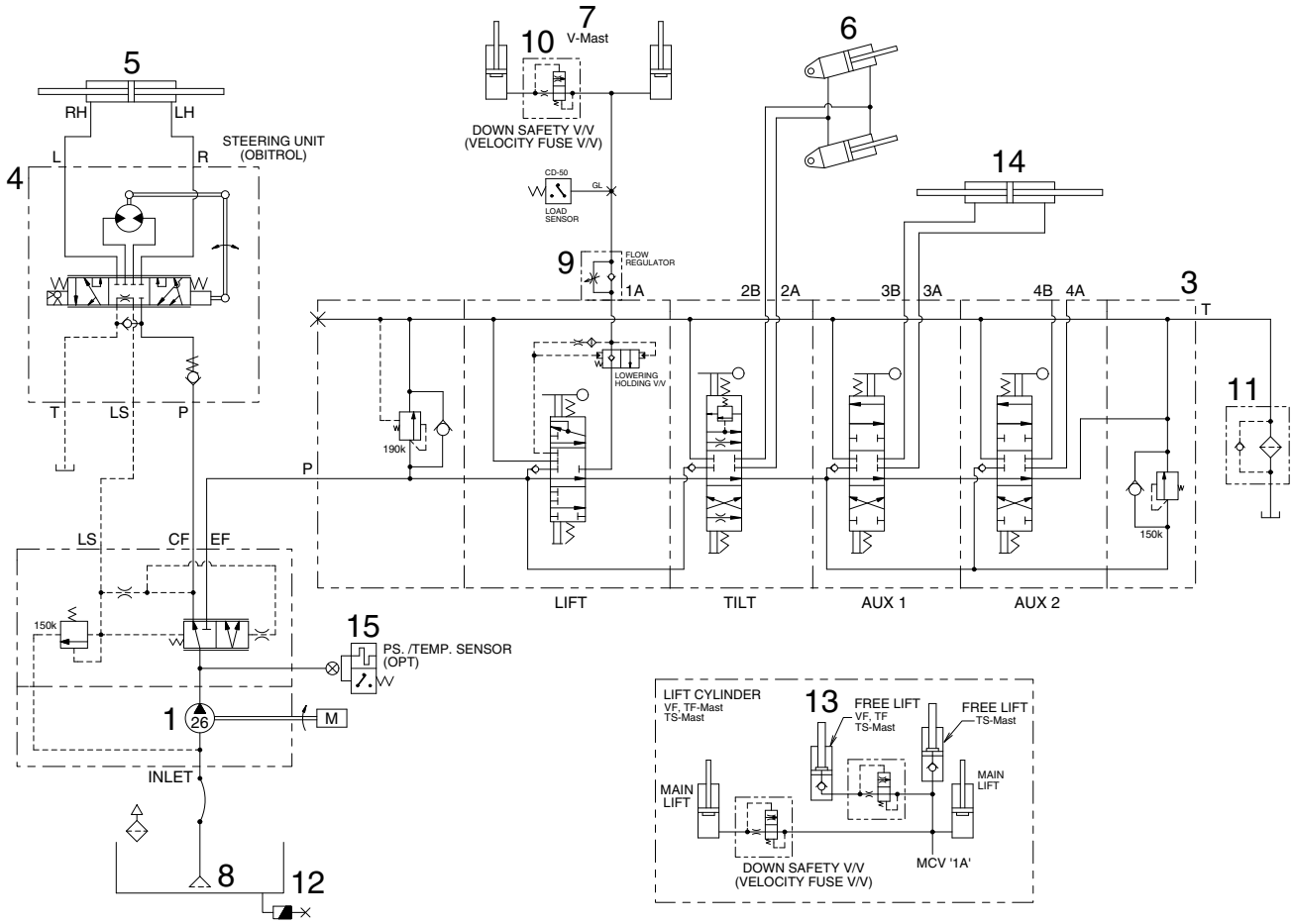
SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. HYDRAULIC CIRCUIT (NON OPSS / TRAVEL OPSS)

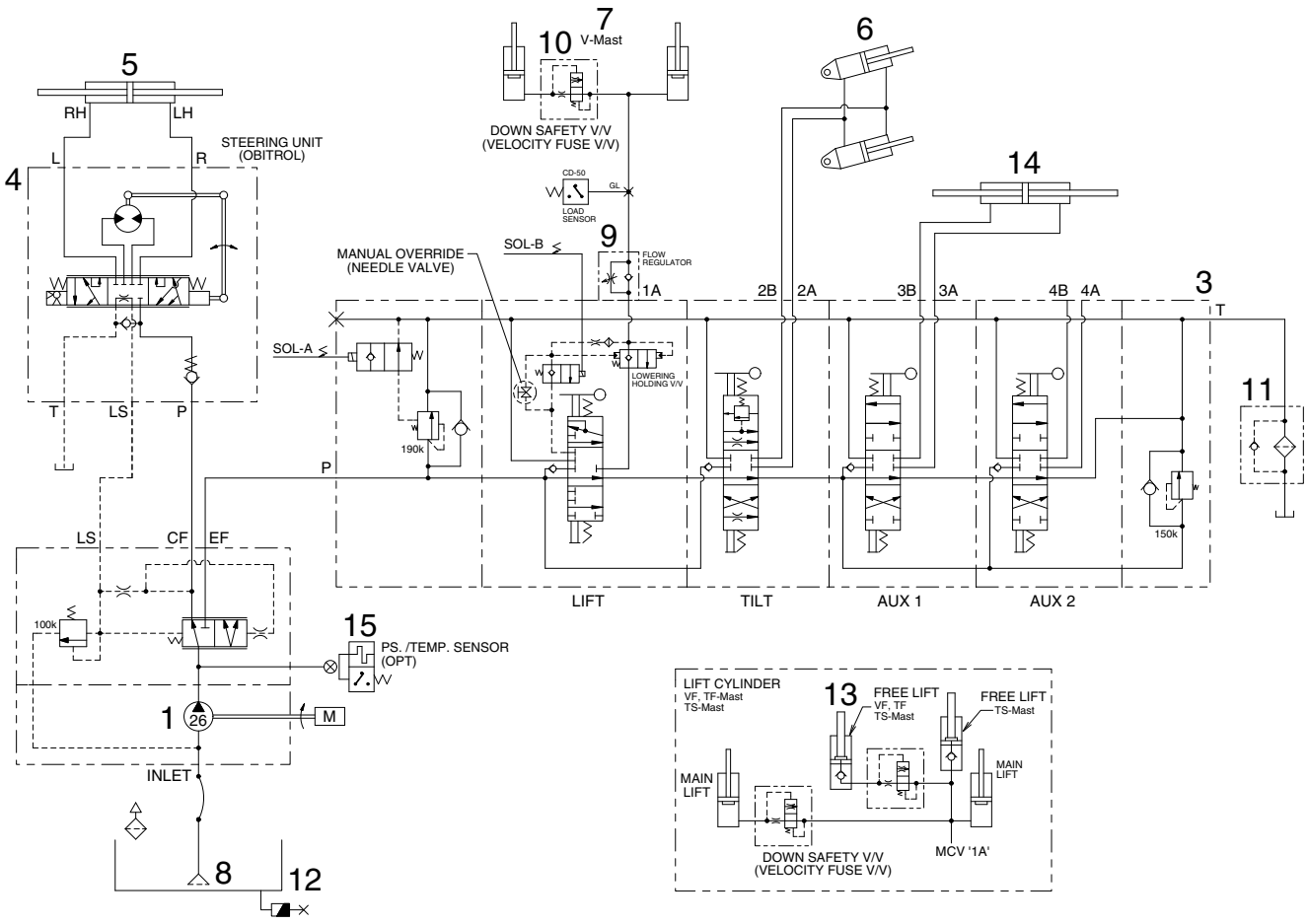


15D9HS01

1	Hydraulic gear pump with priority valve	9	Flow regulator
3	Main control valve	10	Down safety valve
4	Steering unit	11	Return filter
5	Steering cylinder	12	Hydraulic tank
6	Tilt cylinder	13	Free lift cylinder
7	Lift cylinder	14	Side shift cylinder
8	Suction strainer	15	Temperature sensor

※ The circuit diagram may differ from the equipment, so please check before a repair.

HYDRAULIC CIRCUIT (TRAVEL WITH MAST OPSS)

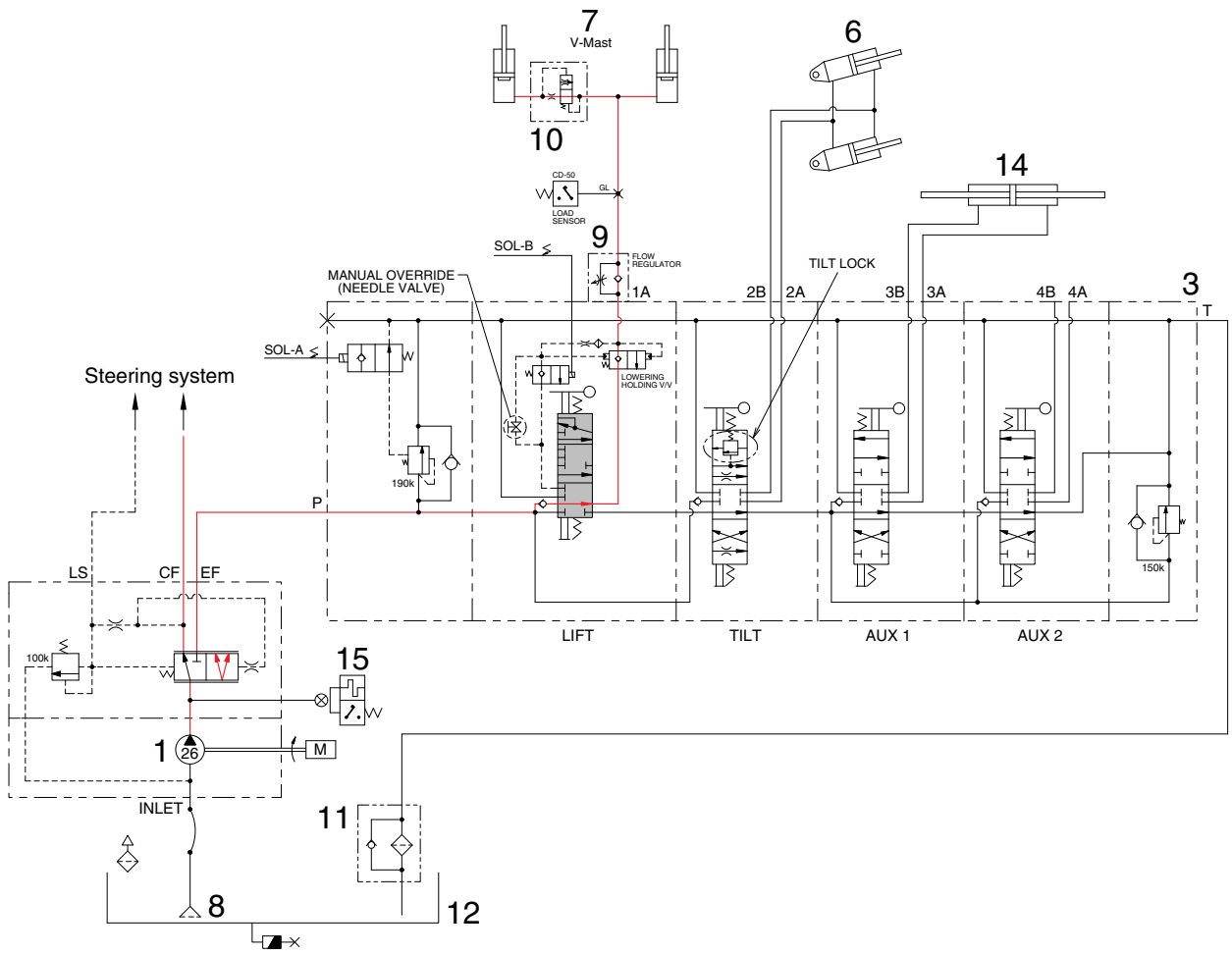


15D9HS02

1 Hydraulic gear pump with priority valve
3 Main control valve
4 Steering unit
5 Steering cylinder
6 Tilt cylinder
7 Lift cylinder
8 Suction strainer
9 Flow regulator
10 Down safety valve
11 Return filter
12 Hydraulic tank
13 Free lift cylinder
14 Side shift cylinder
15 Temperature sensor

※ The circuit diagram may differ from the equipment, so please check before a repair.

