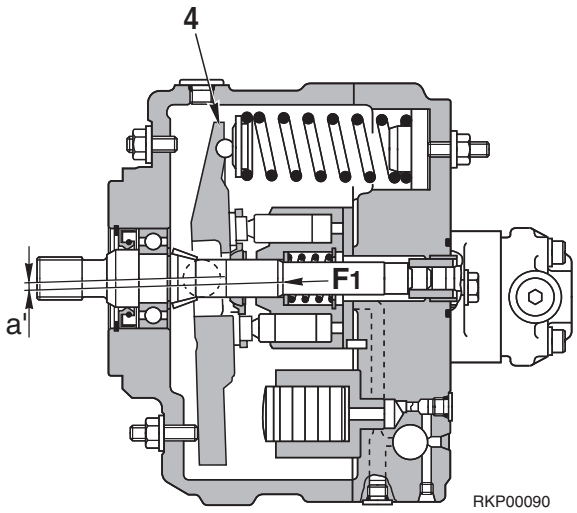
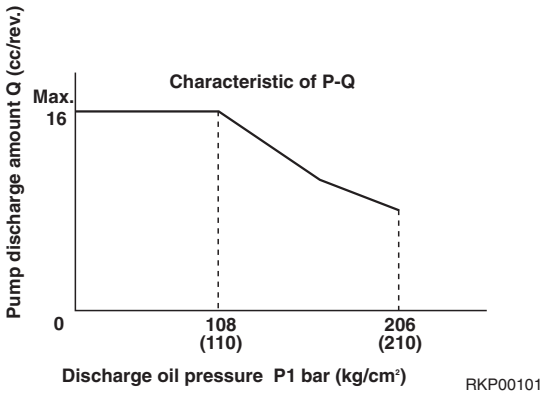
- If the discharge pressure rises further, the angle of swash plate (4) becomes smaller. When this happens, the length of the arm applying total piston force **F1** is reduced from **a** to **a'**, so a larger force **F1** is needed for the angle of swash plate (4).

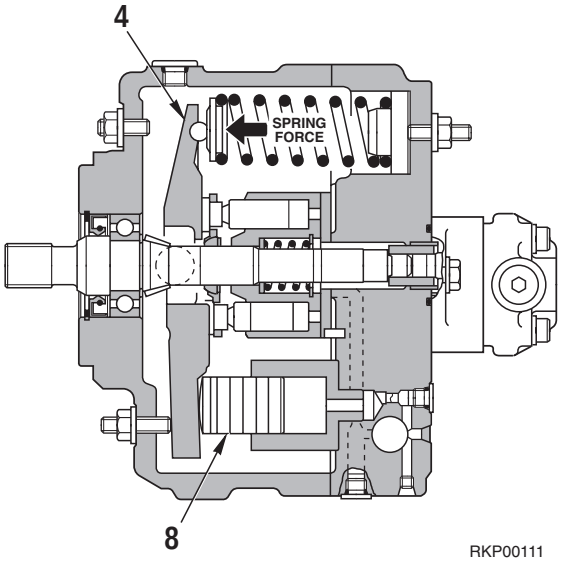


- Is this way, curve **P - Q** becomes a curve (constant horsepower control) which gives effective use of the engine horsepower.



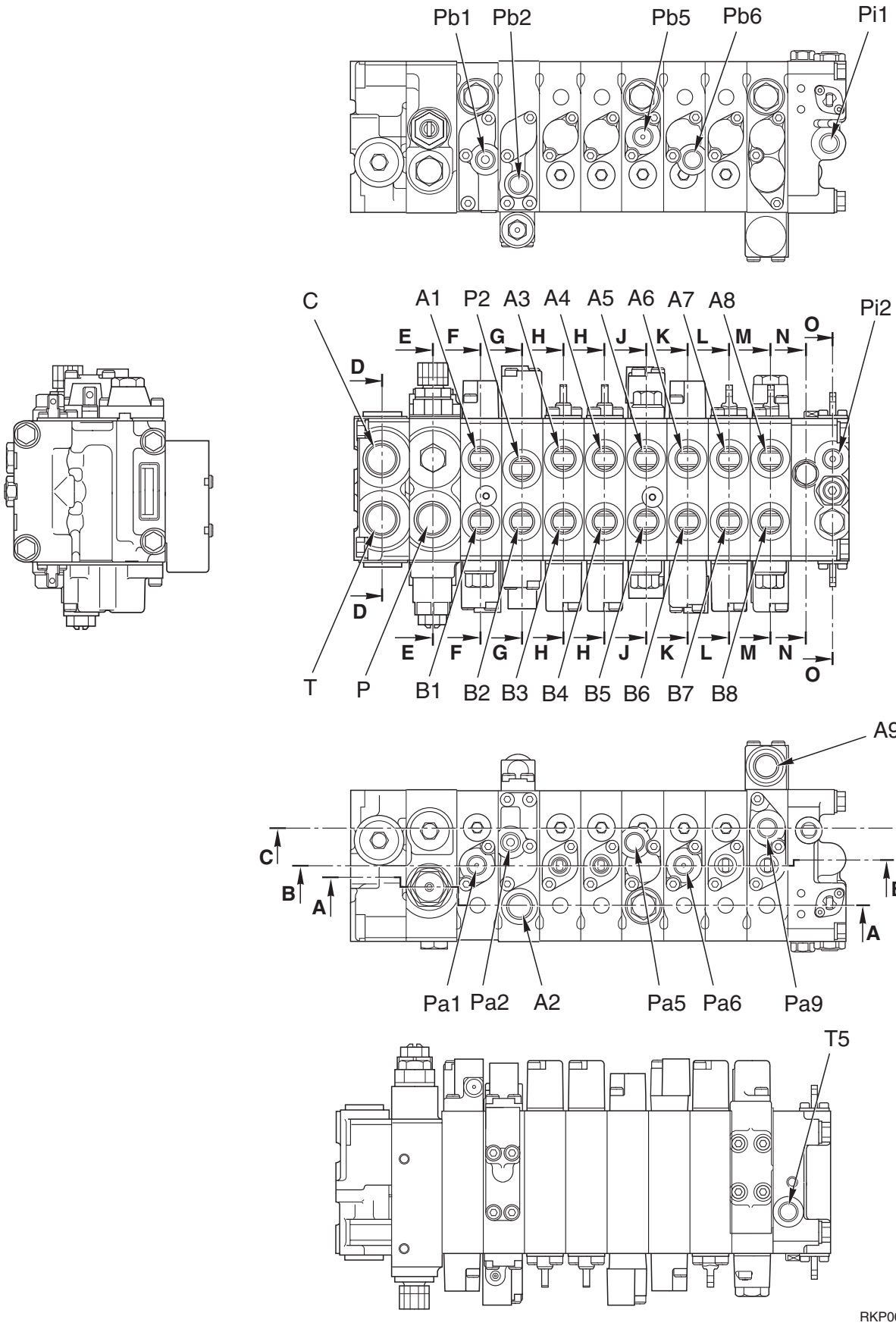
3. Load response control

- When carrying out load response control, the signal pressure from the **LS** valve is transmitted to control piston (8), and control piston (8) pushes swash plate (4). The angle of swash plate (4) changes to a point where this force is balanced with the total force of the spring and piston, so the discharge amount changes.
- Constant horsepower control is carried out with priority over load response control, so the discharge amount changes in the range below the flow at constant horsepower control.



CONTROL VALVE

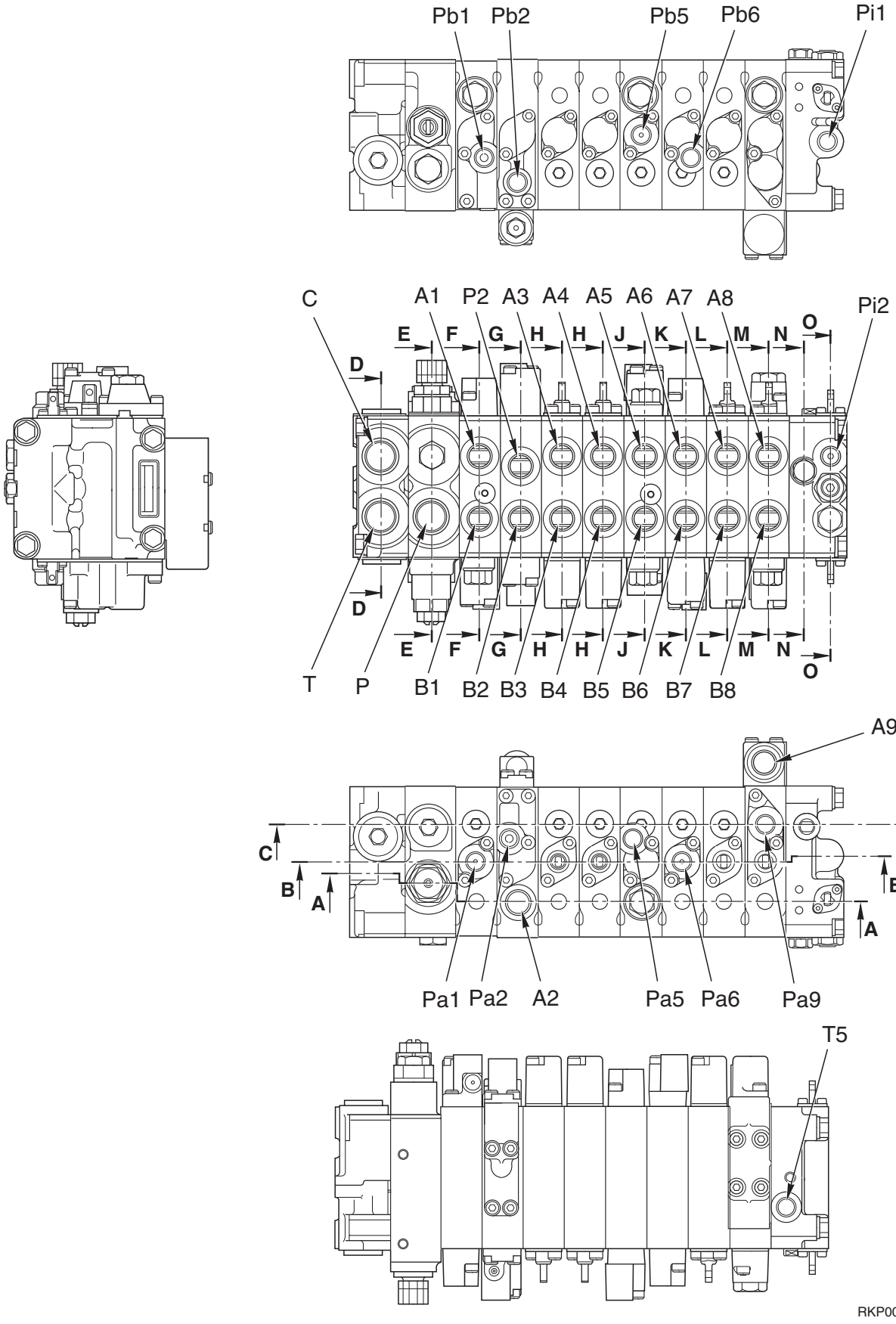
PC12R-8
PC12R-8 MISTRAL (with travel increment)



