



SECTION 3 ASSEMBLING AND ADJUSTMENT OF THE STEERING SYSTEM



- **I. ADJUSTMENT AND OPERATION METHOD OF THE STEERAGE GEAR**

The steerage gear is adjustable, with adjustable scope of the steering wheel $\pm 25\text{mm}$ in height, and angular adjustable scope $\pm 5^\circ$. The operation method: release the regulating handle 15 as shown in Fig. 11-1, adjust hand wheel 1 to a proper operation position, and then tighten the regulating handle 15.

- **II. For double steering front axle type, apply the wheel alignment instrument to align the double**

front axle wheels in a position for straight-line running, then adjust and install the steer draglink, and make the middle rock arm perpendicular to the ground. The two front axle wheel inclination shall not exceed 1mm/m , and shall be inclined to the same side. For details please refer to the relevant part of adjustment for double steering axle straight-line running.



- **III. INSPECTION AND ADJUSTMENT OF THE POWER STEERING SYSTEM**
- The most likely malfunctions for steering system may be heavy steering and direction off tracking. Causes for the two malfunctions are from the mechanical part and the hydraulic pressure boost part. Therefore in practical operation generally the following inspection and adjustment of the steering system shall be performed:
- **1. Sealing Inspection**
- First, visually inspect the steer booster pump, steering gear, steering oil storage tank, hydraulic lines as well as pipe connectors for leakage and damage. In order to ensure the steering hydraulic system without seepage and pollution, during cleaning, do not use water blast gun against the sealing parts in the steering system.



- **2. Inspection of the Steering Hydraulic Oil Level**
- If the hydraulic oil level in the steering oil tank is too low, leakage of air into the steering boosting system may occur, and malfunctions like heavy steering and noise will follow. Therefore, the oil level in the steering oil tank shall be inspected regularly.
- Normally there is an oil dipstick in the steering boost oil tank, and on the oil dipstick there are upper scale mark and lower mark. When the engine is in stop state, the oil level shall be between the upper and lower marks, at least shall not be below the lower mark. After the engine starting, if the oil level is 1 to 2 cm below the normal position, it is normal. When the engine is shutdown, if the oil level in the storage tank rises by 2 cm or more, that means there is air inside the hydraulic system, and the air shall be discharged.



- **3. Inspection of the Oil Pump**
- Inspection of the pumping pressure is the simplest way to test the steering booster pump working order. In case the pumping pressure is below the set value and the steering is heavy, the reason will likely be lack of pumping pressure.
- For measuring the pumping pressure precisely, a special measuring meter is necessary. Such a steering measuring meter is composed actually of a pressure gauge, gate valve and flow meter. It can be used not only for measuring the booster system working pressure, but also for measuring its output.
- The maximum pump pressure of the ZF steering boost system is normally 130~150 bar. Referring to Fig. 11-13 and Fig. 11-14, connect the steering measuring meter in series to the pump and steering gear high-pressure side pipelines, and first of all, open the valve of the measuring meter completely. Start the engine, perform this test only when the oil temperature in the boost system reaches 50°C.



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- Keep the engine running steadily at a low speed (Note: just before the stalling point), close the valve of the measuring meter gradually, which means actually cutting the pump outlet passage gradually, until the valve closes completely (Note: the shorter time period to close the valve, the better for the result; normally it shall not be longer than 10 seconds). Meanwhile observe whether or not the pressure meter reading has reached the set value. If yes, that means there is no problem in the steering booster pump. If no, that means there is problem in the steering booster pump. Of course, allowance of 10% of the set value may apply for the pumping pressure testing.



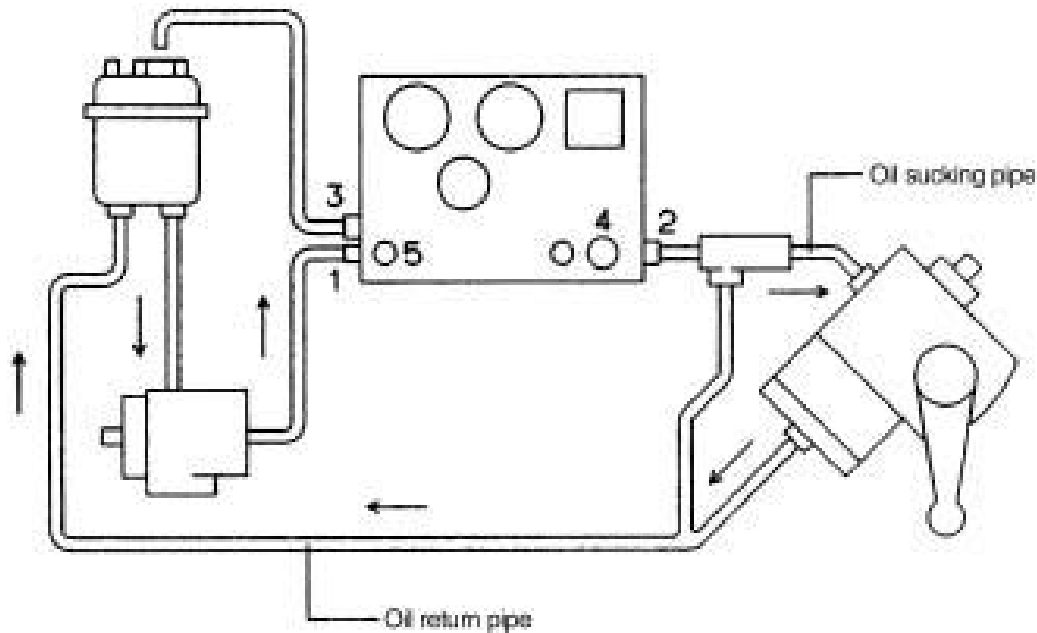


Fig. 11-13 Connection of the steering measuring meter and the boost system
1. High pressure pump output end 2. Inlet end of the steering gear 3. Oil returning pipe of the measuring meter



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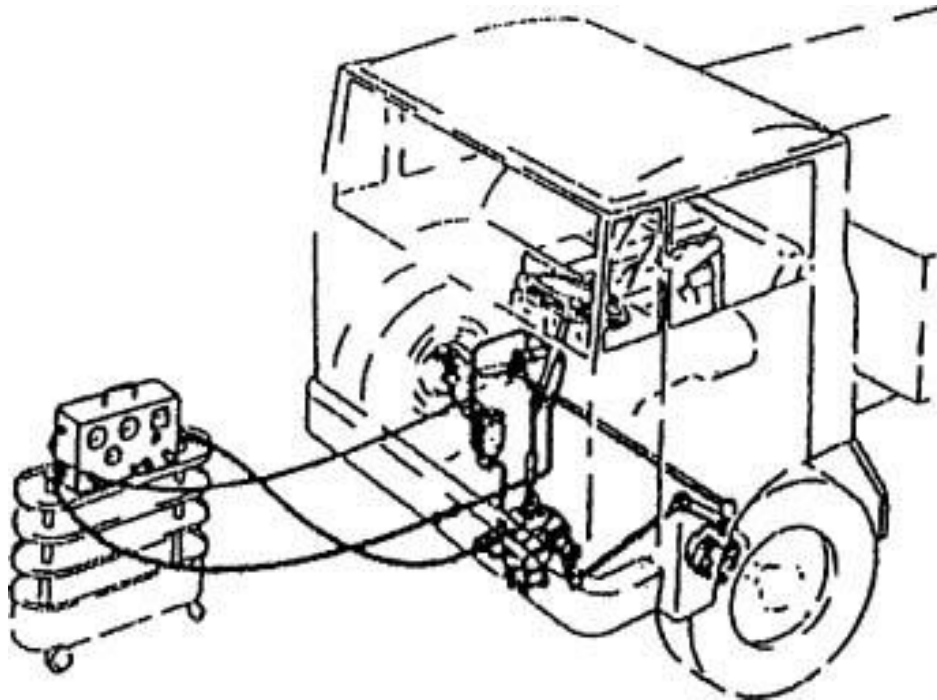


Fig. 11-14 Testing the steering boost system with steering measuring meter





- **4. Inspection of the Pump Output**
- After the pump is generally checked and found OK, it is necessary to check the pump output.
- In consideration of the possibility that pump output may not reach the set value, there has been a flow control valve installed in all the steering booster pumps. The function of this valve is to open the high-pressure return passage when the engine is running over a certain speed. The valve will open wider with the higher engine speed, so the returning oil also increases and thus to ensure a basically constant output flow. In case of the flow control valve malfunction, it will result in less pump output, and lags in steering response will occur when the engine is at a lower speed. In case of pump output failure to meet the requirements, a new pump should be used to replace the old one.





- **5. Inspection of the Limit Valve**
- In case the steering wheel has reached the limit position, and the driver still tries to turn it further, without any other measures, the steering boost pressure oil will continuously add to the steering gear piston high pressure side and increase the pressure rapidly, usually resulting in parts breakage (such as the pump axle breakage). To avoid pump suppression, limit valves have been installed on the both sides of the piston of the steering gear, meanwhile two adjusting bolts have been installed on both sides of the steering gear housing. The purpose to check the limit valve is to see whether it can work normally.



- Use a jack to raise the steering axle and lift the tire off the ground. Turn the steering wheel in one direction and to the limit position, keep adding a 100-200 N force to the steering wheel, and observe and read the measuring meter's indication.
- For 16 dm³/min output, the oil pressure should be in scope of 40—50 bar.
- For 20 dm³/min output, the oil pressure should be in scope of 50—60 bar.
- For output over 20 dm³/min , the oil pressure should be in scope of 70—80 bar.
- **6. Testing the Maximum Pressure of the Steering Gear**
- After the steering booster pump is checked and found OK, it is still necessary to check whether the steering gear can keep sealed pump pressure, and whether the engine can keep working stably when running at a lower speed.
- As shown in Fig. 11-14, move the steered wheel close to the limit position, put a piece of steel plate 15 mm thick between the front axle limit projection and the steered wheel limit bolts, and keep a force of 100-200 N on the steering wheel to the “dead” position (the shorter time period to force it “dead”, the better result, within a maximum of 5 seconds).

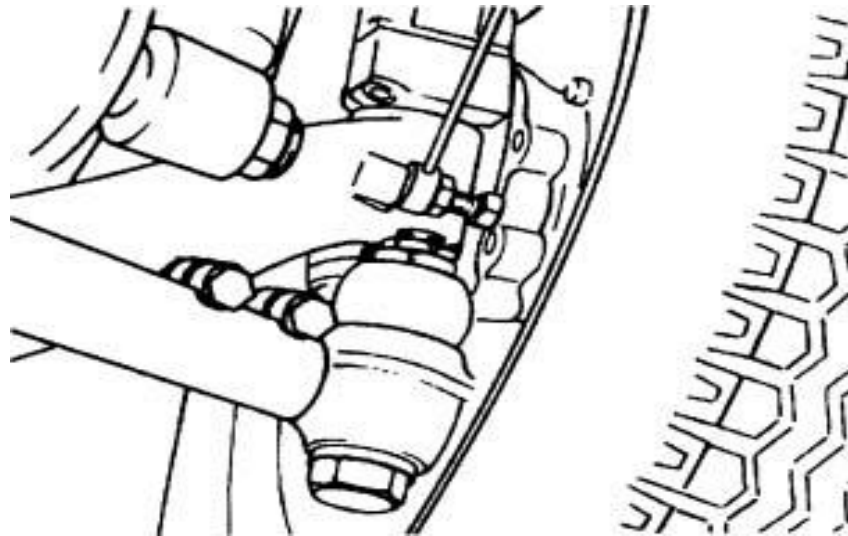


Fig. 11-15 Testing the maximum pressure of the steering gear.

Note: Observe whether the reading of the measuring meter pressure gauge can reach the set value. Repeat the same test on the opposite side steering. If the left and right side maximum oil pressures at the limit position both reach the set value, the steering gear sealing is qualified.

In case both or one of the two sides steering maximum oil pressure can not reach the set value, it means that malfunction of the sealing exists in the steering gear. That's why heavy steering or one direction heavy steering occurs.



- **7.Checking the Steering Gear Leakage Output**
- In order to further check the leak tightness of the steering gear, it is necessary to test the steering gear for leakage output under maximum working pressure.
- In the aforementioned working order, turn the steering wheel to the limit position; tightly clamp the 15mm steel plate by the steered wheel limit screw and the front axle limit projection. While observing the pressure gauge reading, observe the flow meter indication. At this moment the measured leakage output shall not exceed 2.5 dm³/min.
- Time period of this operation in suppression pressure shall not be longer than 5 seconds.
- It is obvious that the leakage output of the steering gear is related with the maximum working pressure. The more the leakage output, the lower the maximum working pressure



• **8.Limit Valve Adjustment**

- If a new steering gear or a repaired steering gear is installed on the automobile, or after discharging air by removing the limit valve adjusting bolt, or if a new limit valve adjusting bolt has been installed, or the steering linked mechanisms (steering arm, tie rod and draglink, steering knuckle) have been serviced, readjustment of the limit valve will be necessary.
- As shown in Fig. 11-16, on the top and bottom end covers, there are limit valve adjusting bolts 20 and 128 installed.
- They are locked respectively by locknut 21 and 129.
- Connect a steering measuring meter of 250-bar pressure in series with the pipeline between the steering pump and steering gear high-pressure side, then start the engine and run the steering boost system load free. When the oil temperature increases to 50°C, begin this testing and adjusting.
- Raise the front axle with a jack and enable the front wheel to leave the ground, thus reducing steering boosting.



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- Turn the steering wheel one side to the limit position, keep adding force to the steering wheel, and observe measuring meter reading (in consideration of the case where the limit valve cannot be opened, the shorter the running time, the better, at most not to exceed 5 seconds) .

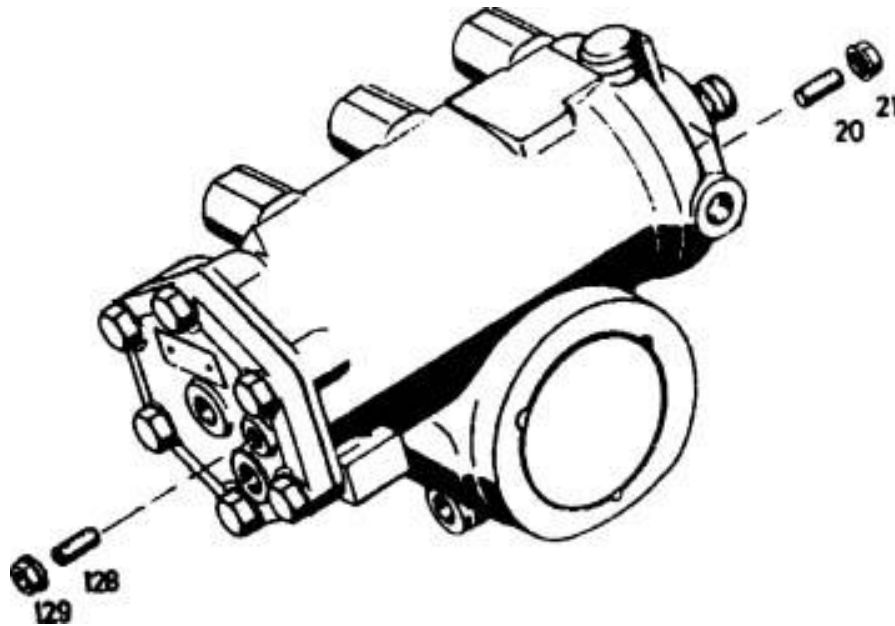


Fig. 11-16 Limit valve

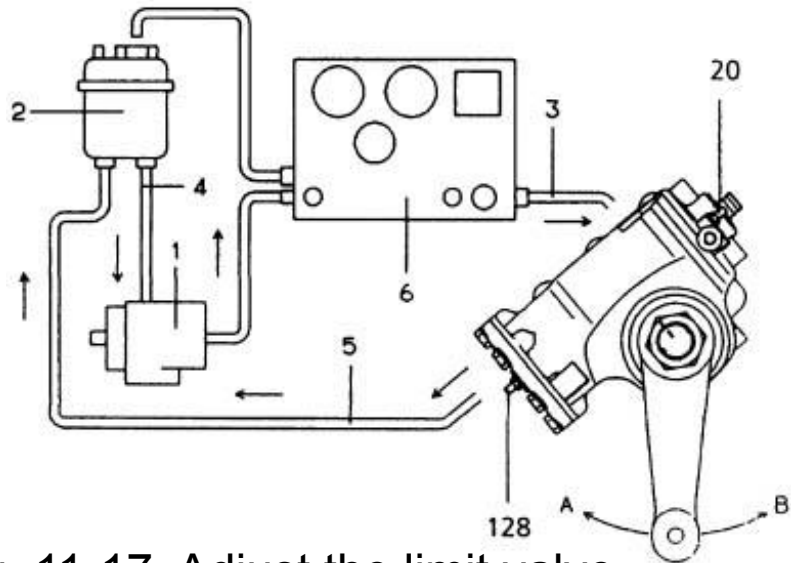


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- For 16 dm³/min output reading, the oil pressure should be in scope of 40—50 bar.
- For 16 dm³/min displacement, the oil pressure should be in scope of 40—50 bar.
- For displacement over 20 dm³/min , the oil pressure should be in scope of 70—80 bar.
- If measured pressure indication is larger than the aforementioned normal value, the limit valve adjusting bolt shall be screwed-in. If practically measured pressure is lower than the criteria, the adjusting bolt shall be outward screwed.





- 1. Steering booster pump
- 2. Storage oil tank
- 3. Steering gear high pressure inlet pipe
- 4. Steering pump inlet pipe
- 5. Steering gear low pressure oil return pipe
- 6. Steering measuring meter
- 20. Left turn (direction of the crank A) limit valve adjusting bolt
- 128. Right turn (direction of crank B) limit valve adjusting bolt

Fig. 11-17 Adjust the limit valve with the steering measuring meter

As shown in Fig. 11-17, the adjusting bolt 20 on the steering gear top cover is for adjusting the crank to limit position in B-direction. After limit valve adjusting is completed in both directions, lock them with locknuts at a torque of 20Nm. Note: The adjusting bolt must be screwed in by 3 rounds or more, or else it may be expelled out by the oil pressure to cause severe leakage. Here we recommend another simple method:

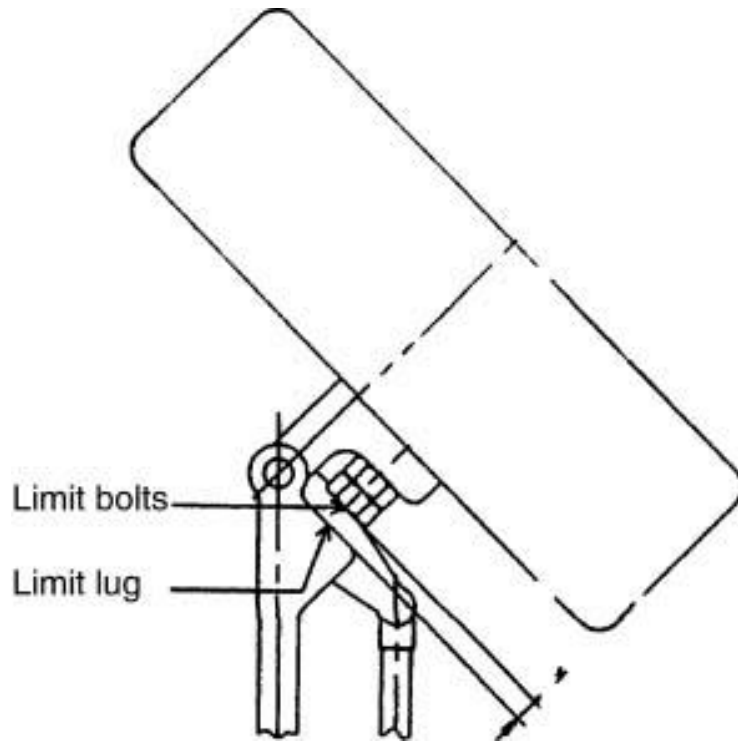


Fig. 11-18 Adjusting the limit valve

As shown in Fig. 11-18, lower the tire down to ground to increase the resistance. Start the engine and make it run steadily at a lower speed. Turn the steering wheel one side to the limit position; on the limit position insert a piece of 3mm thick steel plate between the limit lug on the axle housing and the limit screw on the steering knuckle. Observe the pressure meter reading while turning the steering wheel to the limit position. In case the pressure gauge reading suddenly decreases before the steering wheel reaches the limit position, it means that the time for the limit valve opening is too early. It is necessary to screw the limit valve-adjusting bolt 20 or 128 outwards.



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- In case the steering wheel is turned to limit position and the steel plate is tightly clamped (at that moment it is necessary to keep adding a force to the steering wheel), while the pressure gauge reading not only does not decrease, but keeps increasing (such operation shall be performed in a very short time; the shorter, the better), it means that at the moment the limit valve has not been open. The limit valve-adjusting bolt must be screwed in, until the pressure gauge reading drops suddenly. Then tighten the locknut. The limit position in both directions must be adjusted.
- As for a steering gear equipped with an automatic limit valve, the limit valve shall be replaced without necessity to repair. It is also necessary to remember that the two limit-valve bolts No.28 and No.128 (steering gear top cover and bottom cover adjusting bolts) should not be exchanged.





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- As shown in Fig. 11-19 and Fig. 11-20, the self-correcting limit valve is installed in the same way on the steering gear housing top cover and bottom cover.
- Limit valves 20 and 128 are actually bolts plus a pin sleeve outside. If a larger axial force is added to the pin sleeve, it will retract inwards in relation to the bolt. In other words, the length of the limit valve positioning bolt will be shortened so long as a larger force applies on the pin sheath.
- As shown in Fig. 11-21, suppose the steering gear turns toward a limit position, the limit valve stem installed on the piston is in contact with the limit pin, at this moment the piston continues moving forwards, while the valve stem spring force is not sufficient to push the pin sheath, then the valve stem is pushed away and the limit valve opened.
- As shown in Fig. 11-22, when the limit valve rod is pushed in, the piston body is in contact with the pin sheath, while the steering has not reached the limit position (the limit screw on the steering knuckle has not reached the limit lug on the axle), then keep turning the steering wheel toward the limit position. The piston keeps moving to the right in direction shown in the diagram and moves the pin sheath to the right in the shortening direction, until the steering knuckle limit screw "dies back" onto the limit lug of the side axle. That is the working principle of the self-correcting retainer.





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- The adjusting procedure is as follows:
- Install a new set of limit bolt and pin sheath 20 and 128 in the steering gear. Jack up the front axle and lower the tire down to ground gently, or place the steered wheel on a rotating disk so as to reduce steering resistance. Then turn the steering wheel in one direction, until it reaches the limit position on this side (steering knuckle limit screw "dies back" the limit lug on this side axle). Then, turn in the opposite direction to the limit position. Now the limit valve setting is finally completed.
- Setting the automatic steering limit valve can also be performed without hydraulic pressure boost; therefore it is not necessary to start the engine.
- In case it is suspected after inspection that the limit valve is in malfunction (i.e. the limit pin sheath retracted to a position where it is not able to push open the limit valve), the only solution is to substitute a new limit bolt and pin sheath.
- As the limit pin sheath can be pressed so that the limit bolt is shortened, it is not permitted to turn the steering gear to the limit position before the steering gear is installed on the steering axle or before linkwork of the steering system has been installed properly, otherwise the mechanical thrust may cause excessive shortening of the limit bolt with pin sheath, thus unable to play a role of limiting and hydraulic pressure unloading.





- **9. Steering Wheel Free Play Inspection**
- As shown in Fig. 11-23, fix the front wheels by two adjustable supports (or fix steered front wheels by other means) in a position for straightforward running. Start the engine at a lower speed in stable running. Turn the steering wheel in one direction and observe the measuring meter for the steering wheel position with each 1 bar oil pressure increment, as shown in Fig. 11-24; once again, turn the steering wheel in the other direction and in the same way and observe the steering wheel position with each 1 bar oil pressure increment. Check the circumference distance between the two positions of the steering wheel, which should not be over 40 mm (the steering wheel is 500 mm in diameter) . In case it is over 40 mm, it is necessary to check all the joint spaces of the steering levers, or to replace if necessary.

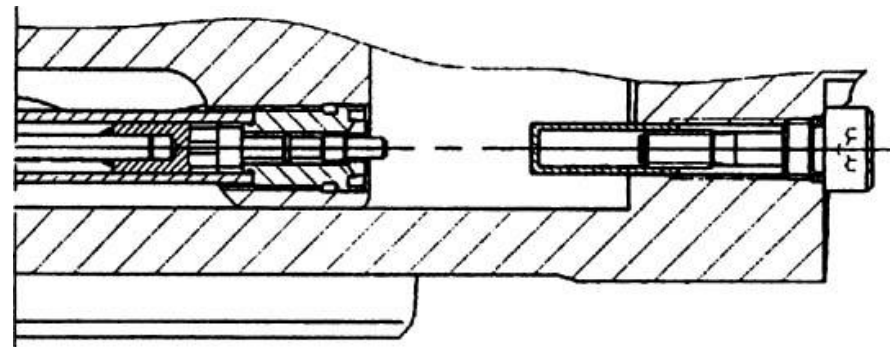
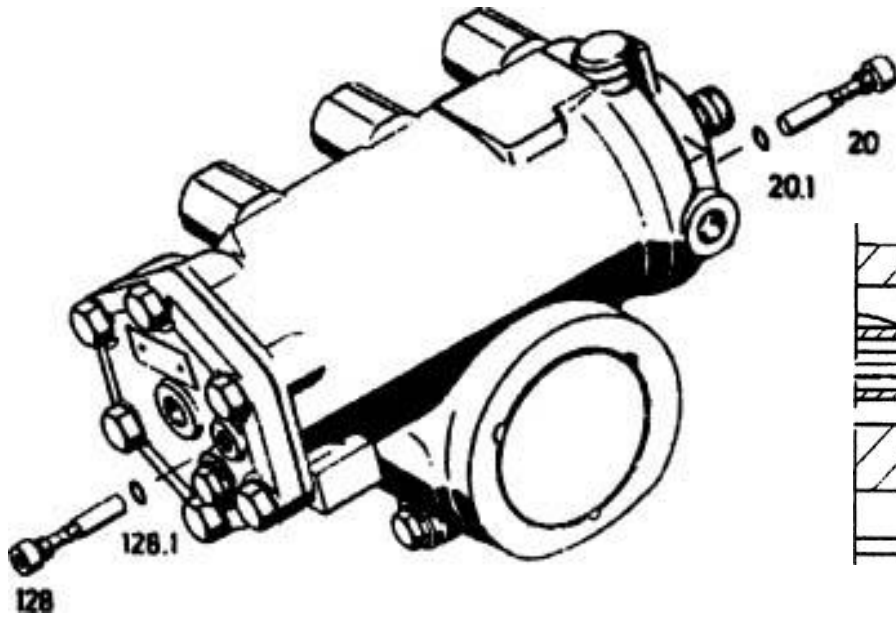