1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION

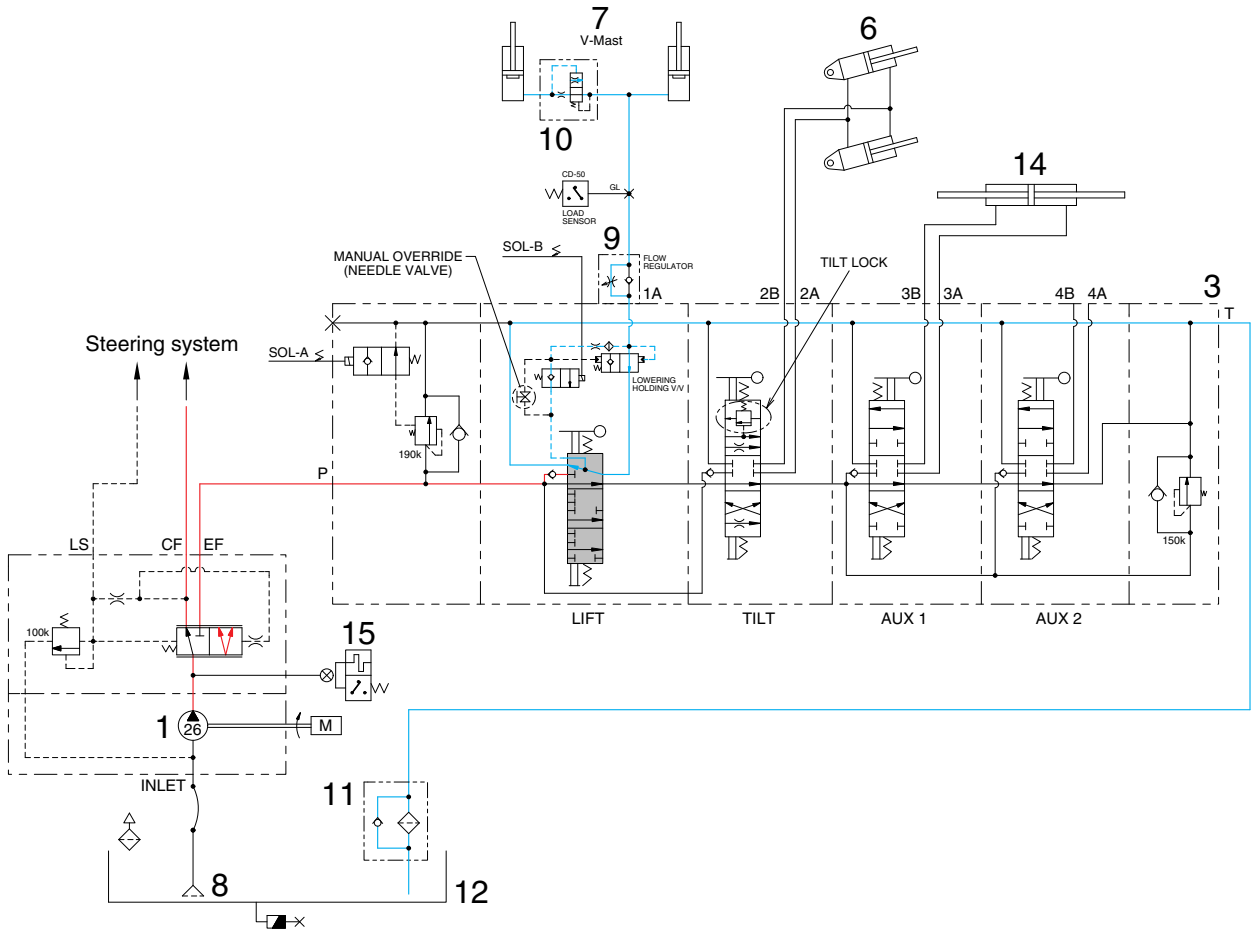


15D9HS03

When the lift control lever is pulled back, the spool on the first block moves to lift position.
The oil from hydraulic gear pump (1) flows into main control valve (3) through the priority valve (1) and then goes to the large chamber of lift cylinder (7) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder (7) returns to hydraulic oil tank (12) at the same time.
When this happens, the fork goes up.

※ The circuit diagram may differ from the equipment, so please check before a repair.

2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION

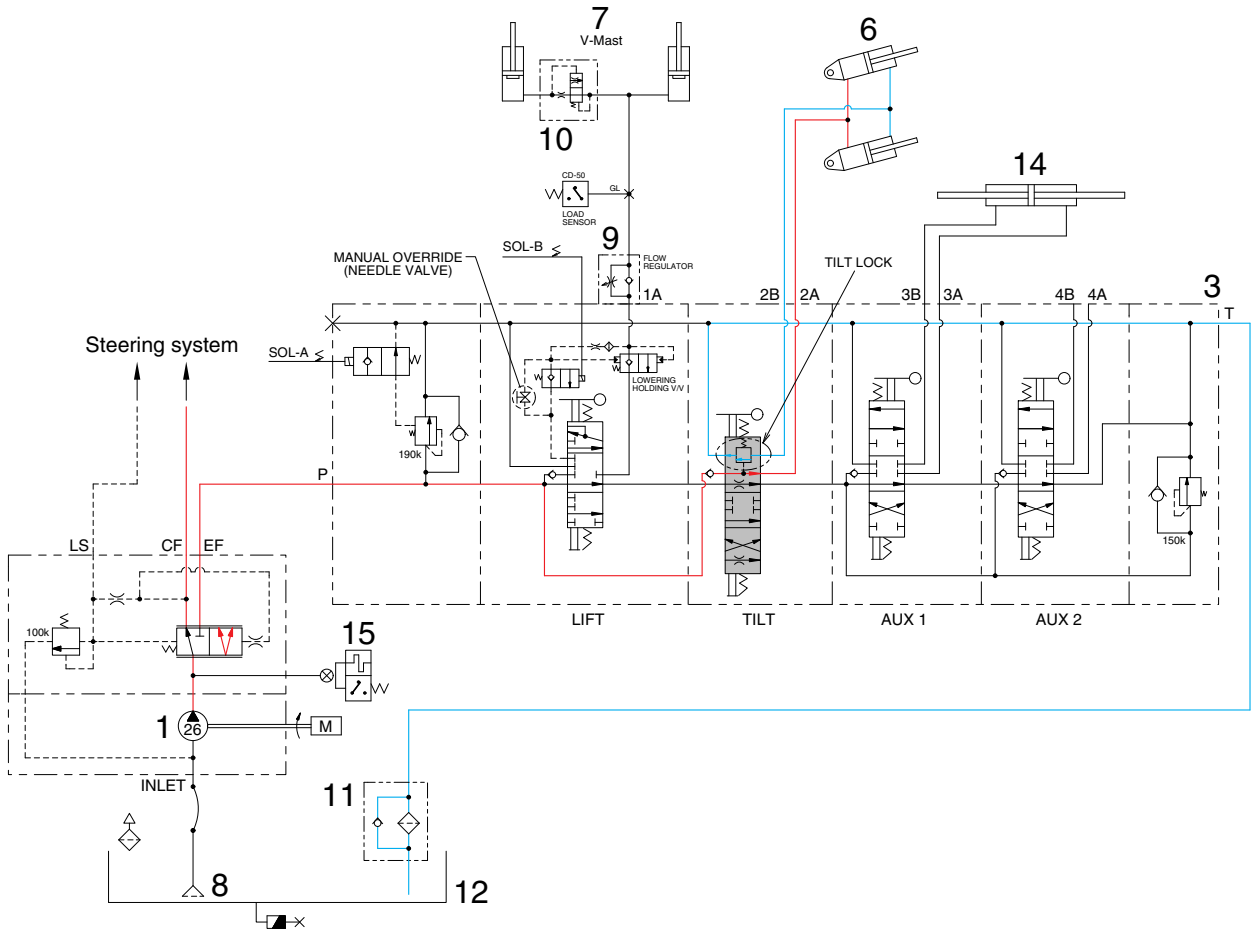


15D9HS04

When the lift control lever is pushed forward, the spool on the first block moves to lower position. The work port (1A) and the small and the large chamber of lift cylinder are connected to the return passage, so the fork will be lowered due to its own weight.

※ The circuit diagram may differ from the equipment, so please check before a repair.

3) WHEN THE TILT CONTROL LEVER IS IN THE FORWARD POSITION

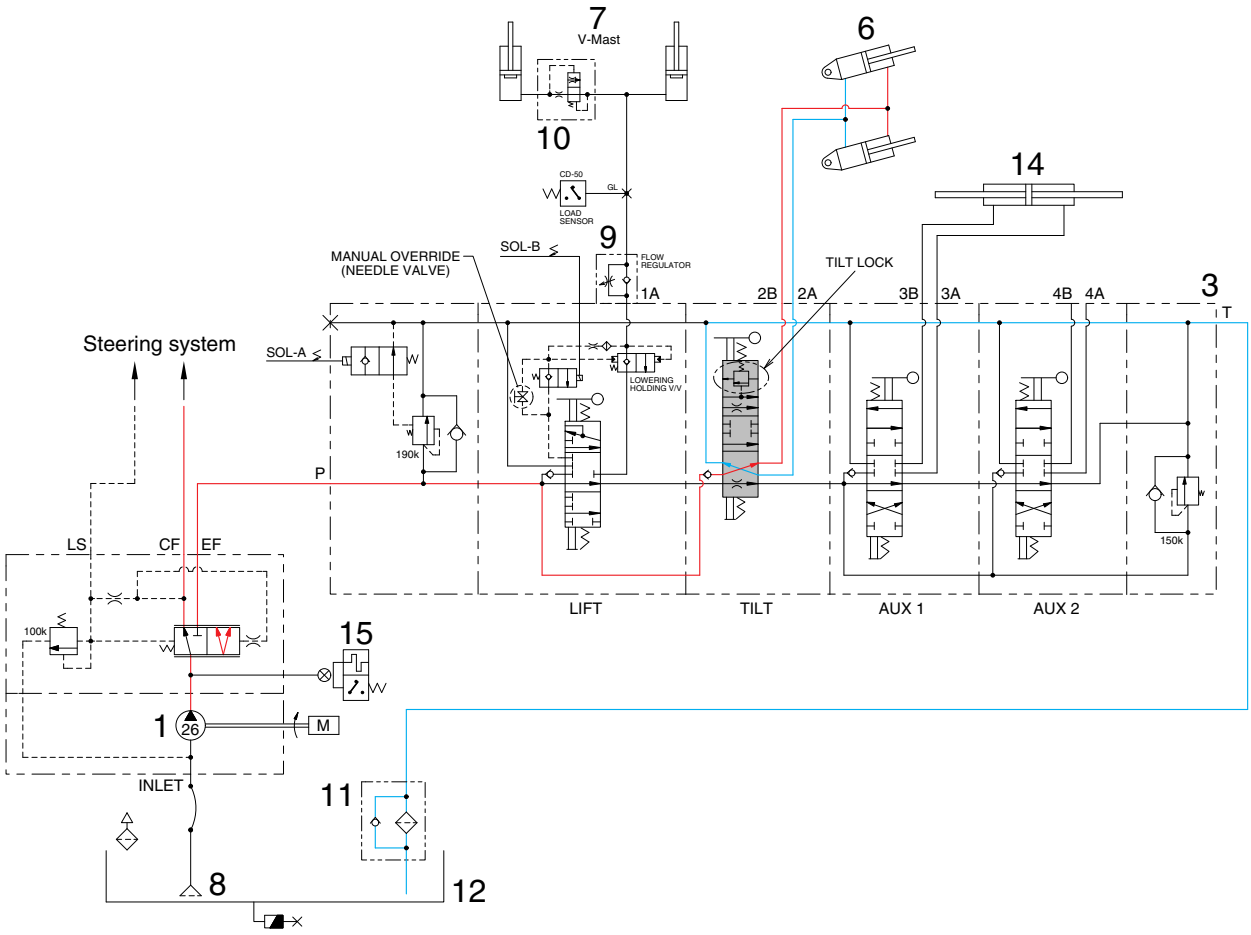


15D9HS05

When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.
The oil from hydraulic gear pump (1) flows into main control valve (3) through the priority valve (1) and then goes to the large chamber of tilt cylinder (6) by pushing the load check valve of the spool.
The oil at the small chamber of tilt cylinder (6) returns to hydraulic tank (12) at the same time.
When this happens, the mast tilt forward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