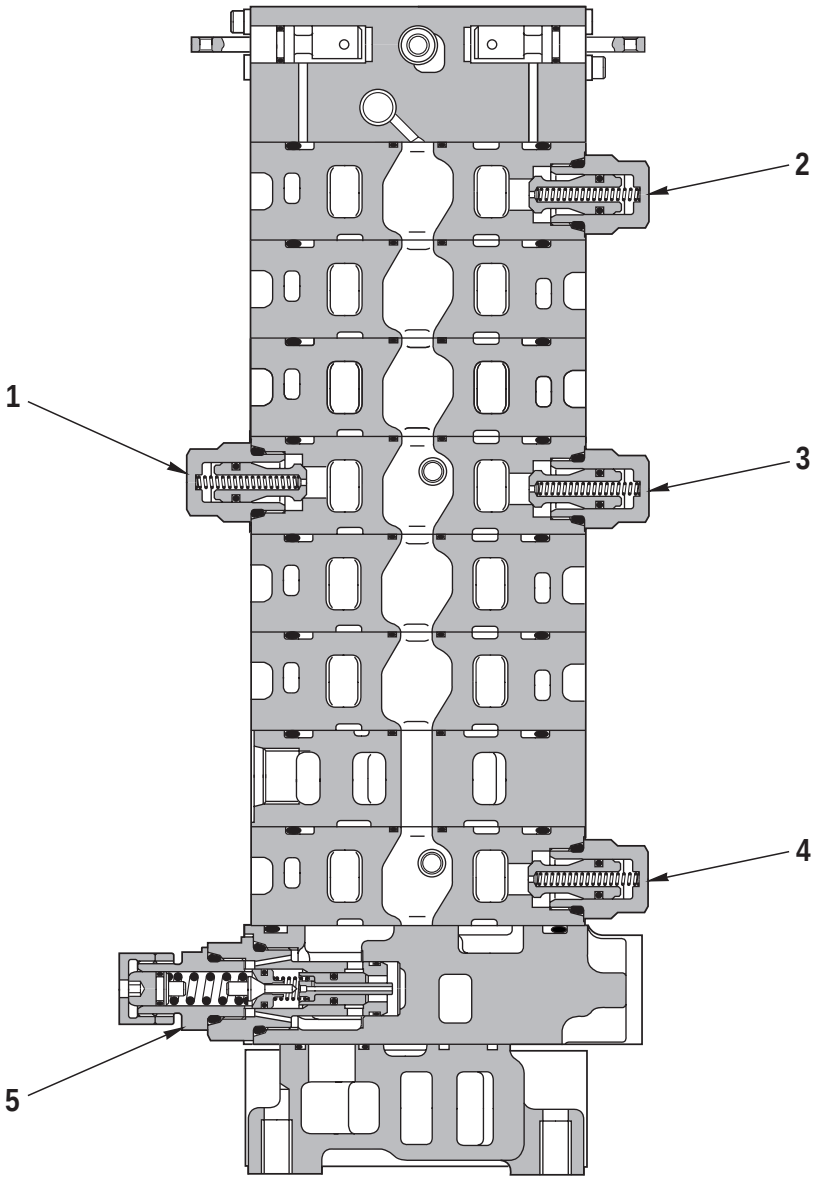
A1 Port - To arm cylinder (Head side)
A2 Port - To swing motor (A Port)
A3 Port - To swivel joint (D Port)
A4 Port - To swivel joint (C Port)
A5 Port - To boom cylinder (Bottom side)
A6 Port - To bucket cylinder (Bottom side)
A7 Port - To swivel joint (F Port)
A8 Port - To boom swing cylinder (Head side)
A9 Port - To attachment
B1 Port - To arm cylinder (Bottom side)
B2 Port - To swing motor (B Port)
B3 Port - To swivel joint (B Port)
B4 Port - To swivel joint (A Port)
B5 Port - To boom cylinder (Head side)
B6 Port - To bucket cylinder (Head side)
B7 Port - To swivel joint (E Port)
B8 Port - To boom swing cylinder (Bottom side)
C Port - To oil cooler
P Port - From hydraulic pump (P Port)
Pa1 Port - From L.H. PPC valve (4 Port)
Pa2 Port - From L.H. PPC valve (1 Port)
Pa5 Port - From R.H. PPC valve (2 Port)
Pa6 Port - From R.H. PPC valve (1 Port)
Pa9 Port - From attachment PPC valve
Pb1 Port - From L.H. PPC valve (2 Port)
Pb2 Port - From L.H. PPC valve (3 Port)
Pb5 Port - From R.H. PPC valve (4 Port)
Pb6 Port - From R.H. PPC valve (3 Port)
Pi1 Port - From hydraulic pump (P3 Port)
Pi2 Port - To ST1 solenoid valve (P Port)
P2 Port - From hydraulic pump (P2 Port)
T Port - To hydraulic tank
TS Port - To hydraulic tank

CONTROL VALVE

PC12R-8 HS (with variable gauge undercarriage)
PC12R-8 MISTRAL HS (with variable gauge undercarriage and travel increment)

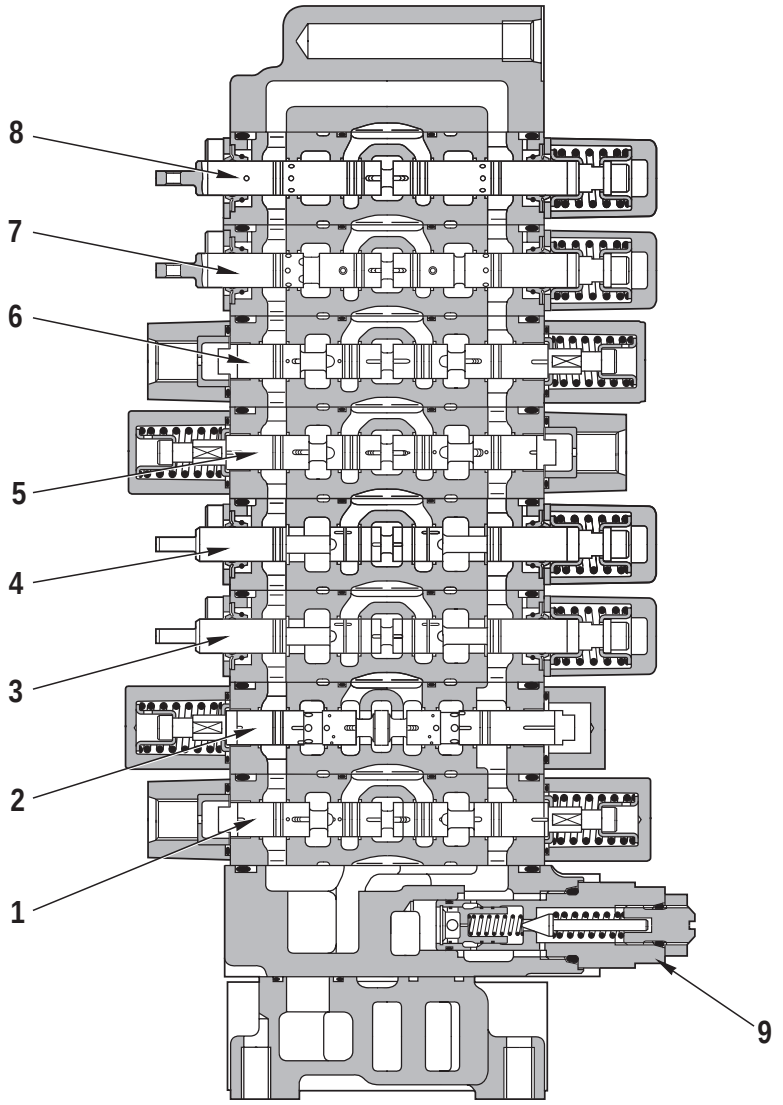


A1 Port - To arm cylinder (Head side)
A2 Port - To swing motor (A Port)
A3 Port - To swivel joint (5 Port)
A4 Port - To swivel joint (6 Port)
A5 Port - To boom cylinder (Bottom side)
A6 Port - To bucket cylinder (Bottom side)
A7 Port - To swivel joint (3 Port)
A8 Port - To boom swing cylinder (Head side)
A9 Port - To attachment
B1 Port - To arm cylinder (Bottom side)
B2 Port - To swing motor (B Port)
B3 Port - To swivel joint (7 Port)
B4 Port - To swivel joint (4 Port)
B5 Port - To boom cylinder (Head side)
B6 Port - To bucket cylinder (Head side)
B7 Port - To EV3 solenoid valve (P Port)
B8 Port - To boom swing cylinder (Bottom side)
C Port - To oil cooler
P Port - From hydraulic pump (P Port)
Pa1 Port - From L.H. PPC valve (4 Port)
Pa2 Port - From L.H. PPC valve (1 Port)
Pa5 Port - From R.H. PPC valve (2 Port)
Pa6 Port - From R.H. PPC valve (1 Port)
Pa9 Port - From attachment PPC valve
Pb1 Port - From L.H. PPC valve (2 Port)
Pb2 Port - From L.H. PPC valve (3 Port)
Pb5 Port - From R.H. PPC valve (4 Port)
Pb6 Port - From R.H. PPC valve (3 Port)
Pi1 Port - From hydraulic pump (P3 Port)
Pi2 Port - To ST1 solenoid valve (P Port)
P2 Port - From hydraulic pump (P2 Port)
T Port - To hydraulic tank
TS Port - To hydraulic tank



Section A - A

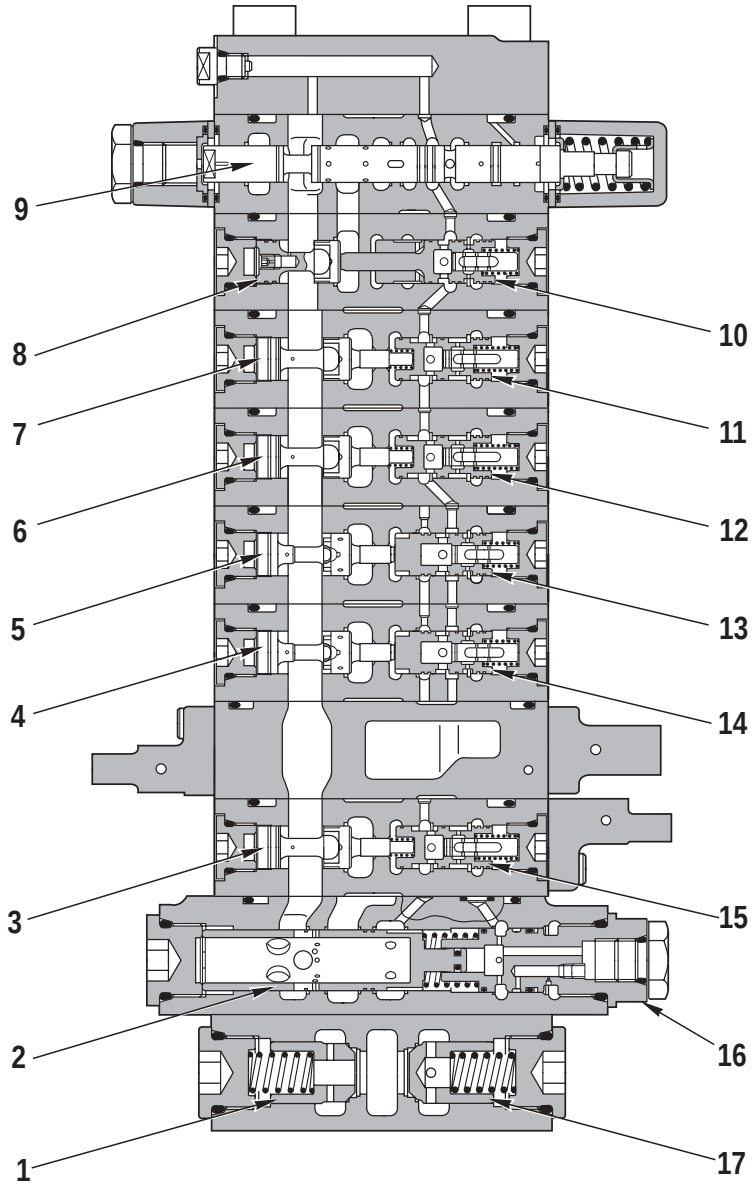
1. Suction valve (Boom lower)
2. Suction valve (Boom L.H. swing)
3. Suction valve (Boom raise)
4. Suction valve (Arm close)
5. Safety valve



