KING LONG
B U S E S

Brake System Maintenance Manual

Xiamen King Long United Automotive Industry Co., Ltd.

Brake System

As for the brake system of King Long Series Buses, the service brake system is of double-loop air brake type; parking brake system and emergency brake system are of spring energy storage type; and auxiliary brake system is of exhaust brake or retarder type. The service brake system is provided with ABS (anti-lock brake system).

Section I. Requirement for Brake of Large Bus

The code of European Community has put forward the following requirements regarding safety and reliability of controlling and actuating mechanism, etc. of the brake system:

1. A large bus must be provided with three brake devices, i.e. service brake, emergency brake and parking brake. In addition, auxiliary device can also be equipped. The service brake and emergency brake must be controllable (adjustable) and the parking brake may be uncontrollable.

The so-called service brake refers to foot brake; parking brake refers to hand brake; and emergency brake device refers to a kind of backup brake device, which take the place of service brake and has identical performance to the service when the service brake control system is completely defective. The emergency brake goes into service when the service brake device is defective.

For King Long Series Buses, the service brake system is of double-loop air brake type; parking brake system and emergency brake system are of spring energy storage and discharging type; and auxiliary brake system is of exhaust brake or retarder type.

2. The service brake, emergency brake and parking brake cam share the same actuating mechanism. The controlling system of service brake, however, must be independent of that of parking brake. That is to say the emergency brake can share the same controlling system with either the service brake or the parking brake. For instance, the service brake, parking brake and emergency brake all perform their respective function finally by means of a set of brake shoe and brake drum. The emergency brake and parking brake on this bus just share the same controlling device.

3. When the controlling systems of service brake and emergency brake are completely defective, the parking brake must be able to ensure a brake effect equivalent to 50％ of service brake effect.

4. A warning signal must be given when the brake medium is defective or when the pressure does not reach the specified value. Two kinds of warning indications are available on this bus. When the service brake air circuit pressure on the complete vehicle does not reach 6.5 bars, the low pressure warning lamp is on and the buzzer gives an alarm. When the pressure of parking brake air circuit or auxiliary brake air circuit is lower than 6.5 bars,

the parking brake indicator lamp is on, indicating that the bus may not begin to run.

5. The parking brake, even in the absence of a driver, must be able to lock the working parts by means of mechanical device absolutely to implement brake application so as to ensure reliable parking on a slope. The spring energy storage and discharging brake device used in the bus just meets this requirement.

6. The brake reaction time from the moment when the main brake valve opens to the moment when the pressure of the farmost brake chamber reaches a corresponding value shall not exceed 0.6 second.

Generally speaking, besides the abovementioned requirements, the brake device of the bus must achieve the shortest possible stopping distance, ensuring driving stability and maneuverability. This is the sole purpose of brake. The stopping distance in the same condition is just the ultimate criteria to evaluate the brake effect

Section II. Factors Influencing Brake Effect

The purpose of the brake is to achieve the shortest possible stopping distance, ensuring driving stability and maneuverability.

The factors influencing brake effect behave in three aspects, i.e. the brake force provided by the vehicle itself, adhesive force of tires to the road surface and the inertia.

Obviously when on the same road surface in the same operating condition (vehicle speed and load), the larger brake force the vehicle can provide itself (with the wheel not locked), the shorter the stopping distance is. When on different road surfaces in the same operating condition, the larger the adhesion coefficient is, the shorter the stopping distance is. When on the same road surface, with the same brake force at the same vehicle speed, it is obvious that brake effect vary with the load; therefore, the larger the inertia is, the longer the stopping distance is.

The factors of brake force and inertia can be controlled by act of man. However, the adhesion coefficient between tires and road surface is uncontrollable by act of man. As demonstrated by lots of practices and experiments, the adhesion coefficient of tires to road surface is not only relevant to road surface material, tire pressure, wearing condition of tire and etc. but also is greatly pertinent to the relative movement of tires to road surface. By analyzing the trace left behind by tires on the road surface during brake application, we can find the following phenomenon – At beginning of brake application, the tires leave behind the tread patterns on the road surface; as brake force increases, the patterns are becoming denser and pulling traces are left behind at last. Tread patterns on the road surface indicate that the tires are not only sliding in relation to the road surface but also rolling during brake application. The pulling traces, however, indicate that the tires are completely sliding on the road surface.