4) WHEN THE TILT CONTROL LEVER IS IN THE BACKWARD POSITION



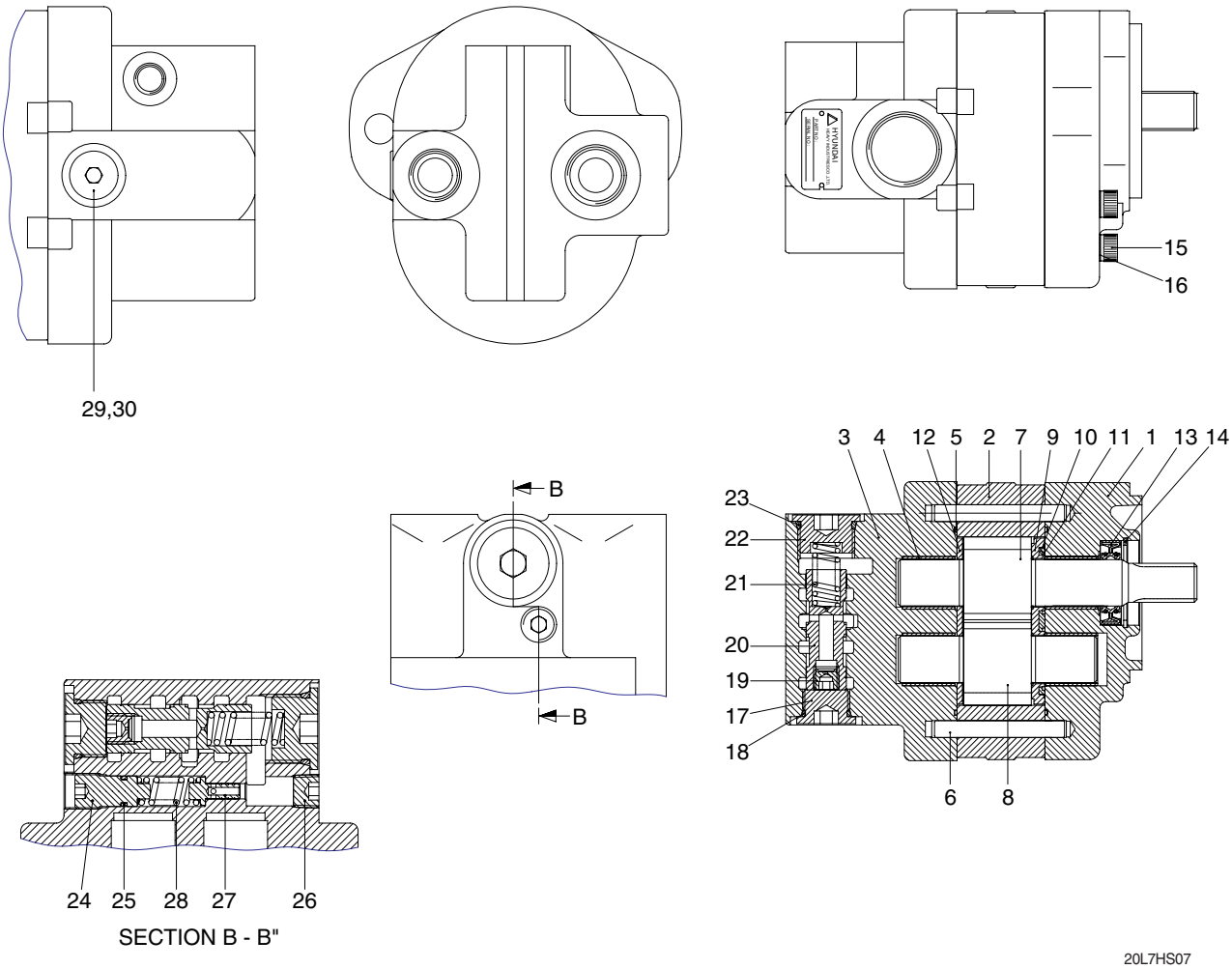
15D9HS06

When the tilt control lever is pulled back, the spool on the second block is moved to tilt backward position.
The oil from hydraulic gear pump (1) flows into main control valve (3) through the priority valve (1) and then goes to the small chamber of tilt cylinder (6) by pushing the load check valve of the spool.
The oil at the large chamber of tilt cylinder (6) returns to hydraulic tank (12) at the same time.
When this happens, the mast tilts backward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

2. HYDRAULIC GEAR PUMP (NON-BOOSTER TYPE)

1) STRUCTURE



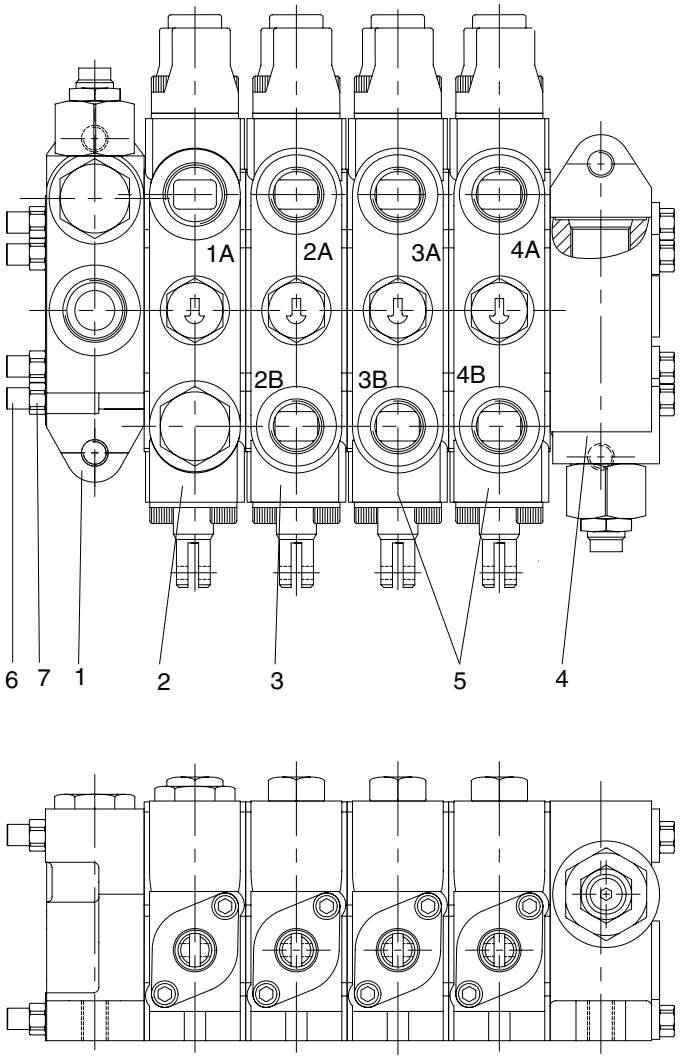
1	Housing	11	Back up ring	21	Spring
2	Body	12	Side plate	22	Plug
3	Body (priority valve)	13	Oil seal	23	O-ring
4	Bushing	14	Snap ring	24	Adjust screw
5	O-ring	15	Bolt	25	O-ring
6	Pin	16	Washer	26	Plug bolt
7	Drive gear	17	Plug	27	Poppet
8	Idle gear	18	O-ring	28	Relief spring
9	Side plate	19	Plug orifice	29	Plug
10	O-ring	20	Spool	30	O-ring

2) OPERATION

This pump comprises of an end cover, a body, bushings and a mounting flange bolted together. The gear journals are supported in plane bearings within pressure balanced bushings to give high volumetric and mechanical efficiencies.

3. MAIN CONTROL VALVE

1) STRUCTURE (4 Spool - NON OPSS / TRAVEL OPSS)



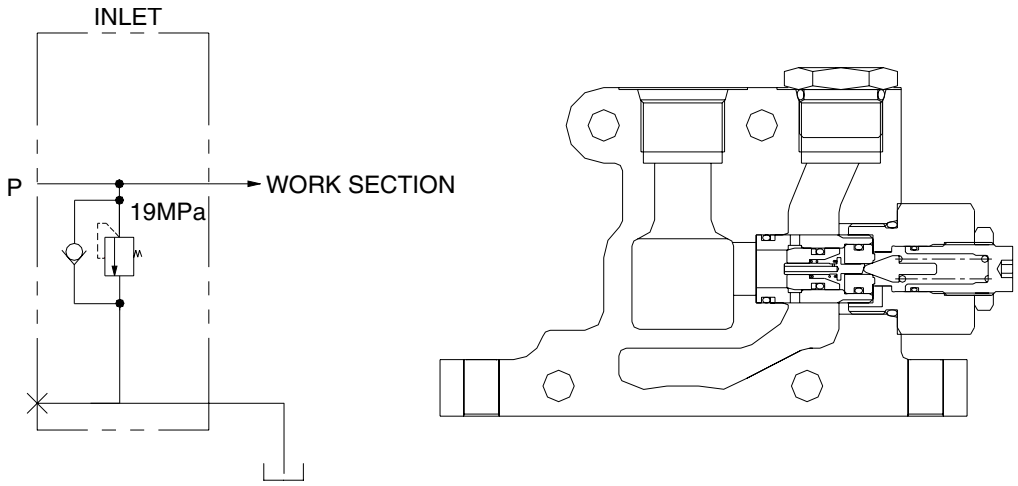
15L7HS07

Port name	Size
Inlet port	7/8-14UNF
Outlet port	7/8-14UNF
Work port	3/4-16UNF

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Outlet block assy
5 Auxiliary block assy
6 Long bolt
7 Nut

2) INLET SECTION OPERATION

(1) Operation

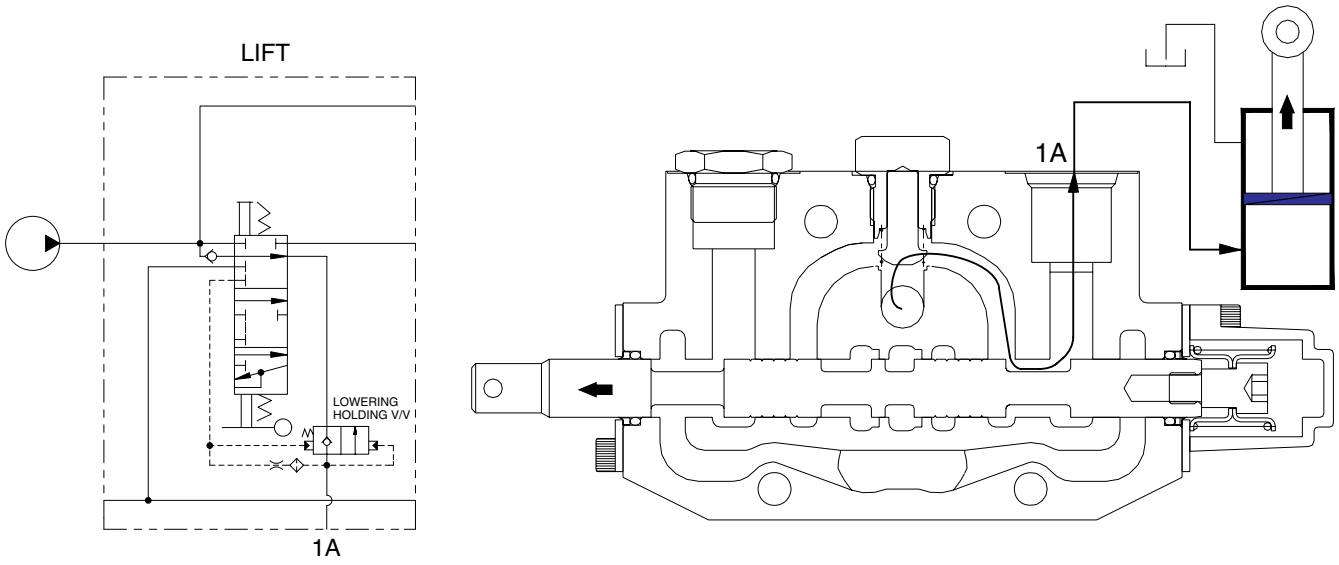


15L7HS08

The inlet section contains the pump inlet connection as well as a diagnostic inlet pressure gage port (new feature to be included).