RKP00140

Section B - B

1. Spool (Arm)
2. Spool (Swing)
3. Spool (L.H. travel)
4. Spool (R.H. travel)
5. Spool (Boom)
6. Spool (Bucket)
7. Spool (Blade)
8. Spool (Boom swing)
9. Main relief valve



Section C - C

RKP00150

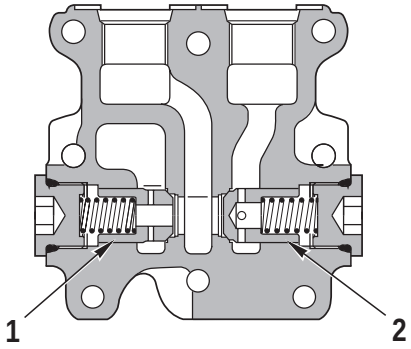
1. Check valve
2. Unload valve

FLOW COMPENSATION VALVE

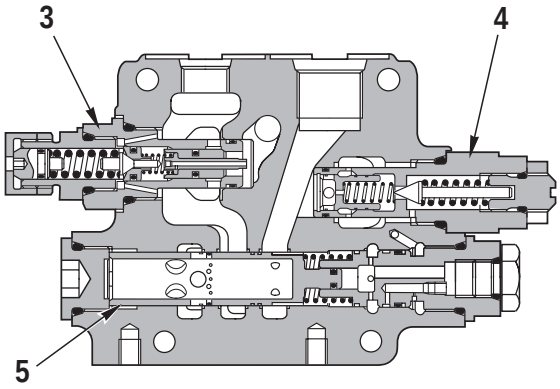
3. Arm
4. L.H. travel
5. R.H. travel
6. Boom
7. Bucket
8. Blade
9. Spool (Hammer)

REDUCING PRESSURE COMPENSATION VALVE

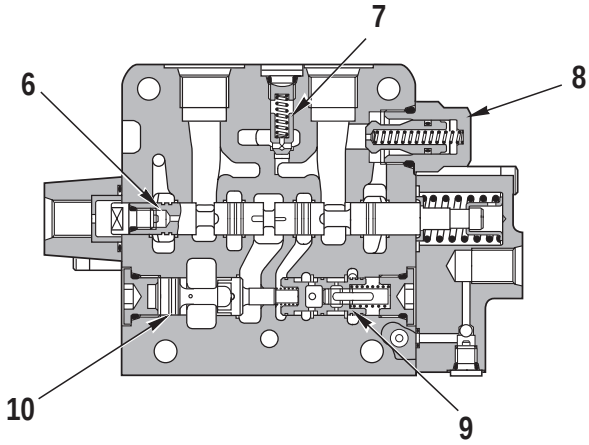
10. Blade
11. Bucket
12. Boom
13. L.H. travel
14. R.H. travel
15. Arm
16. LS by-pass plug
17. Cooler check valve



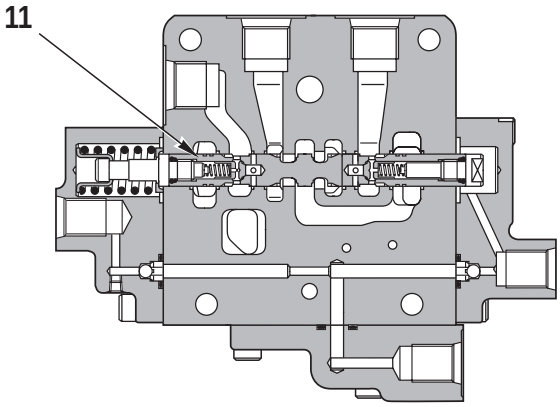
Section D - D



Section E - E



Section F - F



RKP00160

Section G - G

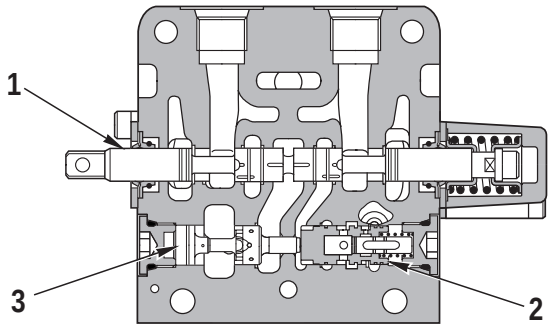
1. Check valve
2. Cooler check valve
3. Safety valve
4. Main relief valve
5. Unload valve

ARM VALVE

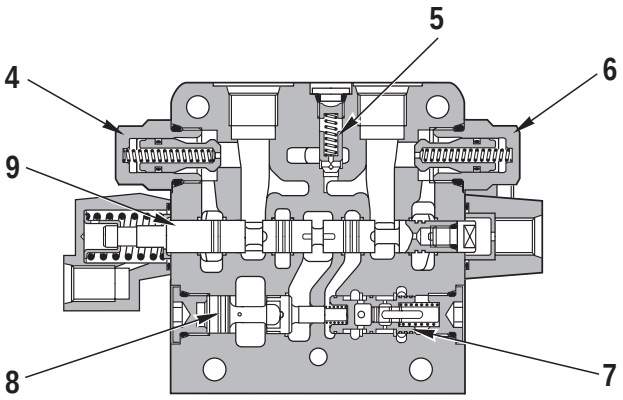
6. Spool
7. Check valve
8. Suction valve
9. Reducing pressure compensation valve
10. Flow compensation valve

SWING VALVE

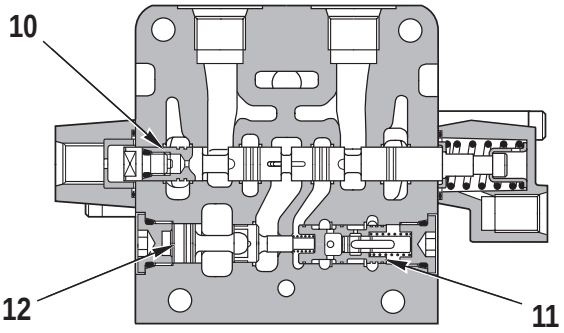
11. Spool



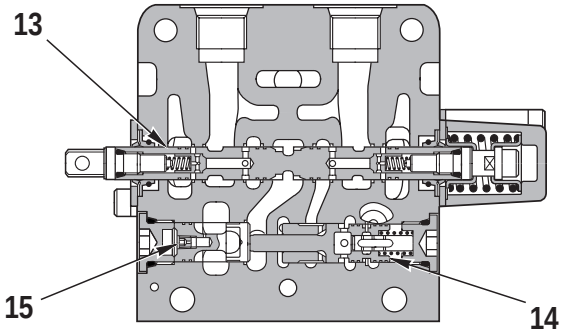
Section H - H



Section J - J



Section K - K



Section L - L

RKP00170

TRAVEL VALVE

1. Spool
2. Reducing pressure compensation valve
3. Flow compensation valve

BOOM VALVE

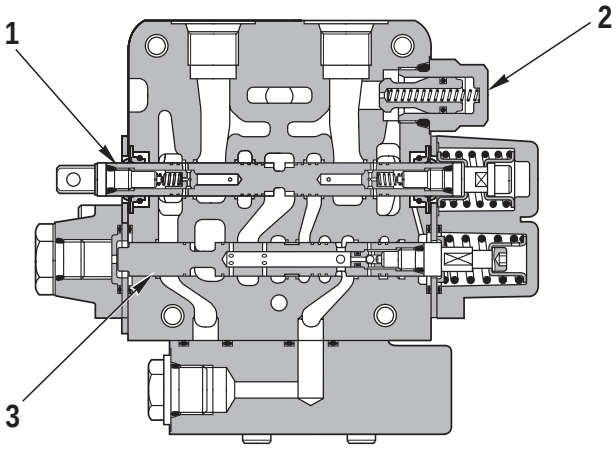
4. Suction valve
5. Check valve
6. Suction valve
7. Reducing pressure compensation valve
8. Flow compensation valve
9. Spool

BUCKET VALVE

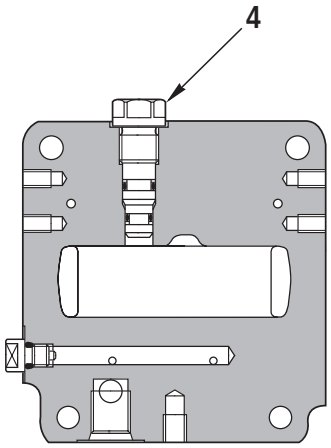
10. Spool
11. Reducing pressure compensation valve
12. Flow compensation valve

BLADE VALVE

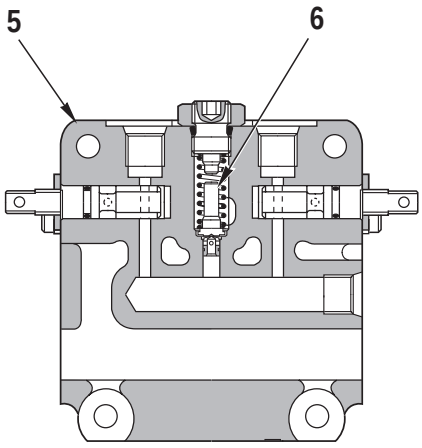
13. Spool
14. Reducing pressure compensation valve
15. Flow compensation valve



Section M - M



Section N - N



Section O - O

RKP00180

BOOM SWING AND HAMMER VALVE

1. Spool (Boom swing)
2. Suction valve
3. Spool (Hammer)
4. Plug
5. Cover
6. Reducing valve (Servocontrol)

CLSS

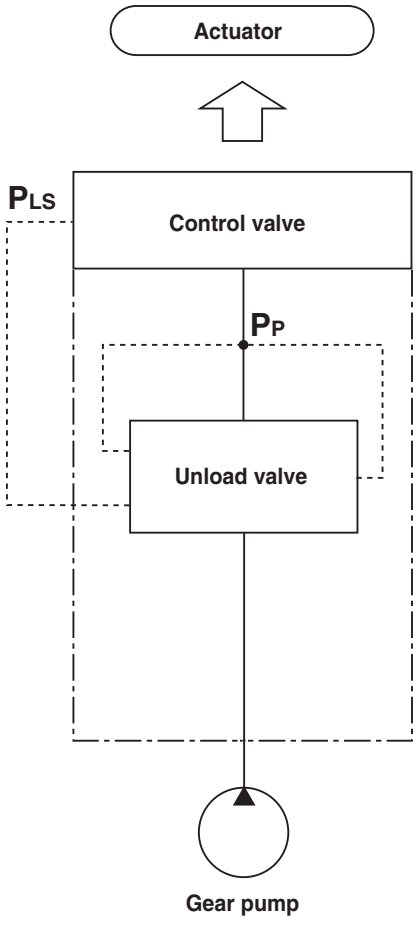
1. OUTLINE

FEATURES

The term "**CLSS**" stands for the "Closed Center Load Sensing System" which has the following features.
a) Fine-controllability not affected by loads.
b) Controllability enabling digging even in the control mode.
c) Complex operability ensured by flow distribution determined according to the opening areas of spools during complex operation.