In order to describe the degree of "sliding" of tires on the road surface during brake application, we introduce the concept of "slip rate S".

Where:

S: slip rate (%);

V: Vehicle speed in m/sec.

ω: angular speed of wheel in radian/sec.

r: Wheel radius in m

Obviously, during absolute rolling of tires on the road surface, $V=\omega\cdot r$, therefore, $S=0$. During absolute "sliding" of tires on the road surface, however, $\omega\cdot r=0$ and $S=100\%$. If $S=100\%$ during brake application, we call it "locking" of tires. When S is between 0 and 100%, it is obvious that tires are not only rolling but also sliding on the road surface. A larger slip rate S indicates a greater sliding degree of tires on the road surface.

Through practice we have found that the adhesion coefficient Φ of tires to road surface is greatly related to the slip factor S. Fig. 13-1 shows the relation curve of adhesion coefficient Φ with slip rate S during brake application.

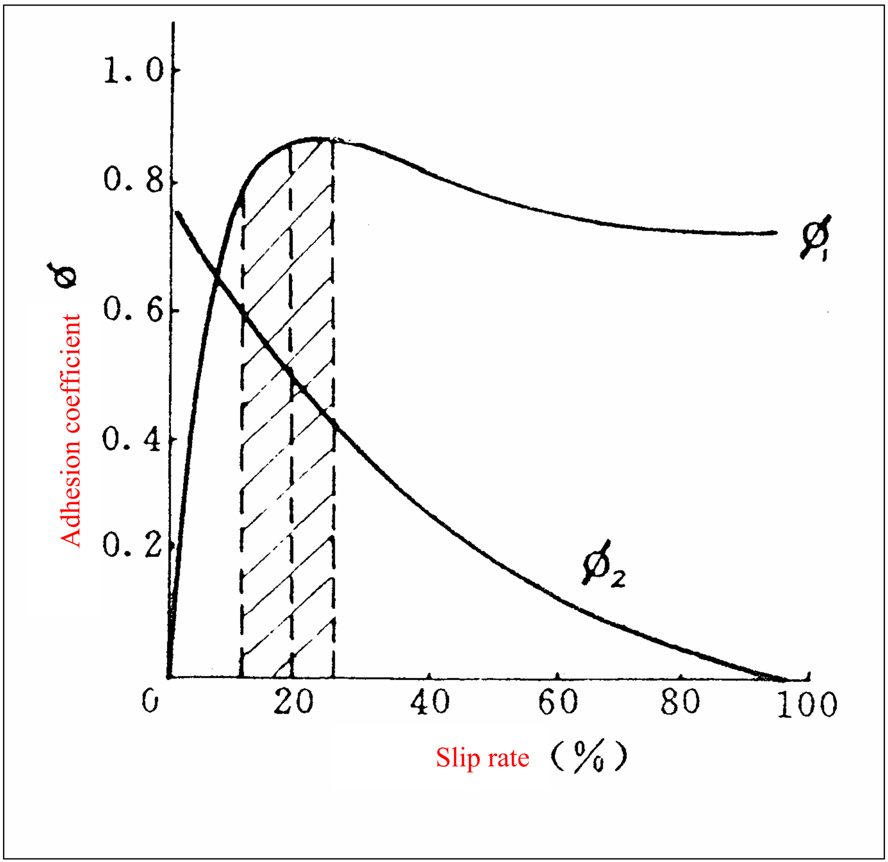


Fig. 13-1 Relation between Adhesion Coefficient and Slip Factor

As shown in Fig. 13-1, when the slip rate S is between 10% and 20%, the longitudinal adhesion coefficient Φ1 is the largest; thereafter, Φ reduces sharply as the slip rate increases; when tires are completely locked, i.e. when S=100%, the longitudinal adhesion coefficient is the smallest. That is to say the adhesive force is at the maximum and the optimum brake effect is available when tires just begin to slide on the road surface during brake application; however, the brake effect is at the worst level when tires are completely sliding on the road surface. It is why we usually say that better brake effect can be obtained in case of “tread pattern trace” than “pulling trace” of tires. Experience has shown that the stopping distance in case of “tread pattern trace” is shorter by nearly one third than in case of “pulling trace” under the same condition.

The Φ2 shown in Fig. 13-1 is the relation between the lateral adhesion coefficient and the slip rate S. As shown by the figure, the lateral adhesion coefficient reduces sharply as the slip factor increases and the Φ2 is almost zero when the vehicle is completely sliding.

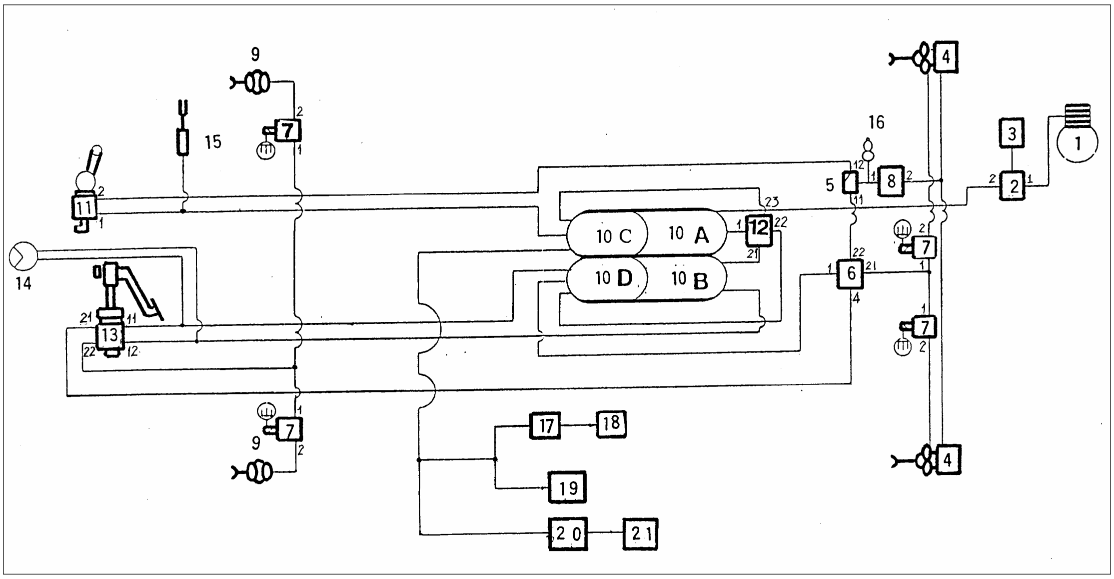
During brake application, the brake effect gets worse if tires are locked and sliding. In addition, if the front wheels are locked, the vehicle will be out of control, i.e. steering is out of function. If the rear wheels are locked, stability of vehicle will be lost, i.e. skid will happen, which is particularly important to a vehicle running on the slippy road (e.g. icy and snowy road). Many accidents are due to the abovementioned cause. The optimum brake state is that both front and rear wheels are at the edge of sliding and rolling at the same time. This is just an important problem to be solved for the brake equipment.

In order to solve the problem of anti-lock brake and synchronous front and rear brake application, various types of anti-lock devices and brake force axle load distribution devices have been developed for modern vehicles.

The King Long luxury bus is just equipped with ABS (anti-lock brake system).

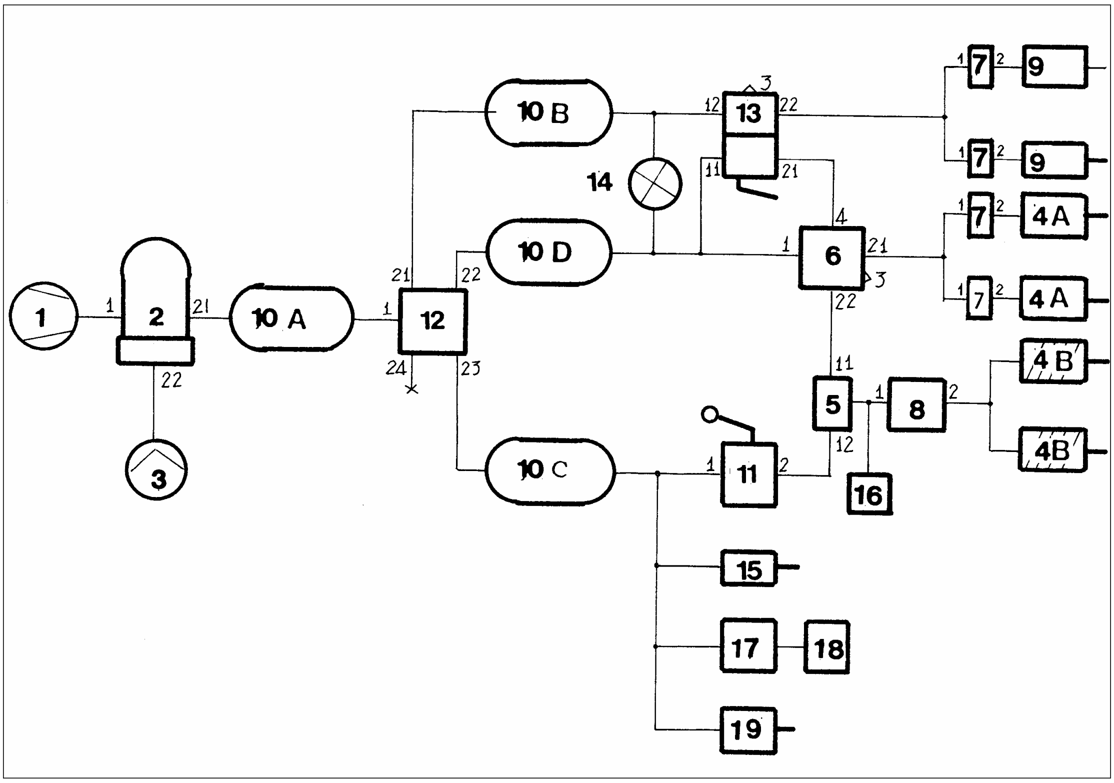
Section III. Brake System of King Long Series Buses and Air Circuit on Complete Vehicle

Fig. 13-2 shows the brake system of King Long series buses and the erection drawing of air circuit on complete vehicle. This erection drawing is prepared according to the actual mounting position of valves on vehicle and the actual connecting method of air circuit pipes. Therefore, the actual layout of brake system can be told from the erection drawing. However, an air circuit erection drawing always seems so complicated and it does not facilitate our understanding the operating principle of brake system. So we provide the brake system drawing 13-3 prepared according to the operating principle. The functional diagram of the system seems quite understandable and particularly in case of troubleshooting, it is clear at a glance.



1. Air compressor 2. Air drier 3. Recoil air reservoir 4. Combined type rear brake chamber
5. Two-way valve 6. Relay valve 7. ABS solenoid valve 8. Quick-release valve
9. Front brake chamber 10A. Air reservoir 10B. Front brake air reservoir 10C. Hand brake air reservoir 10D. Rear brake air reservoir 11. Hand brake valve 12. Four-loop protective valve
13. Brake master cylinder 14. Bi-pin barometer 15. Door control valve 16. Parking brake lamp switch 17. Exhaust brake solenoid valve 18. Exhaust brake working cylinder 19. Clutch assistance pump 20. Air horn solenoid valve 21. Air horn

Fig. 13-2. Erection Drawing of Brake System of King Long Series Buses



1. Air compressor 2. Air drier 3. Recoil air reservoir 4A. Rear service brake chamber 4B. Rear hand brake chamber 5. Two-way valve 6. Relay valve 7. ABS solenoid valve 8. Quick-release valve 9. Front brake chamber 10A. Air reservoir 10B. Front brake air reservoir 10C. Hand brake air reservoir 10D. Rear brake air reservoir 11. Hand brake valve 12. Four-loop protective valve 13. Brake master cylinder 14. Bi-pin barometer 15. Door control valve 16. Parking brake lamp switch 17. Exhaust brake solenoid valve 18. Exhaust brake working cylinder 19. Clutch assistance pump 20. Air horn solenoid valve 21. Air horn

Fig. 13-3. Schematic Diagram of Brake System of King Long Series Buses

The operating principle of brake system is described in the following by classification into air source part, front brake system, rear brake system and hand brake system.

I. Air Source Part:

As shown in Fig. 13-2, the air compressor 1 sucks air from the air filter and delivers it to the drier after compression. Air contains aqueous vapor and the compressor discharges oil continuously, so the compressed air delivered by the air compressor contains aqueous vapor and oil. If the aqueous vapor and oil stain are be removed from air, the increasing accumulated aqueous vapor in the circuit will be condensed into water, which may be frozen in the pipeline and valves in winter, causing defective brake. The drying chamber is provided just to filter and discharger water. Certain quantity of desiccant (molecular sieve) is filled into the drying chamber. When the air-water mixture from air compressor passes through the drier, the water content in the air is absorbed by the desiccant. Purer air is flows to the air reservoir 10A from the drier and at the same time, air is charged to the recoil air reservoir by the drier. A built-in regulating valve is equipped on the drier. The main function of this valve is to limit the maximum pressure the system. That is to say when the pressure in the system circuit reaches the rated valve, the regulating valve will close the passage that charges air to the circuit and open the air compressor exhaust valve, making the compressor run under no-load condition, so that the maximum pressure of the system is limited and wear of air compressor is reduced. The rated pressure of brake system of King Long series buses is generally limited within 0.75 to 0.80 Mpa. In addition, when the system reaches the rated pressure and the regulating valve opens, the compressed air in the recoil air reservoir passes the drier quickly in reverse direction through the orifice so that the aqueous vapor and oily strain absorbed by the desiccant is discharged quickly from the drier. Thus the desiccant is regenerated. When the system pressure reduces and the pressure regulating valve closes, the recoil air reservoir will be closed and the compressor charges air to the circuit and recoil air reservoir through the drier.

The air reservoir 10A is a master reservoir. The compressed air from compressor 1 flows through the air reservoir 10A to the inlet 1 of the four-loop protective valve 12.

As the name implies, the four-loop protective valve divides the air circuit on the complete vehicle into four loops, which are related to and independent from each other. During running of vehicle, if any one of the four loops is subject to disconnection or leakage, the four-loop protective valve will shut off this loop immediately so that other loops may still operate and charge normally, thus ensuring reliable brake.

For the King Long series buses, actually, three air outlets of the four-loop protective valve are used. The remaining one is fully enclosed with a screw plug. Therefore, the four-loop protective valve divides the air circuit on the complete vehicle into three loops, i.e. front brake loop, rear brake loop and hand brake circuit. There is to say when the front brake loop is defective, the rear brake loop can ensure normal function; when both front and rear brakes are in trouble, the emergency brake system on the hand brake can still achieve reliable brake application.

II. Front Brake System

As shown in Fig. 13-2, the air outlet 21 of four-loop protective valve is connected to the front brake air reservoir 10B by means of pipeline. The pipeline from the air reservoir goes forwards to the bottom chamber air inlet 12 of brake master cylinder 13. The brake master cylinder opens when the brake pedal is pressed. Then an air pressure proportional to the brake pedal stroke and controlled by the ABS solenoid valve will be delivered to the two front brake chambers 9 through the front brake ABS solenoid valve from the air outlet 22 of brake master cylinder. Thus the push rod of the front brake chamber extends out. A brake application with corresponding strength is finally generated by means of the brake camshaft, brake block and brake drum.

III. Rear Brake System

As shown in Fig. 13-2, the air outlet 22 of the four-loop protective valve is connected to the rear brake air reservoir 10D by means of pipeline. Two pipelines are led out from the air reservoir 10D, with one of them being connected to the upper chamber air inlet 11 of the brake master cylinder and the other main pipeline being connected directly to the air inlet 1 of relay valve 6 so as to supply air directly to the valve. The vehicle body of King Long bus is long and the brake master cylinder is far from the rear brake chamber. If it is the brake master cylinder that directly delivers compressed air to the brake chamber over a long distance, it will take time for the compressed air to establish pressure inside the brake chamber due to the long delivery distance of compressed air and the large capacity of the two rear brake chambers, causing slow brake application, which is not allowed.

Generally speaking, the period of time, from the moment when brake pedal is pressed to the moment when the pressure in the brake chamber farmost from the master cylinder reaches a value corresponding to the pedal stroke, is called brake reaction time. As specified by the international standard, the brake reaction time of vehicle may not exceed 0.6 sec. If no measure was taken, the brake reaction time of rear axle of King Long series buses would exceed 0.6 sec. greatly.

The relay valve is provided just to cut down the brake reaction time. It is installed on the frame nearest to the rear brake chamber. A thick pipe is connected directly from the air reservoir to the air inlet 1 of relay valve. That is to say the relay valve 6 is supplied with air directly by the air reservoir 10D. The upper chamber air inlet 21 of brake master cylinder is connected to the control orifice 4 of relay valve by means of a thin pipe. When the brake pedal is pressed, the brake master cylinder input a signal of brake pressure to the relay valve control orifice 4 through a thin control pipe and the relay valve opens immediately. The compressed air that is directly from the air reservoir 10D and has been waiting for a long time at the air inlet 1 of relay valve 6 flows rapidly to the main brake chambers of the two rear combined-type brake chambers so that the chambers act quickly to generate brake application.

On the other hand, a mass of compressed air in the two rear brake chambers would have to be discharged from the brake master cylinder over such a long distance, making air discharging time quite long when brake application finishes and the brake pedal is released if there was no relay valve 6. Slow air discharging may cause brake incomplete release, which is an adverse phenomenon. With the relay valve, only small volume of control air is discharged from the master cylinder and the large volume compressed air in the two rear brake chambers is discharged directly from the nearby relay valve. Therefore, the air discharging speed is high too. Thus, brake incomplete release is avoided. So the relay valve is generally known as “quick-charge quick-discharge valve”.

Someone may say “Though near to the brake chamber, the relay valve is still far from the brake master cylinder”. Please note that the brake master cylinder is connected with the relay valve by means of a thin control pipe. For an airtight container, the smaller the volume is, the faster the pressure will be established and hence the faster the control pressure is delivered. In one word, the compressed air actually enters into the rear brake chamber is not from the brake master cylinder but directly from the air reservoir.

As shown in the Fig. 13-2, the brake master cylinder 13 consists of upper and lower chambers and therefore it is a double-loop cylinder. As for double-loop, one of the loops can operate normally without being affected when the other is subject to any problem. We can also tell from this figure that the front brake loop is at the lower chamber of the cylinder and the rear one is at the upper chamber. The action of the lower chamber is controlled by the upper one. Therefore, the upper one acts faster than the lower one, which meets the objective requirement that the rear brake application happens a bit earlier than the front one.

Just like the front brake loop, the rear brake loop is also provided with two solenoid valves 7 controlled by the ABS. These two valves can regulate the air pressure of the brake chamber automatically according to the requirement of the ABS.

IV. Hand Brake Loop

Two combined-type brake chambers are equipped on the rear axle of the bus. The so-called combined-type brake chamber consists of service brake cylinder and hand brake chamber. The service brake chamber is in the front. When the service brake chamber is being charged, the leather cup of the chamber pushes the push rod to generate brake application. The hand brake chamber is attached behind the service brake chamber. A piston is provided inside the cylinder of hand brake chamber. A energy storage spring is behind the piston. When the hand brake chamber is being charged, the compressed air is applied on the piston to overcome the pretightening force of the spring to make the push rod retract. Thus, the brake is released. When the compressed air is discharged from the cylinder of chamber, the spring behind the piston pushes out the piston push rod to generate brake application. So the so-called service brake is “charging brake” and the hand brake is “discharging brake”.

The air outlet 23 of four-loop protective valve 12 is connected to the hand brake air reservoir 10C by means of pipeline. Then one of the two passages is connected to hand brake valve 11 and door control valve 15 and the other is connected to the exhaust brake solenoid valve 17, clutch assistance pump 19, air horn solenoid valve 20 and any other air-consuming components.

When you are ready to drive the vehicle, return the hand brake valve handle. The compressed air from air reservoir 10C flows through the hand brake valve 11 to the two-way valve. The two way valve opens and the compressed air is charged through the quick-release valve 8 to the hand brake air cylinders of the two combined-type brake chambers. When air pressure reaches 0.65 Mpa, The force of compressed air to push the piston is greater than the force of spring of the chamber so that the push rod of the chamber retracts completely. Thus, parking brake is released.

When you would like to park the vehicle, pull the hand brake valve handle upwards to the “Parking” position. The control air pressure of the quick-release valve 8 is discharged through the two-way valve 5 and hand brake valve 11. The compressed air in the hand brake air cylinders of the two combined-type rear brake chambers is discharged directly from the nearby quick-release valve 8. The power spring of the cylinder pushes the piston and push rod to generate full-load parking brake application. The function of release valve 8 is to speed up discharging so as to enable the parking brake to operate rapidly.

The hand brake loop not only performs the task of parking brake but also acts as a backup emergency brake system. Parking brake is fully released when the hand brake valve handle is pulled down completely and full-load parking brake application is achieved when the handle is lifted up completely. Partial brake application is realized if the handle is pulled to any position between “Release” and “Parking”. The higher the handle is pulled, the greater the brake force is. It can absolutely substitute for the brake pedal to achieve controllable brake application. Therefore, when the service brake system (foot brake) is completely defective, the hand brake handle can be used to substitute for the brake pedal to achieve a brake effect the same as obtained through the service brake. This is just the emergency brake.

