Section 2. Planetary Gear Drive Transmission

2.1 Transmission

2.1.1 Components and parts of the transmission

The Illustration 2-1 shows the structure of the transmission. The transmission is composed of following parts and components:

(1) Two planet rows with the same number of teeth and a pair of modified gears (general output of three gear positions) constitute the drive unit.

(2) Four clutches: overrunning clutch (general input of the transmission), and friction clutches for three gear positions including the first reverse gear position and the second reverse gear position.

(3) Hydraulic gear-shift control system (normally it is called one pump – speed gear pump, and one valve – speed distribution valve and control mechanism).

(4) Transmission body.

(5) Oil sump assembly.

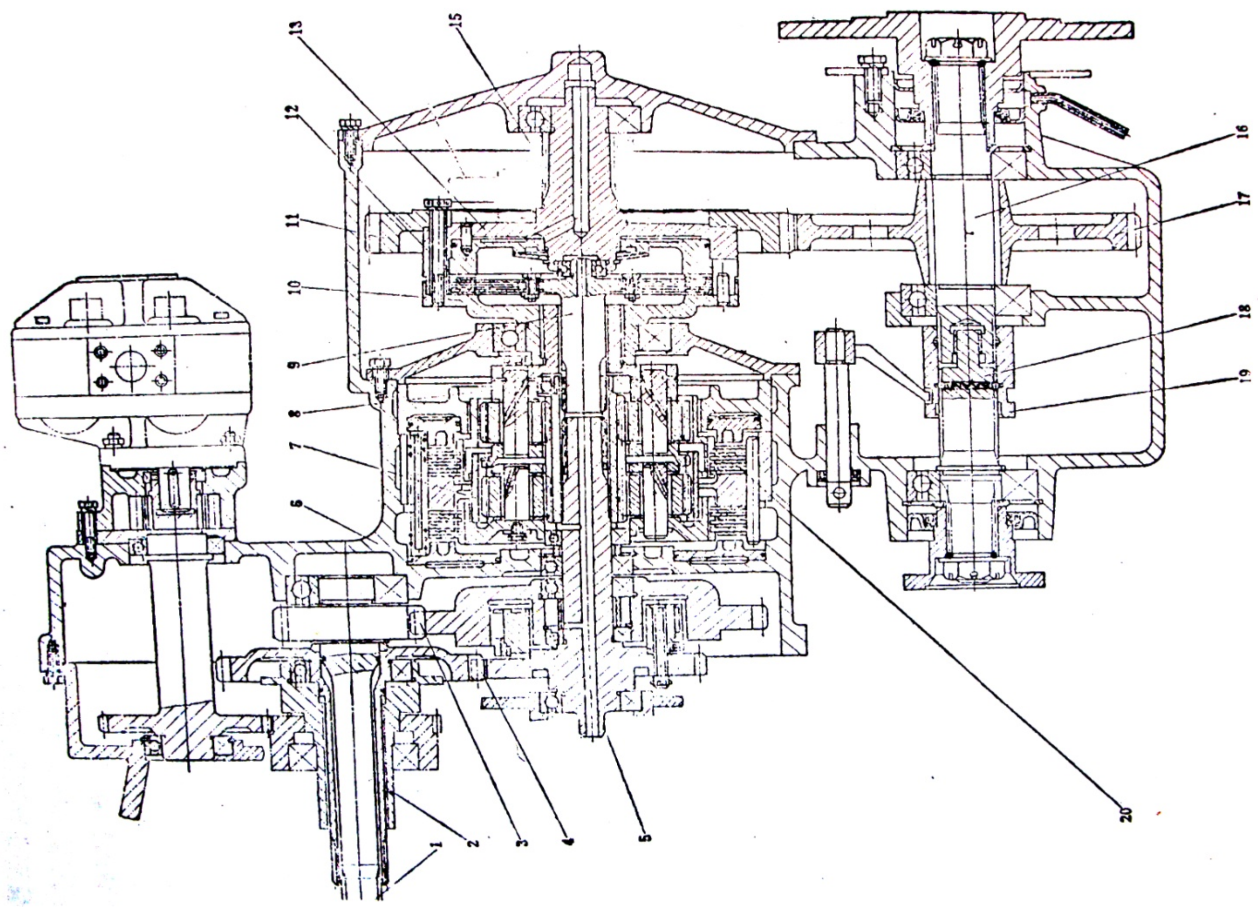


Illustration 2-1 Structure of the transmission

1. Output primary gear 2. Output secondary gear

3. Primary turbine output shaft speed reducing gear pair

4. Secondary turbine output shaft speed increasing gear pair 5. Transmission input shaft

6. Transmission body 7. Front planet row 8. Rear planet row 9. Transmission output shaft

10. Clutch slave drum 11. Intermediate shaft output gear 12. Clutch

13. Clutch cylinder block (intermediate shaft) 14. Gear 15. Tip 16. Output shaft 17. Output shaft gear

2.1.2 Disassembly of the transmission

Disassembly procedures:

(1) Before the disassembly, wash and clean the transmission, and then rest it on the working platform vertically.

(2) Push the overrunning clutch (double shaft assembly) away from the transmission body with two bolts (or threaded screws).

(3) Replace the speed distribution valve and its paper gasket from the side of the transmission body. Normally, the paper gasket can be used for one time only.

(4) Remove the manual brake shoe of the front output shaft; loosen the lock nut M33*1.5 to a proper degree, and then remove the manual brake retainer plate and manual brake shoe. Normally, a lock nut can be screwed and unscrewed for six times. Afterwards, it must be replaced to avoid looseness.

(5) After removing 8 connecting bolts from the rear end cover, push the rear end cover away from the transmission body with threaded screws 2-M10*50. Take extra care to prevent the end cover from falling to the ground and leading to personal injuries during the pushing operation.

(6) Hoist the direct gear assembly (three shafts assembly) that includes first gear friction clutch assembly and large gear. After hoisting the assembly out, disassembly different parts inside the assembly in an order as is shown in the Illustration 2-2.

(7) Rest the transmission body on the working platform horizontally, and then remove the central cover, the two planet rows and the parts of the cylinder small assembly in the central cover.

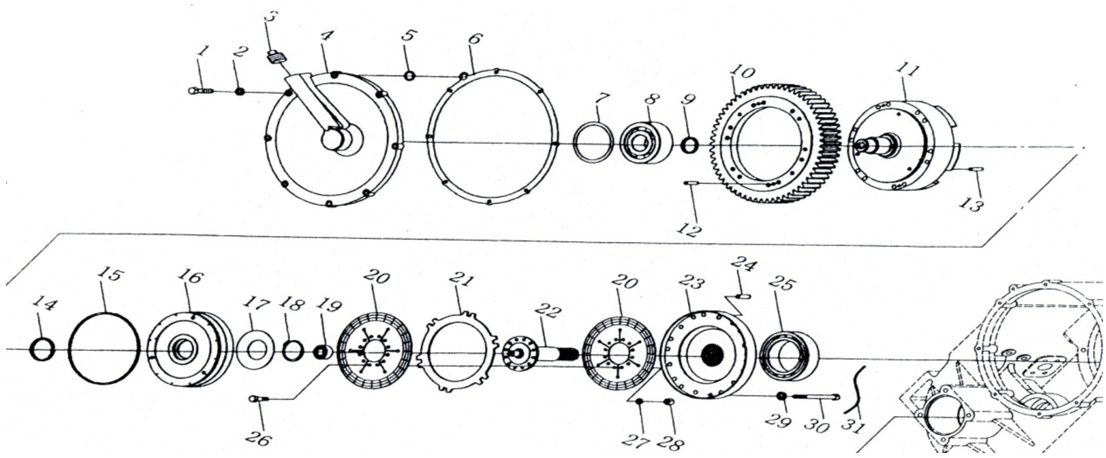


Illustration 2-2 Disassembly of the direct gear

Among all parts in the central cover, 15 return springs are evenly distributed around the transmission body. If the spring force is excessively large, the central cover may be ejected, leading to personal injuries. Therefore, when removing the central cover, secure it with special bolts 2-M14*45, and then unscrew all bolts 8-M14 connecting the central cover the transmission body.

The Illustration 2-3 shows the parts inside the central cover ①:

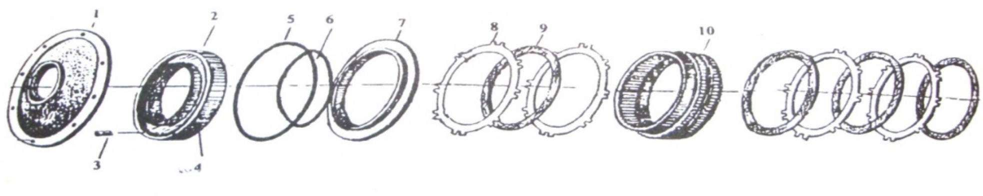


Illustration 2-3 First gear friction clutch

① Central cover

② First gear cylinder

③ Location plate: make sure that there is no relative motion between the first gear cylinder and the transmission body and ensure the alignment of its oil inlet port with the first gear oil inlet port of the transmission body.

④ O-ring oil seal of the oil inlet port, first gear cylinder

⑤ Outer ring oil seal (rubber), first gear piston

⑥ Inner ring oil seal (rubber), first gear piston

⑦ First gear piston

⑧ First gear friction driven plates, four

⑨ First gear friction drive plates, four

⑩ First inner ring gear

Perform the disassembly operation in the order of ① to ⑩.

Take out the outer ring oil seal ⑤, the inner ring oil seal ⑥ and the piston ⑦ of first gear. Two first gear friction driven plates ⑧ and one first gear friction drive plate ⑨ are located at the upper part of the first inner ring gear ⑩ (left side), and the other five plates are located at the lower part of the first inner ring gear (right side).

(8) After the first gear combination is removed, take out the first gear planet row (first gear planet carrier, planetary gear, direct gear connection plate), reverse ring gear, and the sun gear shared by the two planet rows.

(9) Remove the carrier ④ (between the first gear and the reverse gear) and the parts inside the carrier shown in the Illustration 2-4:

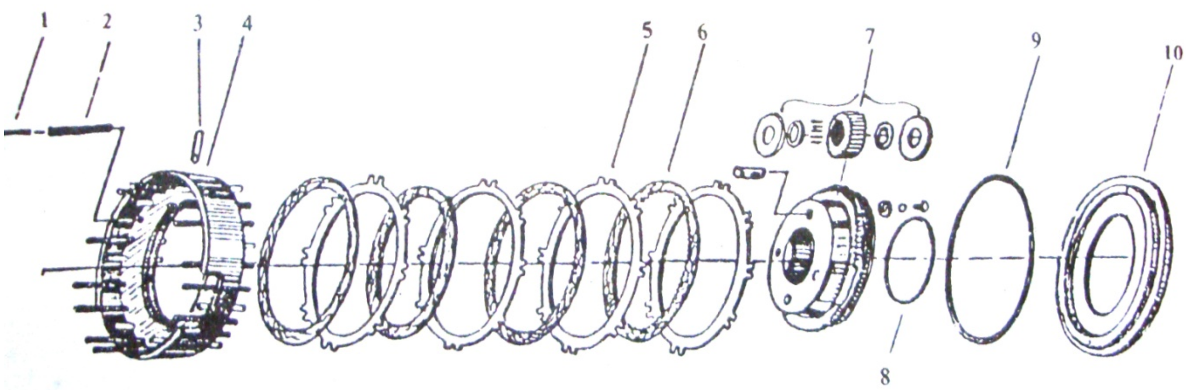


Illustration 2-4 Reverse gear friction clutch

The parts marked with ① and ② are 15 spring pin shafts and 15 return springs in the transmission body. The part marked with ③ is the dowel located between the carrier ④ and the transmission body, and it prevents the relative motion between the carrier ④ and the transmission body. The pin shaft ③ should be taken out after the speed distribution valve is removed.

④ Carrier. The carrier ④ will be taken out only after the pin shaft ③ is taken out.

⑤ Reverse gear friction driven plates, four

⑥ Reverse gear friction drive plates, four

⑦ Reverse planetary small assembly

⑧ Inner ring oil seal, reverse gear piston

⑨ Outer ring oil seal, reverse gear piston

⑩ Reverse gear piston

Perform the disassembly operation in the order of ① to ⑩.

The reverse gear piston and the inner and the outer ring oil seals (⑧⑨⑩) are integral, and can be taken out simultaneously. The drive and driven friction plates are mounted on the reverse planetary carrier, and can be taken out simultaneously. Hoist the reverse piston with proper tools.

(10) Rest the transmission body on the work platform vertically, and remove the front and rear output shafts.

After the lock nut M33*1.5 is taken out, pull out the oil seal seat with the pressure plate and three threaded screws, and check the O-ring oil seal (130*5.7) at the outer ring of the oil seal seat and the skeleton oil seal (SD70*95*12) in the port for damage.

Remove the rear output oil seal seat with the same tools and methods.

2.2 Assembly of the transmission

Assemble the transmission in the following order:

2.2.1 Assembly of the output shaft assembly (four shaft assembly):

Wash and clean the transmission body, and rest it on the working platform. Put the bearing 6312 into the front output port, put the output shaft bearing into the transmission body, pass the output shaft through the gear and install it into the transmission body, and then install the bearing 6312; mount the oil seals on the front and rear output skeleton oil seal seats. During the assembly, make sure that the lip of the oil seal SD70*95*12 on the oil seal seat 4 points to the interior of the transmission body, and that the O-ring oil seal 130*5.7 is not turned upside down or twisted, so that the oil in the transmission will not be leaked onto the manual brake drum and then mitigate the manual brake performance.

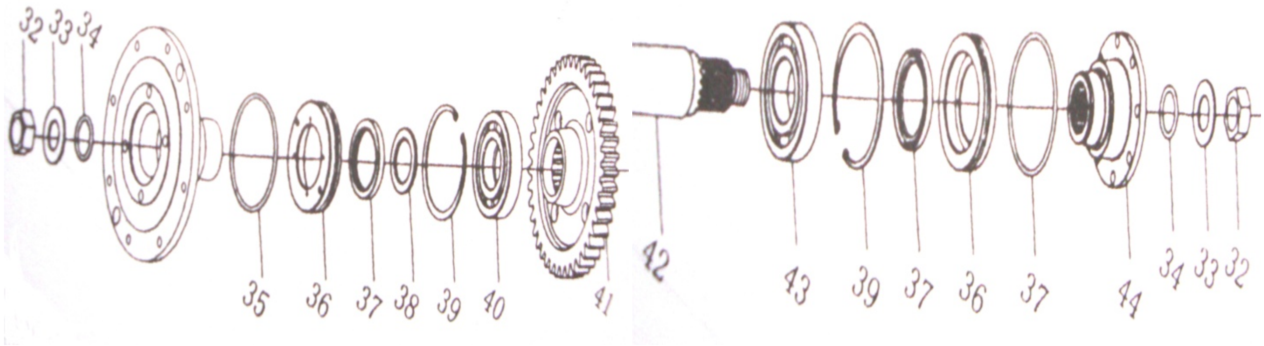


Illustration 2-5 Four shaft assembly

Install the front and rear output flanges.

Before locking the nylon hex nut M33*1.5 and its washer, check the O-ring oil seal to make sure that there is no oil leakage.

After completing the assembly of the front and rear output shaft assembly, check whether it can move flexibly.

2.2.2 Assembly of the planet row assembly (Illustration 2-6)

(Assembly of the reverse gear and the first gear):

Rest the transmission body on the working platform horizontally, and assembly all parts according to their numbering orders. During the assembly, pay attention to:

(1) Strike slightly the 110 ball bearing 2 and the 90 retaining ring 1 into the inner port of the reverse planetary carrier 17;

(2) Apply lubricating oil, put the reverse gear piston and the inner and outer oil seals together into the transmission body with proper tools (tools to remove the reverse gear piston), strike the combination slightly with a copper stick to make it come into contact with the bottom surface of the transmission body.

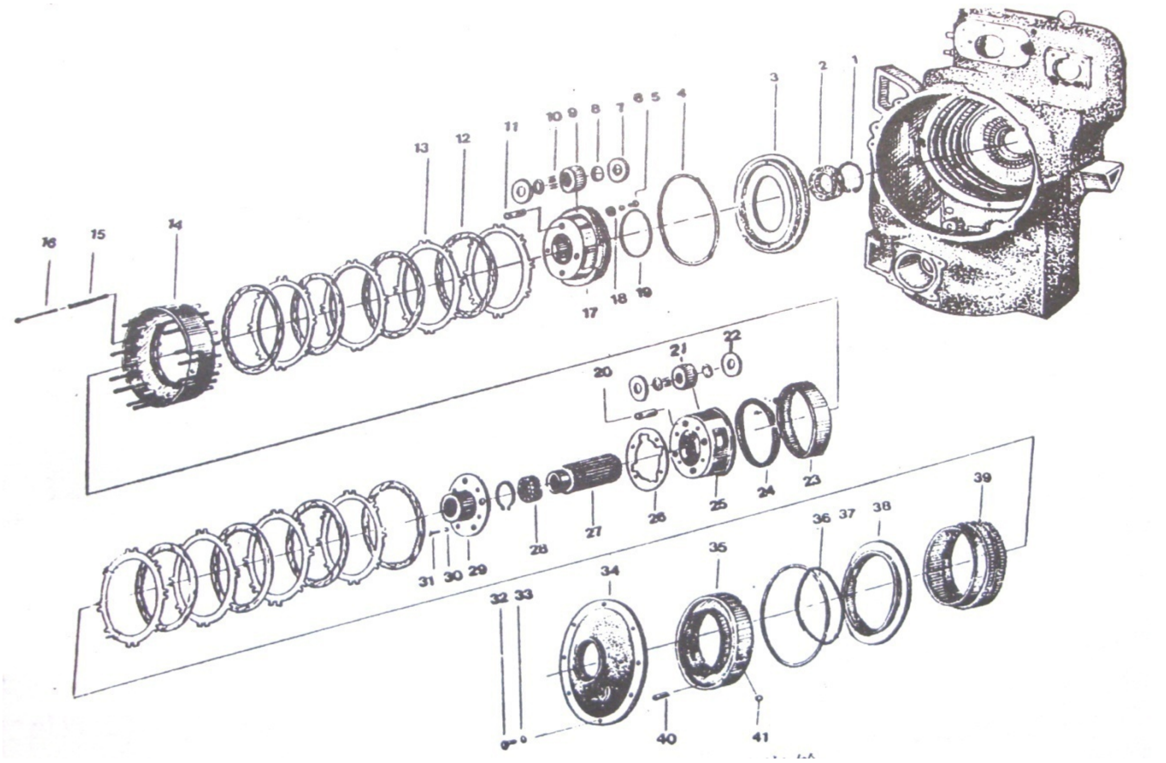


Illustration 2-6 Two planet rows

1. Retaining ring 2. 110 bearing 3. Piston body 4. Outer seal ring 5. Washer 6. M8x14 bolt 7. Shim 8. Spacer ring 9. Planetary gear 10. Rolling needle 11. Reverse planet shaft 12. Reverse gear friction drive plate 13. Reverse gear friction driven plate 14. Friction plate carrier 15. Spring 16. Spring pin 17. Reverse planet carrier 18. Retaining ring 19. Inner seal ring 20. First gear planetary gear shaft 21. First gear planetary gear 22. Shim 23. Reverse inner ring gear 24. Collar 25. First gear planet carrier 26. Retaining disc 27. Sun gear 28. 50210 bearing 29. Direct gear connection disc 30. Washer 31. M10×30 bolt 32. M14×38 bolt 33. Washer 34. Central cover 35. First gear cylinder 36. Inner seal ring 37. Outer seal ring 38. First gear piston body 39. Inner ring gear assembly, first gear 40. Retainer plate 41. O-ring oil seal

(3) Install the eight reverse gear friction plates on the reverse planet carrier 17. During the assembly, pay attention to the installation order; otherwise, the loader cannot move at the reverse gear position. The first friction plate located next to the reverse gear piston 5 is the driven plate. Afterwards, the friction plates should be arranged in alternating drive fiction plate and driven fiction plate. Align the grooves of the driven plates, insert the carrier pins into the corresponding grooves, and make sure that the driven friction plates will move in a straight line along the spring pin guiding direction and will not rotate.