STRUCTURE

The **CLSS** consists of a gear pump, control valve and actuators.



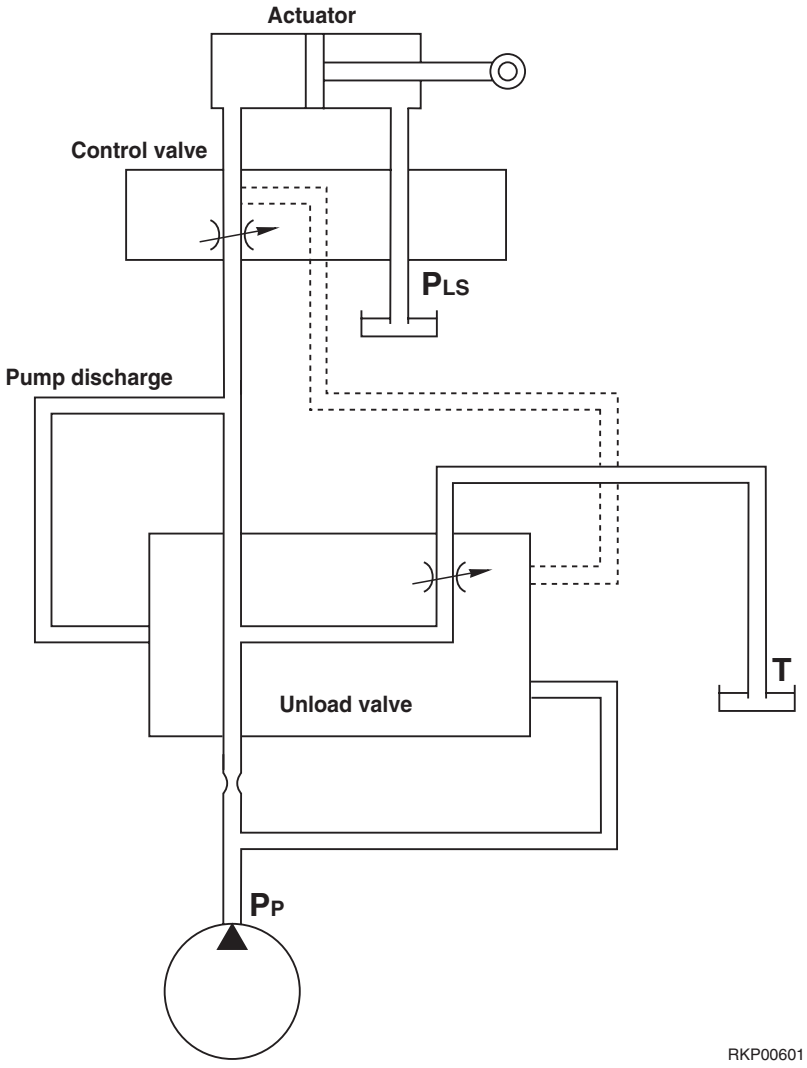
RKP00341

2. BASIC PRINCIPLE

1) Flow control of unload valve

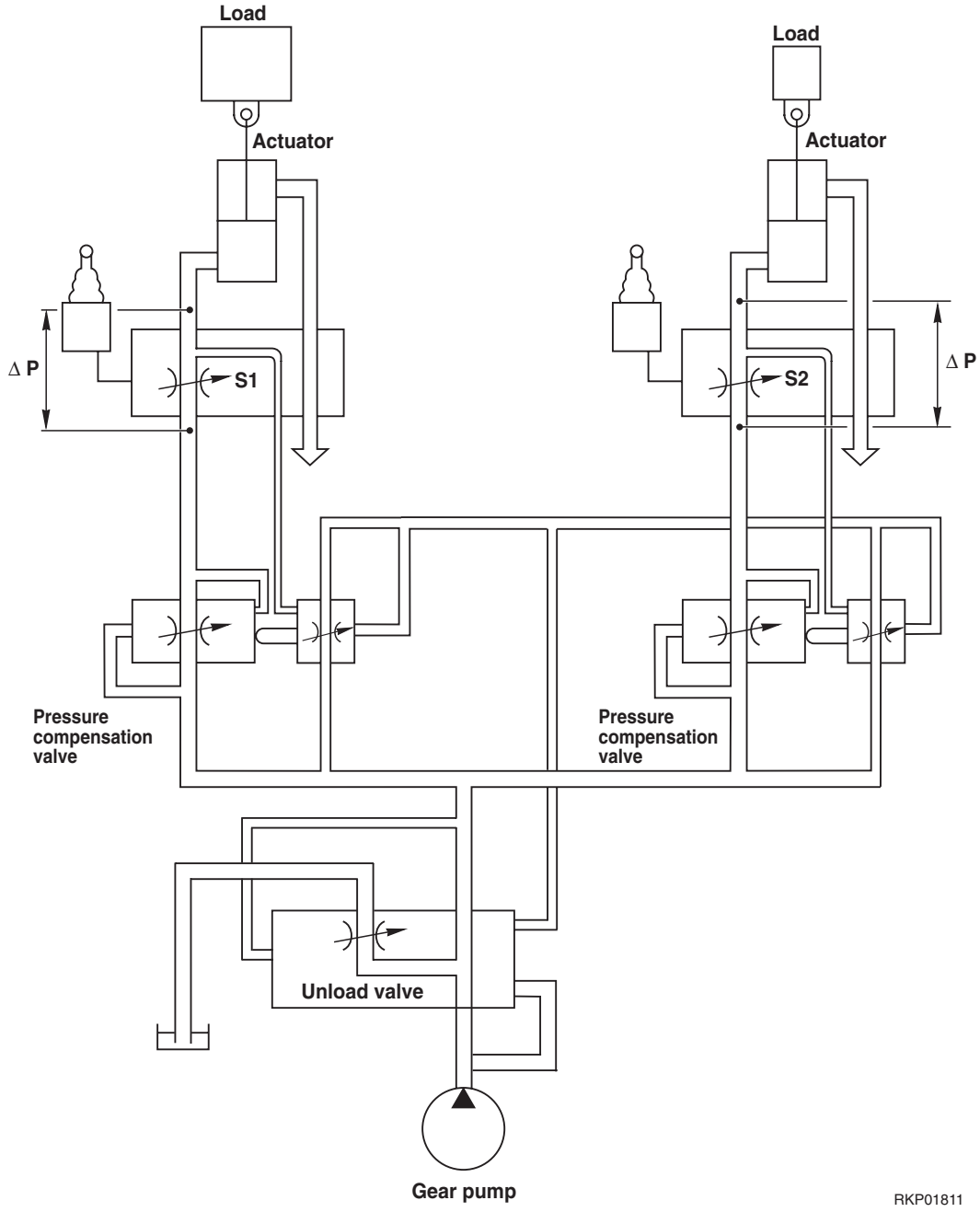
- The unload valve maintains **LS** differential pressure ΔP_{LS} which is differential pressure between the pump discharge pressure P_P and the **LS** pressure P_{LS} at the outlet port of control valve (actuator load pressure) at a constant level. (**LS** differential pressure ΔP_{LS} = Pump discharge pressure P_P – **LS** pressure P_{LS}).
- If the **LS** differential pressure ΔP_{LS} becomes lower than the setting pressure, the Unload valve reduces drain flow to the circuit, and if it becomes higher, the Unload valve increases drain flow.

★ For the details of this action, refer to the descriptions of Unload valve.



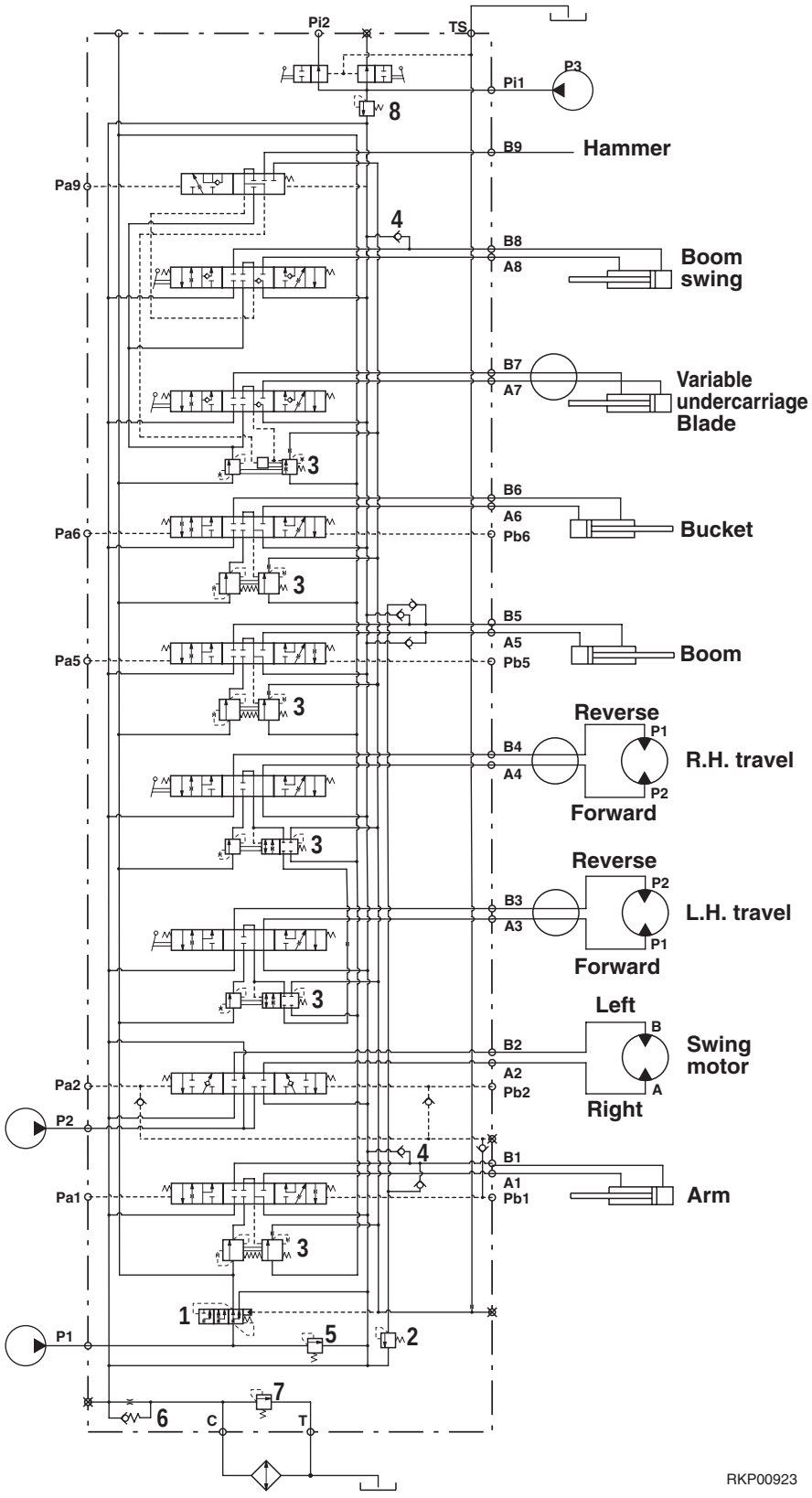
2) Pressure compensation control

- Valves (pressure compensation valves) are installed at the inlet port side of the spools of the control valves to balance the loads.
  When the actuators are complex-operated, the pressure differences **ΔP** at the upstream (inlet) and downstream (outlet) are made equal by these valves.
  In this way, the flow from the pump are distributed in proportion to the opening areas **S1** and **S2** of each valve.



