Section 7. Wheel Drive Axle

7.1 Composition of the wheel drive axle

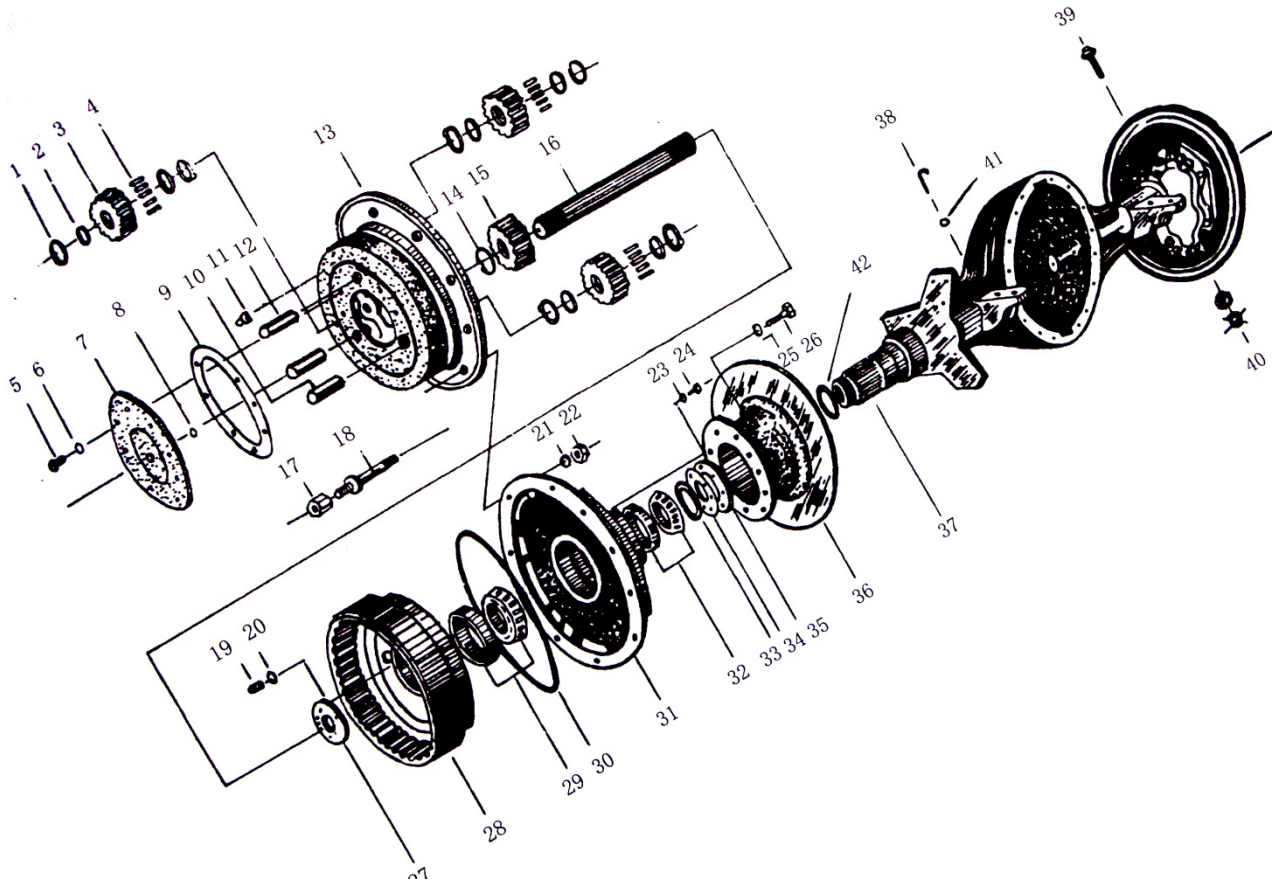


Illustration 7-1 Drive axle

1. Planetary gear shim 2. Retainer 3. Planetary gear 4. Needle pin 5. Bolt 6. Washer 7. Cover plate 8. Steel ball 9. Wheel shim 10. Steel ball 12. Planetary gear shaft 13. Planetary carrier 14. Retainer 15. Sun gear 16. Half shaft 17. Rim nut 18. Rim bolt 19. Threaded screw 20. Washer 21. Washer 22. Nut 23. Washer 24. Bolt 25. Washer 26. Brake disc bolt 27. Round nut 28. Inner gear 29. Tapered bearing 7521 30. O-ring seal 31. Gear housing 32. Tapered bearing 33. Double-port oil seal 34. Gear housing shim 35. Oil seal end cap 36. Brake disc 37. Axle housing 38. Breather pipe 39. Bolt 40. Self-made nut 42. Washer

7.2 Main parts of the wheel drive axle (structure, function and adjustment)

7.2.1 Main drive and differential

The main drive is a pair of spiral bevel gear differentials, and it receives the torque and motion from the drive shaft.