3) LIFT SECTION OPERATION

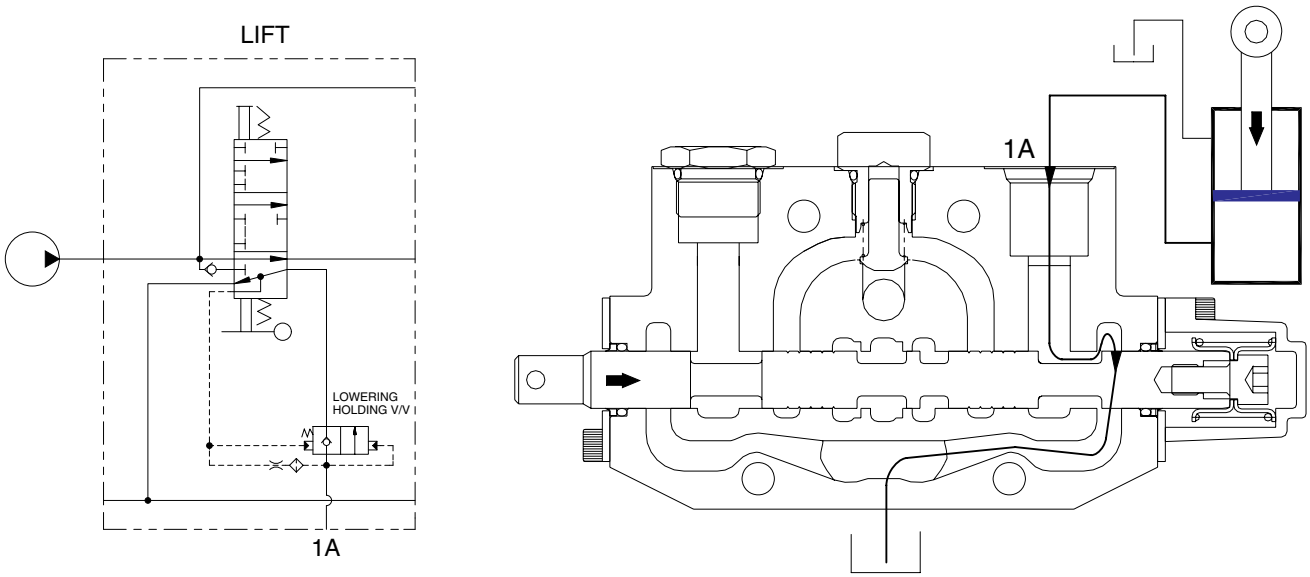
(1) Lift position



15D9HS09

When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and to the head side of the lift cylinder.

(2) Lower position

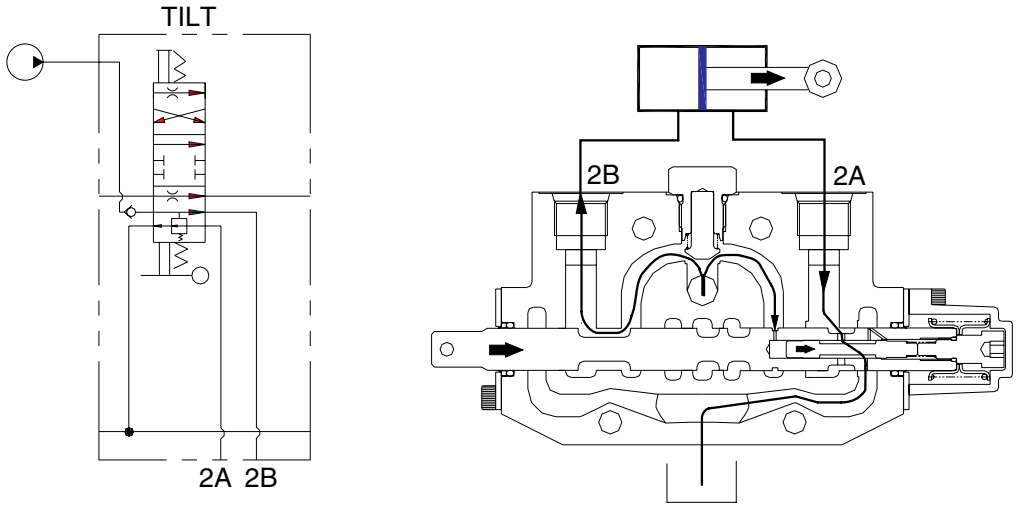


15D9HS10

When the seated operator shifts the lever forwards, the spool retracts into the valve, and the oil is directed from the cylinder, past the lift lock check valve, past the spool metering notches, and to the common tank cavity.

4) TILT SECTION OPERATION

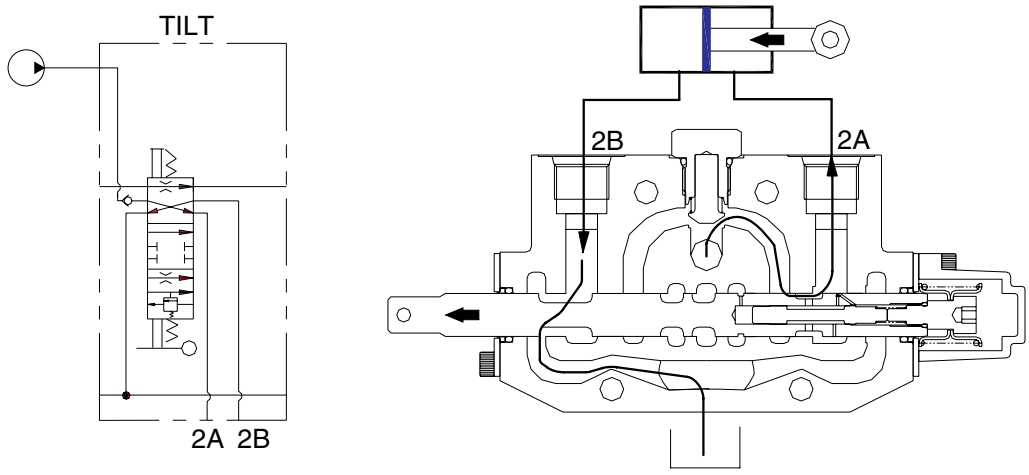
(1) Tilt forward position



15L7HS11

When the seated operator shifts the level forward, pressure is applied to the head of the tilt cylinder, and the forks tilt forward. Oil is past the spool metering notches, and towards the cylinder head. Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool.This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.

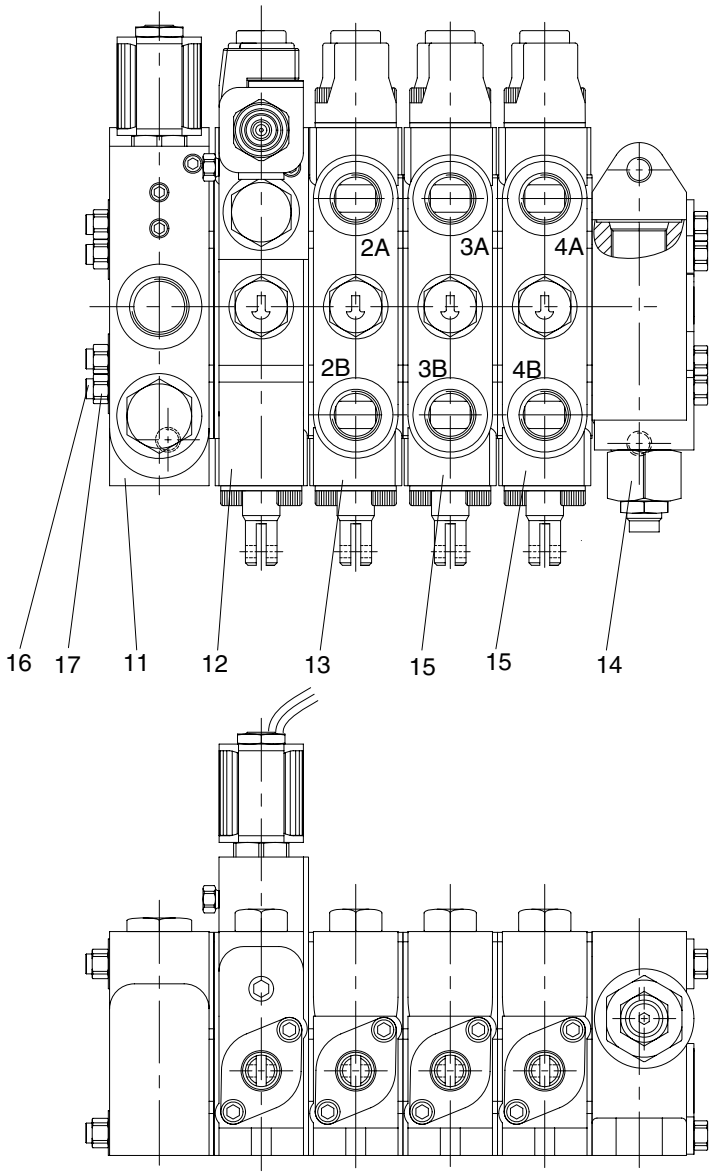
(2) Tilt backward position



15L7HS12

When the seated operator shifts the lever back, the high pressure oil from the parallel passage is directed past the load check valve, past the spool metering notches, and to the rod side of the cylinder.
Exhaust oil from the head side of the cylinder is directed past the spool metering notches to tank.

5) STRUCTURE (4 SPOOL - TRAVEL WITH MAST OPSS)



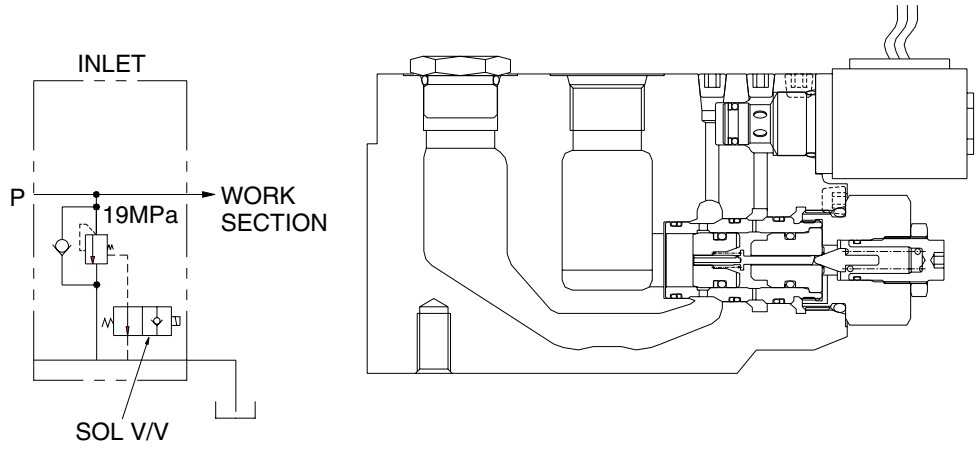
15L7HS57

Port name	Size
Inlet port	7/8-14UNF
Outlet port	7/8-14UNF
Work port	3/4-16UNF

11 Inlet block assy
12 Lift block assy
13 Tilt block assy
14 Outlet block assy
15 Auxiliary block assy
16 Long bolt
17 Nut

6) INLET SECTION OPERATION (TRAVEL WITH MAST OPSS)

(1) Operation



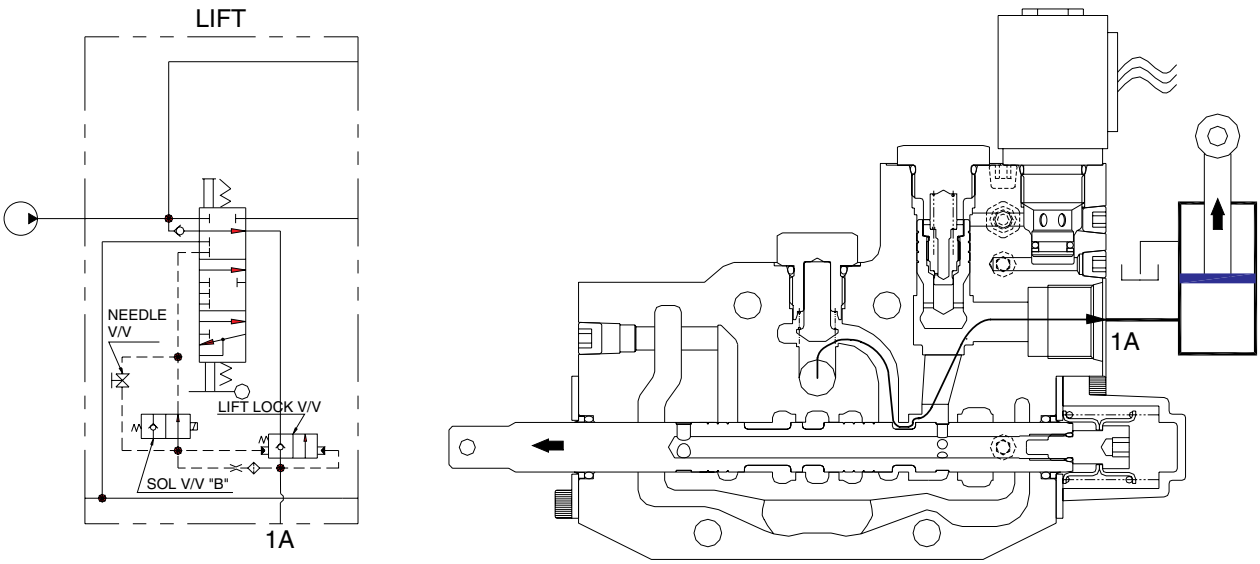
15L7HS58

When the operator is not seated, the solenoid valve is in the normally open position, which helps divert flow from the pump directly to the outlet to tank. In this manner, oil pressure and flow are not able to reach the portions of the valve which control the vehicle functions, so their operation is prevented.

Pressure is limited by the main relief valve.