(4) When installing the carrier 14 into the transmission body, rotate it to check that it does not get stuck,

and then insert the pins from the side of the transmission body into the holes at the side of the carrier 14 to make sure that the carrier is secured to the transmission and will not drift or rotate.

(5) Integrate the sun gear, the reverse ring gear, the first gear planet carrier, the first gear planetary gear and the direct gear connection disc into a small assembly, install it into the transmission body and integrate it with the three shaft assembly. The combination is the general output unit of the three gears of the transmission.

(6) Install the first gear assembly to the transmission body, including the first gear friction plates and first gear cylinder. The Illustration 2-15 shows the assembly of the first gear friction plates and the first ring gear. Make sure that the first friction plate located next to the first gear piston is the driven plate; afterwards, the friction plates should be arranged in alternating drive fiction plate and driven fiction plate. During the assembly, make sure that the second driven plate (the third plates when counted downwards to the upwards) is exactly located at the retaining ring.

ATTENTION: Make sure that the friction plates are arranged in right locations and according to correct turns; otherwise, the loader cannot move at the gear position.

As is shown in the Illustration 2-6, install the first gear piston 38 into the first gear cylinder 35. During the assembly, pay attention to the cleaning of the six holes of the piston to avoid any blockage, because these holes of Φ1.5~2.0mm are the oil inlet and outlet ports of the cylinder piston and meet the needs of piston external ring seal and automatic wear compensation. The O-ring oil seal 20*2.4 is located at the oil inlet and outlet port 41 of the cylinder block. At the side of the cylinder block, there is a retaining plate groove that can secure the cylinder block to the transmission boy prevent the cylinder block from moving.

(7) Install the central cover to the transmission body

As is shown in the Illustration 2-6, the axial clearance of the junction surface between the central cover boss and the first gear cylinder should range between 0.2 and 0.3mm. Normally, the clearance is achieved by machining the central cover boss or with the adjustment of the paper gasket between the central cover and the transmission body. Therefore, when replacing the transmission body, the central cover, the carrier or other parts and components, the installation dimension of the central cover must be re-measured to make sure that the clearance between the central cover and the first gear cylinder cannot exceed the range between 0.2 and 0.3mm. Otherwise, the central cover and its connecting bolts 8-M14*40 will be broken due to the impact force, leading to the malfunction of the reverse gear and the first gear. The connecting bolts 8-M14*40 are made of the 45* steel and the use of common steel is strictly prohibited.

2.2.3 Install the three shaft assembly (second gear or direct gear) to the transmission body

Rest the transmission body on the working platform vertically, and then hoist the assembly into the transmission body.

The three shaft assembly is composed of the second gear clutch, second gear cylinder and piston, the intermediate shaft output shaft, and other parts and components. Before 1987, there were "three functions in one" clutches, and they are not used today. The assembly will be performed according to the order shown in the Illustration 2-7. During the assembly, pay attention to:

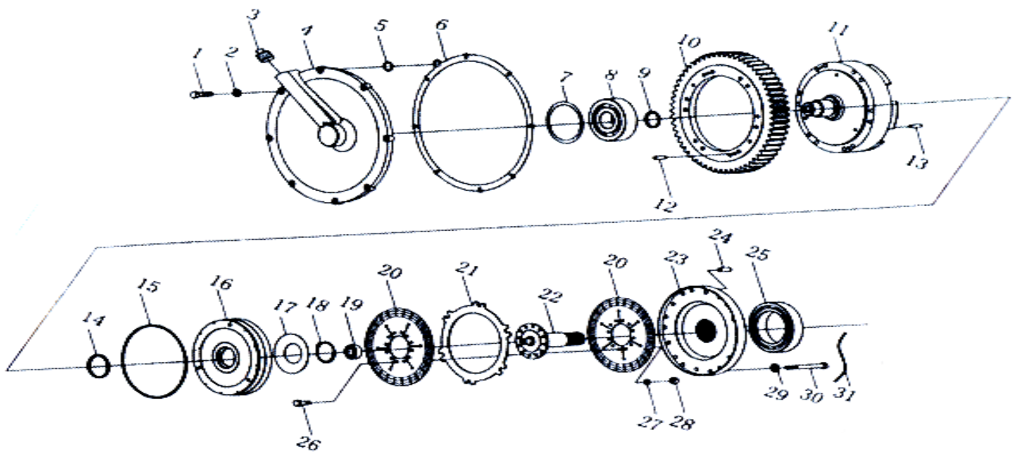


Illustration 2-7 Second gear

(1) The second gear friction clutch contains two drive plates 20 and one driven plate 21, because the second gear piston 16 and the clutch plate 23 transmit torques as one side of the drive plate.

(2) The engagement of the clutch is achieved through the movement of the second gear cylinder piston 16, and the disengagement of the clutch is caused by the elasticity of the cup return spring 17. The three pins 24 in the cylinder block enable the piston 16 to move repeatedly in the guiding direction. The pins and the cylinder block 11 are close fit, and the pins and the piston 16 are running fit.

(3) When installing the large gear 10 to the cylinder block 11, strike into three dowels 13 with Φ10, and lock it with the bolts 12-M12*1.25*100, so that the two parts will not be dislocated when transmitting torques. Static balance may be performed by units that can meet necessary requirements.

2.2.4 Install the rear end cover to the transmission body

(1) Measure the depth from the end surface of the rear end cover to the position of the bearing 411, and the height from the rear end surface of the transmission body to the three bearings, so as to

determine the thickness of the paper gasket at the contact surface between the rear end cover and the transmission and prevent the bearing 411 from being excessively squeezed by the rear end cover when locking the rear end cover to the transmission body. The axial clearance between the position of the bearing at the rear end cover and the bearing 411 should range between 0.3 and 0.5mm.

(2) Install the V-shape rotary oil seal 45*53*5 into the groove at the center of the rear end cove cover with the lip of V-shape surface pointing to the exterior of the transmission body.

(3) Align the third gear oil inlet port at the end surface of the rear end cover with the corresponding oil port at the transmission body. There is an O-ring oil seal between the corresponding oil ports.

(4) Lock the connecting bolts of the rear end cover diagonally, evenly and gradually. The bolt materials should be 45# steel that has been rendered the quenching and high temperature tempering treatment, so that the second gear will not leak due to the deformation and extension of the bolts.

2.2.5 Install the manual break assembly to the transmission body

(1) The manual break shoe support is locked and secured to the boss of the front output shaft port at the transmission body.

(2) Align the mouth of the brake pad of the manual brake shoe with the brake disc, install and secure the brake shoe.

After installing the manual brake to the transmission body, make sure that the loader will not slip when it parks on a slope of 15 degrees and that the users will apply appropriate lever force when operating the manual brake.

(3) Keep the manual brake shoe clean and away from oil dirt, so as to avoid the slipping failure of the manual brake; keep the manual brake shoe away from humidity, or the shoe will expand and cannot disconnect with the brake drum, leading to the permanent braking of the manual brake and preventing the load from working.

2.2.6 Install the speed distribution valve to the transmission body

(1) Check whether the ports of the paper gasket between the speed distribution valve and the transmission body have been aligned correspondingly and whether there is any break or damage to the paper gasket, so as to avoid insufficient pressure at correspond gears.

(2) Since the valve is thin, tighten the locking bolts of the rear end cover diagonally, evenly and gradually and from inward to outward when locking the speed distribution valve assembly to the side of the transmission body; otherwise, the valve may deform after locking, making the valve spool move stiffly or get stuck.

2.2.7 Install the overrunning clutch to the transmission body

The overrunning clutch is the general input unit of the three gear positions of the transmission.

Rest the transmission on the working platform vertically, and then hoist it into the transmission body with a mechanical hand. Afterwards, move a gear. If the gear can move only in one direction in relation to another gear, then the overrunning clutch is properly assembled. If the gear can move in two directions in relation to another gear, then it is not properly assembled. In this case, check the elasticity of the three springs installed in the groove of the carrier and make sure that their length is 32mm.

2.2.8 Install the oil sump to the transmission body

The oil sump assembly at the bottom of the transmission can be installed only after the transmission is installed into the machine.

The oil sump has two permanent magnets and a filter, and they should be cleaned regularly to keep the hydraulic oil in the transmission clean.

It is better to use the oil-proof rubber for the oil sump. During the installation, make sure that the locking force is evenly distributed, so that the oil sump body will not deform or leak oil.

2.3 Structural analysis of the transmission

2.3.1 Overrunning clutch (double shaft assembly)

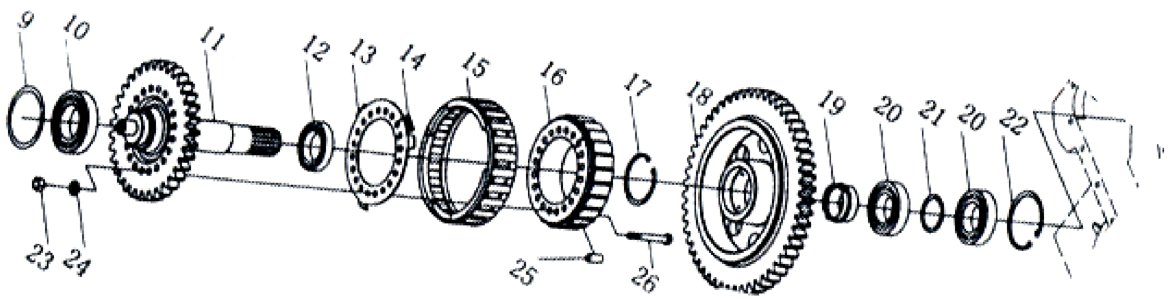


Illustration 2-8 Double shaft

9. Adjusting ring 10. 211 bearing 11. Intermediate input shaft 12. 110 bearing 13. Pressure cover 14. Spring 15. Spacer ring 16. Inner ring cam 17. Retaining ring 18. Outer ring gear 19. Spacer sleeve 20. 6210 bearing 21. Spacer ring 22. Retaining ring 23. Nut 24. Washer 25. Roller 26. Bolt

The Illustration 2-8 shows different parts of the double shaft. When the loader drives at a speed with light load, since the rotational speed of the secondary shaft gear (the intermediate input shaft 11 in the Illustration 2-16) is faster than that of the outer ring gear 18, the clutch disconnects, and only the gear 11 works and the gear 18 idles. When the loader works at a slow speed with heavy load, the rotational speed of the intermediate input shaft 11 drops, and when its rotational speed is slower than that of the outer ring gear 18, the clutch connects, and the gear 11 and the gear 18 work together. In this case, whether the clutch connects or disconnects is determined by the free overrunning of the two gears, and the clutch is called overrunning clutch. In the meantime, it is also called single-way clutch since the two gears rotate relatively in one direction.

2.3.2 Tips on assembling the overrunning clutch

(1) Align the Φ3mm location hole of the pressure cover 13 with the cam locating hole, so that that there will be 2-4mm pre-compression when installing the three springs 14 into the groove of the carrier 15.

(2) Since the carrier is thin, prone to deformation and has a large number of burrs, deformation correction and deburring operations should be performed before the installation, so that the cam 16 and the 24 rollers 25 will not get stuck after the installation.

(3) When installing the 24 high-intensity bolts and 24 rollers, bundle them separately and tightly with a rubber ring to facilitate the installation.

(4) The three springs 14 (with a length of 32mm) will be installed only after the cam 16, the carrier 15 and the rollers 25 have been installed into the inner cam ring.

(5) If it is necessary to replace the 24 rollers with an allowance of 0.005mm, replace them all instead of replacing several of them; otherwise, the stress will not be evenly distributed.

(6) When installing the spacer sleeve 19 into the secondary gear shaft 11, the oil port should point to the interior of the assembly, and make sure that there is sufficient oil for the lubrication of the 24 rollers 25.

(7) Check whether the clutch is correctly assembled after the installation.

2.3.3 Intermediate drive and general output

The shift among three different gears of the transmission is achieved by the intermediate drive that is composed of the two planet rows and their implementation mechanisms.

Assembling tips:

(1) The sun gear 2 of the two planet rows is a stand-alone component. Its left end connects with the input shaft 1 of the overrunning clutch through the inner port splines, and the left end of the input shaft 1 is connected to the housing of the torque converter by the bearing 211. These two shafts limit the left-to-right movement of the input shaft 1. The other end of the sun gear 2 connects with the drive shaft 9 of the lockup clutch (second gear clutch, transmission ratio is 1) through splines.

(2) The section between the planet carrier 21 of the right planet row and the sun gear 2 is supported by the bearing 50210. Install the bearing 110 to the input shaft 1 at the reverse planet carrier 3 of the left planet row.

(3) Install the eight reverse gear friction plates to the left planet carrier 3, and the eight first gear friction plates are installed to the first inner gear 5. They respectively engage with the teeth of the drive plates through the splines.

The driven plates move along the guiding direction through the 15 lock pins that are secured to the transmission body 23 and will not rotate. The driven plates transmit power to the transmission body 23 to ensure the braking effect of the brake.

(4) The braking of the reverse gear clutch is achieved when the reverse gear piston 26 moves rightward and presses the friction plate 4 tightly, and its disengagement is achieved by the 15 return springs 22. The braking operation of the first gear clutch is achieved when the first gear piston 8 moves leftward and presses the friction plate 6 tightly, and the its disengagement is achieved by the force of the 15 return springs 22

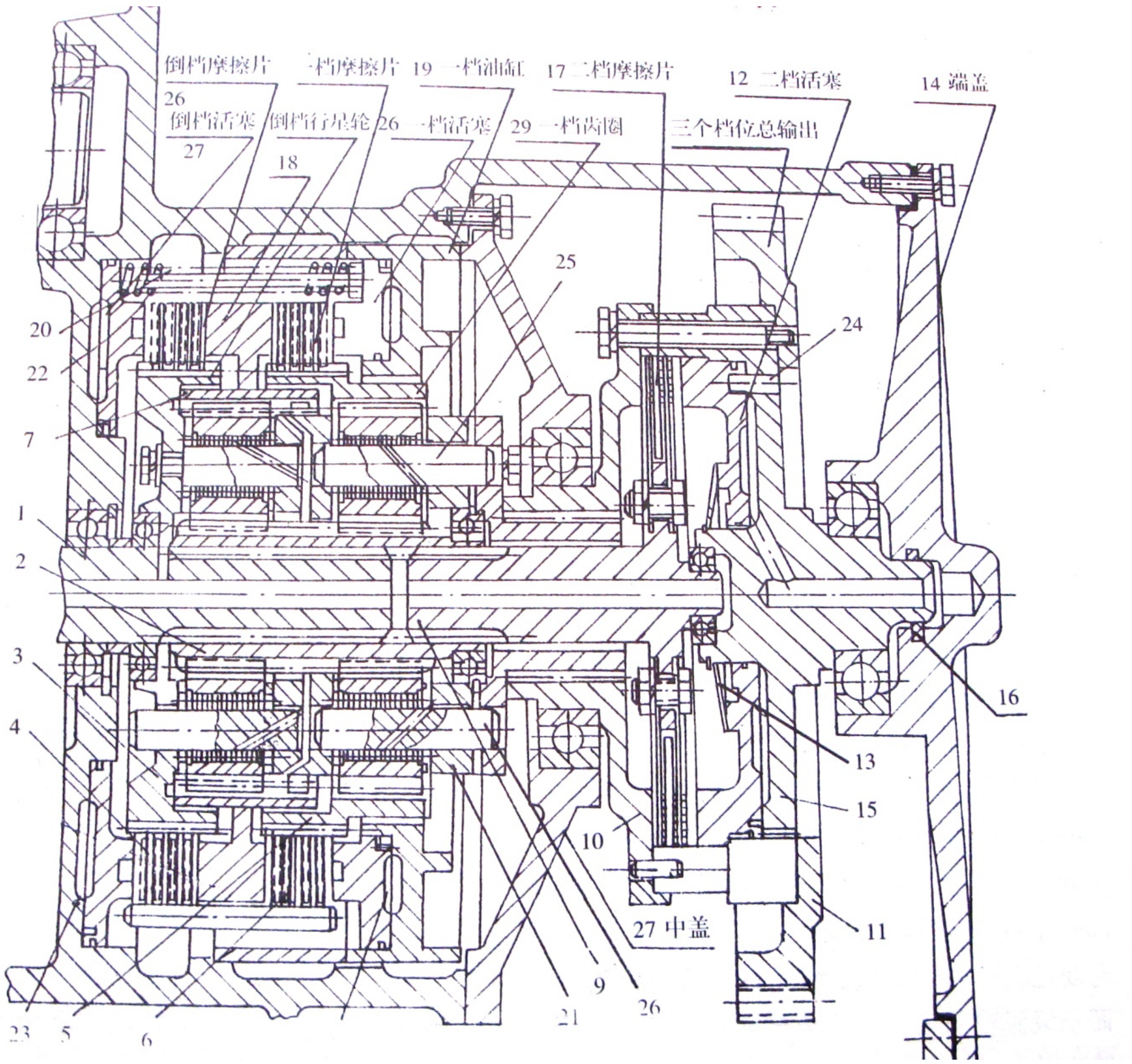
(5) Second gear clutch.