The main driver (Illustration 7-2) is composed a pair of mutually fitted spiral bevel gears. The drive spiral

bevel gear has a small number of teeth, while the driven spiral bevel gear has a large number of teeth. The rotational direction of the spiral can be confirmed by look at the trend of the tooth profile: if the rotational direction of the spiral extends clockwise from the small end to the large end, it is called clockwise rotation; if the rotational direction of the spiral extends anticlockwise from the small end to the large end, it is called anticlockwise rotation. When installed at the front axle, the small spiral bevel gear rotates anticlockwise, and the large spiral bevel gear rotates clockwise; when installed at the rear axle, the small spiral bevel gear rotates clockwise, and the large spiral bevel gear rotates anticlockwise.

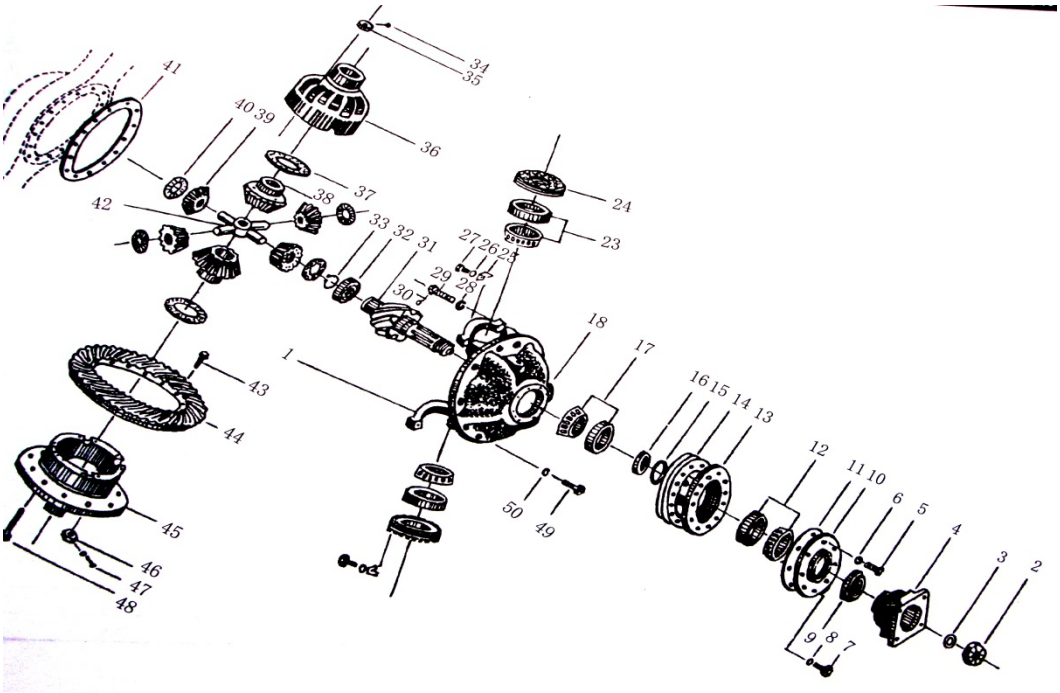


Illustration 7-2 Main drive assembly

To ensure the sufficient supporting rigidity of the small spiral bevel gear, the small spiral bevel gear 31 and the shaft are made into an integral part, with its large end supported onto two tapered ball bearings 17, and its small end supported onto the bracket 18 through the 92606 bearing 32.

Before installing the small spiral bevel gear into the bracket, apply some oil to the outer race of the bearings 27310 and 27311, strike slightly the two parts into the left side and right side of the bearing sleeve 13 respectively, strike slightly the bearing cone 27311, the insulating sleeve and the roller body into the small spiral bevel gear 31 shaft simultaneously, and then place the shims 15 of the shaft collar 13 after the bearing 17.