7) LIFT SECTION OPERATION (TRAVEL WITH MAST OPSS)

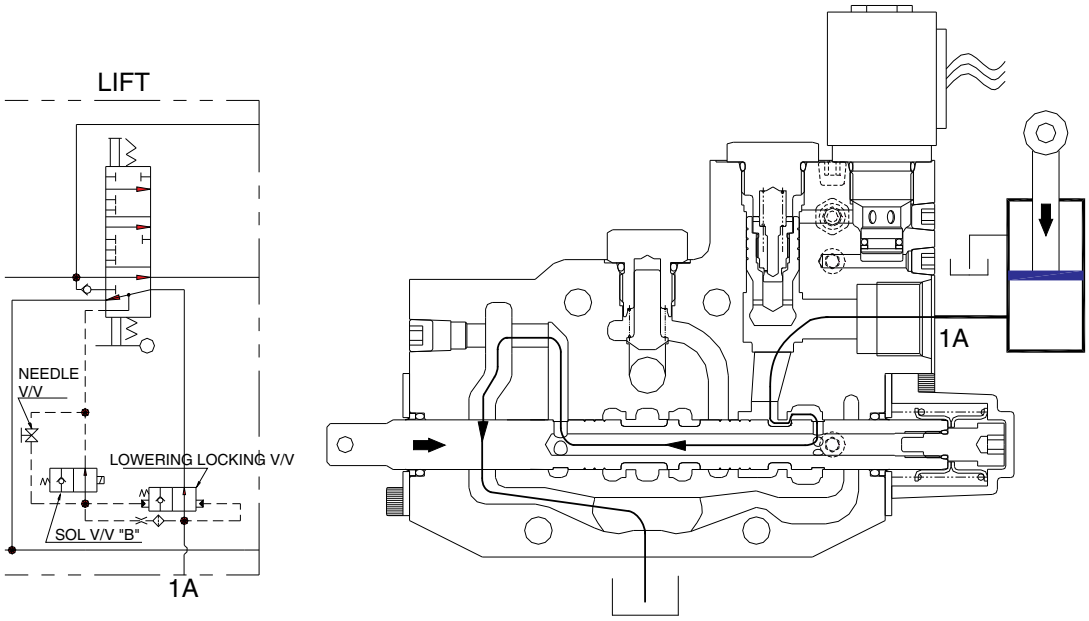
(1) Lift position



15L7HS59

When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and to the head side of the lift cylinder.

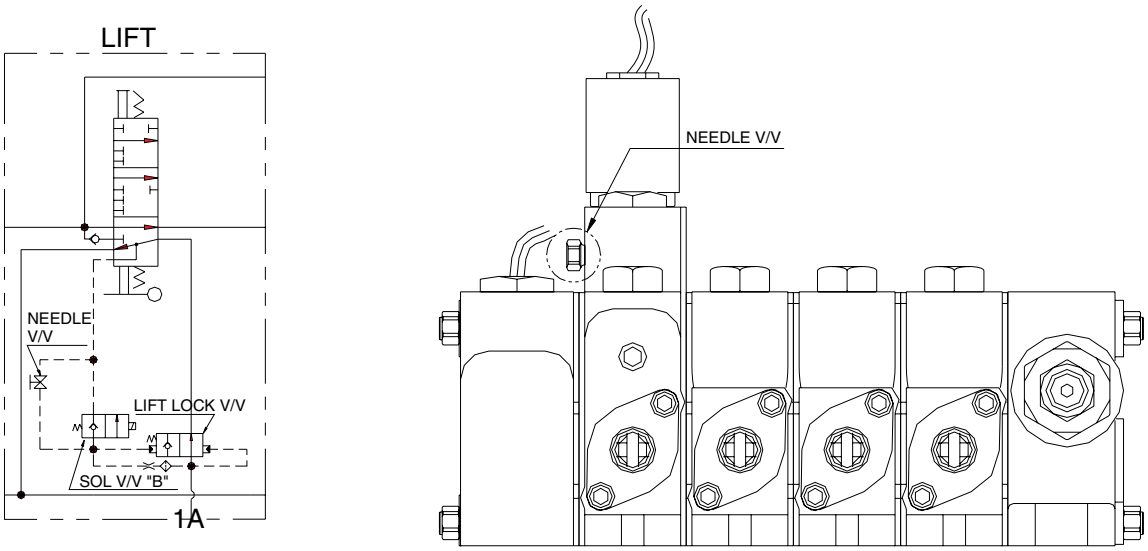
(2) Lower position



15L7HS60

When the seated operator shifts the lever forwards, the spool retracts into the valve, and the oil is directed from the cylinder, past the lift lock check valve, past the spool metering notches, and to the common tank cavity.

(3) Secondary lower position



15L7HS61

Secondary lowering method : A secondary lowering method is available in the event of the loss of engine power that is needed to energize the normally closed solenoid valve.

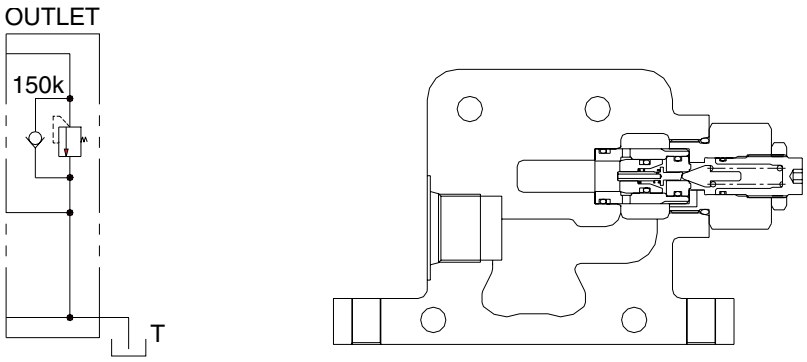
- Important Note : Before opening the secondary needle valve, make sure personnel and equipment are safely positioned to avoid accidents. Be careful to operate this secondary valve slowly, as heavy loads may be suspended.
- A manual valve (needle valve) is located on the lift section, and it can be operated by opening the vehicle cowling and rotating the manual valve (needle valve) counterclockwise with a wrench.

  Open the manual valve (needle valve) approximately 2~3 turns (do not rotate more than 4 turns). Then shift the lift spool slowly for controlled lowering. This should be just enough for slow,
- controlled movement of the mast.

  Pressure is limited by the main relief valve.

8) OUTLET SECTION OPERATION

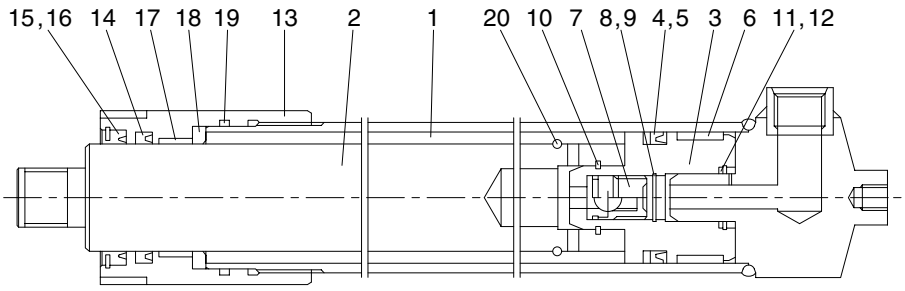
(1) Operation



15L7HS62

The outlet section contains the tank port and the secondary relief valve (with built-in anti-cavitation feature).

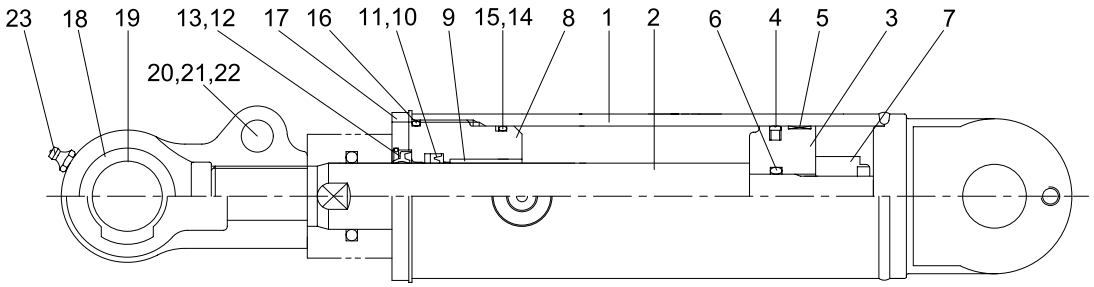
5. LIFT CYLINDER



16B9HS18

1	Tube assembly	8	Spacer	15	Dust wiper
2	Rod	9	Retaining ring	16	Retaining ring
3	Piston	10	Stop ring	17	Rod bush
4	U-packing	11	Cushion seal	18	Spacer
5	Back up ring	12	Retaining ring	19	O-ring
6	Wear ring	13	Rod cover	20	Stop ring
7	Check valve	14	U-packing		

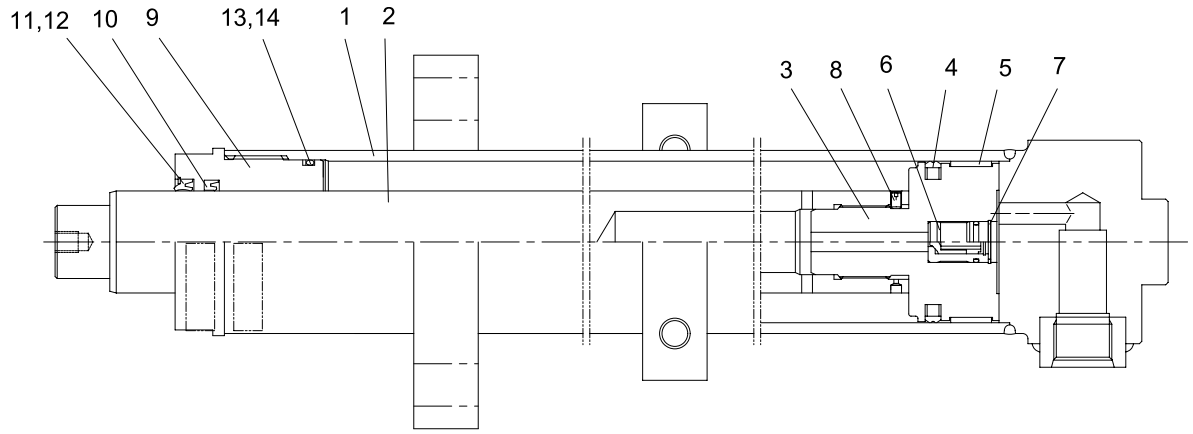
6. TILT CYLINDER



15DHS14

1	Tube assembly	9	DU bushing	17	Washer
2	Rod	10	U-packing	18	Eye
3	Piston	11	Back up ring	19	Bushing
4	Piston seal	12	Dust wiper	20	Hex bolt
5	Wear ring	13	Stop ring	21	Spring washer
6	O-ring	14	O-ring	22	Lock nut
7	Nylon nut	15	Back up ring	23	Grease nipple
8	Gland	16	O-ring		

7. FREE LIFT CYLINDER



D155HS15

1	Tube assembly	6	Check valve	11	Dust wiper
2	Rod	7	Ring retaining	12	Snap ring
3	Piston	8	Set screw	13	O-ring
4	Piston seal	9	Gland	14	Back up ring
5	Wear ring	10	Rod seal		

1. OPERATIONAL CHECKS

1) CHECK ITEM

(1) Check visually for deformation, cracks or damage of rod.

(2) Set mast vertical and raise 1m from ground. Wait for 10 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

· **Check condition**

- Hydraulic oil : Normal operating temp
- Mast substantially vertical.
- Rated capacity load.

· **Hydraulic drift**

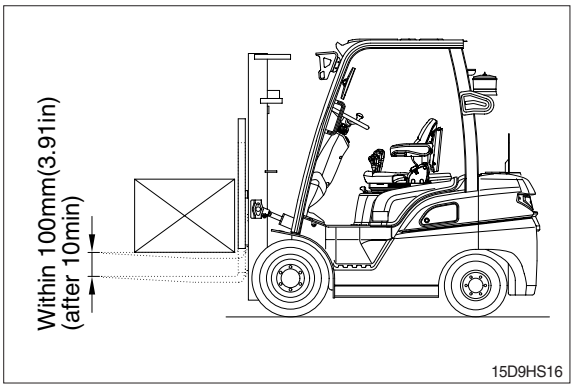
- Down (Downward movement of forks)
  : Within 100 mm (3.9 in)
- Forward (Extension of tilt cylinder)
  : Within 5°

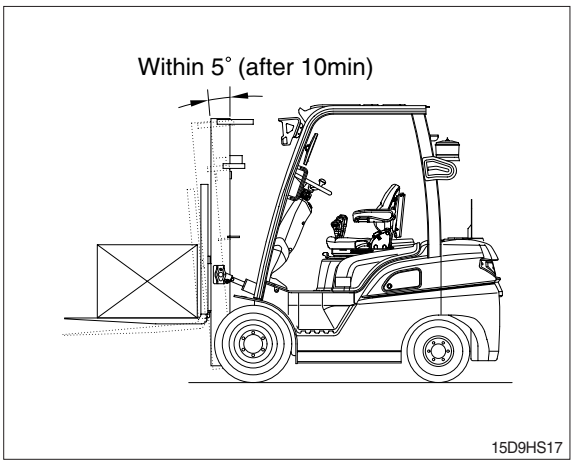
(3) If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.

Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

mm (in)

Standard	Under 0.6 (0.02)

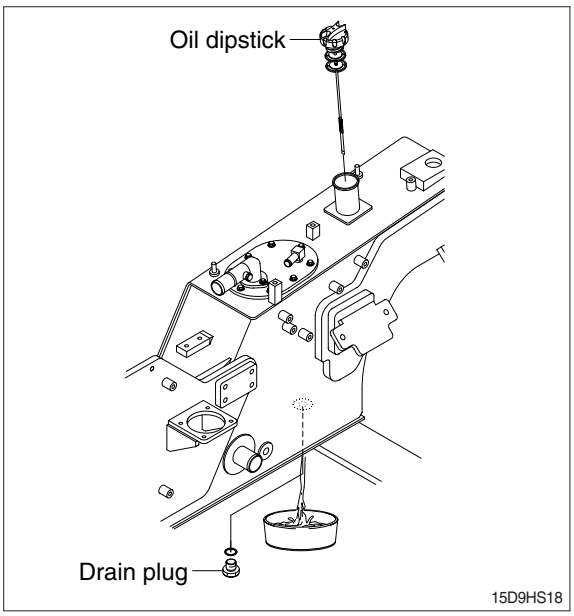




2) HYDRAULIC OIL

(1) Using dipstick, measure oil level, and oil if necessary.

(2) When changing hydraulic oil, clean suction strainer(screwed into outlet port pipe) and line filter(screwed into inlet pipe). Line filter uses paper element, so replace periodically(every 6 months or 1000 hours)



3) CONTROL VALVE

(1) Raise forks to maximum height and measure oil relief pressure.

Check that oil relief pressure is 190kgf/cm^2. (2702 psi)

2. TROUBLESHOOTING

1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed	· Seal inside control valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Replace spool or valve body. · Replace. · Replace packing.
Large spontaneous tilt of mast	· Tilting backward : Check valve defective. · Tilting forward : tilt lock valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Clean or replace. · Clean or replace. · Replace. · Replace seal.
Slow fork lifting or slow mast tilting	· Lack of hydraulic oil. · Hydraulic oil mixed with air. · Oil leaks from joint or hose. · Excessive restriction of oil flow on pump suction side. · Relief valve fails to keep specified pressure. · Poor sealing inside cylinder. · High hydraulic oil viscosity. · Mast fails to move smoothly. · Oil leaks from lift control valve spool. · Oil leaks from tilt control valve spool.	· Add oil. · Bleed air. · Replace. · Clean filter. · Adjust relief valve. · Replace packing. · Change to SAE10W, class CF engine oil. · Adjust roll to rail clearance. · Replace spool or valve body. · Replace spool or valve body.
Hydraulic system makes abnormal sounds	· Excessive restriction of oil flow pump suction side. · Gear or bearing in hydraulic pump defective.	· Clean filter. · Replace gear or bearing.
Control valve lever is locked	· Foreign matter jammed between spool and valve body. · Valve body defective.	· Clean. · Tighten body mounting bolts uniformly.
High oil temperature	· Lack of hydraulic oil. · High oil viscosity. · Oil filter clogged.	· Add oil. · Change to SAE10W, class CF engine oil. · Clean filter.

2) HYDRAULIC GEAR PUMP

Problem	Cause	Remedy
Pump does not develop full pressure	· System relief valve set too low or leaking. · Oil viscosity too low. · Pump is worn out.	· Check system relief valve for proper setting. · Change to proper viscosity oil. · Repair or replace pump.
Pump will not pump oil	· Reservoir low or empty. · Suction strainer clogged.	· Fill reservoir to proper level. · Clean suction strainer.
Noisy pump caused by cavitation	· Oil too thick. · Oil filter plugged. · Suction line plugged or too small.	· Change to proper viscosity. · Clean filters. · Clean line and check for proper size.
Oil heating	· Oil supply low. · Contaminated oil. · Setting of relief valve too high or too low. · Oil viscosity too low.	· Fill reservoir to proper level. · Drain reservoir and refill with clean oil. · Set to correct pressure. · Drain reservoir and fill with proper viscosity.
Foaming oil	· Low oil level. · Air leaking into suction line. · Wrong kind of oil.	· Fill reservoir to proper level. · Tighten fittings, check condition of line. · Drain reservoir, fill with non-foaming oil.
Shaft seal leakage	· Worn shaft seal. · Worn shaft in seal area.	· Replace shaft seal. · Replace drive shaft and seal.

3) MAIN RELIEF VALVE

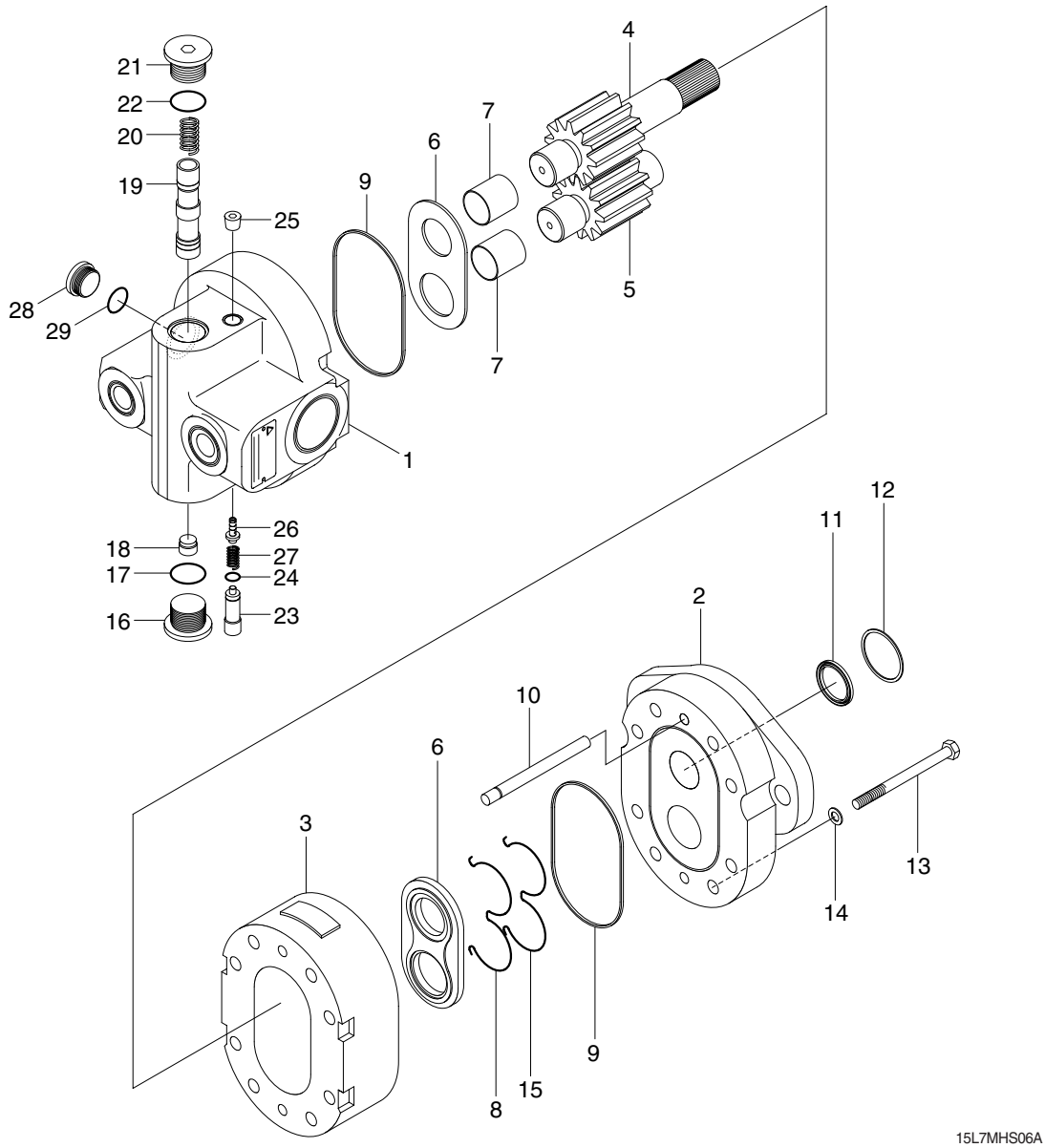
Problem	Cause	Remedy
Can't get pressure	· Poppet stuck open or contamination under seat.	· Check for foreign matter between poppets and their mating parts. Parts must slide freely.
Erratic pressure	· Pilot poppet seat damaged. · Poppet C sticking in D.	· Replace the relief valve. · Clean and remove surface marks for free movement.
Pressure setting not correct	· Normal wear. Lock nut & adjust screw loose.	· See ★How to set pressure on work main relief.
Leaks	· Damaged seats. · Worn O-rings. · Parts sticking due to contamination.	· Replace the relief valve. · Install seal and spring kit. · Disassemble and clean.

4) LIFT CYLINDER

Problem	Cause	Remedy
Oil leaks out from rod cover through rod	· Foreign matters on packing. · Unallowable score on rod. · Unusual distortion of dust seal. · Chrome plating is striped.	· Replace packing. · Smooth rod surface with an oil stone. · Replace dust seal. · Replace rod.
Oil leaks out from cylinder rod cover thread	· O-ring damaged.	· Replace O-ring.
Rod spontaneously retract	· Scores on inner surface of tube. · Unallowable score on the inner suface of tube. · Foreign matters in piston seal.	· Smooth rod surface with an oil stone. · Replace cylinder tube. · Replace piston seal.
Wear (clearance between cylinder tube and wear ring)	· Excessive clearance between cylinder tube and wear ring.	· Replace wear ring.
Abnormal noise is produced during tilting operation	· Insufficient lubrication of anchor pin or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

1. HYDRAULIC GEAR PUMP (NON-BOOSTER TYPE)

1) STRUCTURE



15L7MHS06A

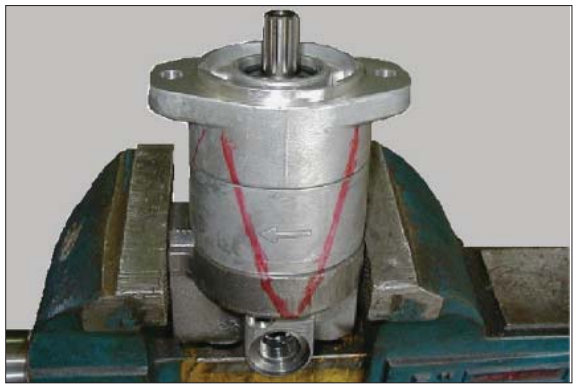
1	Housing	11	Back up ring	21	Spring
2	Body	12	Side plate	22	Plug
3	Body (priority valve)	13	Oil seal	23	O-ring
4	Bushing	14	Snap ring	24	Adjust screw
5	O-ring	15	Bolt	25	O-ring
6	Pin	16	Washer	26	Plug bolt
7	Drive gear	17	Plug	27	Poppet
8	Idle gear	18	O-ring	28	Relief spring
9	Side plate	19	Plug orifice	29	Plug
10	O-ring	20	Spool	30	O-ring

2) DISASSEMBLY

(1) Clamping pump

① Clamping pump in a vice with pump shaft facing up.
(Do not chuck the aluminum parts such as body and housing.)

② Mark V by permanent marker pen.
This will assure proper reassembly.



PUMP101

(2) Housing

① Loosen 8 bolts and remove housing.

② Pry off snap ring for hole and remove oil seal from housing.

③ Remove O-ring from housing.

PUMP102

(3) Gear

① Mark at the end of the idle gear by permanent marker pen before removing gear set. This will assure proper reassembly.

PUMP103

② Dissemble gear set and side plate from body.

③ Dissemble E-type ring and backup ring from side plate.

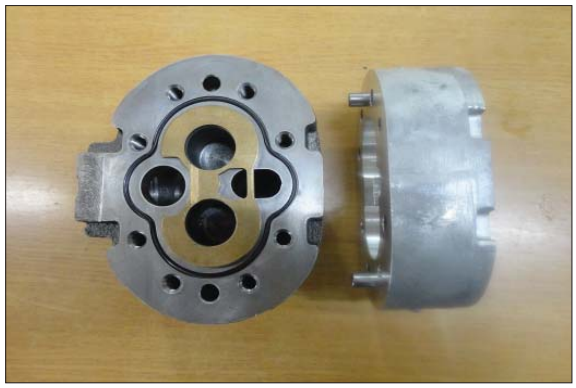
PUMP104

(4) Body and rear cover

① Loosen the vice and remove body and bronze side plate from rear cover.