It is composed of two drive plates and one drive plates. The two drive plates 17 connect with the drive shaft 9 through the bolts 12-M8*20. The drive plates are elastic, and they can deform and make axial movement, so as to perform braking and disconnection operations. The clutch contains the front and rear driven parts: clutch plate 10 and second gear cylinder block 15 and large gear 11. The two parts are locked together with the bolts 12-M12*1.25*100 and supported by bearings 122 and 411 that will respectively limit the axial movement in one direction. The bearing 122 is installed between the central cover 27 and the clutch plate 10, and the bearing 411 is installed between the boss at the right end of the oil cylinder block 15 and the rear end cover 14, and their axial clearance should range between 0.30 and 0.50mm, so that the bearings will not be excessively squeezed and then make the loader unmovable.

The braking of the clutch is achieved by: the second gear piston 12 takes leftward guiding movement along three dowels secured to the oil cylinder block 15, and presses the friction plates tightly; the tightly pressed driven plates make the axial guiding movement through six pin shafts of Φ12*30 that are installed to the second gear clutch plate 10, and transmit power to the second gear cylinder block 15 and large gear 11. The disengagement of the friction plates is achieved through the return of the butterfly disengaging spring 13.

(6) General output of the three gears: the left-row reverse inner ring 7, the right-row planet carrier 25, the pressure plate 10, the second gear piston 12 and the second gear cylinder block 15 are integrated through the engagement of the teeth or the connection of splines.

They transmit power to the front output shaft through a pair of common gears (Z12/Z17=60/40)



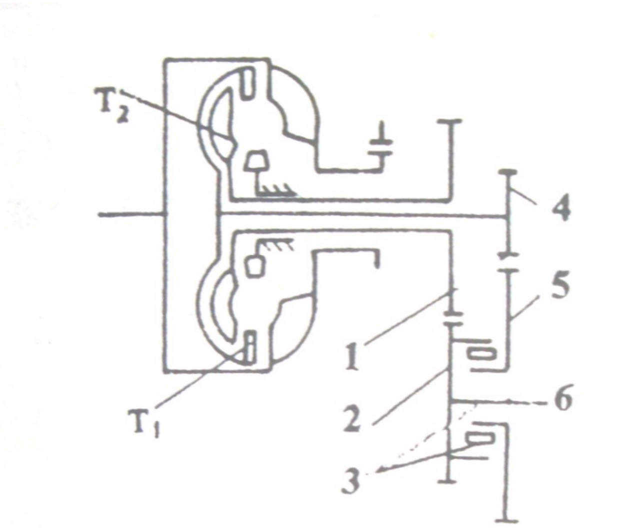
1. Intermediate input shaft　2. Sun gear　3. Reverse planet carrier　4. Reverse gear friction plate
5. First inner ring gear　6. First gear friction plate　7. Reverse inner ring gear　8. First gear piston
9. Second gear drive shaft　10. pressure disc　11. Large gear　12. Second gear piston　13. Butterfly spring
14. End cover　15. Second gear cylinder block　16. Rotary oil seal　17. Second gear friction plate
18. Intermediate disengagement carrier　19. First gear cylinder block　20. Guiding pin
21. First planet carrier　22. Spring　23. Transmission body　24. Second gear pin shaft
25. First planet shaft　26. Reverse gear piston　27. Central cover

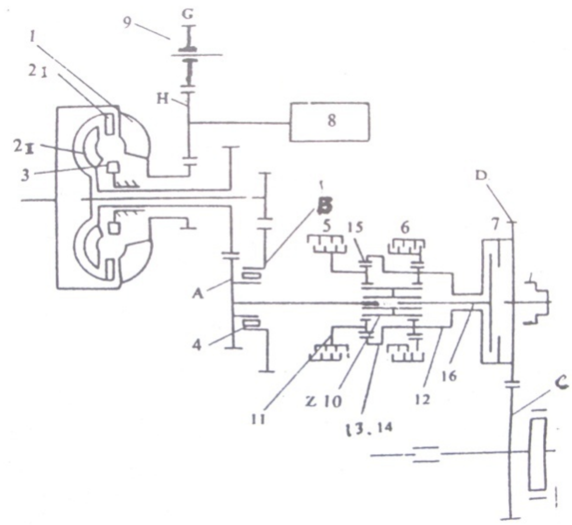
Illustration 2-9 Intermediate drive and general output

2.4 Driving principles of the transmission

2.4.1 General output: driving of the overrunning clutch

The first-stage turbine T1 (Illustration 2-10) of the torque converter transmits power to the output shaft 6 through a pair of speed reduction gears 4 and 5 and then through the cam mechanism of the overrunning clutch 3; the second-stage turbine T2 of the torque converter transmits power to the output shaft 6 through a pair of speed increasing gears 1 and 2. When the loader works, there are two different situations: if the loader drives at high speed with light load, the rotational speed of the gear 2 at the output shaft (driven by the second-stage turbine T2 through the gear 1) is faster than that of the gear 5 (driven by the first-stage turbine T1 through the gear4), the cam mechanism automatically disengages, the first-stage turbine T1 idles, and the power is solely transmitted by the second-stage turbine T2. When the load borne by the output shaft 6 increases, the rotational speed of the output shaft drops. When its rotational speed (the rotational speed of gear 2) is lower than that of the first-stage turbine, they transmit the power together.





2-10 Power transmitted by the transmission and the overrunning clutch

2-11 Power transmission by the three gears

T1 First-stage turbine	1. Second-stage output shaft gear
T2 Second-stage turbine	2. Second-stage input shaft gear
3、Inner ring cam	4. First-stage output shaft gear
5. First-stage input shaft gear	6. Output shaft

As the rotational speed of the output shaft 6 drops, the torque transmitted by the first-stage turbine gradually increases, and the torque transmitted by the second-stage turbine gradually drops. Since the torque of the first-stage turbine is transmitted to the output shaft 6 after the rotational speeds of gears 4 and 5 drops, it will increase the torque of the output shaft 6. Since there are two different situations and transmission results achieved by two pairs of gears (when the loader drives at high speed with light load, only the second-stage turbine works, the gears 1 and 2 increase the rotational speeds; when the loader drives at low speed with heavy load, the first-stage and the second-stage turbines work together, and the gears 4 and 5 decreases the rotational speeds), it functions like an automatic two-gear shift transmission, so the clutch can reduce the number of the gears of the transmission.

2.4.2 First gear transmission (Illustration 2-11)

The first-stage and second-stage input gears A and B work together and drive the sun gear Z10 to rotate. When the clutch 6 (gear shift brake II) at the right-row ring gear brakes, the left-row planet carrier 11 idles, and the right planet carrier 12 is driven to rotate by the sun gear Z10. Since the left ring gear 13, right planet carrier 12, the clutch plate and the output gear D integrate, the gear C is driven to rotate, and this brings about the first-gear transmission.

2.4.3 Second gear transmission (Illustration 2-11)

When the overrunning clutch and the gear B idle, the second-stage input gear A drives the sun gear Z10 to rotate. When the lockup clutch 7 brakes, the left and right planet rows do not function, the drive shaft 16 of the lockup clutch is driven to rotate directly by the inner splines of the sun gear Z10 and forms the second gear transmission through the gears D and C.

2.4.4 Reverse gear transmission (Illustration 2-11)

The overrunning clutch drives the sun gear Z10 to rotate. The clutch 5 at the left planet carrier brakes, the sun gear Z10 drives the reverse planetary gear to rotate, the first gear planet carrier 12 is under pressure, the clutch plate and the gear D integrates and drive gear C to rotate, forming the reverse gear transmission.

2.5 Oil supply system of the transmission

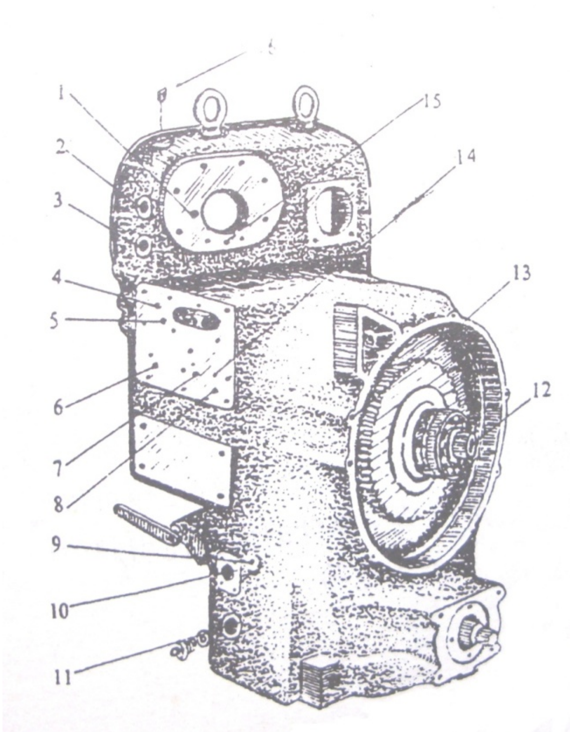


Illustration 2-12 Transmission body

The oil supply system is composed of the oil tank (transmission), the gear pump, the filter, the speed distribution valve, the gear cylinder assemblies, and the lines.

Here are the structural features of the hydraulic elements.

2.5.1 Transmission body (oil tank)

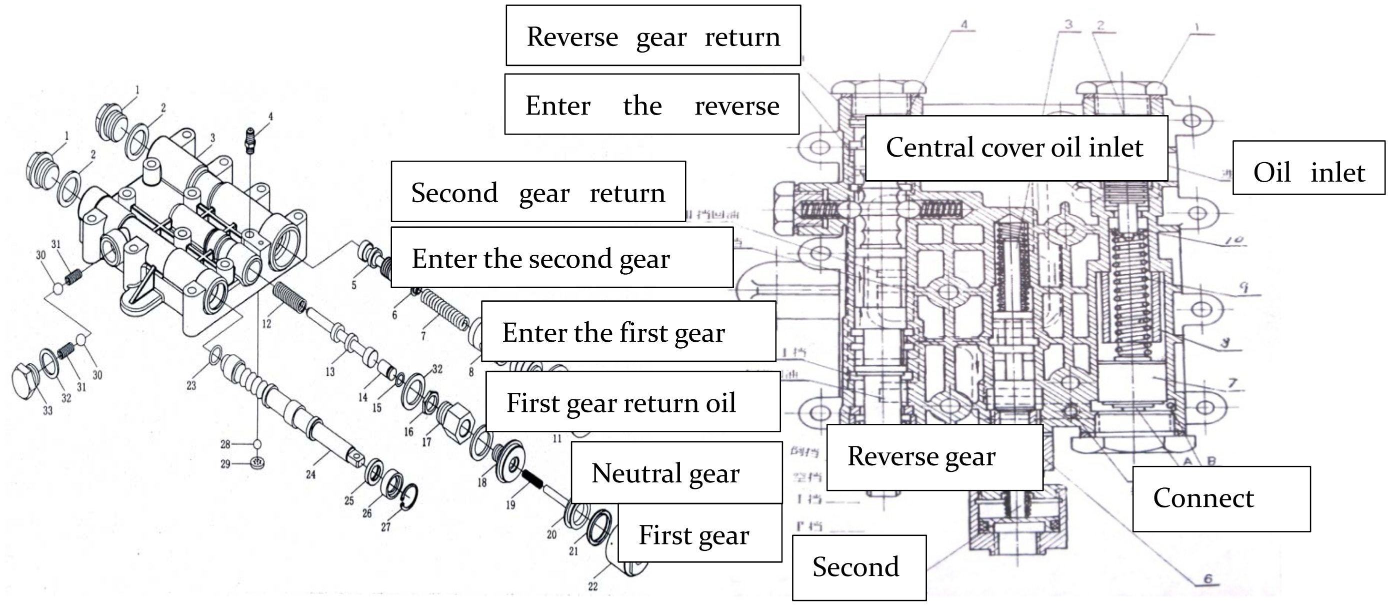
1. The oil pumped from the gear pump flows into the transmission from the hole.
2. The high pressure oil flows through 1, the oil passage in the transmission body and flows out from the hole to the filter.
3. The oil flows through the filter and enters the oil passage in the transmission body through the hole. The parts 2 and 3 are separated in the transmission body by the plug 16, and they will not directly connect, so as to make sure that only the filtered oil can enter the speed distribution valve.
4. The oil coming from the 3 flows into the 4 through the oil passage in the transmission body and then into the corresponding holes of the speed distribution valve.
5. When the desired gear is filled with oil, the oil flows from the hole into the torque converter housing through the inner oil passage of the transmission body and the docking hole at the junction surface between the transmission and the torque converter.
6. Reverse gear oil hole. It is directly interlinked with the oil hole of the reverse gear cylinder (the same oil hole with the oil outlet port).
7. The parts 7→13→12 constitute the second gear oil passage: the high pressure oil enters 12 along 7 and through the passage 13 and flows into the second gear cylinder.
8. First gear oil hole: it is directly interlinked with the first gear cylinder.
9. Oil level inspection switch hole. When the oil level is in the static state, if the oil level switch is turned on, the oil flows from the hole, and this means that the oil storage has reached the desired quantity.
10. Oil filling hole
11. Oil suction hole of the gear pump

14. Return oil hole (low pressure chamber)

15. Return oil hole of the variable-variable-speed pump.

2.5.2 Speed distribution valve

(1) The composition (Illustration 2-13) and the assembly and disassembly are basically performed according to the ordinal numbers of parts.



2-13 Speed control valve

Illustration Assembly of speed distribution valve

(3) Structural analysis of the speed distribution valve

1. Plug 2. Pressure valve lever 3. Damper valve lever 4. Distribution valve lever 6. Circular plunger 7. Accumulation piston 8. Spring (set) 9. Spring 10. Spring seat

The distribution valve comprises three parts: pressure regulating valve2, shut-off valve 3, gear shift valve 4 and accumulation damper valve 7.

The pressure regulating valve has the following three functions:

A. Make sure that the oil supplied to the gears of the transmission meets the necessary pressure standard (1.1-1.5MPa).

B. Control the stability of the pressure rise of different gears of the transmission by using the oil flow diversion to the torque converter and the effect of the accumulation damper valve, and ensure the smooth gear shift start of the loader.

C. Protect the oil pump, lines and other hydraulic elements.

ATTENTION (Illustration 2-14):

a. Install the pressure regulating valve: apply lubricating oil to the inner hole of the valve body, and install the pressure valve lever 2 into the valve body with the radial clearance ranging between 0.025 and 0.035mm. During the assembly, make sure that there is no blockage in the small incline hole at the right end of the valve lever, and then install the sealed washer and the locking plug 1.

   Install the other end of the valve body into the spring seat 10 (apply some sealing cement), the two springs 8 and 9 with opposite rotational direction and the accumulation piston 7 (its fit clearance with the valve body ranging between 0.035 and 0.040mm), and lock the left end plug and the sealed washer (or the plug and rubber washer combination). When installing the valve lever 2 and the accumulation piston 7, make sure that they are movable leftward and rightward and that there is no crack in the spring seat 10, or there will be no pressure in the transmission system.

   Refer to the "Torque Converter: the Process of Oil Supply to the Transmission" part for the details about the adjustment of the transmission pressure.

b. Pneumatic brake valve shut-off valve: apply lubricating oil to the valve hole, incorporate the weak activating spring into the brake valve lever, and install the combination into the valve body; install the circular plunger with the O-ring oil seal of$\Phi 13*1.9$ into the valve body, with its right end surface coming into contact with the valve body 3, and its left end surface keep an axial clearance of 0.5-1.0mm from the pneumatic valve lever 5 installed in the valve body, so that the installation error will not put the pneumatic valve lever 5 at the shut-off position permanently.

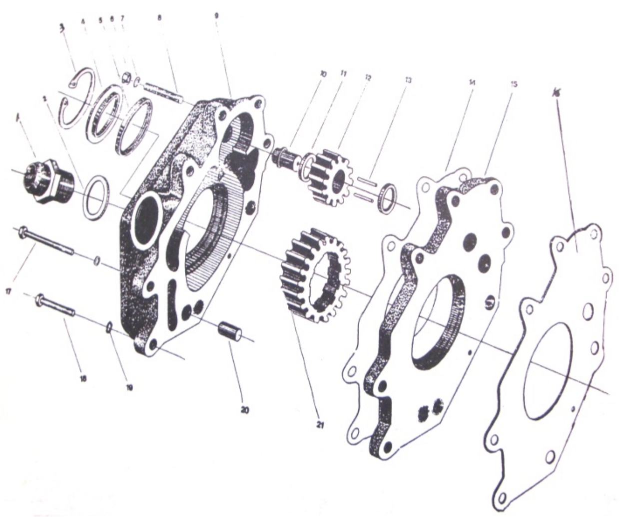
   Install the YX seal (32*40) of the pneumatic valve into the pneumatic valve lever 5, incorporate the weak activating spring into the small end, install the combination into the pneumatic valve body, lock it with the pneumatic valve seat and the nuts, and install the small assembly into the valve body.

   After the pneumatic brake valve shut-off valve is assembled, insert a screwdriver (or a thin iron stick) into the pneumatic brake valve and push the valve lever 5, so as to check that the piston of the valve lever 5 moves flexibly or get stuck, leading to the malfunction of the shut-off valve.

c. Gear shift valve: apply lubricating oil to the valve body hole (and valve lever 4)，install the locating spring and locating ball from the side of the valve body, and then insert the valve lever 4 into the valve body hole. Make sure that the locating ball and the valve lever 4 are exactly located and put into the groove. Install another locating spring and locating ball, and make sure that that the locating lever and the two locating balls exactly located and put into the groove. The moving valve lever has 4 gear positions: second gear, first gear, neutral gear and the reverse gear by turn. When the valve lever 4 stays at a gear position, the corresponding gear clutch interlinks with the pressure oil and is in the disengagement state, and its disengaging clutch is interlinked with the return oil passage and in the disengagement state. As is shown in the Illustration 2-14, the valve lever 4 is put at the neutral position, and the pressure oil entering the different gears of the gear shift valve is in the state of closure. At this moment, the clutches of these gears are in the oil discharging state.