As is shown in the Illustration 7-2, the input flange 4 is pushed through its splines into the drive spiral bevel gear 31 shaft. In the seal cover, there is a 62*93*12 skeleton oil seal 9 with its lip facing inwards, so as to prevent the external leakage of the lubricating oil in the differential housing. The skeleton oil seal is press-mounted into the seal cove 10.

Install the O-ring seal and the shims at the connection joint of the flange 4 and the drive spiral bevel gear 31 shaft end, and secure the lock nut with a locking force of 35--40kg.f.

ATTENTION:

The tightening of the two tapered bearings 27311 and 27310 should be determined by gradually adjusting the shim depth when the oil seal and the seal cover are not installed. When the locking force applied to the two tapered bearings is 35-40kg.f, connect a tension meter to the installation hole of the input flange, pull the tension meter in the tangential direction, and it should read 4—5kg.f.

7.2.2 Installation of the differential and assembly of the main drive

(1) Install four bevel gears 39 to the spider 42 with the clearance ranging between 0.3 and 0.5mm. In the meantime, drill three lubricating oil holes at the place corresponding to the tooth space of each taper bearing so as to preventer the wear of the spider and the tapered bearing due to the oil loss. Place the four copper shims 40 covered with oil storage grooves after their corresponding tapered bearings with an axial clearance ranging between 0.3 and 0.5mm, so that each bevel gear can have a thin oil retention cover that will protect the copper shims from early wear.

(2) Rest the right housing 45 of the differential on the working platform horizontally, put a copper shim 37 covered with oil storage grooves into the right housing 45, place the half shaft bevel gear 38 on the copper shim 37, and install the spider 42 and four bevel gear assembly into the right housing 45 and the half shaft bevel gear 38. Move the gears to make sure that they can move flexibly after the installation. The engagement clearance between the bevel gear and the half shaft gear is between 0.3 and 0.4mm.

(3)Install a copper shim 37 and then the half shaft bevel gear 38 into the left housing 36 of the differential, and the two parts and the spider, the four bevel gears and shims and the right housing 45 constitute the differential. The locking force of the left and right housings is 8-10kg.f (80--100Nm). Drill three symmetrical oil holes at the tooth space of the half shaft gear.

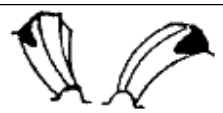
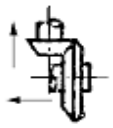
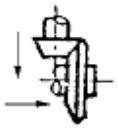
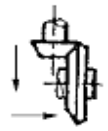
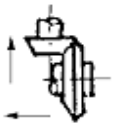
(4) Insert a proper tool into the spline groove of the half shaft gear to check that the gears inside the locked differential can move flexibly and that the differential can allow the outer drive wheel to rotate faster than the inner drive wheel during a turn, and then strike slightly the two bearings 7515 into the early reserved bearing installation spaces at the left and right housings of the differential respectively.

(5) Lock the large spiral bevel gear to the boss of the left and right housings of the differential with bolts (40Cr) marked with steel grade, with a locking force of 20kg.f (200Nm). The clearance between the bolts and the holes ranges between 0.3 and 0.5mm.

(6) When installing the small bevel gear and the output flange into the bracket, the bracket is placed upside down on the bracket. Rotate it by 180 degrees, strike slightly the shaft collar 92606 into the top of the small end of the small bevel gear, and secure it with a collar.

(7) Integrate the combination of the large bevel gear and the differential with the combination of the small bevel gear and the bracket, and then adjust the contact area at the engagement clearance.

7.2.3 Engagement and adjustment of the main drive

Contact area at the tooth surface of the driven gear	Adjustment method	Moving direction of the gear
	Adjust the driven gear towards the direction of the driving gear. Move the driving gear outward if the clearance is excessively small	
	Adjust the driven gear away from the driving gear. Move the driving gear inward if the clearance is excessively large	
	Adjust the driving gear towards the direction of the driven gear. Move the driven gear outward if the clearance is excessively large	
	Adjust the driving gear away from the driven gear. Move the driven gear inward if the clearance is excessively small	

Normal contact area and clearance should be guaranteed during the engagement of the main drive in addition to sufficient intensity and rigidity. The main drive is a key element of the drive axle of the loader, and it bears huge loads and complicated stress. Therefore, inaccurate engagement position may lead to the dropout of the tooth space, fast wear, loud noise and even the break of gears.