② Remove O-ring from rear cover.

③ Disassemble pin from body.



PUMP105

(5) Priority valve

① Loosen the plug at the side of drive gear, be careful not to bounce out spring.

② Take out spring.

③ Loosen plug opposite side and draw out spool carefully.

PUMP106

(6) Relief valve

※ **Do not disassemble relief valve when pressure setting and caulking is not possible.**

① Loosen adjust screw, be careful not to bounce out spring.

② Take out spring and draw out poppet.

③ Loosen plug for port of gage mounting.

④ Remove O-ring from plug and adjust screw.

3) ASSEMBLY

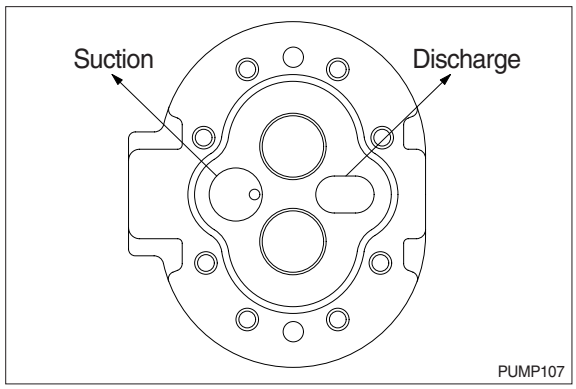
(1) Preparation

① Clean all parts and dry them with compressed air thoroughly.

② Check the permanent mark.

③ Apply grease O-ring, oil seal, E-type ring and side plate lightly.

(2) Priority valve



· **Relief valve : if disassembled**

① Fit O-ring on plug and adjust screw.

② Tighten plug for port of gage mounting. (Tightening torque : 35 Nm)

③ Assemble poppet, spring and adjust screw into body in that order.

④ Install relief valve to the machine after final assembling and set the relief pressure and caulk 3 places (equivalent), not to loosen.

· **Priority valve**

① Insert spool into spring groove from idle gear side of body carefully and tighten plug. (Tightening torque : 80 Nm)

② Put spring the other side and tighten plug. (Tightening torque : 100 Nm)

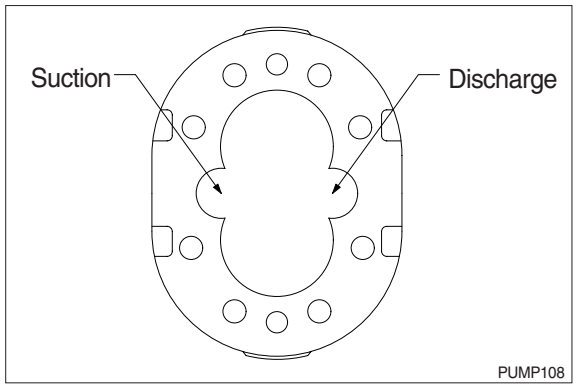
(3) Rear cover and body

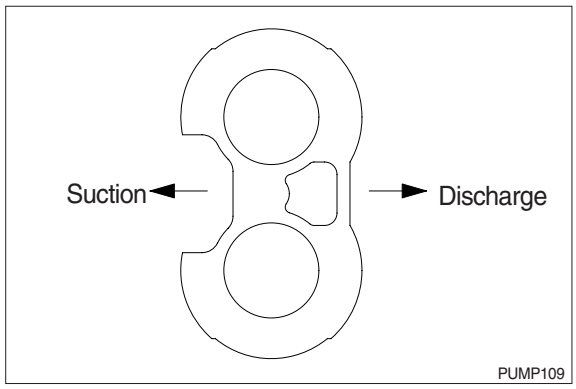
① Assemble pin into body.

② Assemble O-ring on the groove of rear cover.

③ Place the bronze face of side plate contact with gear on rear cover.
Insert side plate into body and adjust pin by pressing after adjusting pin hole of rear cover and pin of body.

④ Confirm the direction of rear cover, bronze side plate and body same as drawing.





(4) Gear

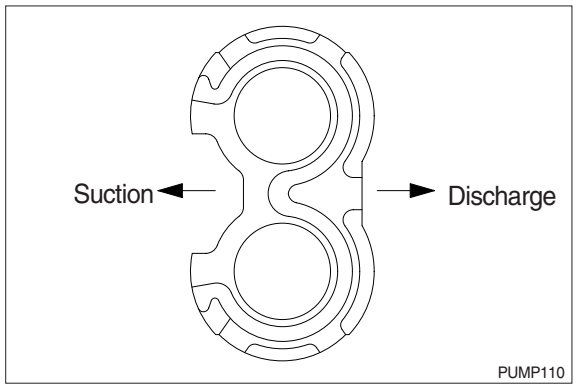
① Place body up.

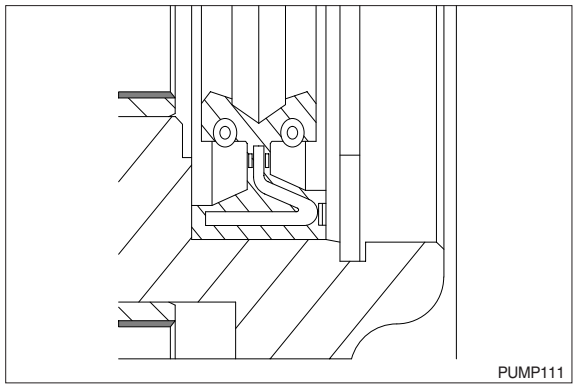
② Place peck center of idle gear up and assemble drive gear and idle gear to body.

③ Fit E-type ring and backup ring and combine side plate with gear set.

④ Confirm the direction of side plate same as drawing.

⑤ Confirm the face of backup ring side contact with housing.





(5) Housing

① Press fit oil seal with same direction as drawing carefully and fit snap ring.

② Fit O-ring into groove of housing.

③ Insert drive gear into housing and combine housing with body pressing lightly after confirmed pin position.

④ Tighten bolt with washer zigzag lightly, be careful not to leave O-ring its place.

⑤ Clamp rear cover in a vice.

⑥ Tighten bolt zigzag with tightening torque 35~38 Nm.

(6) Inspection

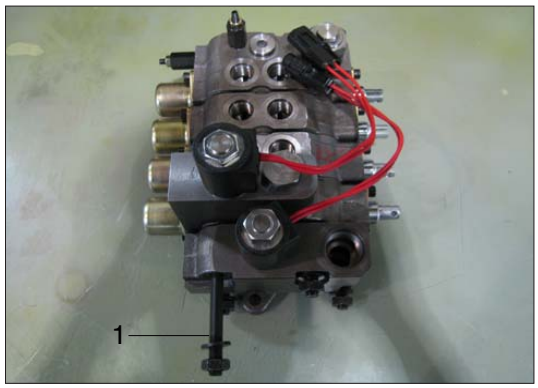
① Clamp drive gear shaft in a vice.

② Rotate the gear pump.

③ Confirm rotation smoothly.

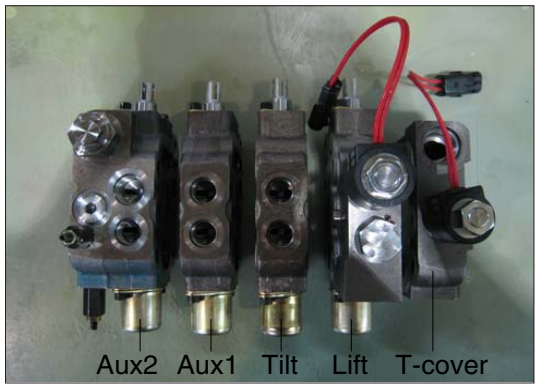
2. MAIN CONTROL VALVE

1) Remove bolt (1) to separate the valve section.
   · Bolt torque (1) : $10.0^{+0.6}_{0}$ kgf · m



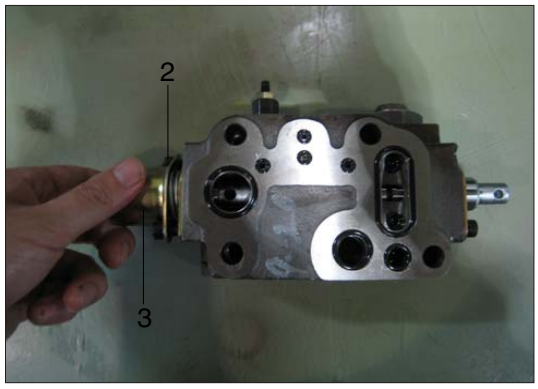
20D7MCV01

2) Divide the valve body.



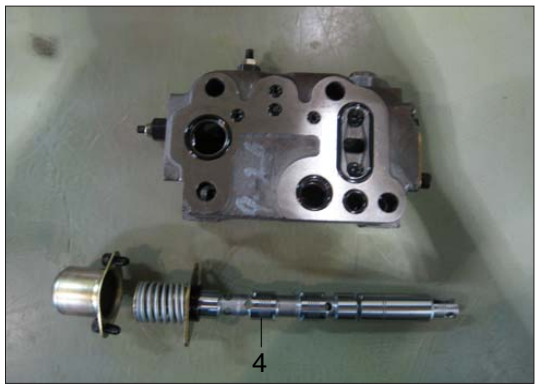
20D7MCV02

3) Remove dust cap (3) and bolt (2) from the valve body.
   · Bolt torque (2) : 1.2 kgf · m



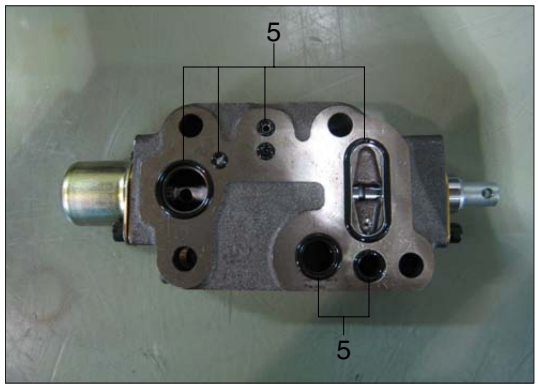
20D7MCV03

4) Remove attachment spool (4) from the valve body.



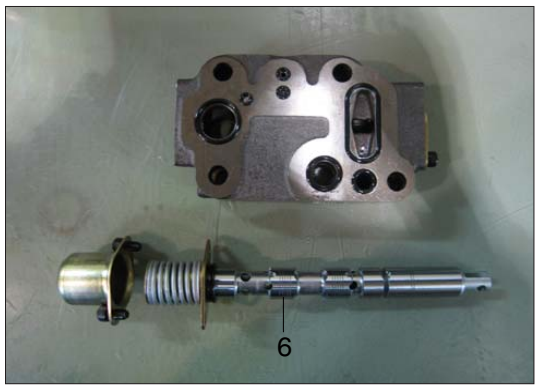
20D7MCV04

5) Remove O-ring seals (5) from the valve body.



20D7MCV05

6) Remove tilt spool (6) from the valve body.

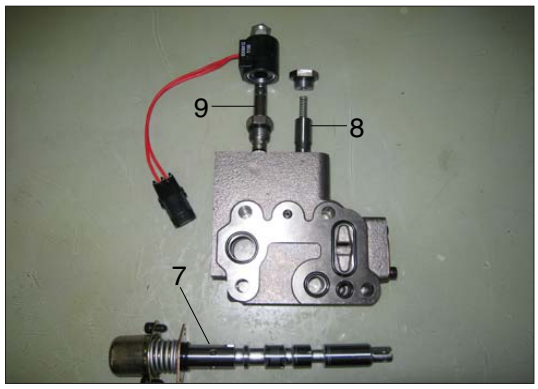


20D7MCV06

7) Remove lift spool (7) from the valve body.

8) Remove lock poppet (8) from the valve body.

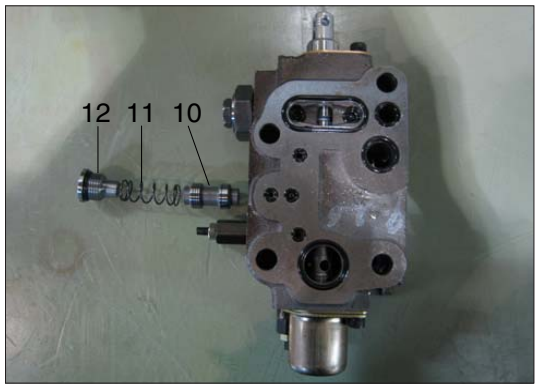
9) Remove normal close solenoid valve (9, Opt) from the valve body.