The arrangement of the gear positions conforms to the users' operating habits. When users move forward the control lever handle, the slowly moving forward gear is firstly activated, and then the high-speed moving forward (second gear). Between the two forwarding gears and the reverse gear, there is the neutral gear. The arrangement can prevent the occurrence of accidents because if there is any error made by users during their pulling the control lever handle, the loader may perform wrong forward and reverse movement.

2.5.3 Speed gear pump



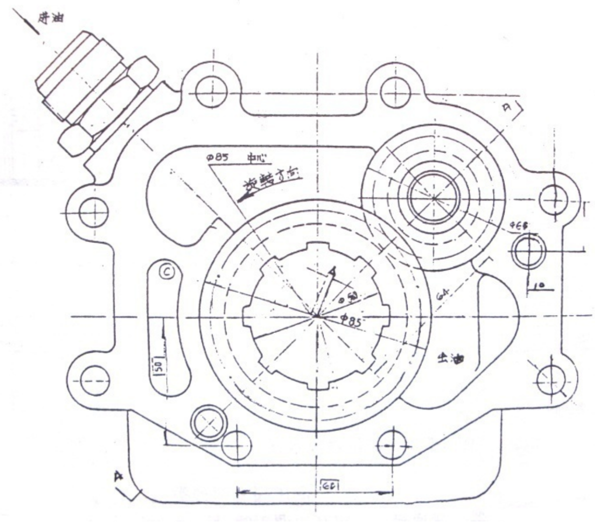


Illustration 2-15 Speed gear pump

Illustration 2-16 Assembly of the speed gear pump

(1) The speed gear pump is also called as variable-speed pump, and it is composed of following parts (Illustration 2-15):

1. Line joint 2. Washer 3. Retaining ring 4. Snap ring 5. Oil seal 45×62×12 6. M12 nut 7. Shim 8. Stud bolt 9. Pump body 10. Shaft 11. Disengaging sleeve 12. Gear 13. Rolling needle 14. Sealer 15. Pump cover 16. Sealing shim 17. Bolt 18. Bolt 19. Washer 20. Dowel pin 21. Large gear

(2) During the assembly of the variable-speed pump gear, pay attention to:

A. During the assembly, make sure that the centerline of the pump body and the centerline of the engagement deviates towards the high pressure chamber (Illustration 2-16) by Δ=0.12mm, so that the pump body at the low pressure chamber will not be burnt when the gear pump works normally.

B. The end surface clearances between the pump cover and two mesh gears should range between 0.06 and 0.08mm (one end) to prevent the pump cover from being burnt.

C. The axial clearance between the mesh gear and the pump body should range between 0.15 and 0.25mm. Though the axial clearance is a high figure, yet is does not greatly affect the capacity and efficiency of the gear pump; in addition, since the variable-speed pump is installed at the side of the transmission body and a working oil pump of 80kg is installed at the back of the pump, it will affect the installation perpendicularity of the centerline of the variable-speed pump to the side of the transmission body due to the deadweight, it is necessary to enlarge the axial clearance to make up for it.

D. Since the two ends of the drive shaft of the variable-speed pump are installed to two different parts (the torque converter and the transmission), it is necessary to calibrate the perpendicularity of the drive shaft to the side of the transmission body, or the junction surface between the variable-speed pump and the transmission body should be smoothened.

E. Install a skeleton oil seal PG45*62*12 at the fitting place between the gear pump extending end and the pump body to avoid the external leakage of oil. The practices have shown when the skeleton oil seal is broken, the oil in the pump will be sucked into the oil passage in the working hydraulic system by the working gear pump installed backwards, and that means the oil in the transmission goes into the working oil tank.

2.5.4 Filter

Working principles of the filter

The filter can eliminate the impurities and sediments in the oil passage, so as to ensure the safety of the oil supply system of the torque converter and the control oil passage of the transmission.

The filter is installed at the line that is located after the oil pump and before the speed control valve. It protects all parts except the pump. Normally, the pressure of the filter element ranges between 0.33 and 0.07MPa. To avoid the overload of the filter due to the blockage, a relief valve (bypass valve) is installed in the filter. When there is blockage in the filter element and the inner and outer pressure difference exceeds 0.54MPa, the relief valve automatically opens.

Filter principles:

The high-pressure oil from the gear pump directly enters the inner space of the housing through the oil inlet line of the filter and then into the inner space of the filter element, and then flows out from the oil outlet joint. When the filter element is blocked by impurities, the oil cannot flow through the filter element. When the system exceeds 0.54MPa, the bypass valve opens, and the oil flows out from the oil outlet joint through the bypass valve.

Replace the old filter element with a new one each time the users replace the transmission oil.

2.5.5 Working process of the gearbox-transmission oil supply system

(1) Torque converter-transmission oil supply process (Illustration 2-17)

As is shown in the Illustration 2-18, the work oil flows through the coarse filter screen 1, and then it is sucked in by the gear pump 2. The pressure oil from the gear pump 2 reaches the filter 4 through the oil passage 3 in the transmission body, and then enters the chamber of the pressure regulating valve 5. To ensure that the prioritized oil supply to different gears of the transmission, the oil in the chamber 5 flows into the chamber of the shut-off valve 6. If the shut-off is not at the shut-off position, the oil flows into the three chambers 7, 8 and 10 of the gear shift valve. The oil in the chamber 10 moves along the oil passage 11 in the speed distribution valve body, enters the right chamber 25 of the accumulation valve through the damper valve 12, and drives the accumulation piston (valve spool) to move leftward and compress the pressure regulating spring. When the oil pressure of the system reaches 1.1-1.5MPa, the pressure oil enters the chamber 23 from chamber 5 through the small incline hole at the pressure regulating valve lever, drives the pressure regulating valve lever rightward, and compresses the pressure regulating spring from the two ends together with the accumulation valve spool. At this moment, the chamber 5 and the chamber 16 interlink, the pressure oil enters the oil inlet and overflow pressure valve 17 - the second pressure valve of the torque converter from chamber 5 and through the chamber 16, and then flows into the torque converter 18 to keep it working. Since there are clearances between different working wheels of the torque converter and the torque converter requires sufficient heat dissipation to continue normal operation, the oil entering the torque converter should be able to ensure the normal operation of the torque converter; in the meantime, the fluid flows out from the oil outlet 19 of the leading wheel base through the clearance between the leading wheel base and the second-stage output gear, enters the oil outlet valve (counterbalance valve) 20 of the torque converter through the outlet 21 of the heat radiator (water cooler since 1988) after it is treated in the heat radiator and to the lubricating overrunning clutch 22 and its bearing, and then flow into the transmission body 2 (oil reservoir). This is the torque converter-transmission oil supply process.

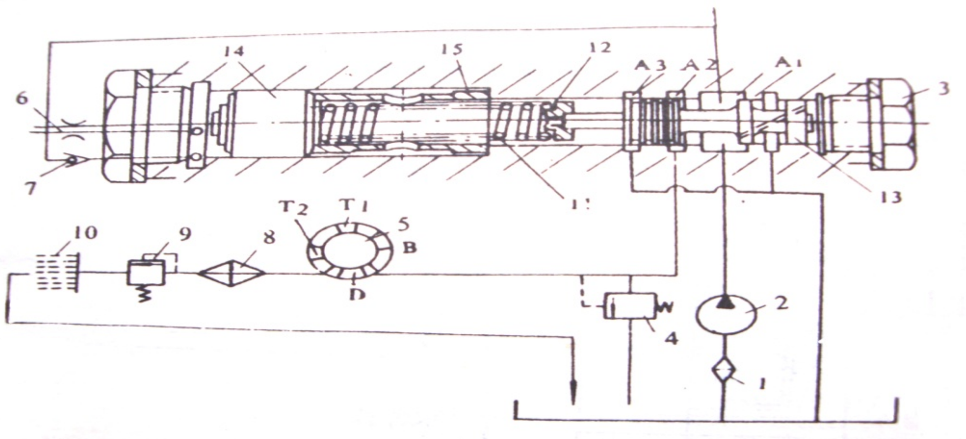


Illustration 2-7 Pressure regulating valve

(1) Pressure regulating of the transmission (Illustration 2-17)

1. Coarse filter screen 2. Variable-speed pump 3. Screw head 4. Oil inlet valve of the torque converter 6. Throttle valve 7. Single-way oil outlet valve 8. Heat dissipation cooler 9. Oil outlet counterbalance valve of the torque converter 10. Lubricating overrunning clutch and bearing

11. Pressure regulating spring 12. Spring seat 13. Valve lever 14. Accumulation piston

15. Locating sleeve

The pressure regulating valve in the Illustration 2-17, the pressure borne by its pressure regulating spring is in the direct proportion to the gear force according to the torque converter-transmission oil supply process.

There are two types of pressure regulating valves: the one with single spring and locating sleeve, and the one with double springs. For the pressure regulating valve with single spring and locating sleeve, when the gear pressure exceeds 1.1-1.5MPa, the length of the locating sleeve 15 can be lengthened accordingly; if the gear pressure does not exceed the given value, shorten the locating sleeve. Normally, each time the locating sleeve gets the increase of 2mm in length, the pressure drops by 0.10MPa; the pressure increases by 0.10MPa each time the locating sleeve decreases by 2mm in length. Adjust the double-spring pressure regulating valve according to the above-mentioned methods: adjust the gear pressure by changing the length of the thick spring.

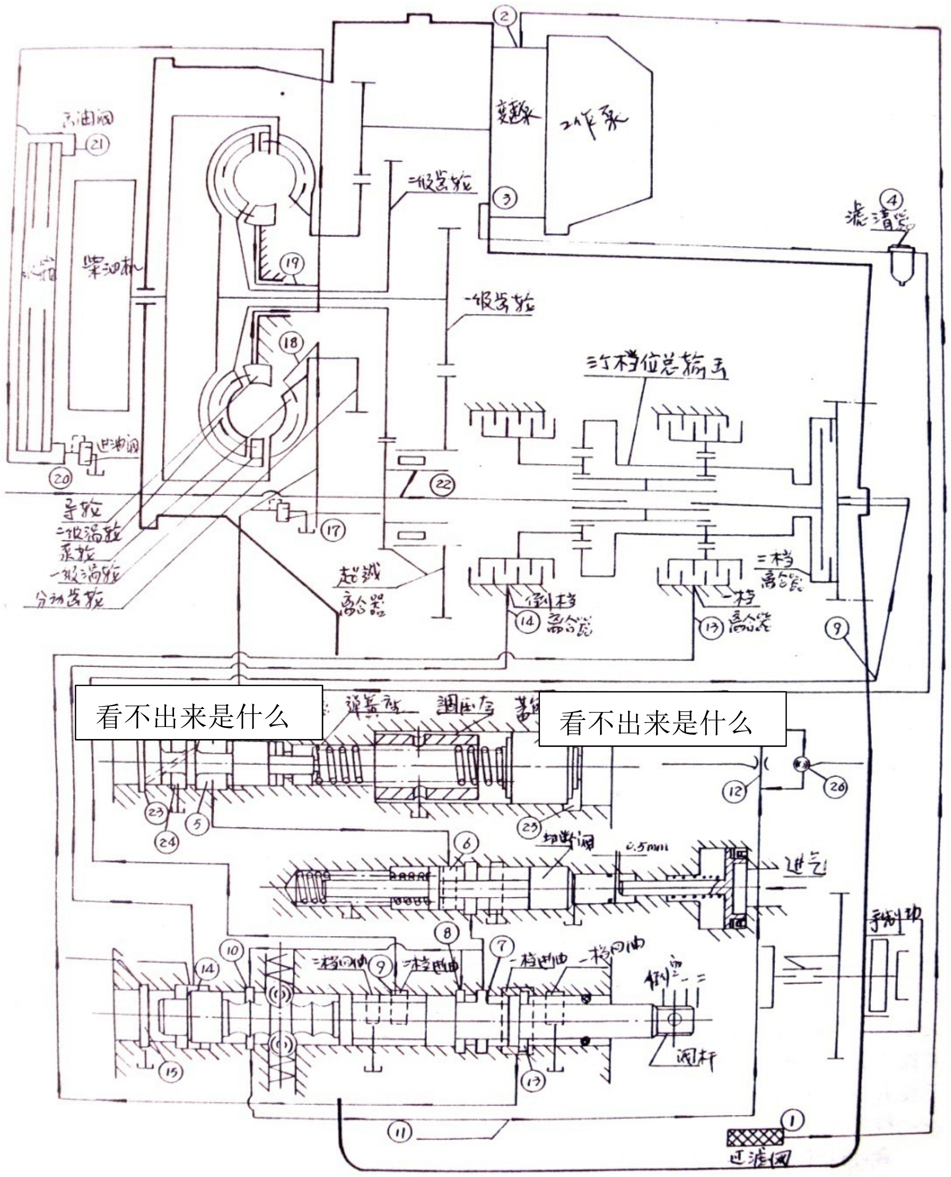


Illustration 2-18 Torque converter-transmission oil supply system

变油阀：oil valve of the transmission 油箱：oil tank 柴油机：diesel engine 变速泵：variable-speed gear
工作泵：working pump 滤清器： filter 二级齿轮：second-stage gear 一级齿轮：first-stage gear
一档离合器：first gear clutch 二挡离合器：second gear clutch 倒挡离合器：reverse gear clutch
超越离合器：overrunning clutch 进油阀：oil inlet valve 切断阀：cut-off valve 一档进油：first gear oil inlet
一档回油：first gear return oil 弹簧座：spring seat 调压阀: pressure regulating valve 进气：air inlet 过滤网：filter
二挡进油：second gear oil inlet 二挡回油：first gear return oil 倒: reverse gear 空：neutral gear 过滤网：filter screen
三个档位总输出：general output of the three gears 导轮：leading wheel 二级涡轮：second-stage turbine
泵轮：pump gear 一级涡轮：first-stage turbine 分动齿轮：transfer gear 进油阀：oil inlet valve

The speed of the compression of the pressure regulating valve 11 determines the in-gear time of the gear positions. If the in-gear time is too short, the loader will start or perform the gear shift violently. If the in-gear time is longer, the loader starts in a steady and smooth manner. However, the in-gear time cannot be too long; otherwise, the friction of the gear position friction plates will drive the oil temperature to rise tremendously. Therefore, it is important to properly control the engagement time of the clutch.

Since the spring determines how the pressure regulating valve controls the oil pressure, the process of the clutch engagement and the speed of oil temperature rise are determined by the speed of the spring force rise (the speed of the accumulation valve moving rightward). In the time, since the pressure oil entering the accumulator from the small throttle hole 6, the flow is small, the accumulation piston makes a slow movement rightward, the spring force increases slowly, and the clutch oil pressure rises steadily.

During the gear shift, the clutch at the old gear position disengages, and the one at the new gear position engages. When the pressure oil enters the clutch at the new gear position, it firstly fills the cylinder at the new gear position. In this case, the oil pressure in the clutch drops, the pressure oil in the accumulator opens the sing-way valve (without passing the throttle hole 6) to quickly drains oil to the clutch at the new gear position, and the piston 14 re-moves to the leftmost position under the action of the spring force. The clutch at the old gear position disengages when the piston 14 moves leftward, and the oil starts to fill the oil passage of the clutch at the new gear position when the piston 14 arrives at the leftmost position.

During the process of the clutch disengagement at the old gear position and the engagement at the new gear position, since there is oil resistance from the accumulator of the pressure regulating vale to the oil cylinders at different gear positions, and this means that there is certain oil pressure at the accumulator. Though the single-way valve 7 is arranged, the oil in the accumulator cannot be immediately drained at the time of gear shift, preventing the accumulator piston from returning to the leftmost position. In this case, the valve does not offer satisfactory cushion performance to the start of the new gear. In order that the accumulator piston 14 can immediately drain the pressure oil at the time of gear shift and be in a state of no counterbalance, depress the brake pedal before the gear shift to make the brake cut-off valve fully relieve pressure of the clutch oil passage. The accumulator piston 14 can move to the leftmost position during the gear shift and make the loader perform steadily at the new gear position.

(2) Gear shift valve

The gear shift valve controls the oil filling and drainage of clutches at different gear positions. That is to say, it enables the gear shift by controlling the engagement and disengagement of clutches at different gear positions.

The gear shift valve lever has 4 positions that are located by steel balls: first gear, second gear, neutral gear and the reverse gear by turn. When the valve lever stays at a gear position, the corresponding gear clutch at interlinks with the pressure oil and is in the engagement state, and other clutches are is interlinked with the return oil passage and in the disengagement state.

When the valve lever is put at the neutral position, the pressure oil entering the gear shift valve is in the state of closure. At this moment, the clutches of all clutches are in the disengagement state.

The practices show that it matters a lot whether the valve lever is correctly installed, or there will be gear position confusion or wrong gear position.

2.6 Common fault troubleshooting methods

The transmission assembly (torque converter + transmission) of the ZL50 wheel loader is composed of a double-turbine hydraulic torque converter and a simple planetary transmission. It is the core part of the loader. The faults with the transmission assembly will prevent the loader from working or even cause damage to the loader. Therefore, it is of great importance to correctly determine and quickly troubleshoot the faults.

The most common faults with the torque converter of the ZL50 wheel loader include: low speed shift pressure, excessively high transmission oil temperature, the loader does not move or moves or works with insufficient power, the increase of the transmission oil level. These five faults will be analyzed in detail in the manual. In the meantime, the overrunning clutch is the part that has the highest fault frequency and brings about the greatest effect. Therefore, main overrunning clutch problems are also covered.

I. Fault description and troubleshooting methods of the transmission assembly of the ZL50 wheel loader

Features, causes and shooting methods of the five major faults with the transmission assembly of the ZL50 wheel loader are listed in the following form.