If the spiral bevel gears are correctly engaged, the pitch cones of the two gears should be totally overlapped. However, it is impossible to ensure the correct engagement with the manufacturing precision or by audio-visual means. Therefore, the technique of combining the measurement of tooth side clearance and the observation of engagement mark has been developed. During the process of installation and assembly, make gradual adjustments to achieve ideal engagement.

When installing a pair of fitted spiral bevel gears, the correct tooth side clearance should range between 0.25 and 0.45mm. If the value exceeds 0.60-0.65mm, the gear cannot be used further and must be replace immediately. The engagement mark on the tooth surface should be no less than 50% in the tooth length and tooth height directions. When the gear transmits the power, large deformation will occur at the tooth at the small end. And the engagement mark will move towards the large end in practical operations. Therefore, such facts should be taken into account when making adjustments. The best method is to make the contact area a little nearer to the small end in the tooth length direction.

After the contact area is successfully adjusted, secure the two adjustment nuts 13 and use iron wire for locking protection.

7.2.4 Working principles and functions of the differential

The structure of the differential indicates that the differential housing and the spider (equipped with four tapered bearings) are integral. Since it is connected with the large spiral bevel gear, the integral part is the main drive element of the differential. A common differential enables tyres on the two ends of the same drive axle roll on the ground at different rotational speed. The “Slippage friction” phenomenon will not occur even though the tyres rotate with different rotational speeds, so the speed difference is achieved. However, it cannot allow tyres on the two ends of the same drive axle to transmit forces according to different torques, that is to say that the differential can achieve the result of speed difference but not the “force difference”. For example, if the load drives on a muddy road and its tyres on one side gets stuck in a muddy pit, the tyres will keep slipping in the mud due to small adhesive force between the tyres and the mud, and the pulling force applied to the tyres will tremendously drop. In the meantime, there is large adhesive force between the tyres on the other side and the road surface, but the tyres cannot function normally but to keep sliding on the road surface because the differential torque are equally distributed to the two ends of the drive axle.

7.2.5 Final drive

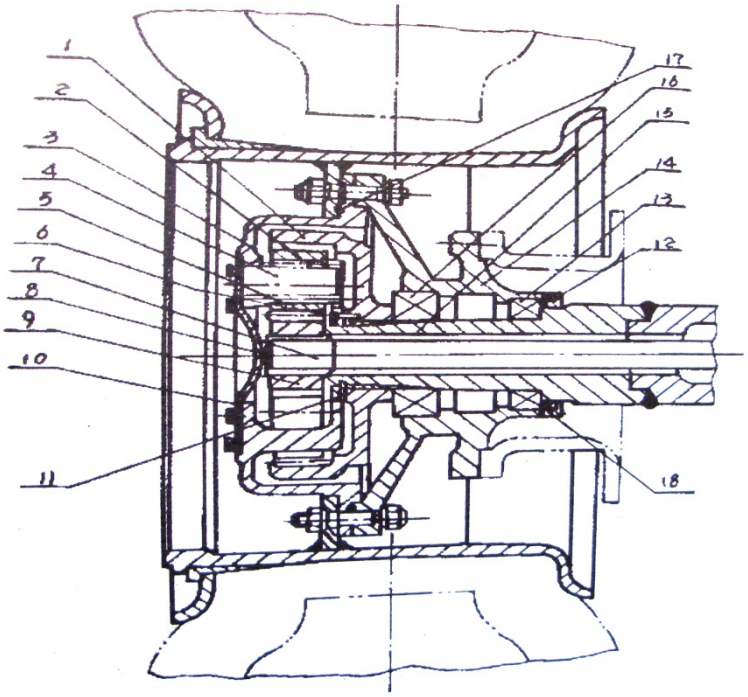


Illustration Wheel reduction differential gear

1. Inner gear 2. Needle pin 3. Planetary carrier 4. Planetary gear shaft 5. Planetary gear

6. Threaded screw 7. Half shaft 8. Steel ball 9. Sun gear 10. End cover 11. Round nut

12. Oil seal 140×170×16 13. Tapered bearing 14. Gear housing 15. Axle housing

16. Tapered bearing 7521 17. O-ring seal 18. Wheel shim

The final drive uses the straight-tooth and single-row planetary gear speed reduction mechanism, and it is composed of the parts and components indicated in the Illustration 7-3. The final drive is also called as the wheel reduction differential gear. Perform following procedures to assemble and adjust the final drive:

Strike the tapered bearing 13 into the gear housing 14, integrate the gear housing shim 18, the double-port oil seal 12, the oil seal cover and the brake disc with the gear housing 14 with a bolt locking force of 16kg.f, mount the gear housing-brake disc combination parts onto the hub carrier, and adjust the clearance of the tapered bearing 16 with round nuts. The adjustment procedures are: lock the round nut 11 to a degree that the gear housing will be barely rotated with great force, and then unscrew the round nut 11 by 1/20~1/10 circle so that the gear housing and its combination parts can freely move, and do not get stuck or have obvious axial drifting or swinging motion, and secure the round nut with inner hex threaded screws.

When replacing the roller pinsΦ5-45 (31 pins in a group. Classify the pin groups, and select and fit the pins) between the planetary gear and the planetary gear shaft, the diameter difference of the roller pins in the same group cannot exceed 0.005mm. The gear engagement can be inspected with the coloring and extruding methods. The gear engagement should be no less than 50% in the tooth length direction, 40% in the tooth height direction, and the tooth side clearance should be about 0.13mm. Replace the gear immediately when these values exceed the given errors after the adjustment.

7.2.6 Half shaft and axle housing

The half shaft is a solid shaft that transmits power between the differential and the final drive. With one end of the half shaft connected with the sun gear through splines, it transmits power through the planetary differential mechanism to the gear housing that is mounted onto the axle housing through two distant tapered bearings; with the other end of the half shaft connected with the half shaft gear in the differential, the half shaft and the axle housing do not directly relate to each other. Therefore, the half shaft only bears the torque but not the reactionary force or the bending moment. This means that the half shaft can be of fully-floating support structure, and it can improve the engagement conditions of the sun gear and the planetary gear.

The splines at the two ends of the half shaft are identical to the splines inside the half shaft gear bores, the splines of the sun gear of the final drive, and the splines of the input flange of the main drive. Therefore, the machining process broaches of the half shaft gear, the sun gear, and the input flange can be simplified into one broach. The half shaft often uses the 30CrMnTi or the 20CrMnTi materials.

Axle housing:

The axle housing is a hollow beam, and it supports and protects the main drive, the differential and the half shaft; it connects with the loader frame by appropriate means to support the weight of the whole machine; during the process of driving, it bears the road surface reactionary force and torque transmitted by the loader and sends the reactionary force and torque to the loader frame (whole machine).

The axle housing assembly is composed of the axle housing and the left and right support axles. The two support axles are welded to the two ends of the housing with thermal bead welding method. In addition, two brake caliper plates are welded to the two ends of the axle housing that is near the support axles. Two

brake calipers are separately located on the two ends of the axle housing. Normally, the welded integral part of the axle housing, the support axles and the brake caliper plates is called the axle housing assembly.

7.3 Common faults with the wheel drive axle

(1) What is the reason for abnormal sound that is emitted by the "Axle package"?

The problem is caused by the break of the main drive spiral bevel gear teeth. It happens due to:

Firstly, improper operations: normally, the loader's front axle and rear axle keeps driving when it works. At this moment, the front axle bears more load than the rear axle does. Therefore, the drive elements of the front axle are prone to damage. However, if the approach angel of the shovel is excessively large or the boom is laid to an excessively low degree, the front axle lifts and the rear axle bears all loads, leading to the damage of the rear axle (break of the teeth). In addition, when the loader works, the front axle tyres lift due to the excessively large load on the shovel, the front axle bears all loads, leading to the break of the front axle spiral bevel gear teeth.

Secondly, improper adjustment of the main drive: normally a pair of large spiral bevel gear and small spiral bevel gear of the main drive is exclusively fitted. Therefore, when pairing the two gears, pay attention to their marks and adjust the spiral bevel gear engagement contact area and clearance according to requirements. In the meantime, all connecting bolts must be the high-intensity ones marked with steel grade; the lock force applied to the bolts should be evenly distributed, so that the bolt will not be damaged when the parts deforms and bear uneven stress during the driving process.

(2) Methods for determining the half shaft break and the loader's shoveling and cutting force drop:

When the oil temperature and the pressure of the transmission are normal, the weak shoveling and cutting force possible comes from the break of the half shaft in the drive axle. To determine whether the front axle half shaft breaks, move the connection-disconnection handle in the driving cab, place the rear axle at the disconnection position, and then start the engine by driving the front axle solely. In this case, if the loader cannot move, it means that the front axle half shaft breaks. To determine whether the rear axle half shaft breaks, move the shovel downwards, get the front wheels of the loader away from the ground, place the lever at the reverse gear position, depress the acceleration pedal, and then observe whether the loader can

drive backwards; or remove the front drive axle shaft, disconnect the front axle, and observe whether the loader can move. If the loader cannot move and the rear drive shaft keeps moving, the rear axle half shaft breaks.

(3) Where do the three leakages of the drive axle occur?

① The brake disc leaks the gear oil, and this will affect the braking performance.

Normally, the double-port oil seal SD140*170*16 of the axle housing of the final drive breaks or ages, the sealing performance will deteriorate, leading to the external leakage of the gear oil. In this case, replace the oil seal SD140*170*16.

② The paper gasket (or the O-ring oil seal) at the junction surface betweenthe two end covers 10 of the final drive and the planetary carrier 3 is damaged; the O-ring oil seal at the junction surface betweenthe planetary carrier 3 and the axle housing 14 is damaged, leading to oil leakage.

③ Due to the overlong use or too much screwing and unscrewing of the bolts connecting the bracket and the axle housing and the bolts connecting different parts of the final drive, there will be clearance or looseness at the junction surface betweendifferent parts, leading to oil leakage. In this case, replaced the deformed bolts and check whether the bolts are high-intensity connection bolts, or machine the bolts to a proper length (reduce the length of the bolt), and then lock it properly.

④ For the oil leakage of the brake clipper, check that:

A. There are blisters in the brake caliper body.

B. The aging or break of the O-ring seal at the junction surface betweenthe upper caliper and the lower caliper ages or breaks, or the greater depth of the O-ring groove is greater, makes the pressurized height of the O-ring seal installed into the groove 1/4 less than the section of the O-ring seal.

C. The greater depth of the rectangular oil seal groove at the piston in the caliper body, the aging of the rectangular oil seal or the shearing break of the rectangular oil seal in the installation leads to the malfunction of the oil seal.

D. The screws of the oil drainage nozzle are not sealed and sufficiently tightened.

(4) What is the reason for the break of the planetary gear train of the final drive? What are the reasons for the break of the teeth of the planetary gear train of the final drive, for the rolling and runout of the tyres due to the burn of the tapered bearing 2007122 mounted on the hub carrier, and sometimes even for the break of the place where the hub carrier is welded to the axle housing?

When installing the 2007122 tapered bearing on the hub carrier, the tapered bearing inclines, and its end

surface is not actually and fully contacted with the entire ring of the step at the bearing installation place of the hub carrier. Therefore, after the inner gear is installed into the hub carrier, it inclines, and the round nuts fail to secure the inner gear in the axial direction when locking the gear to the hub carrier. In this case, the inner gear will make axial drifting along the hub carrier, and the tapered rollers of the tapered bearings fall into the planetary gear train, leading to the breaks of the gears and the rollers of the planetary gear train due to squeeze.

Solution: make sure that the bearings are actually and fully assembled. In the meantime, lean the inner gear and the tapered bearing closely against the step of the hub carrier with round nuts, and lock the round nuts and secure them with lock bolts.

(5) What is the reason for the tensile failure of the bolts connecting the small spiral bevel gear with the bracket? What are the reasons that the connecting bolts locking the small spiral bevel gear (including the input flange, the oil seal, and the seal seat) to the bracket are easily lengthened and even broken, preventing the main drive spiral bevel gear from driving the large spiral bevel gear?

When the newly designed spiral bevel gear drives, there is an axial force. The large spiral bevel gear and the small bevel gear should be pulled away from each other in the axial force direction, so that the bearings have certain clearance and will not make the gear teeth get stuck, leading to accelerate wear of the tooth surface and even the tooth breaks. Since the front axle drive bears more force, the drive spiral bevel gear rotates anticlockwise, the driven spiral bevel gear rotates clockwise; in the real axle drive, the drive spiral bevel gear rotates clockwise, the driven spiral bevel gear rotates anticlockwise.