20D7MCV07

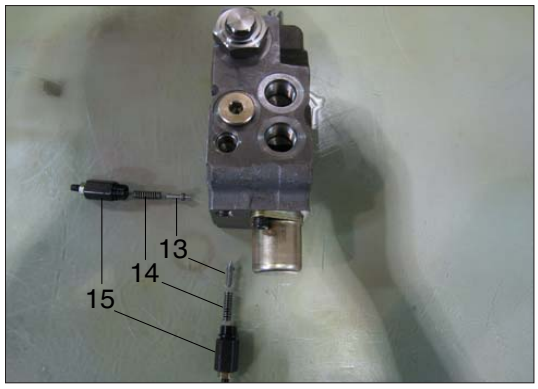
10) Remove plug (12) and spring (11).

11) Remove hydrostat (10).



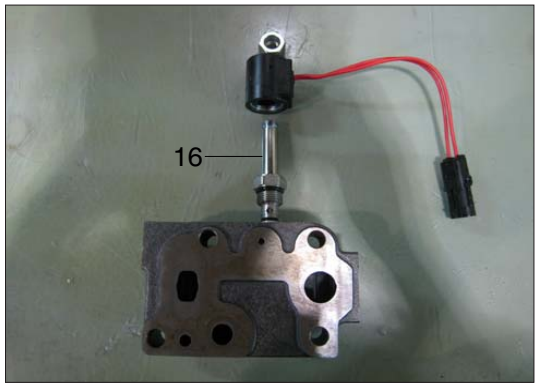
20D7MCV08

12) Remove relief plugs (15), springs (14) and poppets (13).
 · Relief plugs torque (15) : 2.5 kgf · m



20D7MCV09

13) Remove normal open solenoid valve (16, Opt) from the valve body.

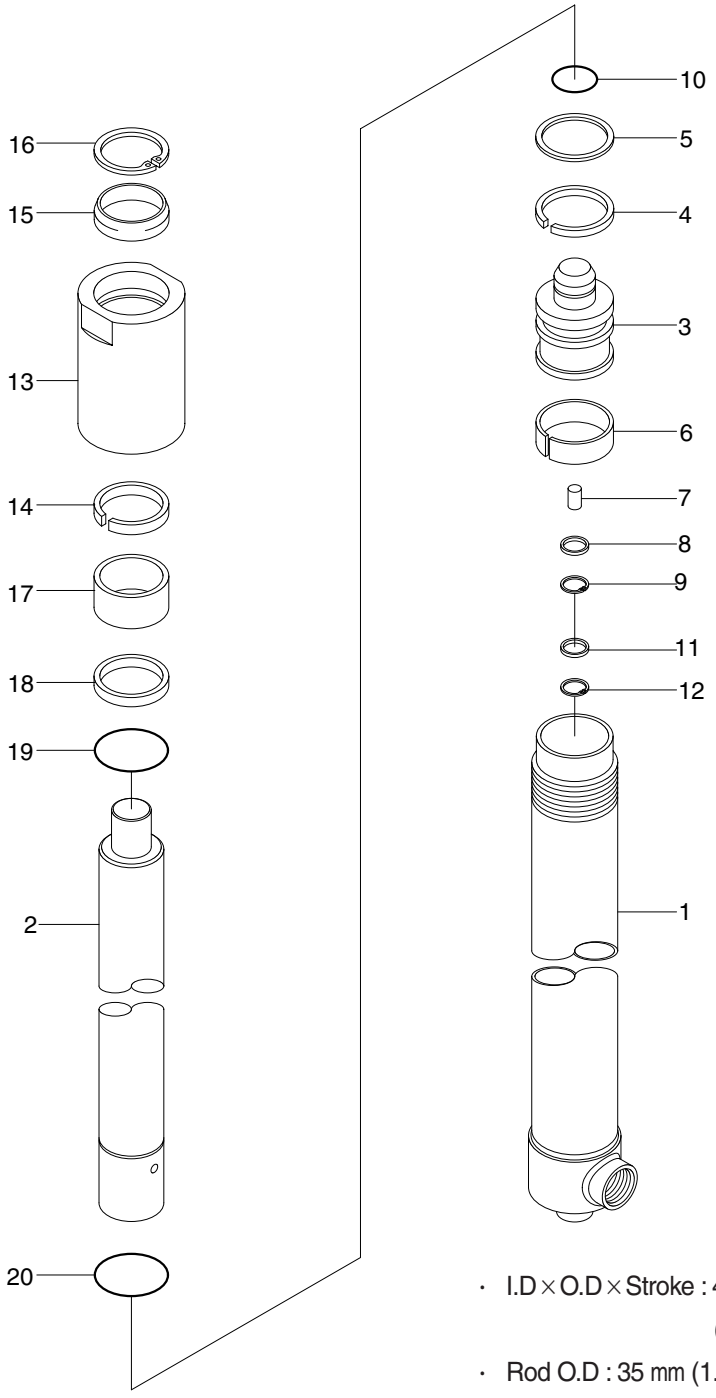


20D7MCV10

14) Assembly procedure of the main control valve is the reverse order of the removal procedure.

3. LIFT CYLINDER

1) STRUCTURE



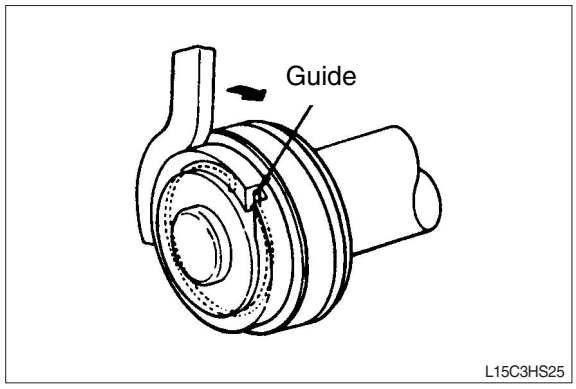
- I.D × O.D × Stroke : 45 × 55 × 1245 mm
  (1.7 × 2.2 × 49~108 in)
- Rod O.D : 35 mm (1.4 in)

15D9HS16A

1	Tube assy	8	Spacer	15	Dust wiper
2	Rod assy	9	Retaining ring	16	Retaining ring
3	Piston	10	Stop ring	17	Rod bush
4	U-Packing	11	Cushion seal	18	Spacer
5	Back up ring	12	Retaining ring	19	O-ring
6	Wear ring	13	Rod cover	20	Stop ring
7	Check Valve	14	U-Packing		

2) DISASSEMBLY

(1) Hold the cylinder tube in a vice, loosen the cylinder head and remove it.
Remove the spacer from the cylinder tube and knock out the bushing. Hook a wrench in the hole in the retainer at the piston end and turn. Lever up the edge of the guide, then turn the guide in again and the guide can be removed.



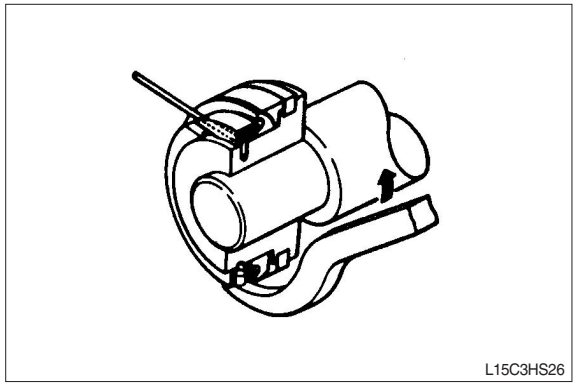
3) CHECK AND INSPECTION

mm (in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between piston ring & tube	0.05~0.030 (0.002~0.012)	0.5 (0.020)	Replace piston ring

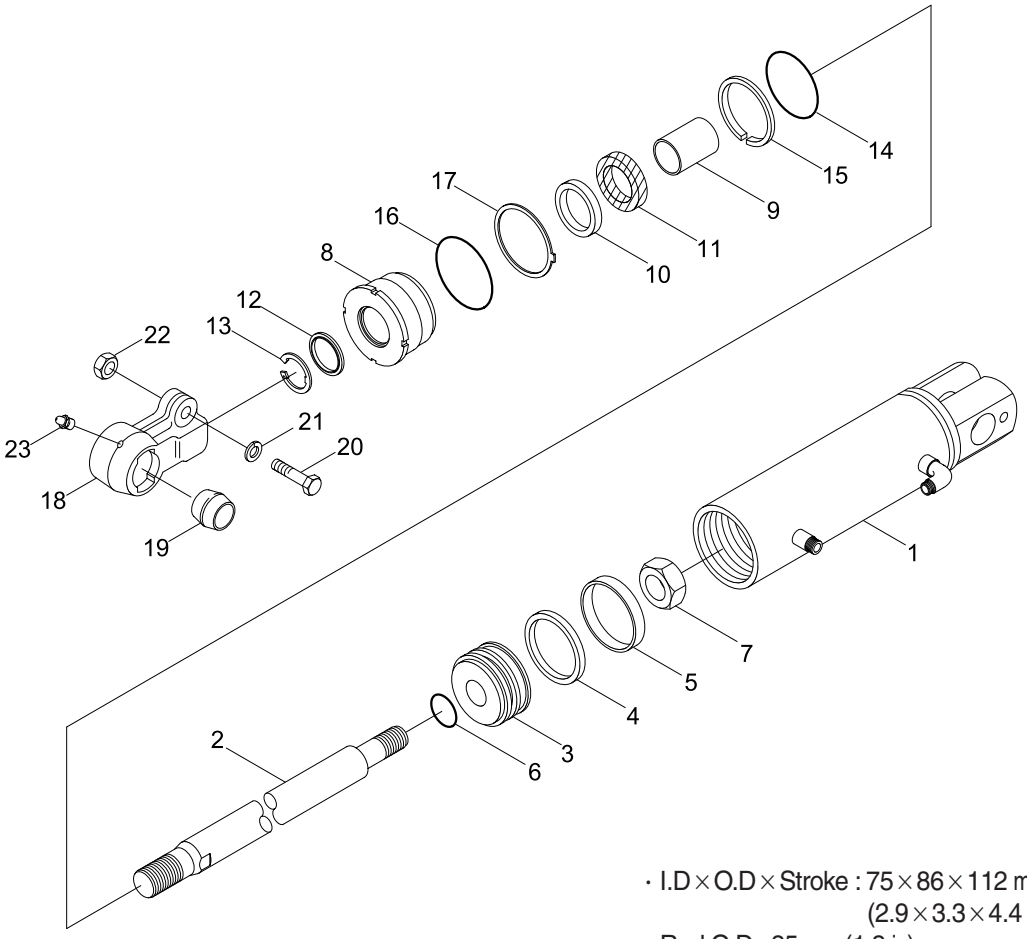
4) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50°C, expand the inside diameter and assemble on the piston. Install a piston seal.
Bend the edge of the guide and rotate it to install the guide completely.



4. TILT CYLINDER

1) STRUCTURE



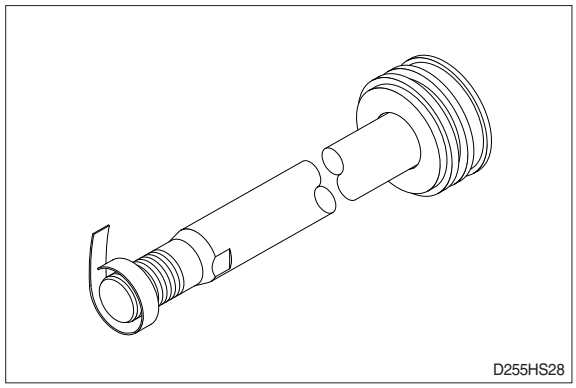
- I.D × O.D × Stroke : 75 × 86 × 112 mm (2.9 × 3.3 × 4.4 in)
- Rod O.D : 35 mm (1.3 in)

15DHS21

1	Tube assembly	9	DU bushing	17	Washer
2	Rod	10	U-packing	18	Eye
3	Piston	11	Back up ring	19	Bushing
4	Piston seal	12	Dust wiper	20	Hex bolt
5	Wear ring	13	Stop ring	21	Spring washer
6	O-ring	14	O-ring	22	Lock nut
7	Nylon nut	15	Back up ring	23	Grease nipple
8	Gland	16	O-ring		

2) DISASSEMBLY

(1) Hold the parallel parts of the cylinder tube bottom in a vice and mark the rod head end to show how much it is screwed in, then remove the rod head. Next, hook a wrench into the notch at the cylinder head and remove the cylinder head from cylinder tube.
When doing this, wind tape round the threaded part of the rod and be careful not to damage the dust seal and rod seal inside cylinder head.



3) CHECK AND INSPECTION

mm (in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing