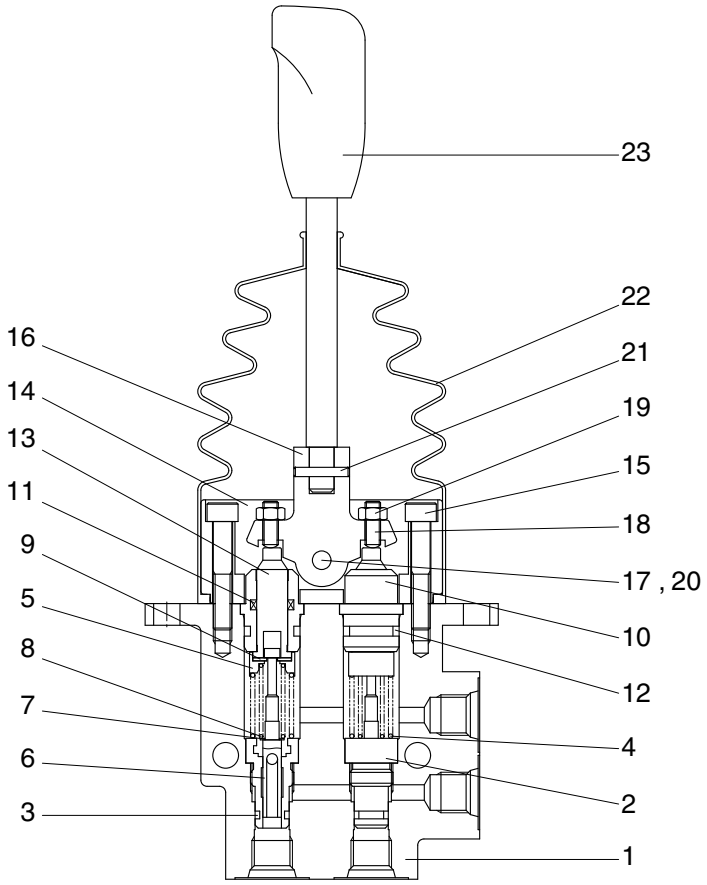
R35Z72DL01



Hydraulic circuit

Port	Port	Port size
P	Pilot oil inlet port	PF 1/4
T	Pilot oil return port	PF 1/4
1	Dozer blade up port	PF 1/4
2	Dozer blade down port	PF 1/4

2) COMPONENT



R35Z72DL02

1	Body	9	Stopper	17	Pin
2	Plug	10	Plug	18	Socket bolt
3	O-ring	11	Rod seal	19	Nut
4	Spring	12	O-ring	20	Snap ring
5	Spring seat	13	Push rod	21	Spring pin
6	Spool	14	Cover	22	Bellows
7	Spring seat	15	Wrench bolt	23	Lever
8	Spring	16	Guide		