The direction of the axial force is also the direction for the bolts connecting the small spiral bevel gear assembly with the bracket to bear the tensile force. The loader often drives forward and backward and sometimes even with impact force, this means that the connecting bolts are under multiple and long pulling force. If the connect bolts are of poor quality or no re-inspection and re-locking of the connecting bolts have been done from time to time, the connecting bolts are prone to deformation or damage.

Faults with the drive axle of the wheel loader and the troubleshooting methods

No.	Fault description	Reason	Troubleshooting method
1	Abnormal noise	1) Inappropriate clearance of the drive/driven spiral bevel gear 2) Damage of the tooth surface of the drive/driven spiral bevel gear 3) Improper bearing clearance adjustment 4) Excessive wear of the differential planetary gear shims or the half shaft gear shims 5) Damage of the differential gear or the spider 6) Wrong oil (for example, ZF axle)	1) Readjust the engagement clearance 2) Replace the spiral bevel gear 3) Readjust the bearing clearance 4) Replace the shims of the planetary gear or the half shaft gear 5) Check and replace the differential gear or the spider 6) Add oil according to specific requirements
2	Overheating	1) Low oil 2) Different adjustments of the gear and bearing clearance 3) The brake is not disconnected	1) Add oil according to specific requirements 2) Adjust the gear and bearing clearance 3) Refer to the “Braking System”
3	Oil leakage	1) Oil leakage at the junction surface betweenthe main drive and the axle housing 2) Oil leakage at the seal between the wheel hub carrier and the hub 3) Oil leakage at the wheel end cover 4) Oil leakage in the skeleton oil seal of the input flange	1) Screw tightly the bolts or replace the seal 2) Replace the skeleton oil seal 3) Screw tightly the bolts or replace the seal 4) Replace the skeleton oil seal
4	The axle drives powerlessly	1) Break of the half shaft or the hub carrier 2) Severe damage of the main drive gear or bearing 3) Severe damage of the wheel differential gear or bearing	1) Check and replace the half shaft and repair or replace the axle housing and wheel hub carrier assembly 2) Check and replace the gear or bearing 3) Check and replace the gear or bearing

Typical fault analysis

1. Abnormal sound in the drive axle

Repair case: a ZL50 wheel loader has operated for over a year. It emits abnormal sounds during driving. It is not that obvious when the loader drives on smooth roads, but it becomes noticeable when the loader turns or works, and the sounds come from the rear axle. According to the analysis the working principles of the differential, it is certain that the problem is caused by the faults with the rear differential. The

disassembly and inspection of the rear axle main drive and differential shows that: the two half shaft gear shims are thin and unevenly worn; the half shaft gear has severely worn, and it is even worse with the planetary gear and the planetary gear shims, and two shims are invisible; there are a lot of metal scraps at the bottom of the oil sump of the drive axle housing; the drained oil is very dirty, and its color has even changed.

After the replacement of all damaged parts, the drainage of dirty oil, the thorough cleaning, the commissioning and the assembly, the loader comes back.

The excessive wear of the differential in over a year is mainly attributable to the dirty oil. Therefore, users should replace the oil regularly; in particular, the newly added oil must conform to standards for cleanness, grades and quality. It is strongly recommended that the special oil produced by the loader manufacturing company should be used.

2. Oil leakage at the skeleton oil seal of the wheel hub carrier

Repair case: a ZL50C loader has worked for a long period of time. The skeleton oil seal of the wheel differential hub carrier at the rear axle leaked oil and made the brake clipper sticky, the braking performance was dissatisfactory, and it was not easy to wash. After removing all wheel-relevant parts from the rear axle, the technician found that the skeleton oil seal had hardened and deteriorated and lost elasticity. In this case, it could not achieve the desired sealing performance at all. According to the loader operator, due to the faults with the brake accumulator a couple of days ago, the brake clipper at the rear axle could not be disconnected, and there was high temperature at the braking parts. It is certain the skeleton oil seal 7 was burnt and leaked oil due to the high temperature. After the replacement of the oil seal, the assembly and the commissioning, the problem was solved.

ATTENTION: the main ingredient of the skeleton oil seal is rubber, so it cannot bear excessively high temperature which will lead to the ageing and deterioration. Therefore, when the temperature rises sharply due to braking faults, fix the problem immediately to avoid damage to the skeleton oil seal.