ZL50 wheel loader transmission assembly faults

No.	Fault description		Reason	Troubleshooting method	Note
1	Low speed shift pressure	Low speed shift pressure at all gear positions	1) Excessively low oil level in the oil reservoir of the transmission 2) Main pressure oil passage leaks 3) Blockage in the transmission filter 4) Failure of the speed gear 5) Improper pressure regulating of the speed control vale and the pressure regulating valve 6) Speed control vale pressure regulating valve spring fails or gets stuck 7) Speed control valve accumulator piston gets stuck or there is a blockage in the oil passage to the accumulator 8) The cut-off valve lever gets stuck at the cut-off position 9) The cut-off spring is damaged and gets stuck at the cut-off position 10）No compressed air enters the chamber A of the speed control valve pneumatic valve (Illustration 4.3-11) 11）Elastic plate is damaged or its connecting bolt gets loose 12） Oil pressure gauge reads incorrectly	1) Add oil to the required level 2) Check the main pressure oil passage and perform troubleshooting operation 3) Clean or replace the oil filter 4) Disassemble and check the oil filter or replace it 5) Check the pressure regulating valve and re-install it 6) Replace the pressure regulating valve spring or disassemble and check the pressure regulating valve spring and fix the getting stuck problem 7) Disassemble and check the speed control valve accumulator piston and fix the getting stuck problem, or check the oil passage to the accumulator 8) Check the cut-off valve and fix the getting stuck problem 9) Replace the cut-off valve spring 10) Check the reason for no compressed air in the chamber A, and fix the problem (refer to the "Brake system faults" part) 11) Replace the elastic plate or install and secure the connecting bolt of the elastic plate 12) Adjust or replace the oil pressure gauge	Normally, the fault occurs to the parts of the speed control valve or the parts located before the valve. Therefore, the torque converter and the transmission parts are not checked usually
2	Low speed shift pressure	Low speed shift pressure at a gear position	1） The gear piston seal ring is damaged 2） The seal ring in the oil passage is damaged 3） The oil passage of the gear leaks 4） Crack in the reverse gear on the transmission body 5） Dropout of the guiding pins on the second gear piston	1） Replace the seal ring 2） Replace the seal ring 3） Find out the reason for oil leakage at the oil passage of the gear and perform troubleshooting operation 4） Replace the transmission body 5） Re-install the guiding pins	Normally, the faults occur to the transmission parts

3	Excessively high transmission oil temperature	1） Excessively low oil level in the oil reservoir of the transmission 2） Excessively high oil level in the oil reservoir of the transmission 3） Low speed shift pressure, clutch drag 4） Blockage in the torque converter heat radiator 5） Excessively long working time of the torque converter with high load 6） Heat radiator fan belt deforms permanently and gets loose 7） Heat radiator fan belt tension device malfunctions 8） Heat radiator surface is too dirty 9） Excessive oil leakage at the rotary seal ring of the torque converter 10） Excessively low inlet and return oil pressure of the torque converter 11） Clutch plate drag due to excessive wear 12） When the gear is not engaged, incomplete disengagement of clutch plate causes excessive wear 13） Camber and deformation of clutch plate 14） Abnormal friction of torque converter impeller	1) Add oil to the required level 2) Drain oil to the required level 3) Refer to the "Low speed shift pressure" part 4) Clean or replace the heat radiator 5) Park the loader for cooling for an appropriate period of time 6) Replace with the new belt once and for all 7) Replace or repair the hat radiator fan belt tension device 8) Clean the heat radiator surface ore place with the new heat radiator 9) Replace the seal ring, repair the transfer gear and the leading wheel seal ring surface or replace with new ones 10) Replace the oil inlet valve spring 11) Replace the friction plate as required 12) Fix the problem that causes the incomplete disengagement 13) Replace the clutch plate 14) Detect the loose part, eliminate the abnormal friction, and repair or replace the impeller if necessary	
4	The engine operates at a high speed, but the loader does not move	1） Failure to engage to drive position 2） Expressively low gear shift pressure, almost none 3） Damage to intermediate input shaft splines 4） Break of direct gear connection disc splines 5） Shearing of the intermediate output gear connecting bolt	1） Retry or readjust the speed control lever system 2） Refer to the 1, 2, 3, 4, 8, 9, 10 and 11 parts of the "Low speed shift pressure" 3） Replace the intermediate input shaft 4） Replace the direct gear connection disc 5） Reinstall the connecting bolt	
5	Insufficient drive force	1） Expressively low gear shift pressure 2） Excessively high torque converter temperature 3） Damage to torque converter impeller 4） Damage to large overrunning clutch 5） Insufficient engine output power 6） Drive axle failure 7） Brake is not disengaged 8） the relief valve of the hydraulic system does not return after opening	1) Refer to the "Low gear shift pressure" part 2) Refer to the "Excessively high transmission oil temperature" part 3) Disassemble and check the converter and replace the impeller 4) Disassemble and check the large overrunning clutch and replace the damaged parts 5) Check and repair the engine 6) Refer to the "Drive axle" part 7) Refer to the "Brake system" part 8) Check and adjust the distribution and master relief valve of the hydraulic system	
6	Transmission oil level increases	1) Oil pumping at the steering pump shaft end 2) Oil pumping at the working pump shaft end of the working hydraulic system	1) Replace the oil seal at the steering pump shaft end 2) Replace the oil seal at the working pump shaft end	

II. Typical "low speed shift pressure" fault analysis

Speed shift pressure is a controlled monitoring indicator of the loader. Its changes are caused by faults in many aspects. Therefore, the successful troubleshooting of the excessively low speed shift pressure problem can help fix the faults with the loader.

The normal gear shift pressure of the ZL50 wheel loader ranges between 1.1 and 1.5MPa. If the speed shift pressure is lower than 1.1MPa, it is considered to be excessively. In this case, it is certain that there are faults with the system. Normally, when the gear shift pressure ranges between 0.7 and 1.1MPa, the loader keeps working though the working performance has dropped. Especially when the gear shift pressure is above 0.8MPa, the loader's working capacity drops slightly, and many users do not take it seriously and do nothing about it, leading to terrible accidents and serious loss. Therefore, it is necessary to find out what happens when the gear shift pressure drops to an excessively low degree and fix the problem.

The features, main reasons and troubleshooting methods of the excessively low gear shift pressure problems have been analyzed in details in the form listed above. Here are some typical cases that familiarize users with the analyzing and troubleshooting methods involved.

1. Excessively low speed shift pressured caused by improper pressure regulating operations of the speed shift valve pressure regulating valve

Repair case: after the transmission overhaul, a ZL50C wheel loader moved powerlessly in the trial drive. The following inspection showed that the speed shift pressure was lower than 0.7MPa.

Since the transmission assembly (torque converter-transmission assembly) was just overhauled and the variable-speed pump was replaced before the overhaul, the problem could not be caused by the variable-speed pump. In the meantime, during the overhaul, the entire system including the oil filter and lines was inspected and repaired, so there was a little chance that these parts went wrong. However, the repair technician found that the speed control valve was not inspected and repaired in the overhaul. After careful analysis, the technician guessed that the problem might come from the malfunction of the speed control vale pressure regulating valve. As is shown in the following illustration, after disassembling and checking the pressure regulating valve, the technician found that the four pressure regulating rings 4 located between the accumulator plunger (slider) 5 and the spring 3 were the cause for the excessively speed shift pressure.

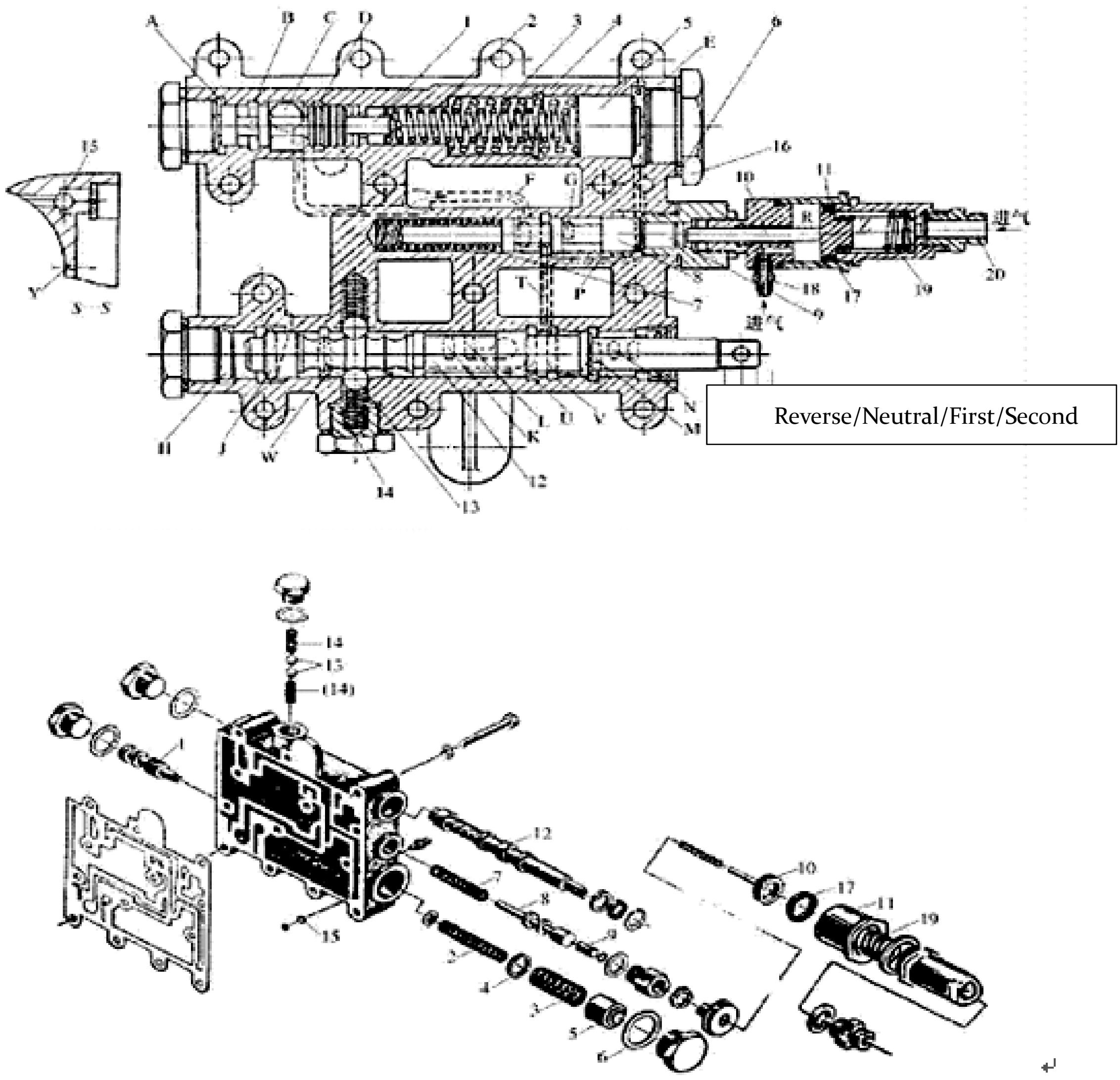


Illustration 2-19 Speed control valve

The pressure regulating ring plays a role of regulating the pressure, but it is different from a common pressure regulating device. Normally, the pressure will go up after the thickness of the pressure regulating ring is increased. However, it was totally different for the ZL50C wheel loader: the thicker the pressure regulating ring, the lower the pressure. According to the above-mentioned pressure regulating principle, the more leftward the accumulator plunger 5 moved with the action of the pressure oil in the chamber E, the higher the pressure. When the pressure came to 1.5MPa, the highest point of the system, the plunger 5 moved to the leftmost position, came into contact with pressure regulating ring 4, and could not move leftward due to the limitation of the pressure regulating rings 4. The loader manufacturer has configured and limited the highest pressure before the shipment of the product. In this sense, it has played the same role as that of a relief valve. Therefore, the increase in the thickness of the pressure regulating rings 4 will not increase the pressure, but lower it.

The loader had moved powerlessly for a long period of time, and the on-site repair technician did not fully understand the working principles of the speed control valve pressure adjusting valve. He thought it would fix the problem by increasing the pressure, and then he mistakenly adjusted the thickness of the pressure regulating valves 4. When the loader was overhauled, the technician did not check the speed control valve, and he simply removed the valve and reinstalled it after the overhaul. And then the excessively speed shift pressure problem occurred. After the number of the pressure regulating rings 4 was reduced to one, the speed shift pressure was within the permitted range, and the loader worked normally.

2. Excessively low speed shift pressured caused by blockage in the main oil pressure passage

Repair case: the transmission assembly of a ZL50 wheel loader was overhauled, the variable-speed pump, oil filter and lines were replaced with new ones, and the speed control valve was broken down for inspection. After the inspection and overhaul, the removed parts were reassembled and then the whole loader was given a trial drive. However, it turned out the speed shift pressure was lower than 0.6MPa, and the pressure value remained same at different gear positions. According to the working principles of the torque converter, the transmission and the speed control valve, the problem could not be caused by the torque converter or the transmission. It was almost certain that there were faults with the speed control valve and the parts located before the valve, because the variable-speed pump, the oil filter and the lines were already replaced with brand new ones, and they were found faultless in the re-inspection. Now, except the speed control valve 3, all parts were checked again. However, the repair technician did not find anything wrong with the valve in the re-inspection. Then he removed the valve assembly, and found out what had happened: there was a paper gasket (see the following illustration) located at the installation surface between the speed control valve and the transmission body. The oil inlet port of the paper gasket was not aligned with the oil inlet port at the transmission body, with more than half of the oil inlet port on the valve covered by the paper gasket, leading to oil inlet difficulty and excessively lower speed shift pressure. After the paper gasket was readjusted, the main pressure oil passage functioned normally, and the problem was solved.

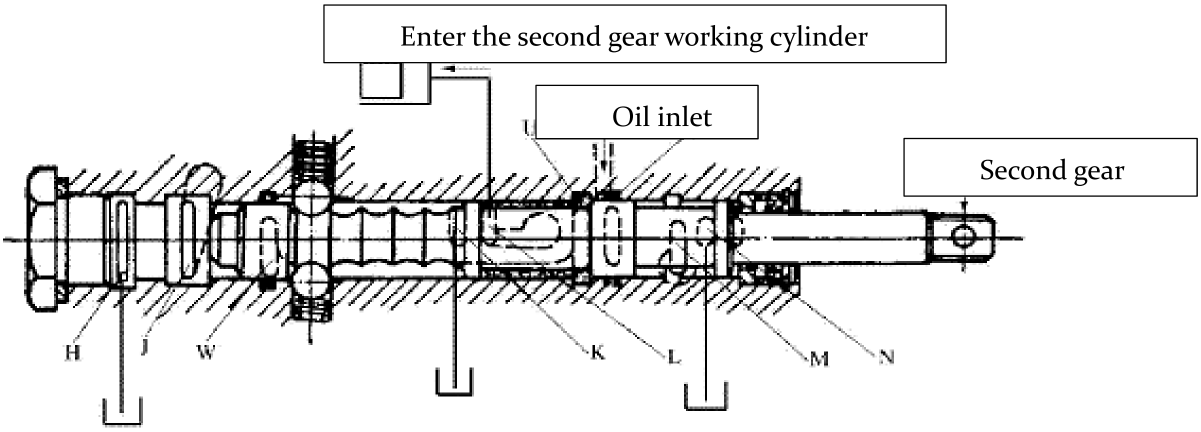


Illustration 2-20 Second gear oil passage

3. Excessively low speed shift pressure at the second gear caused by the dropout of a guiding pin at the second gear piston

Repair case: a ZL50 wheel loader has worked for a long period of time. One day, the speed shift pressure at the second gear (direct gear) dropped to an excessively low level, and the loader was unable to work, but the pressure at the first gear and the reverse gear was normal. During the following inspection and repair, the speed shift pressure was examined and tested for numerous times, but the result remained unchanged. Therefore, it was almost certain that the problem was caused by the fault with the whole oil passage of the second gear.

The second gear oil passage is arranged like this: there is a second gear oil inlet at the speed control valve; correspondingly, there is a second gear oil inlet at the same side of transmission body. So, is there anything with the two corresponding oil inlet ports? The technician removed the speed control valve and found nothing. He then took the inspection to a deeper level: checking the second gear cylinder and pushing the inner oil passage of the second gear piston. As is shown in the following illustration, after the oil enters the second gear oil passage at the transmission body from the speed control valve, it flows along the transmission wall to the end where the transmission body and the end cover fit, and then to the inner oil passage at the end over 60 from the end of the transmission body. Between the end cover and the end of the transmission body, there is a seal ring at the joint extending to the chamber Q in the middle of the end cover and interlinking with the inner oil passage in the middle of the direct gear (second gear) cylinder 64. At the junction surface, there is an O-ring seal that extends to the bottom of the direct gear cylinder 64 and pushes the direct gear piston 65. During the whole process, the oil keeps flowing in the inner oil passage. It is possible that there is a blockage in the inner oil passage; if it is blocked, there will be speed shift pressure even though the pressure cannot enter the oil cylinder and drive the loader to move further. Since there is excessively low speed shift pressure at the second gear, it means that there will be no possibility that there is a blockage in the inner oil passage. In the meantime, the oil passage breaks and the oil leakage can lead to the excessively low pressure, but the inner oil passage is cast or processed on castings, and it has been used for a long period of time. There was a little chance that the inner oil passage leaked oil. The technician checked whether the two seal rings at the oil passage were damaged. He disassembled and checked the second gear (direct gear) assembly. As is shown in the illustration, he found that the guiding pin 82 located between the direct gear piston 65 and the direct gear cylinder 64 had dropped out. This led to the pressure oil leakage from the hole of the guiding pin at the direct gear cylinder 64, brought about excessively low speed shift pressure at the second gear position, and prevented the loader from working normally. After the reinstallation of the guiding pin 82, the problem was solved.

This typical case is a good example for how to analyze and solve pressure problems at different gear positions.

There are a large number of examples about the excessively low speed shift pressure. Other problems, such as excessively low transmission oil level, blockage in the oil filter, malfunction of the variable-speed pump, flattening of oil suction tube, incorrect reading of oil pressure gauge, are frequently encountered, but they are easy to find and solve. In addition, there is a special case: the damage to the elastic plate or the looseness and dropout of connecting bolts, but this is a common problem. In this case, no power is transmitted, the speed shift pressure is dropped to zero, and the loader cannot move, the oil pumps of the working and steering hydraulic system stop working. Therefore, it is easy to determine that the connection between the output part of the engine flywheel and the input part of the torque converter has broken.