3. Funzionamento per ogni circuito e valvola

SCHEMA IDRAULICO E NOME DELLE VALVOLE



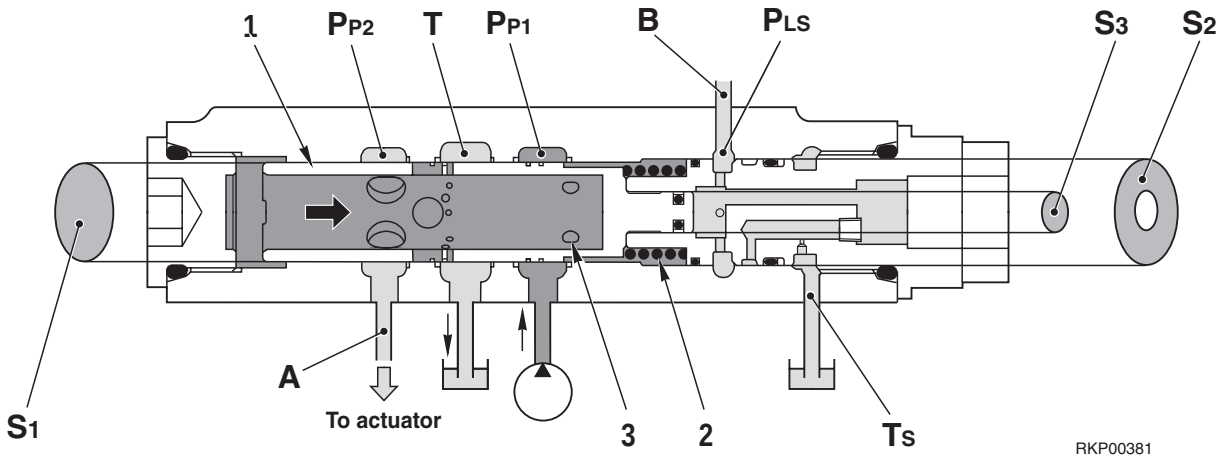
1. Unload valve:
   (LS pressure + 19.6 $^{0}_{+9.8}$ bar
   (LS + 20 $^{0}_{+10}$ kg/cm^2)
2. Safety valve:
   186 bar (190 kg/cm^2)
3. Pressure compensation valve
4. Suction valve
5. Main relief valve:
   206 bar (210 kg/cm^2)
6. Back pressure check valve: 4.5 bar (4.5 kg/cm^2)
7. Cooler by-pass valve:
   4 bar (4 kg/cm^2)
8. Pilot relief valve:
   29.5 bar (30 kg/cm^2)

1. Unload valve

FUNCTION

1) In the case of fixed pump system, the Unload valve has functions included variable pump and **LS** valve of variable pump system.

- When the control valve is at HOLD, pump discharge amount Q is released to the tank circuit.
- When the control valve is operated, the flow from pump is sent to the actuator circuit in proportion to the opening areas of valve spool.
- The **LS** differential pressure **ΔPLS** is become variable according to engine speed. (Engine speed sensing function).



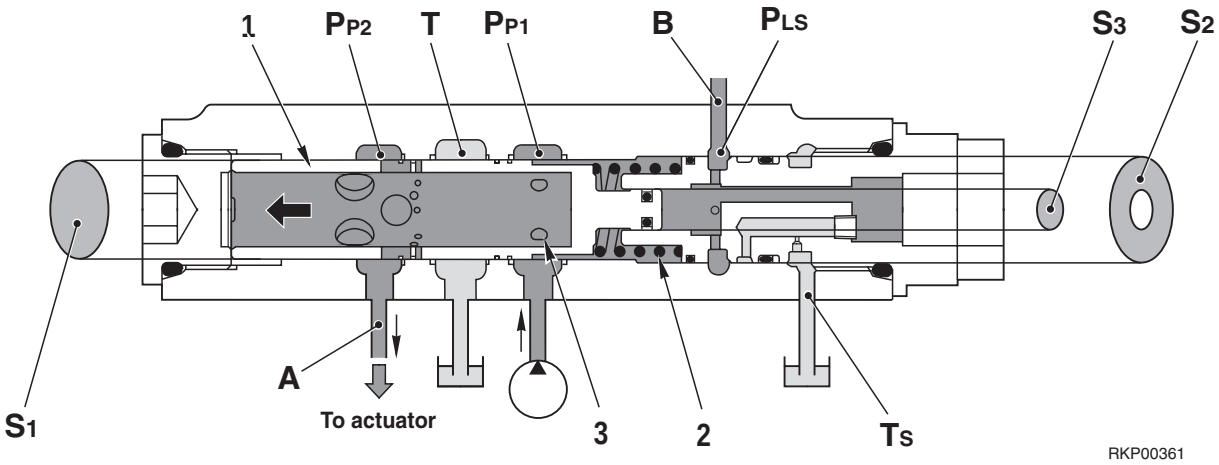
OPERATION

When control valve is at HOLD

- At the left end of spool (1), pump pressure **PP1** is acting on area **S1**, and at the right end of spool (1), pump pressure **PP2** and spring force of spring (2) is acting on area **S2**, and **LS** pressure **PLS** is acting on area **S3**.
- The reason of difference between pump pressure **PP1** and **PP2** comes from pressure loss **PP**, when the pump discharge amount passes through the orifice (3) of spool (1). (**PP1** = **PP2** + **ΔPP**).
- When the control valve is at HOLD, **LS** pressure **PLS** is not generated, so the pump pressure **PP1**, **PP2**, and spring force of spring (2) is acting on spool (1).
- As pump discharge pressure **PP1** rises and reaches the **PP2** x **S1** = **PP1** x **S2** + spring force of spring (2), spool (1) is moved to the right. Pump circuit **PP1**, **PP2** are then connected to tank circuit **T** through the drill hole.
- In this way, the differential pressure (**LS** differential pressure) between pump discharge pressure **PP1** and **LS** pressure **PLS** is set to $19.6^{0}_{+9.8}$ bar (20^{0}_{+10} kg/cm^2).

PP = Pump circuit
PLS = Load Sensing circuit
T-TS = Tank circuit
A = To control valve spool
B = To **LS** valve

2) When control valve is operated, pump discharge pressure **P_{P1}** is set to **LS** pressure **P_{LS}** + 19,6 $^{0}_{+9,8}$ bar (20 $^{0}_{+10}$ kg/cm^2).

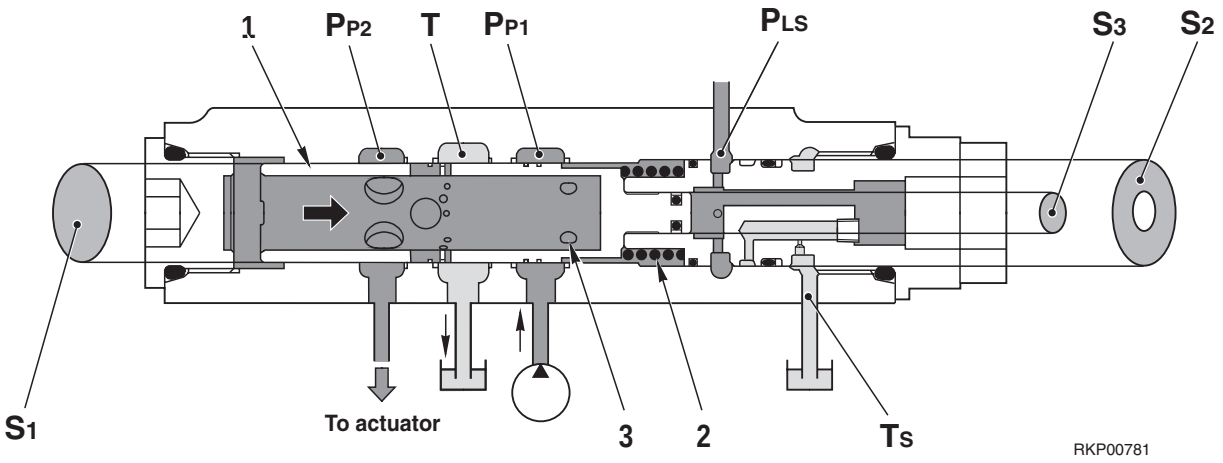


OPERATION
Control valve operated

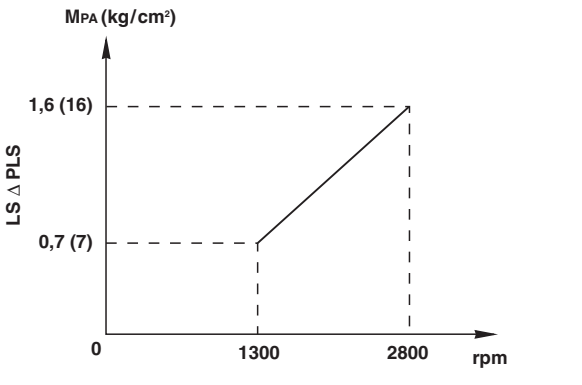
- When the control valve is operated, **LS** pressure **P_{LS}** is generated and acts on area **S3** at the right end of spool (1).
- When the differential pressure between pump discharge pressure **P_{P1}** and **LS** pressure **P_{LS}** raises and reaches 19,6 $^{0}_{+9,8}$ bar (20 $^{0}_{+10}$ kg/cm^2), spool (1) is moved to the left, and the oil flowing to tank circuit when control valve is at HOLD flows to actuator circuit.
- The operation is same when fine control is carried out on the control valve.
- When the pump discharge amount become smaller than actuator requirement amount (Pump discharge amount < Actuator requirement amount) with operating actuators at same time, spool (1) is moved to the left more till full stroke. As a result, pump circuit **P_{P1}**, **P_{P2}** and tank circuit **T** are shut off, and all the pump discharge amount Q flows to the actuator circuit.

3) Engine speed sensing function

- All the pump discharge amount Q flows through the orifice (3) of spool (1). On the fixed pump system, the relation between engine speed and pump discharge amount Q is in proportion. Therefore when engine speed is high, pump discharge amount is much, and little pump discharge amount flows at engine speed low.
- For this reason, oil flow through the orifice (3) of spool (1) is different when engine speed is high and low. At that time, the pressure loss **ΔPP** is varied.



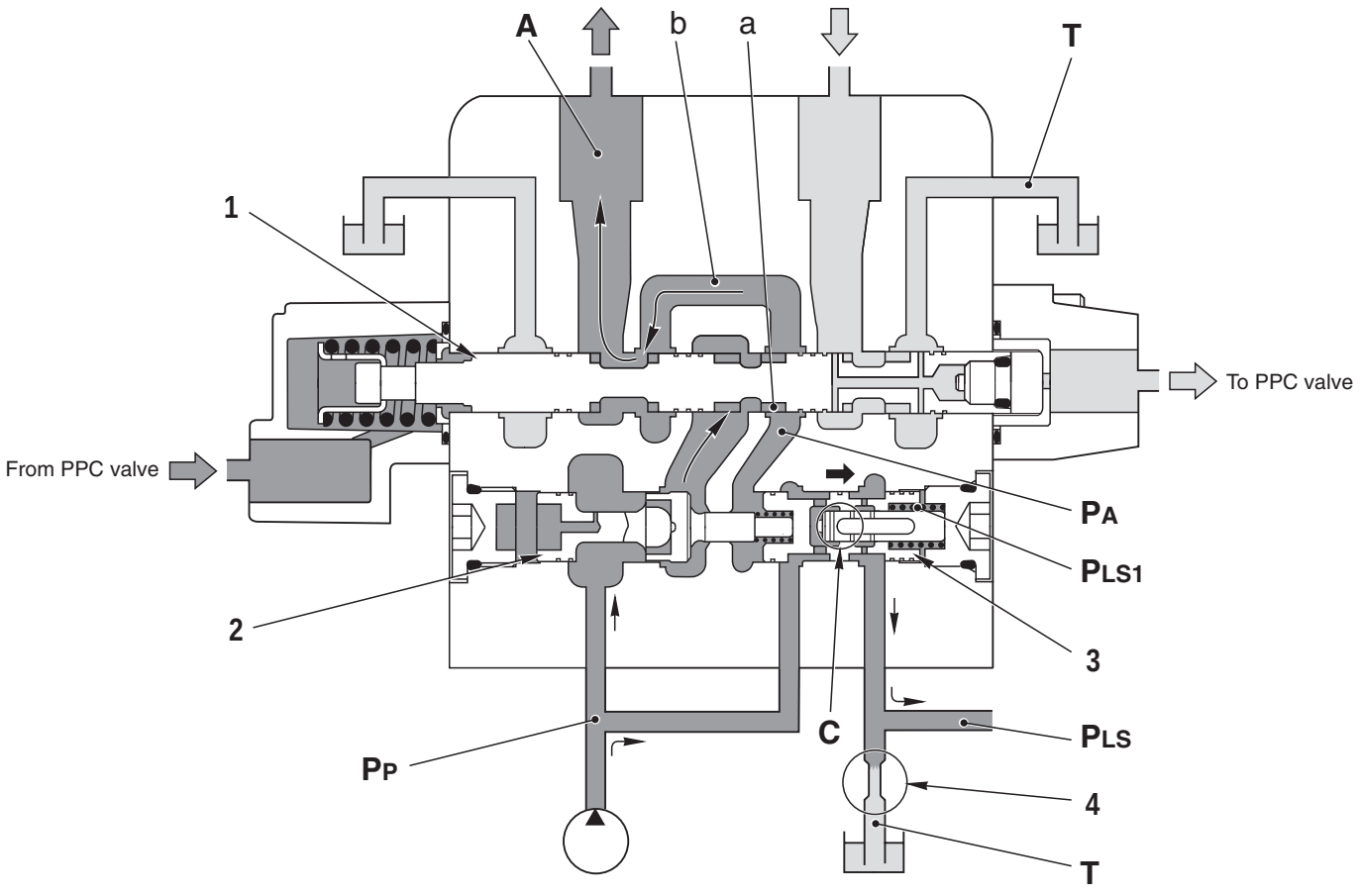
- The balance of unload valve is:
  (**PP2** x **S1**) = (**PP1** x **S2**) + (**PLS** x **S3**) + spring force of spring (2).
  Developing above formula, **LS** differential pressure **ΔPLS** = **PP1** − **PLS** is expressed:
  PP1 − **PLS** = **ΔPLS** x **S1/S3** + spring force of spring.
  Therefore **LS** differential pressure **ΔPLS** is varied according to **PLS**. In other words, when engine speed varies, **LS** differential pressure also varies.
- **LS** differential pressure **ΔPLS** varies as figure shown.



2. Introduction of LS pressure

FUNCTION

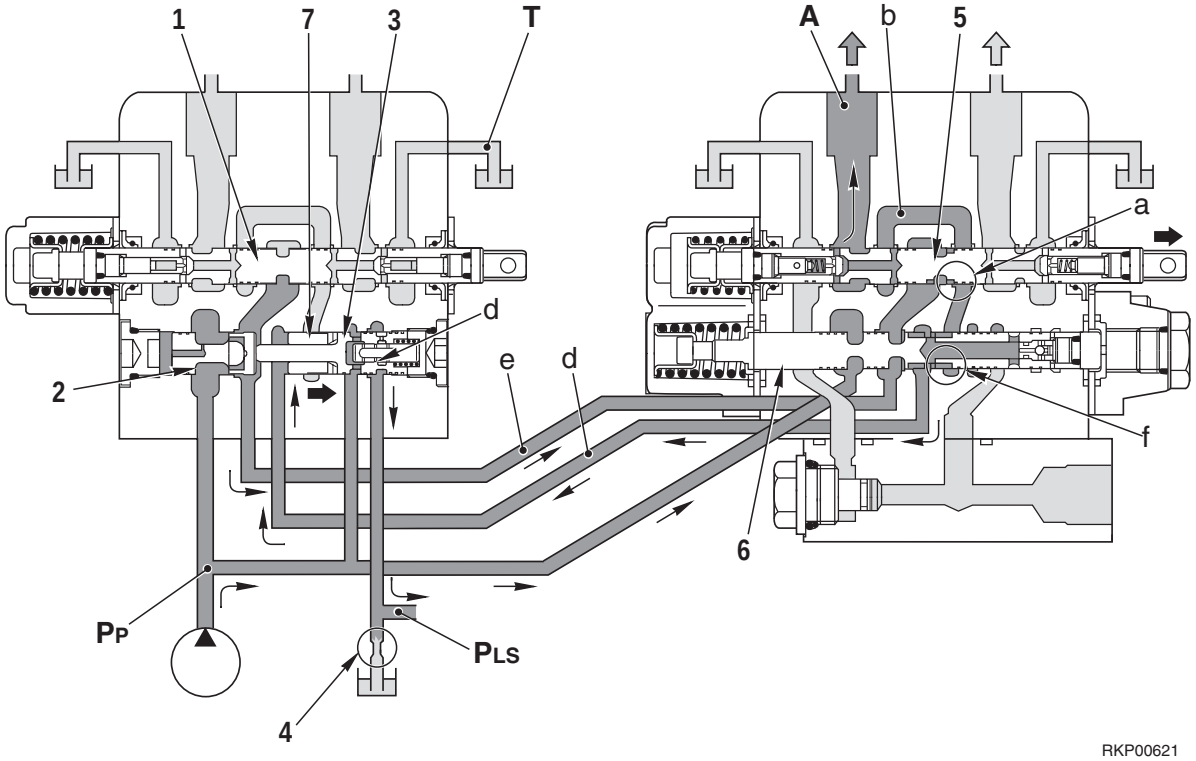
- The **LS** pressure is the actuator load pressure at the outlet port end of the control valve.
- It actually reduces pump pressure **P_P** at reducing valve (3) of the pressure compensation valve to the same pressure as actuation circuit pressure **A**, and sends it to the **LS** circuit **P_{LS}**.
- With the boom swing and blade valves, pump pressure **P_P** is reduced to the same pressure as actuator circuit pressure **A** by one reducing valve (3) used for both systems, and the pressure is sent to the **LS** circuit **P_{LS}**.
- With the hammer valve, actuator circuit pressure **A** is taken directly to the **LS** circuit **P_{LS}**.



OPERATION

1) Boom, arm, bucket, travel valve

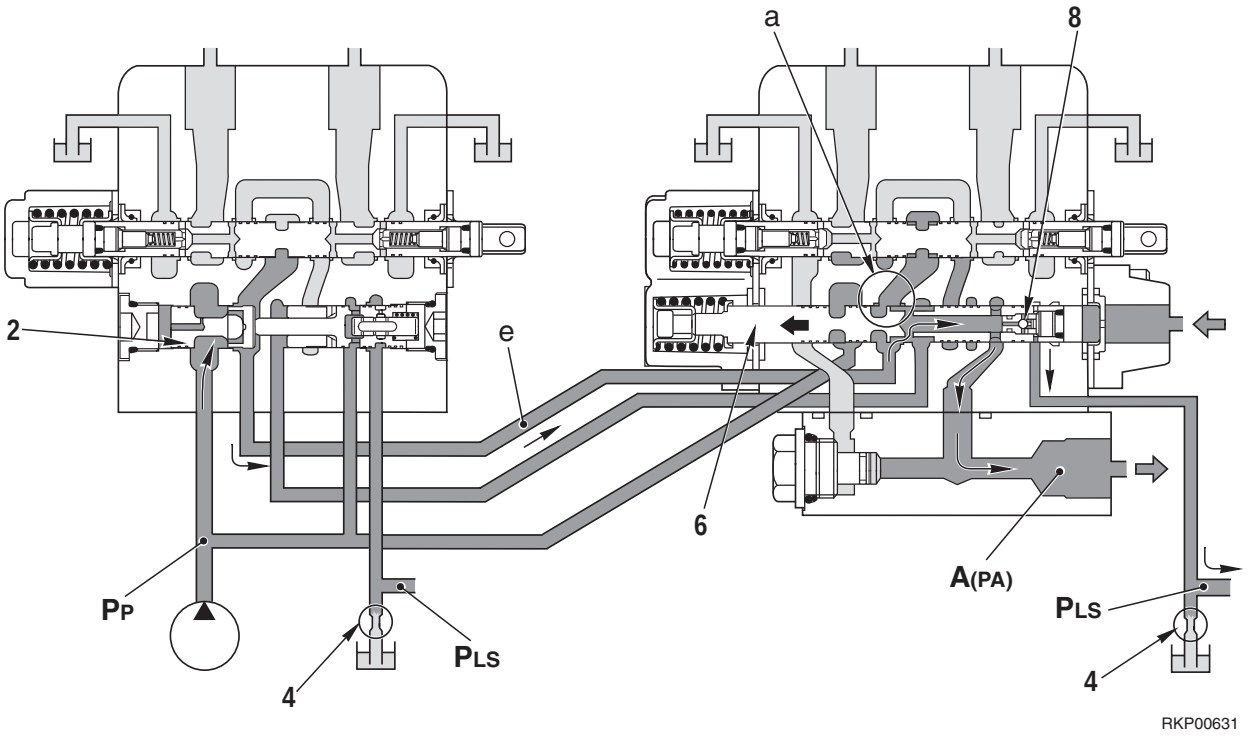
- When spool (1) is operated, pump pressure **P_P** flows from flow control valve (2) an notch **a** in spool (1) through bridge passage **b** to actuator circuit **A**.
- At the same time, reducing valve (3) also moves to the right, so pump pressure **P_P** has its pressure reduced by the pressure loss at notch **C**. It is introduced to **LS** circuit **P_{LS}**, and then goes to spring chamber **P_{LS1}**.
- When this happens, **LS** circuit **P_{LS}** is connected to tank circuit **T** from **LS** bypass plug (4) (see the section on the **LS** bypass plug).
- Actuator circuit pressure **P_A** (= **A**) acts on the left end of reducing valve (3); the reduced pump pressure **P_P** acts on the other end.
- As a result, reducing valve (3) is balanced at a position where actuator circuit pressure **P_A** and the pressure of spring chamber **P_{LS1}** are the same. Pump pressure **P_P** reduced at notch **C** becomes actuator circuit pressure **A** and is taken to **LS** circuit **P_{LS}**.



2) Boom swing, blade valve

- When boom swing spool (1) is operated, pump pressure **PP** is reduced by reducing valve (3) (in the same way as in item 1), and is sent to the **LS** circuit **PLS**.
- When blade spool (5) is operated, pump pressure **PP** flows from flow control valve (2), passage **e**, and notch **a** in blade spool (5) through bridge passage **b** to actuator circuit **A**.
- At the same time, the actuator circuit pressure passes through notch **f** in hammer spool (6), then goes through passage **d**, and acts o the left end of piston (7). Piston (7) and reducing valve (3) then move to the right.
- As a result, pump pressure **PP** is reduced at notch **d**, becomes the actuator circuit pressure, and is sent to **LS** circuit **PLS**.

★ The boom swing and blade valves are different from the boom, arm, bucket, and travel valves: they share one pressure compensation valve and bring in the **LS** pressure.



3) Hammer valve

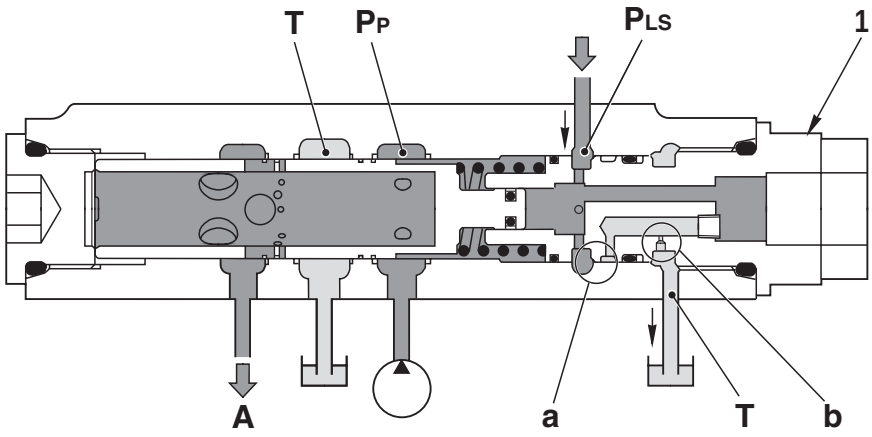
- When hammer spool (6) is operated, pump pressure **PP** flows through flow control valve (2), passage **e**, and notch **a** in hammer spool (6) to actuator circuit **A**.
- At the same time, actuator circuit pressure **PA** passes through check valve (8) and is interconnected with the **LS** circuit **PLS**.

★ The hammer circuit is different from the other circuits: actuator circuit pressure **PA** goes directly to **LS** circuit **PLS**.

3. LS bypass plug

FUNCTION

- It releases the residual pressure of **LS** pressure **PLS**.
- It makes the speed of the rise in pressure of **LS** pressure **PLS** more gentle. In addition, with this discarded throttled flow, it creates a pressure loss in the throttled flow of the spool and increases the stability by lowering the effective **LS** differential pressure.



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OPERATION

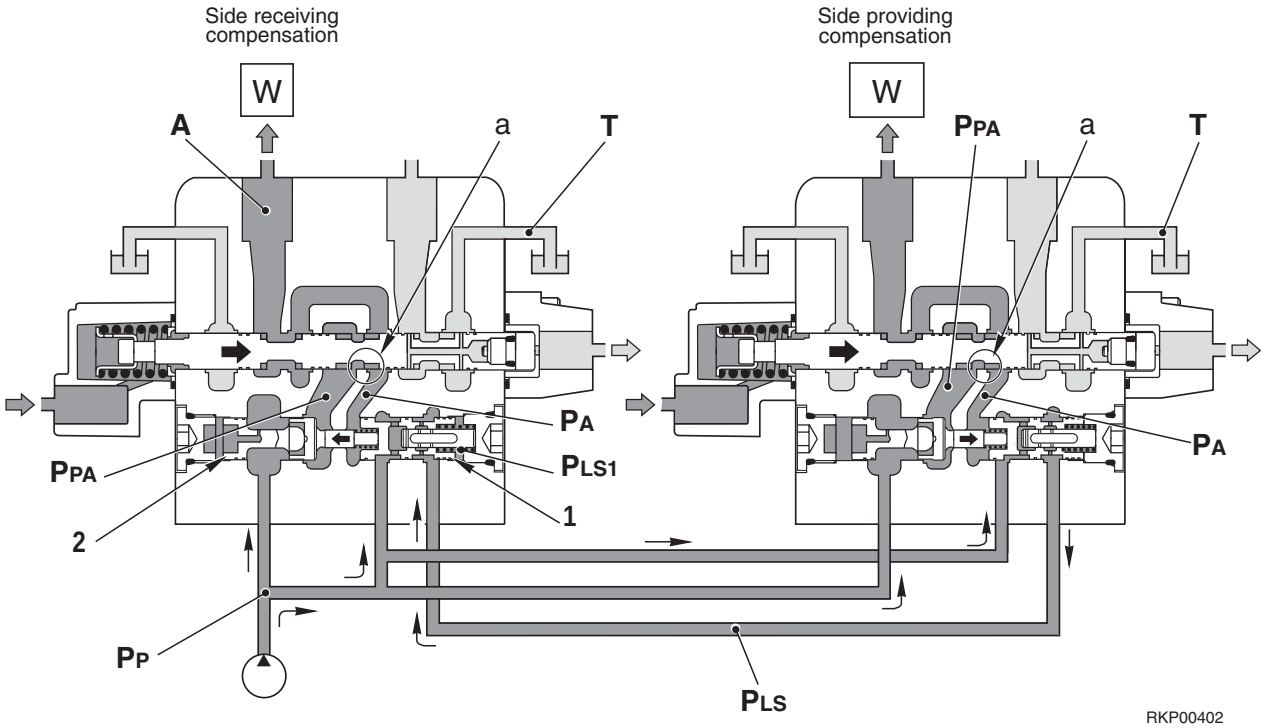
- The pressurized oil for **LS** circuit **PLS** passes from clearance filter **a** (formed by the clearance **LS** bypass plug (1) and the valve body) through orifice **b** and flows to the tank circuit **T**.

PP = Pump circuit
PLS = LS circuit
T = Tank circuit
A = To control valve spool

4. Pressure compensation valve

FUNCTION

- During compound operations, if the load pressure becomes lower than the other actuator and the oil flow tries to increase, compensation is received. (When this happens, the other actuator being used for compound operation (right side) is at a higher load than the actuator on this side (left side)).



OPERATION

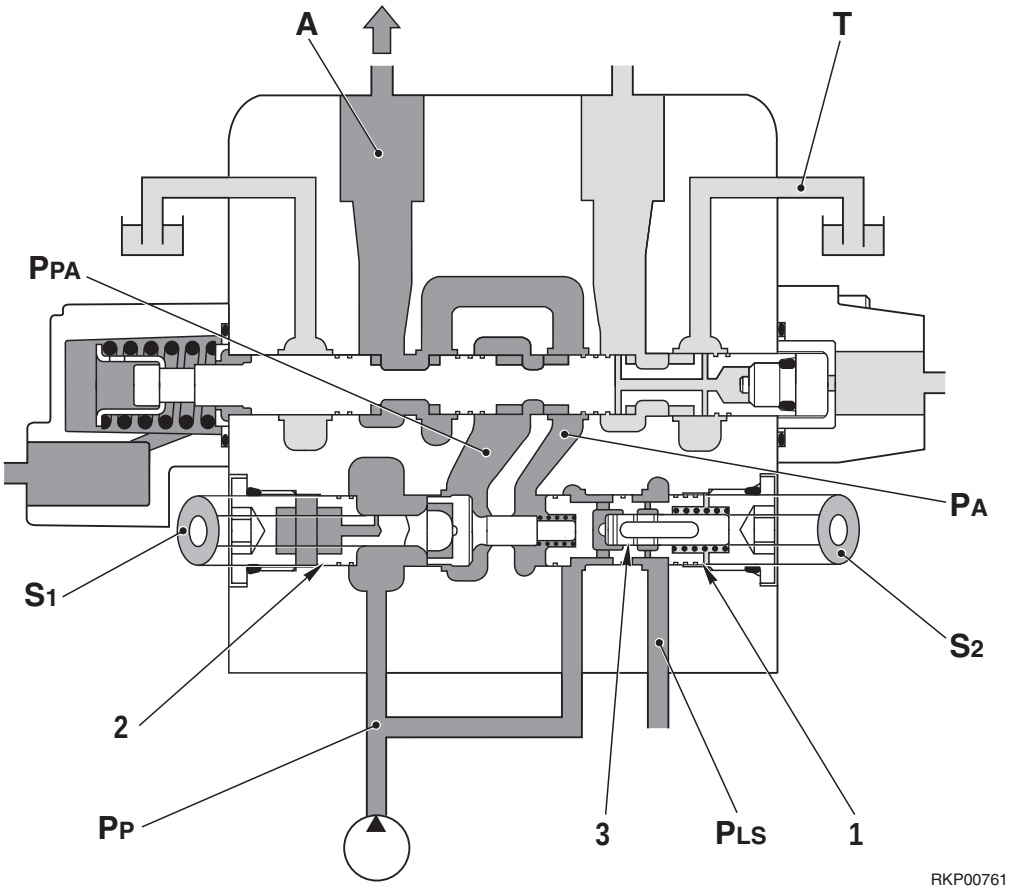
- If the load pressure of the other actuator (right side) becomes higher during compound operations, the oil flow in actuator circuit **A** on this side (left side) tries to increase.
- If this happens, the **LS** pressure P_{LS} of the other actuator acts on spring chamber P_{LS1}, and reducing valve (1) and flow control valve (2) are pushed to the left (←).
- Flow control valve (2) throttles the area of opening between pump circuit P_P and spool upstream P_{PA} and pressure loss is generated between P_P and P_{PA}.
- Flow control valve (2) and reducing valve (1) are balanced in position where the difference in pressure between P_{LS} and P_A acting on both ends of reducing valve (1) and the pressure loss between P_P and P_{PA} on both sides of flow control valve (2) are the same.
- In this way, the pressure difference between upstream pressure P_{PA} and downstream pressure P_A of both spools used during compound operations is the same, so the pump flow is divided in proportion to the area of opening of notch **a** of each spool.

5. Area ratio of pressure compensation valve

FUNCTION

- The pressure compensation valve determines the compensation characteristics by carrying out fine adjustment of the area ratio (**S1**/**S2**) between area **S2** of reducing valve (1) and area **S1** of flow control valve (2) to match the characteristics of each actuator.

S1 = Area of flow control valve (2) – area of piston (3).
S2 = Area of reducing valve (1) – area of piston (3).