Fig. 11-19 Self-correcting limit valve

Fig. 11-20 Self-correcting limit valve

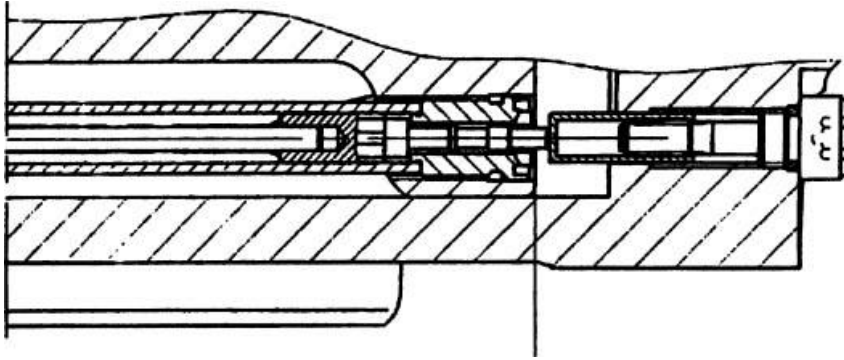


Fig. 11-21 Limit valve just opened

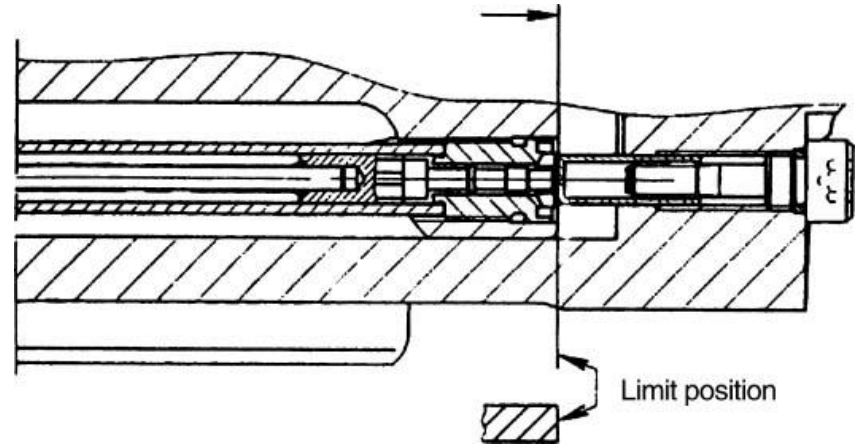


Fig. 11-22 Limit valve fully opened

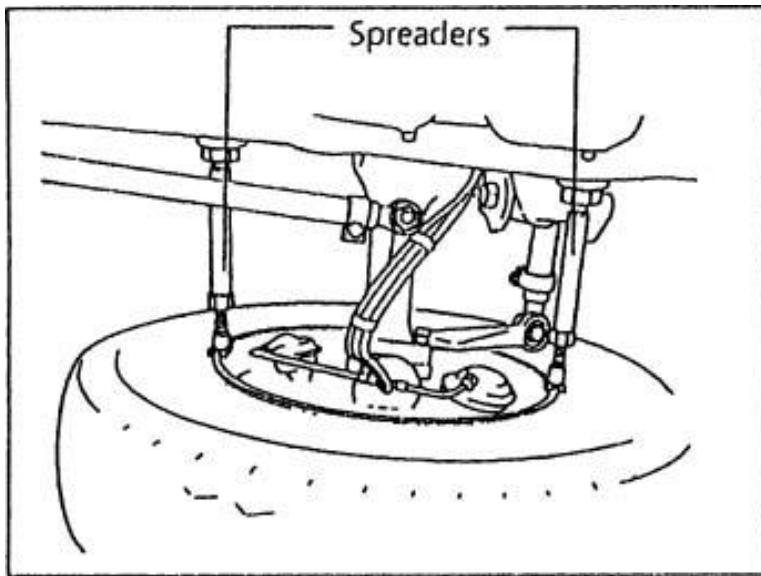


Fig. 11-23

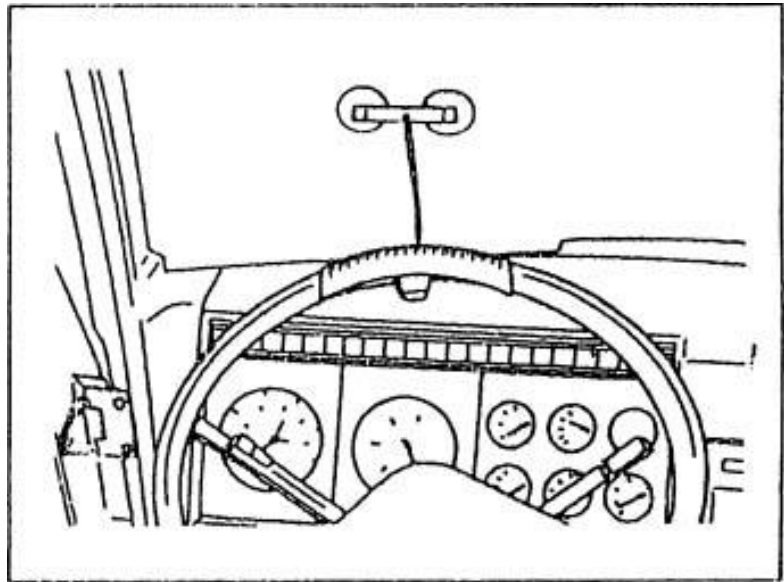


Fig. 11-24



- **10. Oil Change And Air Discharge**
- Most steering hydraulic troubles (such as booster pump pull damage, steering gear seal damage, piston scuffing, etc.) are due to dirty oil. Therefore it is essential to change hydraulic oil regularly.
- When changing the hydraulic oil, all the components of the system must be cleaned from outside, especially the storage tank, as internally every component of the steering system is composed of precise fit hydraulic pressure parts. Any slight dirt can cause boost system malfunction. So, higher requirements to the site and environment should apply, and oil change must proceed in a dustless workshop.
- First of all, disconnect the oil return pipe connector of the storage tank from the steering gear, discharge the old oil via oil return pipe from the storage tank. Then start the engine for a while; the rotating oil pump will remove the remaining oil from the oil pump and the steering gear.



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- In case discharged oil is not found quite dirty, you can connect the oil return pipe with the steering gear. In case discharge oil is found quite dirty, it is necessary to drain off all the old oil remaining in the steering gear. At this time it is better to disconnect the steering gear from the frame, disconnect the limit adjusting bolt of the steering gear 20 and 128 (or automatic limit bolt), screw the clog 55 and air-out plug 57 up and down to drain off the old oil. After the old oil is drained completely, tighten the limit bolt 20 and 128 to torque $12+3$ Nm, tighten the plug 55 to torque 50 Nm, and the air-out plug 57 to torque 30 Nm. And then install the steering gear to the frame; after the limit valve adjusting is completed, tighten the adjusting bolt lock nut to torque $20+10$ Nm.
- Refill new oil to the storage tank. Start the engine at a lower speed in steady running. Now you can loosen the air-out plug 57, observe the oil flow from the air-out plug. Do not tighten the air-out plug until no air foam appears.
- In case there is an air-out plug on the steering gear, use a jack to raise the front wheel from ground to reduce steering resistance. After that and while filling new oil to the storage tank continuously, turn the steering wheel from one limit position to the other limit position. In this way alternate the steering wheel repeatedly, and observe the return oil to the storage tank, until the return oil appears pure without foam. Stop the engine from running; fill hydraulic oil into the storage tank up to the level marked on the oil dipstick.