III. Typical “excessively high transmission oil temperature” fault analysis

The ZL50 wheel loader’s torque converter works with the hydraulic drive oil. A large amount of heat will be generated during the churning of the oil in the torque converter, with the flow of the oil in the hydraulic system, and by the regulation of the valve. In the meantime, the friction heat generated when the large gear of the transmission churns the oil and when the movable parts and components move will increase the temperature of the transmission & torque assembly hydraulic system. To ensure the normal operation of the loader, a hydraulic heat radiator is installed in the hydraulic system, limiting the system temperature within an allowable range. The best temperature ranges between 80 and 90℃, the normal allowable temperature between 70 and 110℃. When the oil temperature drops to an excessively low level, the oil viscosity rises and its efficiency drops, and this makes the loader move powerlessly. Normally, the lowest oil temperature is equal to and more than 70℃. The problem caused by excessively low oil temperature seldom occurs. When the oil temperature rises to an excessively high level, the oil viscosity and its lubricating performance will drop, and this accelerates the friction of parts and components. The excessively high oil temperature will also accelerate the aging, deterioration and damage to the sealed parts, lead to oil leakage, and lower the working performance of the loader. In the meantime, with the clutch friction plate drag, the oil temperature will rise further, and this will probably cause the deterioration of the hydraulic drive oil and the burnout of the clutch. Therefore, it is necessary to keep the oil temperature within the allowable range, with the highest temperature between 110 and 120℃. When the oil temperature exceeds 120℃, immediately shut off the loader and find out what has happened.

Normally, the excessively high oil temperature may occur in the following two cases: firstly, when the loader keeps driving a long distance along the high way in hot summer, the oil temperature of the transmission & torque assembly can reach above 110℃, and sometimes even above 120℃; secondly, the loader keeps working with heavy load in hot summer, the l temperature of the transmission & torque assembly will reach 120℃ and above. Under these two special working conditions, the heat dissipation system cannot adapt to the environment very well. It cannot be considered as a fault, because it only features high oil temperature and the loader does not have any driving or working difficulty. In this case, shut off the loader, and restart it when the oil temperature of the drive system drops into the normal range. The actually and excessively high oil temperature problem occurs in normal weather conditions with normal load and for normal working hours. The oil temperature exceeds the allowable range very quickly. In the meantime, the water temperature rises quickly and even becomes boiled. The abnormal phenomena are caused by faults, and they should be immediately eliminated.

The oil temperature of the transmission & torque assembly hydraulic system relates to many factors. When the oil temperature becomes excessively highly, achieve thorough understanding of the features of the loader, check whether the drive force, the water temperature, the torque converter and the oil pressure read correctly, and then take into account different factors to make an estimation of the possible causes.

During this process, eliminate different possibilities by starting from easy points to difficult ones, from the inner system to the outer parts, and from the simple problems to complicated conditions.

1. Oil temperature rise caused by oil brand or oil quality that does not conform to standards

The excessively high oil temperature will be caused by excessively large or small amount of oil, improper oil brand, excessive amount of water or air contained in the air, deteriorated oil, or excessively dirty oil.

Firstly, check the amount of the oil. If the amount is too large, there will be huge churning loss, leading to excessively high oil temperature. If the amount is too small, there is less oil that generates heat and then takes the heat generated during the friction of different parts and components to the oil cooler, leading to excessively high oil temperature. The oil in the transmission & torque assembly hydraulic system is stored in the oil sump that is located at the lowest part of the transmission body. At the upper part of the oil sump, the lowest oil level switch is located under the speed control valve. The oil surface is higher than the lowest oil level switch, so it is normal that the oil overflows when the switch is turned on. To ensure that is sufficient oil in the system, check the oil level again after the engine works for 5 minutes. If the oil level is still higher than the lowest oil level switch, the amount of oil is considered to be sufficient. If not, add some oil to meet the requirement. It is of great importance for a first-time loader user to check the oil amount. Several years ago, a user in Harbin, China had its loader's transmission & torque assembly repaired, but the loader could not move and worked powerlessly, and the oil temperature rose very fast. The user was a little confused and asked for technical help. The repair technician was certain that there was insufficient oil in the assembly, and the check proved that he was right. After the oil replenishment, the loader worked normally.

Next, check that the oil brand is correct, whether the oil quality and cleanliness conform to the standards, and the oil does not deteriorate, because problems in these aspects will also lead to excessively high oil temperature. At the repair site, it is a little hard to find out whether the oil brand is correct, and this must be done with special inspections. Currently, major manufacturers sell the packaged oil special for their products and recommend users to use such specially developed and produced oil, so that the users will not add wrong oil to their machines. If the special oil is not available, users should purchase the oil that conforms to the standard. Even though the special oil is used, do not make any confusing during the process.

Different transmission & torque assembly uses different oil. For example, the oil for the ZF transmission & torque assembly is different from that for the double-turbine and transmission & torque assembly. Therefore, the mistaken use of the special oil will lead to system faults.

An experienced repair technician can immediately determine whether the oil is excessively dirty, deteriorated or contains air bubble or water. The deteriorated or excessively dirty oil is black and looks like sticky and thick paste. In this case, drain the oil in the system, make thorough cleaning, and add oil that conforms to the standard.

2. Oil temperature rise caused by cooling efficiency decrease

The blockage in the heat radiator of the torque converter and its line, the deformation and looseness of the heat radiator fan belt, the malfunction of the heat radiator fan belt tension device, or the excessively dirty heat radiator surface, will decrease the cooling efficiency, leading to excessively high oil temperature.

The cooling system is mainly composed of the heat radiator and the low-pressure rubber pipes that pass into and out of the heat radiator. The interior of the heat radiator is composed of the lines in which the oil flows and the fins outside of the lines. If there is a blockage at the oil inlet and outlet lines or the inner lines of the heat radiator, the high-temperature in the heat radiator cannot flow freely, leading to the drop of the heat dissipation result and excessively high oil temperature. Such faults have occurred for a number of times. During the troubleshooting process, repair technicians did not consider the blockage factor at the beginning, and they failed to find out the reasons for the excessively high oil temperature. Finally, they found a blockage in the system’s lines. The blockage method is to remove the pipes and the heat radiator and blow the lines with compressed air. By doing so, technicians can check whether the lines are blocked and remove the blockage if any.

The heat radiator surface is composed of dense fins. After a long period of use, oil dirt and dust accumulate on the fins, and this has greatly reduced the working efficiency of the heat radiator and leads to excessively oil temperature. These faults can be detected through visual inspection. When eliminating the failure, remove the heat radiator, blow it with high-pressure air, and clean it thoroughly with cleaner. If it is not that dirty, do not remove the heat radiator and blow it directly with the high-pressure air. However, if the fins cannot be cleaned due to the long period of use, replace the heat radiator with a new one.

The air-cooling heat radiator and the water tank of the engine constitute the heat radiator assembly that uses the engine fan for heat dissipation. If the heat radiator fan belt is not appropriately adjusted or it has been used for a long period of time, its tension drops. In the meantime, there may be permanent deformation and looseness of the heat radiator fan belt. Such factors will make the working efficiency and the air quantity drop tremendously, leading to excessively high oil temperature and water temperature, and even boiled water. The readjustment of the fan belt tension device or the replacement with new part will solve the problem. When a belt deforms permanently, it must be replaced with new ones. During the replacement, all fan belts must be replaced simultaneously, or the stress will not be evenly distributed, leading to the damage to the part.

3. Excessively high oil temperature caused by excessively low oil pressure in the torque converter

(1) Excessively low inlet and return oil pressure

The excessively low oil pressure in the torque converter comes from insufficient oil. If the amount of oil flowing to the heat radiator decreases, the oil rises excessively.

As is shown at the K direction in the Illustration 2-21, the pressure oil from the variable-speed pump interlinks with the passage D at the leading wheel base 10 through the hole A and its passage at the torque converter housing, enters the working chamber of the torque converter through the clearance between the passage E and the bearing, and the overflown oil flows through chamber G, circular passage F and return oil at the leading wheel base 10 to the oil passage B at the housing 13 and to the joint 30. The Illustration 2-22 shows the process how the return oil from the heat radiator passes through the pressure valve 18 at the passage when it enters the torque converter through the hole A. The pressure valve limits the highest pressure to a degree of no more than 0.5MPa, and it does not function to the lowest pressure. Therefore, if the pressure of the speed control valve is normal, only the highest pressure is limited. In this case, the highest pressure at the outlet pressure is no more than 0.45MPa. Normally, the outlet pressure ranges between 0.28 and 0.45MPa. When the out pressure is lower than 0.28MPa, it is considered to be excessively low. In the meantime, the highest pressure of the return oil through the heat radiator is limited to a degree of no more than 0.2MPa by the counterbalance valve 23 (see the Illustration 2-22), and the torque converter works normally.

However, as the oil pressure of the speed control valve drops, the oil that flows to the torque converter will decrease. When the oil pressure of the speed control valve drops to a degree of lower than 0.7MPa, the oil that enters the torque converter will become insufficient gradually. In this case, the pressure at the inlet and outlet of the torque converter will drop continuously. When it drops to a degree of lower than 0.28MPa, the oil that flows to the heat radiator will decrease gradually and greatly, leading to excessively high oil temperature of the entire system. This analysis shows that an important reason for the excessively low pressure that flows into and out of the torque converter is that the pressure of the speed control valve is excessively low. To fix the fault, it is necessary to solve the excessively low speed shift pressure of the speed control valve. When the pressure is excessively low, it can be determined by reading the pressure gauge. This analysis also shows that, even if the speed shift pressure is normal, the blockage in the oil inlet passage (inner oil passage) of the torque converter will lead to excessively small amount of oil that enters the torque converter, the excessively low oil pressure at the outlet, leading to excessively high oil temperature. It is a little harder to check whether there is blockage in the inner oil passage, its removal and inspection should be conducted after other parts have been checked.

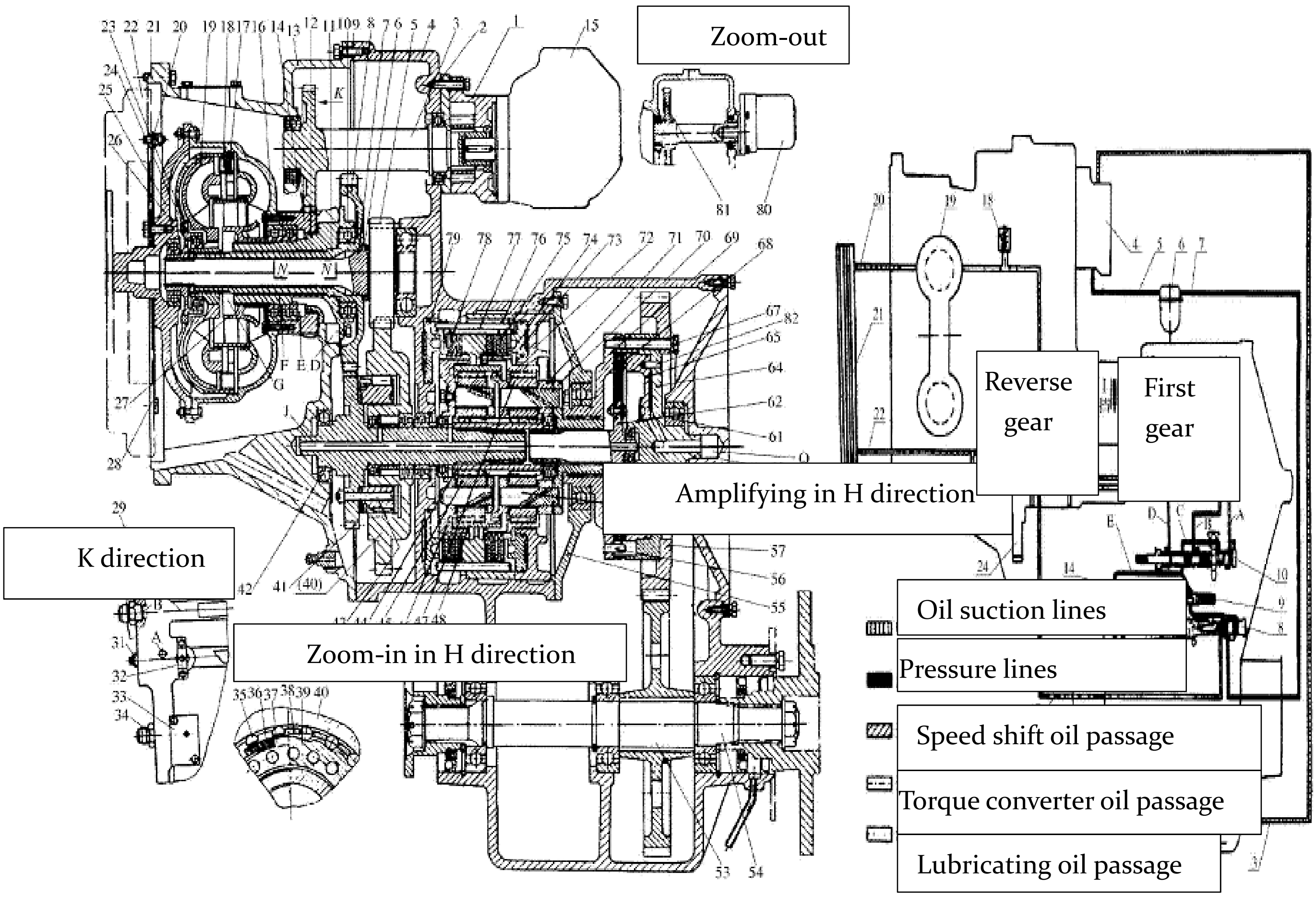


Illustration 2-21 Structure of the transmission & torque assembly

Illustration 2-22 Hydraulic system of the transmission & torque assembly

(2) Excessive oil leakage at the rotary seal ring of the torque converter

Excessive oil leakage will lead to excessively low pressure at the outlet of the torque converter, the reduction in the amount of oil flowing to the heat radiator, and the excessively high oil temperature. It happens due to:

① Heavy wear of the rotary oil seal. Currently, the common rotary oil seals are the snap type metal seal rings and the snap type poly tetra fluoroethylene seal ring. Except the normal wear due to the long period of use, the oil seal performance weakens due to the elasticity decrease, leading to the degraded seal between the transfer gear and the leading wheel base and excessive oil leakage. From the end of 1980s to the beginning of 1990s, the rotary and stationary sealing structure, a new rotary oil seal for torque converters emerged (see the zoomed numbers 13-17 at the sections A and B in the Illustration 2-23).

The rotary ring 13 is tightly installed in the inner hole of the transfer gear 1, and it rotates around the leading wheel base 6 with the transfer gear 1. The right end surface of the rotary ring contacts with the left end surface of the stationary ring 14, and the two rings move relatively. The contact surface bears certain pressing force applied by the spring 17 to ensure the sealing performance of the rotary face. The section between the stationary ring 14 and the leading wheel base 6 is sealed with the O-ring seal 16. This sealing structure boasts excellent sealing performance, long service life and great liability. Therefore, it is widely used in the ZL wheel loader series since 1990s.

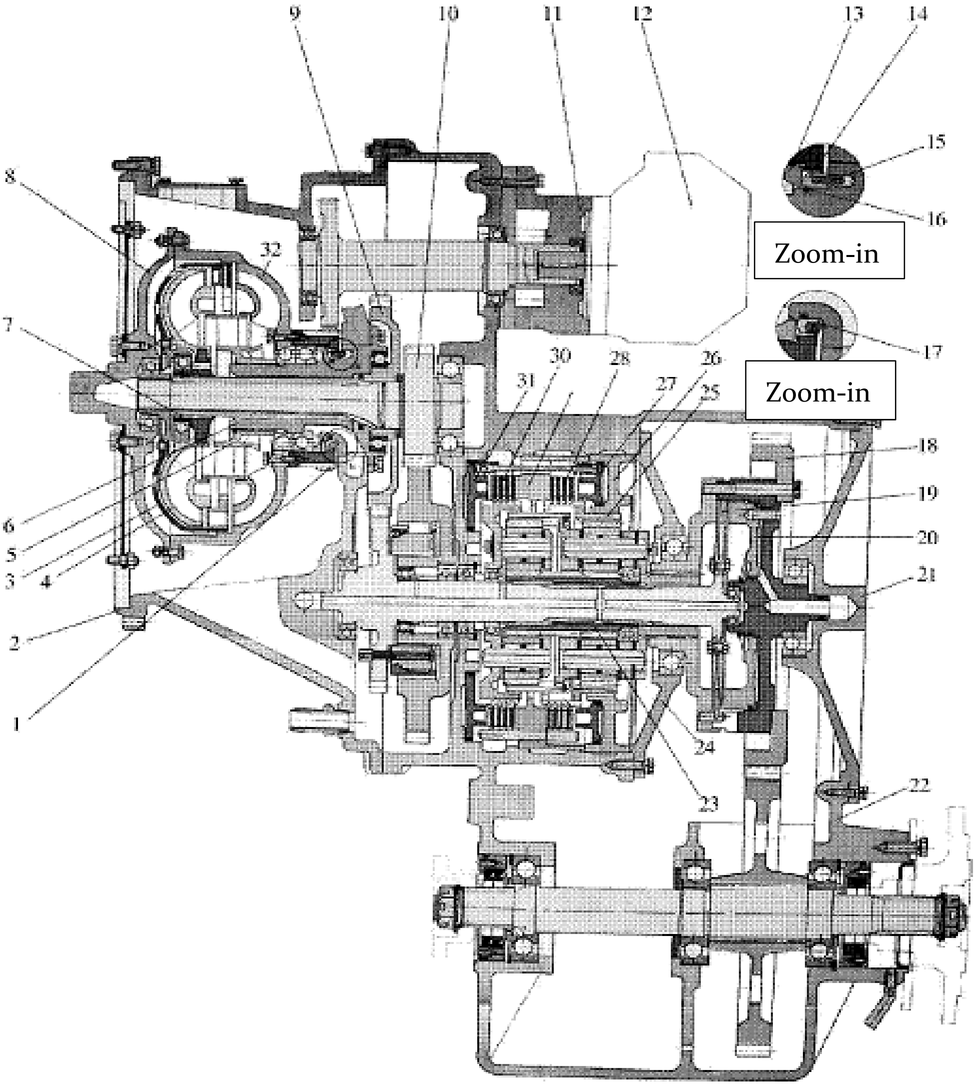


Illustration 2-23 Transmission & torque assembly

However, the structure requires higher oil cleanliness. If impurities enter the sealing surface that rotates at high speed, the excessive oil leakage will occur (the problem happens sometimes). In addition, there will be sealing failure and excessive oil leakage if the precision of the contact between the rotary and stationary rings and the smooth finish do not meet the requirements, the spring 17 serves a shorter life, and the elasticity weakens. Therefore, to adopt the structure, pay attention to the oil cleanliness, the processing precision of parts and the quality of spring. In particular, purchase the authentic products that conform to the standard from professional manufacturers when replacing the parts with new ones.

② Wear of the transfer gear. No. 14 gear in the Illustration 2-21 is the transfer gear. Its inner circular surface and the outer circular face of the oil ring 12 contact to seal the oil. There is high-speed rotational movement between the seal ring and the inner circular surface of the transfer gear. If the oil is too dirty, the hard dirt is somewhat of the nature of abrasive grit and wears the inner circular surface of the transfer gear at the outer surface of the seal ring. The seal ring will carve a deep grave at the inner circular surface, leading to seal ring malfunction and excessive oil leakage. In the meantime, the eccentric wear resulting from the dis-alignment between the seal ring and the inner circular surface of the transfer gear for different reasons will accelerate the oil leakage at the rotary oil seal.

③ Other factors. As is shown in the Illustration 2-21, the aging and failure of the O-ring seal at the leading wheel base, the insufficient or improper contact between the pump gear 16 and the hood wheel 25 and between the pump gear 16 and the transfer gear 14 or the loose connection will lead to excessive oil leakage and excessively high oil temperature of the torque converter. In this case, the loader works powerlessly.

(3) Inspection methods of main parts that lead to oil leakage

①Inspection of the rotary seal ring: snap the steel or poly tetra fluoroethylene seal ring, and put it steadily into the inner hole of the transfer gear. At the snapped section, there should be clearance that conforms to the standard to ensure sufficient outward ejecting space and the service life of the seal ring. Afterwards, conduct the elasticity inspection of the seal ring: pull the seal ring opening slightly by about 20mm to ensure that the previous clearance (normally about 10mm) will be maintained after releasing the opening, and then pull the opening leftward or rightward along the axial direction to achieve a deviation about 20mm of the two openings, and after releasing, the two ports will return to the same horizontal plane. This inspection is to determine that the spring of the seal ring basically conforms to the requirement. Thirdly, conduct the sealing performance inspection: put the snapped seal ring horizontally into the inner hole of the transfer gear, insert a piece of stiff paper in the middle, and inspect the seal ring under the lamp light. If there is no light leakage, the sealing performance conforms to the requirement.

Through these inspections, if the seal ring is found to be of high quality, it can be used for further installation. The reason that there will be strict inspections of the seal ring is that bad sealing will lead to excessive oil leakage, excessively high oil temperature, and powerless working of the loader. In the meantime, the seal ring is located inside the loader, meaning there will be troublesome disassembly and overhaul of the relevant parts and components. Therefore, strict inspections must be taken to make sure that it will be successfully installed and fitted at the first time without further removal or repair.

②Inspection of the transfer gear and the leading wheel base: mainly check whether the inner circular seal face of the transfer gear, the smooth finish and processing procession of the sealed groove of the leading wheel base conform to requirements; in particular, whether the locating face and the seal ring face are coaxial. If there is large coaxial difference, the eccentric wear of the sealed structure will lead to oil leakage. Normally, the coaxial degree is within 0.03mm.

4. Excessively high oil temperature caused by the clutch plate drag

When the clutch drags, the clutch plates friction abnormally and generate large amount of heat, leading to excessively high oil temperature. The reasons for clutch plate drag have been listed in the fault form, including: incomplete disengagement, excessive wear, and camber and deformation of clutch plates, and excessively low oil pressure.

(1) Incomplete disengagement of friction plates

When the second gear (direct gear) does not work, the friction plates are disengaged by the cup spring 59 (Illustration 2-21). When the first and the reverse gears do not work, the friction plates are disengaged by the spring 76. If the elasticity of the two springs decreases due to long period of use, the insufficient elastic force will prevent the friction plates from complete disengagement when they do not work, leading to abnormal friction between the friction plates and excessively high oil temperature.

Repair case: there were faults that the loader works powerfully at different gear positions, but the oil temperature was excessively high. Repair technician could not find out the reason in following inspection. Through careful analysis, the technician believed that it happened due to gear problems. The inspection of the gears after the disassembly of the transmission & torque assembly showed that the cup spring 59 of the second gear had rotated by 180 degrees. As is shown in the Illustration 2-21, normally the convex surface (back surface) of the cup spring should face the left and the concave surface face the right. Since the faulty cup spring was rotated by 180 degrees, the convex surface and the concave surface were in opposite directions. In this case, the elastic force to push the piston 65 back to its previous position was lost, leading to incomplete disengagement of friction plates and excessively high oil temperature. The problem was solved after the replacement of the cup spring, and the loader worked normally.

(2) Excessive wear of clutch plates

The stroke of gear pistons that compress the friction plates is within a certain range. Once the stroke exceeds the given range, the pistons fail to compress the friction plates during the gear engagement, generating a large amount of heat and leading to excessively high oil temperature. In this case, the loader moves or works powerlessly. The problem may happen to one or two gears. The operating limit of the friction plates is shown in the illustration 2-21. Replace the friction plate when the operating limit is reached.

(3) Camber and deformation of clutch plates

Clutch plates, especially the driven plates (steel plates), are prone to camber and deformation with the action of different external forces. Due to the camber and deformation, the clearance between the friction plates will decrease and even vanish when the clutch does not work, generating a large amount of heat and leading to excessively high oil temperature when the friction plates friction abnormally. In this case, there is no other problem except the excessively high oil temperature. In serious conditions, the excessively high oil temperature will make the clutch plates sintered and cause the gear disengagement.

Repair case: there was excessively high oil temperature problem with a newly overhauled ZL50 wheel loader. The transmission body emitted a large amount of steam that was beyond hand's touch. After careful analysis of the phenomenon, the repair technician found out what happened and solved the problem

The inspections of the hydraulic system of the transmission & torque assembly were performed from easy steps to difficult ones. Firstly, observe the speed shift pressure gauge to make sure that the pressure is within the given range; secondly, check the oil quality and oil replenishment amount to make sure that they both conform to the requirement; thirdly, check the cooling system for abnormal working performance; fourthly, check the hydraulic system of the transmission & torque assembly to make sure that different parameters, including the pressure at the inlet and outlet of the torque converter and the return oil pressure, are within the normal ranges and that there is no excessively low oil pressure.

Through the careful analysis based on the working principles of the transmission & torque assembly, it is certain that there are faults with the inner parts of the assembly. When the oil pressure in the transmission is normal but the oil temperature was excessively high, the strongest possibility is that there is damage to torque converter parts or fault with the overrunning clutch. In this case, the loader's whole shoveling, loading or moving operations or such operation at a gear position are powerless. However, there were no such problems with the newly overhauled loader.

Therefore, it was certain that there was problem with the gear shift clutch. The standard pressure of the transmission & torque converter shift gear clutch of the ZL50 wheel loader ranged between 1.1 and 1.5MPa. The loader worked normally when the pressure was above 0.7MPa. The repair technician removed the speed control valve, conducted air pressure tests by blowing different gears with the compressed air with the pressure ranging between 0.6 and 0.7MPa, and kept the blowing operation for a certain period of time. Normally, there should be clear return sound. The inspection of the three gear positions found that the return sounds for the pistons of the first and the reverse gears were obvious, but it was almost inaudible for the second gear (direct gear). Therefore, the technician ascertained that there was fault with the second gear.

After removing the second gear, the technician found that the second gear shaft did not rotate. Further disassembly showed that the clutch driven plates (steel plates) was steeply cambered and greatly deformed, and the two drive plates were burnt and did not function any more. After replacing with the new clutch plates, reinstallation and commissioning, the fault was successfully fixed.

5. Excessively high oil temperature caused by abnormal wear of parts and components

As is listed in the fault form, the excessively high oil temperature is caused by abnormal wear of the parts and components of the transmission & torque assembly of the ZL50 wheel loader. The problem happens due to abnormal friction of the torque converter impeller and the different gears of the transmission, the excessive wear of the variable-speed pump, and the malfunction or damage to the overrunning clutch, leading to abnormal wear of parts and components and excessively high oil temperature in the hydraulic system of the assembly. Besides, there will also be the moving fault or abnormal working pressure of the loader.

(1) Abnormal friction of the torque converter impeller

As is shown in the Illustration 2-21, the torque converter is composed of four aluminum impellers: hood wheel 25 that is integrated with pump gear 16, leading wheel 27, first-stage turbine 18, and second-stage turbine 19. The left end of the pump gear and the hood wheel assembly is supported on the diesel engine flywheel, and the right end is supported on the leading wheel base through two bearings 117. The first-stage turbine and the second-stage turbine are supported on the bearings 113 and 210, and the torque converter assembly performs axial locating through the retainer on the left end of the leading wheel base. The first-stage turbine impeller integrates with the turbine through the elastic pin 17. The second-stage turbine connects with splines on the second-stage input gear 8 through the splines in the iron core that is cast together with the turbine. The most common faults with these structures are: ① damage to bearings; ② breaks or dropout of the elastic pin 17; ③ looseness or dropout of the second-stage turbine core; ④ breaks or dropout of the axial locating retainer; ⑤ looseness or dropout of the connecting bolts that connect the impeller with other parts and components. These faults will change the location between the impellers and make the impellers friction with one another, leading to excessively high oil temperature and reducing the working efficiency of the torque converter tremendously. Worse still, the aluminum scraps will be mixed in the oil and cause the blockage in the oil passage. In this case, the pressure drops, the oil temperature rises even higher, and the loader moves powerlessly and cannot work. In the meantime, the impeller damage due to excessively long period of use or for other reasons will lead to excessively high oil temperature, the mixture of oil and aluminum scrap, and the powerless movement of the loader.

At the early stage of the problem, only the oil temperature rises, so it is hard to ascertain the fault. When the problem becomes serious, the temperature drops, the loader moves powerlessly and even cannot work, and the aluminum scrap is found in the oil, it is easy to ascertain that there are faults with the impeller. However, a repair technician should find out what happened at the early stage when the oil temperature rises, so as to avoid greater loss. The inspections, as discussed in this chapter, should be conducted in accordance with the principles of from simplicity to complication and from easy parts to difficult ones. As long as the structural principles are observed during the inspections, the reasons for the faults will be found out in the end.

(2) Abnormal friction of different gears of the transmission

The gear parts and components may be damaged due to long period of use or for some special reasons. The damage to gears and bearings, the looseness, drops and shear break of connecting bolts, will lead to abnormal friction of gears, which will generate a large amount of heat and drive the oil temperature to an excessively higher degree. For example, a ZL50 wheel loader could not exert any tunneling force when it was at the second gear position, and the oil temperature rose quickly. The speed shift pressure and other parameters were found to be normal in the inspections. After disassembling and checking the transmission, the repair technician found that the teeth of the planetary gear at the first gear position broke and got stuck with the sun gear. In this case, when the first gear was engaged, the ring gear at the first gear position was forced to rotate since the planetary gear at the first gear position could rotate reversely. Therefore, a large amount of heat was generated and the oil temperature rose to a higher degree very quickly. In the meantime, the first gear was basically out of work. Considering the fast rise of oil temperature and the faults with the gear position, a repair technician may ascertain that the problem is caused by the abnormal friction of parts and components in the transmission.

(3) Excessive wear of the variable-speed gear

The variable-speed pump is also called gear pump. If there is excessive wear of the large gear and the small gear, the stator and the rotator at the pump body will friction seriously, and the clearance between the gear end surface and the pump cover will become excessively large (normally exceeding 0.07mm), leading to excessive oil leakage and insufficient oil supply. In this case, the pressure of the speed shift system will drop to an excessively low degree (the system pressure is lower than 0.7MPa), the clutch plates will not be tightly compressed, drag and generate heat when the gear is engaged, leading to excessively high oil temperature. To solve the problem, replace the excessively worn gears; make appropriate repair of the seriously fractioned stator and rotator, and replace with new parts if they cannot be repaired; adjust the end cover clearance, and machine an appropriate part of the contact surface between the pump body and the end cover with a grinding machine.

(4) Failure or damage to the overrunning clutch

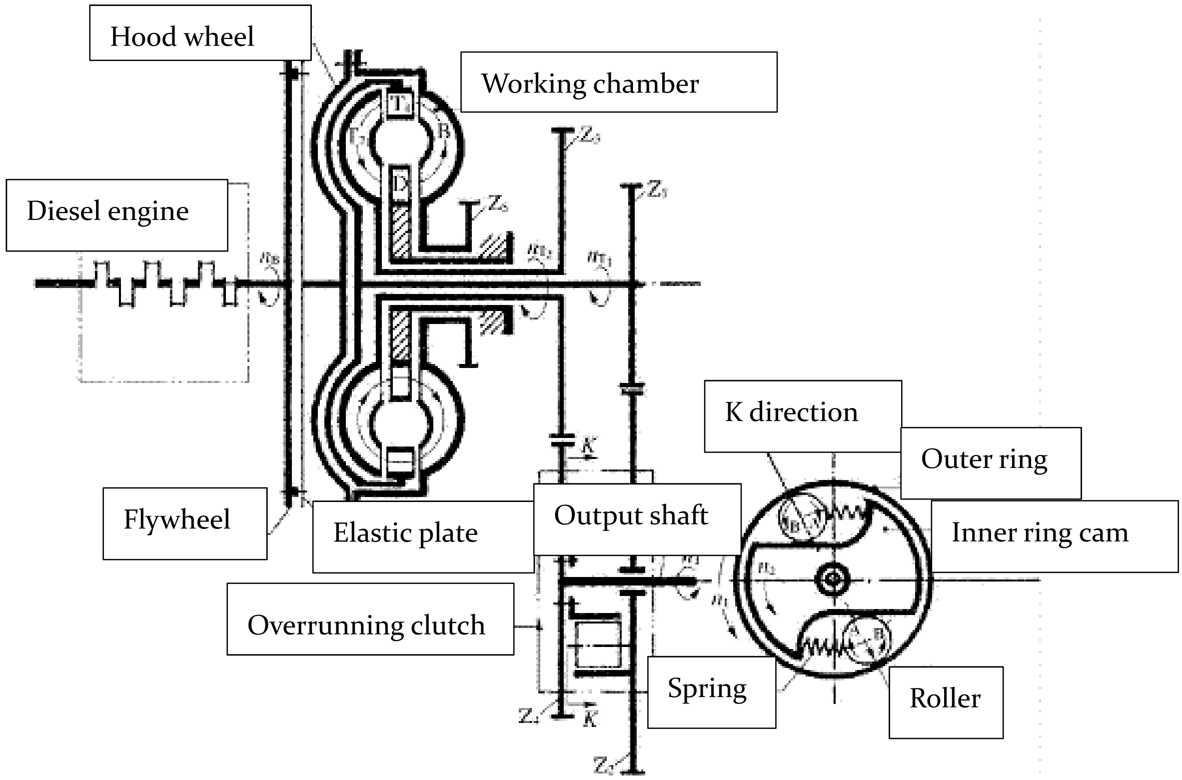


Illustration 2-24 Working principles of the torque converter

The overrunning clutch is an important of the transmission & torque assembly, and it is prone to faults. The problem will be discussed separately, and this chapter only focuses on the oil temperature rise due to the failure or damage to the overrunning clutch. When the rotational speed of the outer ring gear (see the K direction in the Illustration 2-24) is higher than that of the inner ring cam, normally the rollers are wedged tightly and the two turbines transmit power simultaneously, featuring a low speed and large torque. However, for different reasons, i.e. the excessive wear or abnormal damage to the contact surface between the out ring gear and inner ring cam and rollers, the rollers cannot be wedged tightly. In this case, the rollers will slip unexpectedly and generate excessive heat, driving oil temperature to rise quickly in addition, the faults with the spring and the disengagement ring will also prevent rollers from being tightly wedged.

Therefore, if the working oil temperature rises too fast and the reason cannot be find out, there may be faults with the overrunning clutch. Therefore, perform appropriate troubleshooting operations accordingly as soon as possible, or it will lead to greater problems and loss.

IV. Typical analysis of “the engine operates at a high speed, but the loader does not move” fault

“The engine operates at a high speed, but the loader does not move” is one of common faults with the loader. The typical problems include the failure to engage, the excessive low speed shift pressure, the faults with the direct gear connection disc, and connection failure of the intermediate output shaft gear.

The failure to engage is a common problem, and it is easy to detect and solve. When the engine operates at a high speed, but the loader does not move, check whether the desired gear is engaged. When a loader works for a long period of time, a gear may not be engaged due to changes of the speed control lever. Sometimes, there is even confused, skipped or stiffened gear engagement (it feels like making a sudden brake when making a gear position shift). Normally, these problems can be solved by readjusting the operation system. The speed control distribution valve lever performs locating operations by using two springs to compress tightly two steel balls. If the steel balls are not aligned with the groove of corresponding gears on the distribution valve lever, or the springs that compress the steel balls tightly are damaged, causing skipped or confused gear engagement and preventing the loader from driving smoothly. When shifting from the second gear position to the first gear position, if the position of distribution valve lever is not correct, the oil will flow into the first gear and the second gear simultaneously and makes the first gear and the second gear interfere with each other, and the loader will not move or suddenly brake. In this case, do not continue to drive the loader until the problem is solved, or there will be more serious consequence.

When the speed shift pressure is excessively low and even approaches to zero, the loader cannot move further. Refer to the “Failure caused by excessively low speed shift pressure” for more details.

The problem caused by the engagement failure and excessively low speed shift pressure is easy to solve. If the loader cannot move, and the problem is not caused by the engagement failure and excessively low speed shift pressure because the engine works normally, the speed shift pressure and the transmission oil temperature are normal, there are three possibilities: firstly, as is shown in the Illustration 2-21, the intermediate input shaft 41 connects with the sun gear 45 through the spline at the right end, and the power is transmitted to the transmission by the spline. If the spline is damaged, the entire power transmission system is cut off, and the loader will not move; secondly, if the spline of the direct gear connection disc 70 breaks, there will be no power transmission, and the loader cannot move; thirdly, if the connecting bolt 67 of the intermediate input shaft is cut, there will be no power transmission, and the loader cannot move. To solve such problems, it is necessary to check the relevant parts of the transmission and replace with the new ones.

Normally, these damages may occur in the use and repair of the loader. The troubleshooting method is: if the engine works normally, the speed shift pressure and the transmission oil temperature are normal, and the loader cannot move at all, the problem is caused by the cut-off of the power input and output resulting from the damage to relevant parts and components. Therefore, when the problems occur, make careful and thorough analysis and check relevant parts until the problems are solved.

In addition, there is a problem that the loader cannot move when a gear is engaged. If the loader works normally at other gear positions, the engine works normally, and the speed shift pressure and the transmission oil temperature are normal, it is certain that the parts and components at the gear are damaged and lead to the power cut-off. In this case, take the same analysis and inspection methods.

V. Typical "insufficient drive force" fault analysis

The problem has been discussed in the section four of the fault form. It is mainly caused by nine faults. Most faults have been discussed previously or will be discussed later. As is mentioned above, the damage to torque converter impeller will drive the oil temperature to rise and lead to insufficient drive force. In the meantime, when the engine and the transmission oil temperature and pressure are normal, the damage to torque converter impeller will also lead to insufficient drive force.

① Insufficient drive force caused by the damage to the transmission gears (common fault). As is shown in the Illustration 2-21, the torque converter has three groups of bearings: the first one is the two bearings that support the pump gear 16, and the other two are double-unit bearings that respectively support the first-stage turbine and the second-stage turbine. If the bearings that support the pump gear is damaged, there will be no drive force; worse still, the power that drives the working oil pumps is cut off, the variable-speed pump does not work and provide no speed shift pressure. The damage to bears that support the first-stage turbine and the second-stage turbine only leads to the insufficient drive force at the early stage, and no other problems can be found in this stage.

② The dropout of the second-stage turbine iron core. As is shown in the Illustration 2-21, the second-stage turbine 19 body is an aluminum part, and the second-stage turbo hub with splines is a steel part, and they are cast together. If these two parts are not securely cast, the second-stage turbine and its turbo hub will become loose and separate from each other, making the second-stage turbine lose the ability to transmit power (one of the most common fault with the torque converter).

If the drive force is insufficient and no problem has been found in a number of inspections, it is necessary to consider whether there is any damage to the torque converter turbine bearing or the second-stage turbine iron core has dropped out. To ascertain the fault, the transmission assembly must be removed, disassembled and inspected. However, since the removal and disassembly operation is not an easy task, it should be done after other reasons have been eliminated. When the problem is found out, replace the damaged parts with the new ones and conduct reinstallation and commission operation, and the fault will be fixed.

VI. Typical analysis of the overrun clutch faults

The overrunning clutch is at the central location of the transmission assembly, and it is the core part that bears the strong force in the assembly, so it is prone to problems and faults. Since the overrunning clutch has to be removed and disassembled for further inspections, it is important to make correct judgment of faults to avoid unnecessary and troublesome operations.

The overrunning clutch works when the roller, the inner circular surface of the outer ring gear and the contact surface of the inner ring cam are tightly wedged. Therefore, the three parts are under great compression stress. In particular, the cam surface is prone to deformation and even the compression marks and grooves, leading to the disengagement of the overrunning clutch rollers, the engagement difficulty and the faults. Sometimes there is damage to the inner contact surface of the outer ring gear and the roller surface. If the parts get stuck at a disengagement position, the first-stage turbine cannot participate in the work, making the loader move and work powerlessly. When the loader moves upwards, it moves slowly and even does not move. This problem also happens when the rollers of the old- and new-structure overrunning clutches are not tightly wedged. If the rollers get stuck at the engagement position due to the damage to the junction surface, the first-stage turbine and the second-stage turbine cannot be disengaged, and the two turbines are in the working state in all conditions. In this case, the loader works powerfully, but it drives slowly. Even if it runs at the second gear position (high-speed gear) on a smooth road without load, it drives slowly, the oil temperature rises quickly, and the transmission assembly overheats. This happens to both the old and new overrunning clutches.

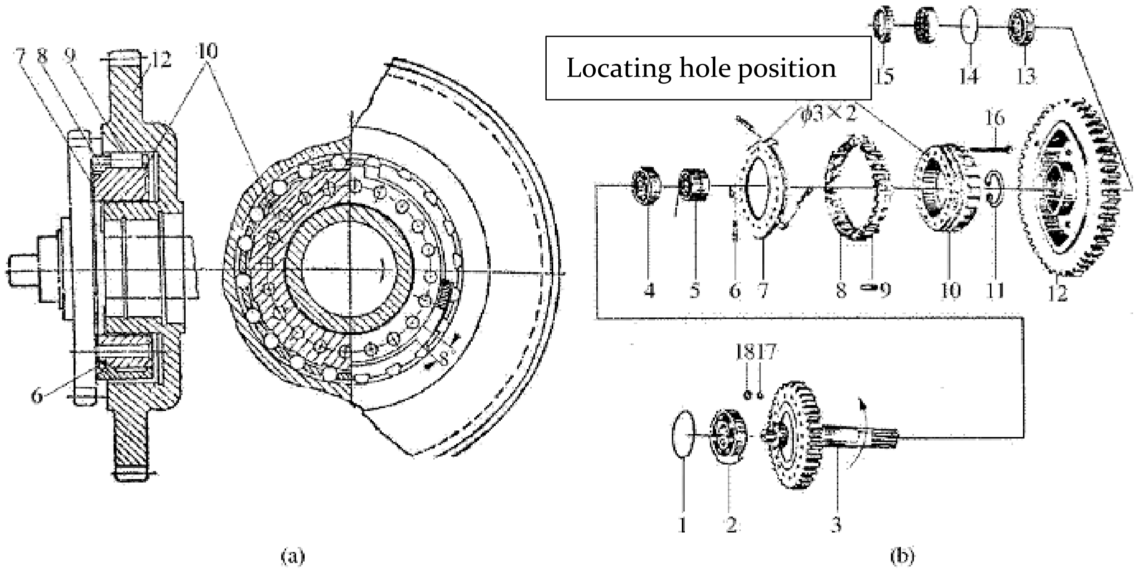


Illustration 2-25 Structure of the overrunning clutch (double shaft)

In general, one of the most typical overrunning clutch faults is that the loader drives normally at the second gear on a smooth road, but it works or moves upwards powerlessly, and the problem remains unsolved when the first gear is engaged. In this case, if the results of other inspection results are normal, it is basically certain that the parts of the overrunning clutch are damaged, preventing the rollers from being tightly wedged and the first-stage turbine from working. This problem will occur if there is any damage or failure of the parts in the overrunning clutch assembly shown in the Illustration 2-25a. As long as the problem has been found, take an earlier inspection to fix it, or the damaged parts will break other parts in the transmission and lead to greater loss.

Another problem is that the loader works powerfully when the first gear is engaged, but powerlessly when the second gear is engaged. If the results of other inspection results are normal, it is also certain that there are faults with the overrunning clutch. Possibly, the rollers, the inner surface of the outer ring gear and the working surface of the inner ring cam or one of the three parts have been damaged, or the rollers get stuck at the working surface due to faults with other parts, making the first-stage turbine and the second-stage turbine in the joint working state and cannot disengage. In this case, if the loader continues to drive or work, the oil temperature will rise quickly to a higher degree. At the early stage of the problem, the loader drives with heavy load, and it suddenly emits clicking sound. This phenomenon will disappear if the acceleration pedal is depressed or the loader keeps driving or working. However, the clicking sound will come more and more as the loader drives or works further, leading to the disengagement or engagement failure of the overrunning clutch and even the break of parts. In addition, when the loader drives normally at the second gear position and it suddenly drives powerlessly, it is basically certain that the problem occurs due to the engagement failure of the overrunning clutch. Check the engine, the speed shift pressure and other aspects carefully to achieve a better judgment. If no problems are found during such inspections, it is certain that there are faults with the overrunning clutch. These problems occur at the early stage, but it should be taken seriously and handled carefully because many parts and components are prone to damage. A delayed troubleshooting may lead to the breakdown of the whole transmission.

(1) What are the reasonable values of pressure at different gear positions? How to regulate the pressure?

The required pressure value of the transmission at different gear positions ranges between 1.1 and 1.5MPa (11-15KGf/cm^2). However, the loader can work when the pressure drops to 0.85MPa, but it is not allowable that the pressure exceeds 1.5MPa. It is recommended that users control the pressure of the transmission within the range between 1.1 and 1.3MPa, so that the thin bottom surface of the reverse gear cylinder at the transmission body will not break. If the break occurs, it is not easy to repair. Normally, the transmission body has to be replaced. And after the replacement, it is necessary to re-measure the central cover and the installation clearances between the rear end cover and relevant parts.

The speed distribution valve is located in the oil supply system of the transmission & torque assembly. It includes pressure regulating, cut-off and gear shift valves. There are two types of pressure regulating valves: single spring and anchorage bush type and double spring type. For the pressure regulating valve featuring the single spring and anchorage bush type, when the system pressure exceeds 1.5MPa, the length of the anchorage bush can be increased appropriately. Normally, when the length of the anchorage bush increases by 2mm, the system pressure drops by 0.10MPa; when the length decreases by 2mm, the system pressure increases by 0.10MPa. The same adjustment method also applies to the double-spring pressure regulating valve.

(2) How many possibilities are there for the excessively low pressure at different gear positions?

① The pressure is excessively low for all three gears, the oil temperature is normal, but the loader does not move.

A． In this case, normally it is unnecessary to check the transmission. The problem is possibly caused by the excessively low efficiency due to the serious burn of the variable-speed gear pump or by the insufficient oil supply due to the excessively low oil in the transmission.

B. The pressure regulating valve malfunctions and loses its elasticity. In this case, the spring seat is broken, the valve lever or the accumulator piston gets stuck and cannot compress the spring, so the normal pressure of the system cannot build up.

C. The cut-off valve lever gets stuck or the return spring breaks, making the cut-off valve stays at the cut-off position permanently.

D. The reading of the pressure gauge is not correct, and it does not show the actual pressure at different gear positions. Therefore, users need to check whether the pressure gauge works normally before increasing the transmission pressure.

② The pressure of the first gear and the reverse gear cannot increase, the pressure at the second gear position is normal, and the oil temperature is normal

In this case, normally it is unnecessary to check the variable-speed pump gear and the speed distribution valve but the transmission. Check whether the bolt connecting the central cover and the transmission body breaks, and then check and measure whether there is axial clearance between the central cover and the first gear cylinder block.

③ The pressure of the first gear cannot increase, the pressure of the second gear and the reverse gear is normal, and the oil temperature is normal

In this case, check whether there is any damage to the oil seal of the first gear piston or the air bubbles in the first gear cylinder block. During the inspection, it is unnecessary to hoist the whole transmission out the machine body but to remove the three shaft assembly from the rear end cover of the transmission, and disassemble the central cover to check the first gear cylinder assembly for the damage to the piston oil seal or of the O-ring seal at the oil inlet.

④ The pressure of the reverse gear cannot increase, the pressure of the first gear and the second gear is normal, and the oil temperature is normal

In this case, check whether there is any crack at the reverse position of the transmission body, and it happens due to excessively high system pressure. In addition, check whether the operation has adjusted the pressure to a higher degree without authorization due to the damage to the pressure gauge, leading to the system pressure exceeding the set value.

⑤ The pressure of the second gear cannot increase, the pressure of the first gear and the reverse gear is normal, and the oil temperature is normal

In this case, check whether there is any damage to the rotary oil seal at the junction between the middle of the rear end cover of the transmission and the second gear cylinder, whether there is any damage or absence of the O-ring seal at the oil outlet port of the second gear oil passage at the junction between the transmission body and the rear end cover, whether the three guiding piston pins of the second gear cylinder block has dropped out, making the second gear high pressure chamber interlinks with the oil reservoir, and whether there is any break in the paper gasket at the junction surface of the speed shift valve and the transmission body, making the high pressure chamber interlinks with the low pressure chamber and preventing the system pressure from building up.

(3) What are the reasons for confused or skipped gear engagement?

The problem is directly caused by incorrect locating of the shift gear valve lever. For example:

① The two locating balls in the gear shift lever and the valve body are not aligned with the groove or the spring between the two locating balls are damaged, leading to locating confusion.

② The location or length of the gear shift lever system has changed since it is under the pulling and pushing force for a long period of time. In this case, the leverage ratio is not correct, leading to the deviation of the operating position and dislocation.

Solution: remove the connecting pin between the gear shift valve lever and the control linkage, pull the gear shift valve lever to the neutral gear position and then the control linkage also to the neutral gear position, and adjust the locations and lengths of different connection joints of the levers to connect the two levers.

(4) Why will the “brake” phenomenon suddenly occur when the loader shifts from the second gear to the first gear?

If the control lever system of the gear shift valve is not correct, the pressure will enter the first gear and second gear simultaneously during the gear shift, making the two gears interfere with each other. In this case, the loader cannot move and suddenly brake.

(5) Why are there iron scraps or metal fragments in the oil sump of the transmission?

If the metal fragments or spring debris are found after the oil sump is disassembled, there have been damages to the overrunning clutch (double shaft assembly). If the aluminum scrap is found, the working wheels of the torque converter have fractioned seriously. In these two cases, removal, disassemble and repair relevant parts and then replace the oil, and further use is strictly prohibited.

(6) What is the reason for small tunneling force when the loader moves at a normal speed and the pressure of different gears is normal?

Since the pressure of different gears is normal, the problem is not caused by the faults with the hydraulic system. If the pre-compression amount of the three springs is too small, the first-stage gear and second-stage gear of the overrunning clutch will be in the disengagement positions permanently and cannot work together. The three springs have a normal length of 32mm and are not prone to plastic deformation.

Solution: check the double shaft assembly.

(7) What is the reason for slow moving speed of the loader when it works powerfully, and the pressure of different gears is normal?

Due to the damage to the overrunning clutch cam, the rollers and the cam surface are glued together, preventing the first-stage input gear and the second-stage input gear from disengaging and working separately.

Solution: replace the 24 rollers and carriers of the cam to press and cover the three springs

(8) What is the reason for the problem that the oil in the transmission decreases, the oil in the engine oil tank increases, or the engine oil decreases, and the oil in the transmission increases?

When the oil in the transmission flows into the engine oil tank, replace the skeleton oil seal (PD45*62*15) of the variable-speed gear pump; when the oil in the engine oil tanks flows into the transmission, replace the skeleton oil seal (SG42*62*12) of the working gear pump or replace the skeleton oil seal (35*56*12) of the steering gear pump. If the problem remains unsolved after the replacement of the working gear pump, check the copper seal sleeve of the working gear pump because its damage will make the high-pressure directly impact and break the skeleton oil seal. The radial clearance between the drive gear shaft of the gear pump and the copper seal sleeve should range between 0.035 and 0.045mm without any geometric deformation.

(9) What is the reason for the reason for the problem that there are air bubbles in the oil of the transmission, the finger of the pressure gauge swings unsteadily, and the loader works powerlessly?

The joint of the oil suction tube from the transmission gear pump to the oil tank is not tightly locked, so a large amount of air has been sucked into the oil passage and then into the transmission, leading to the air bubbles in the oil. In the meantime, there will be noise and vibration in the oil passage.

(10) What is the reason for the problem that there is engine oil in the water tank or in the cooler, and the amount of the oil keeps increasing?

Check the engine oil cooler core for cracks or unsoldering, because the oil will flow through the engine oil cooler, and the flow of the coolant for the cooler connects with that for the water tank.

(11) Why does the loader start in a violent manner? How to solve the problem?

The accumulator piston in the speed shift valve gets stuck due to the dirty oil, or there is blockage in the upper hole of the single-way valve A, failing to play the role of a damper and leading to violent start.

Solution: clean the accumulator piston and the hole A. Sometimes, it is necessary to move the control valve handle to make the high pressure at the right end of the accumulator piston in the low pressure state before the loader starts, so as to enhance the cushion performance of the accumulator piston.

2.7 Engine-torque converter-transmission combination

Steps:

(1) Rest the transmission assembly vertically on a level plane

From the junction surface of the transmission and the torque converter, measure the axial dimensions from these two components to the bearing 311 and the bearing 211 respectively and the depth of the bore, and select the thickness of the paper gasket for the junction surface, so as to ensure that the bearing 311 and the bearing 211 will not be excessively compressed after the combination. The axial clearance should range between 0.3 and 0.5mm.

(2) Apply the sealing glue to the paper gaskets for the junction surfaces between different combination parts;

(3) Align the two locating pins at the junction surface of the transmission and the torque converter, and then lock the two parts evenly and diagonally.

(4) Assemble the engine to the transmission & torque assembly. Pay attention to the connection between the engine flywheel and the elastic plate of the torque converter. When locking the nut, insert it from the window of the torque converter. **Do not drop the nut into the housing**.

(5) Strike slightly the ball bearing 211 into the transmission body, install the steering gear pump and its paper gasket (pay attention to the application of sealing glue), and make sure that the high pressure chamber of the steering pump is near the variable-speed pump at left side.

(6) When installing the variable-speed gear pump to the transmission body, deburr the junction surface with an oil stone, and align the locations of the oil inlet port and return port. Install the paper gasket at the junction surface and apply sealing glue. Do not cut or break the skeleton oil seal of the gear pump, and then lock the two small-end bolts 2-M10*75 and the outer bolts 6-M10*50.

(7) Place a paper gasket after the variable-speed gear pump, and align the working gear pump with the spline and push it into the variable-speed gear pump, and then secure it to the variable-speed gear pump with bolts.

(8) The oil sump of the transmission is hoisted onto the loader frame and then secured after the engine, the torque converter and the transmission are combined. Since the oil sump is thin, do not use excessive force when securing the bolts, so as to prevent deformation and oil leakage.

When securing the oil plug head, use the glued paper for sealing.

The oil sump is installed at the bottom of the transmission body. When the variable-speed gear pump sucks the oil, it filters impurities to prevent them from entering the hydraulic system. The oil sump should be regularly cleaned to eliminate the impurities from the oil system, so as to avoid the oil filter blockage that will affect the working performance of the hydraulic system.