Area ratio (S1:S2) and compensation characteristics

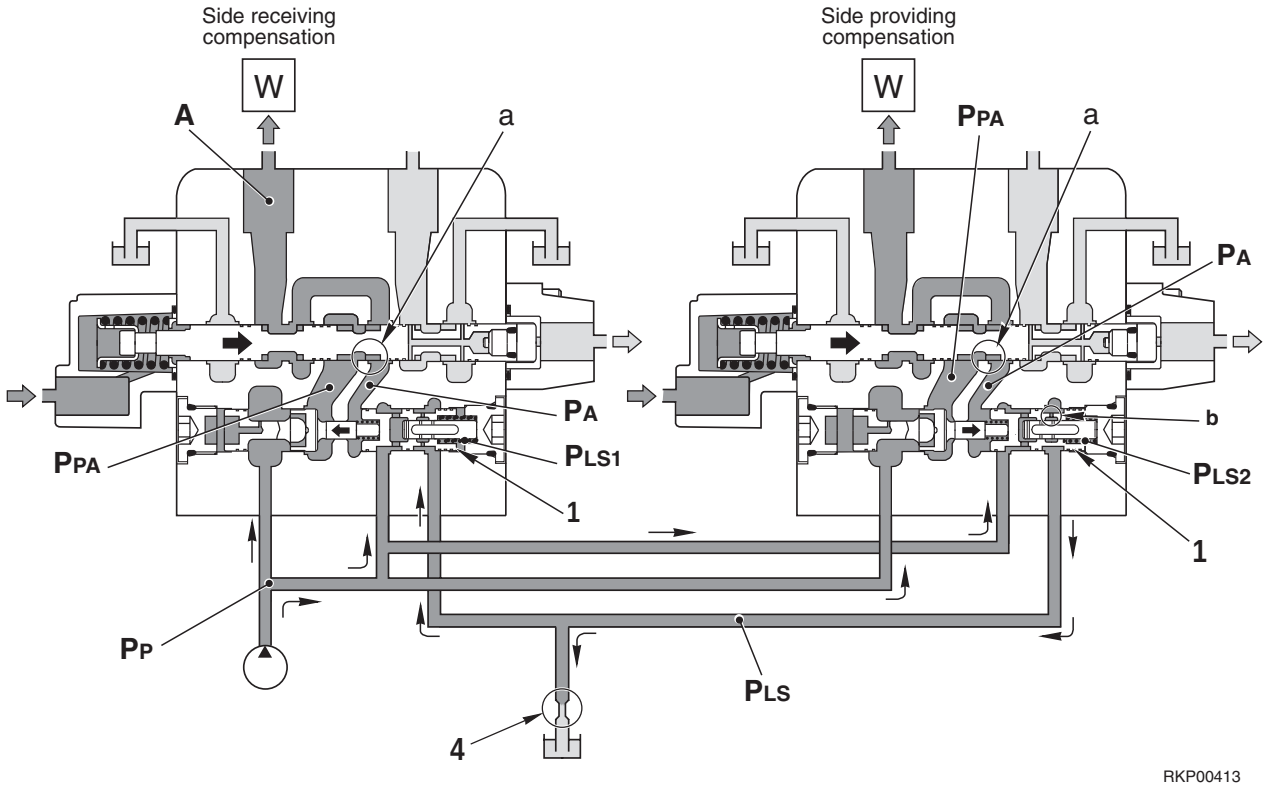
- When ratio is 1.00 :
  [Pump pressure **PP** – spool notch upstream pressure **PPA**]≒[**LS** circuit pressure **PLS** – actuator circuit pressure **PA** (= **A**)] and oil flow is divided in proportion to area of opening of spool.
- When ratio is more than 1.00 : **PP** – **PPA** > **PLS** – **PA** (= **A**) and oil flow to side receiving compensation is divided in a proportion less than area of opening of spool.
- When ratio is less than 1.00 : **PP** – **PPA** < **PLS** – **PA** (= **A**) and oil flow to side receiving compensation is divided in a proportion more than area of opening of spool.

Ratio of area **S1** and **S2**			
Valve	Ratio	Valve	Ratio
Arm	0.98	Boom swing	0.98
Travel	1.00	Blade	0.98
Boom	0.95	Hammer	1.00
Bucket	1.00	Swing	0.95

6. Throttling LS introduction of pressure compensation valve

FUNCTION

- If the other actuator is relieved during compound operations, **LS** introduction throttle **b** of reducing valve (1) divides the flow and sends more oil to the side receiving compensation.



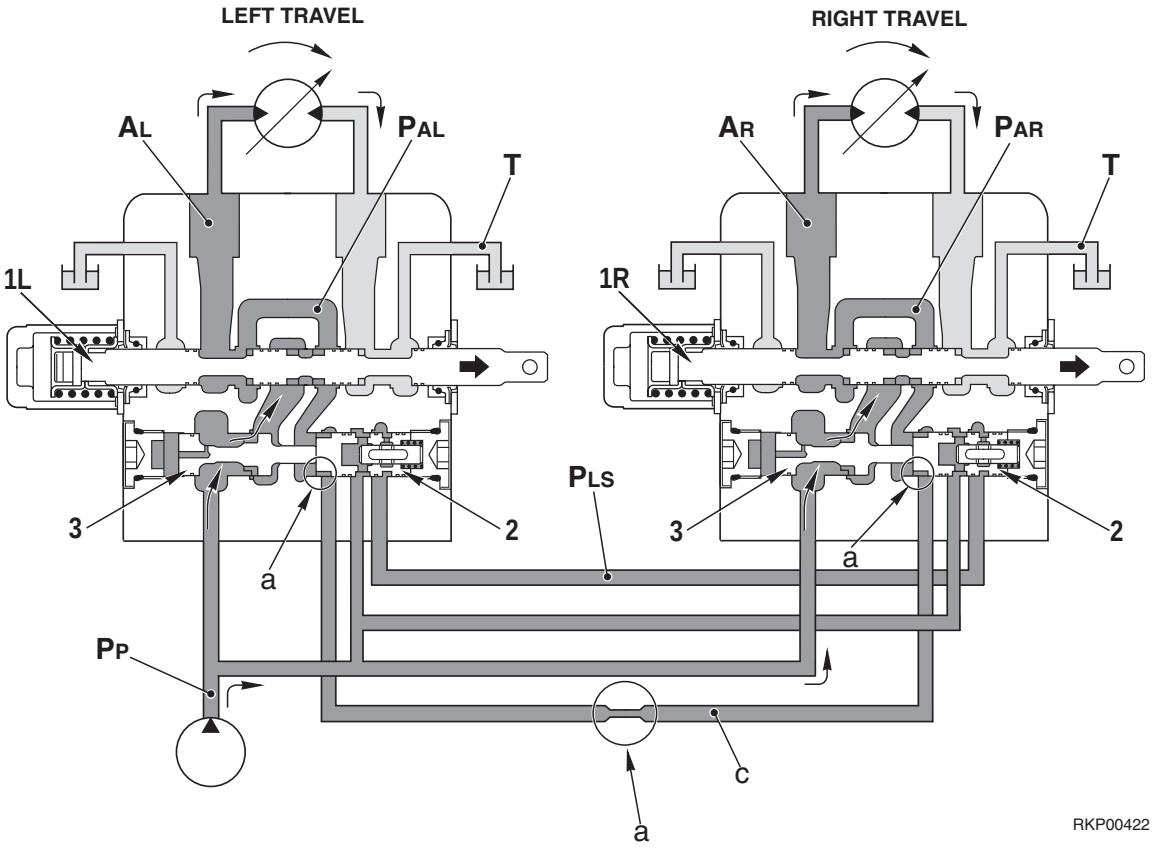
OPERATION

- If the other actuator (right side) is relieved during compound operations, each circuit pressure (**PPA** and **PA**) of the other actuator becomes the same as the pump circuit pressure (**PP** = relief pressure).
- In this case, spring chamber **PLS2** of the other actuator (right side) becomes the same as pump circuit pressure **PP** because of the balance of reducing valve (1).
- **PLS2** passes through **LS** introduction throttle **b** of reducing valve (1) and becomes **PLS**. **PLS** is connected to the tank circuit from **LS** bypass plug (4), so pressure loss is generated at **LS** introduction throttle **b** (the condition becomes **PLS** < **PLS2**).
- As a result, even if the other actuator is relieved, a pressure differential is created between **PP** and **PLS**, so more oil flows to actuator circuit **A** on this side (left side).

7. L.H., R.H. travel junction circuit

FUNCTION

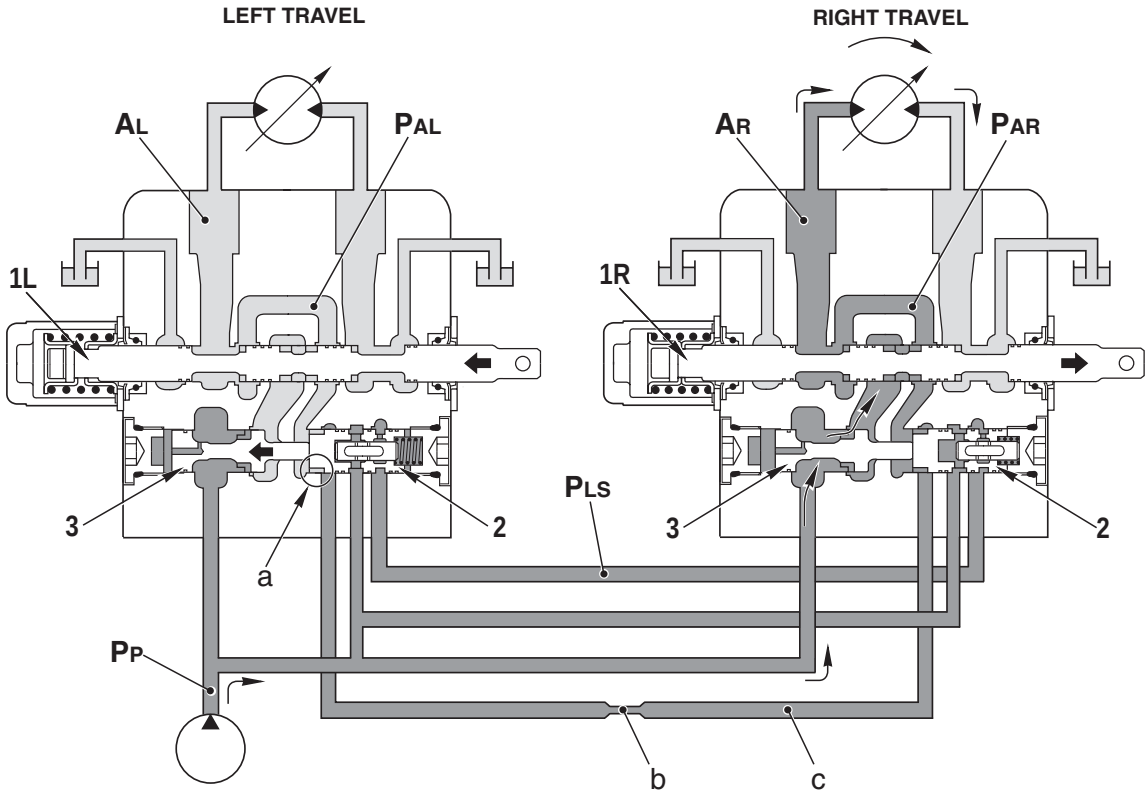
- To compensate for any difference in the oil flow in the left and right travel circuits when travelling in a straight line, the junction circuit opens when the left and right travel spools are operated.
  In this way, the flow of oil to the left and right travel motors is almost the same when travelling in a straight line, so there is no travel deviation.
- When steering the machine, the difference in the load pressure returns the reducing valve of the travel on the inside of the turn and the opening of the notch in the travel junction valve spool becomes smaller, so the machine can be steered.



OPERATION

When travelling in a straight line

- When left and right travel spools (1) are operated, the pump discharge flows from pump circuit **PP** and circuits **PAL** and **PAR** to actuator circuits **AL** and **AR**.
- When travelling in a straight line, to make actuator circuits **PAL** and **PAR** equal, left and right reducing valves (2) are pushed to the right by the same amount, and notch **a** and the travel junction circuit are opened.
- In this way, the left and right travel actuator circuits are interconnected by the travel junction circuit **c**, so if any difference occurs in the flow of oil to the left and right travel motors, the compensation is carried out to prevent any deviation in travel.



Steering when travelling

- When travelling in a straight line, if left travel spool (**1L**) is returned to the neutral position and the steering is operated, a difference (**AR** > **AL**) is generated in the load pressure of left and right travel actuator circuits **PAL** and **PAR**, and **LS** pressure **PLS** becomes the same pressure as **AR** (the side with the high load pressure).
- As a result, flow control valve (3) on the left travel side is pushed to the left by **LS** circuit **PLS**. Because of this, the opening of the left notch **a** is made smaller, so it becomes possible to operate the steering when travelling.
- Damper **b** is provided in the circuit to dampen any excessive characteristics in the opening or closing of the travel junction circuit if the spool is operated suddenly.