The function of two-way valve 5 is to prevent the brake push rod from overload operating due to duplex loads applied on the brake cam when the driver implements the parking brake and foot brake at the same time. In the operating condition of parking brake application, if the brake pedal is pressed too, the service brake relay valve 6 will deliver an air pressure from the air outlet 22 to the two-way valve 5. Then air will be charged through the quick-release 8 to the hand brake air cylinder of combined-type brake chamber 4 so that the push rod pushed against the leather cup of the chamber is retracted. Thus, no component may be damaged due to overload.

Components of the auxiliary air consuming system of the King Long series buses, including door control valve 15, exhaust brake solenoid valve 17, clutch assistance pump, 19, air horn solenoid valve 20 and etc. are all in the same system as the hand brake loop.

The parking brake lamp switch 16 equipped on the hand brake loop has double functions. One is parking brake application indication and the other is hand brake low pressure warning. When the pressure sensed by this switch is lower than 0.65 Mpa, the indicator lamp will be on. So when the hand brake valve is positioned at “Parking” and hand brake loop is charged, this indicator lamp will be on to show that parking brake is applied. When the vehicle is ready to run and the hand brake handle is positioned at “Driving” but the hand brake loop pressure is lower than 0.65 Mpa, this indicator lamp will also be on to warn that the hand brake loop is underpressure. Remain the vehicle at the original place to charge the air and never drive until the indicator lamp is off.

As shown in Fig. 13-2, lead out two pipelines from the front and rear brake air reservoirs respectively to the bi-pin barometers on the instrument panel (the King Long bus is provided with two pressure transducers and there are two electrical barometers installed on the instrument panel). It is obvious that one of barometers indicates the pressure of front air reservoir and the other the rear one.

The Fig. 13-3 is a functional diagram prepared according to the working principle of brake system. With this functional diagram, it is easy for us to understand the operating process of various loops of brake system.

Section IV. Operating Principle of Main Valves of Brake System

For troubleshooting in the brake system, we not only have to know the working process of the entire brake system but also should get acquainted with structures and working principles of the main valves. The operating principles of main valves of brake system on the King Long series buses are described in the following.

I. Air Compressor

The air compressor is the air source of air circuit. The King Long series buses are equipped with single-cylinder water-cooled air compressor originally matched with Cummins engine. Its delivery capacity is 215cm^3 and the maximum operating pressure is 1.0Mpa.

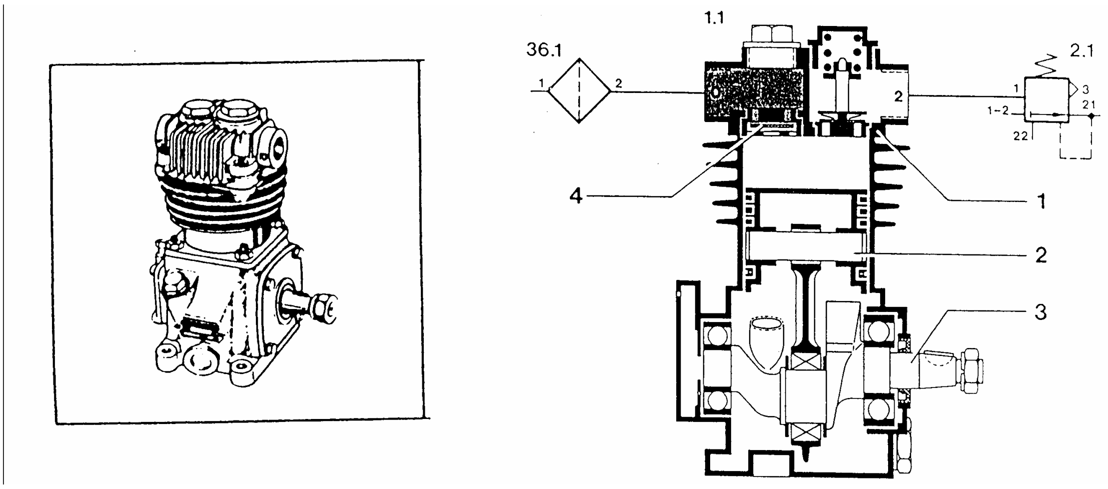


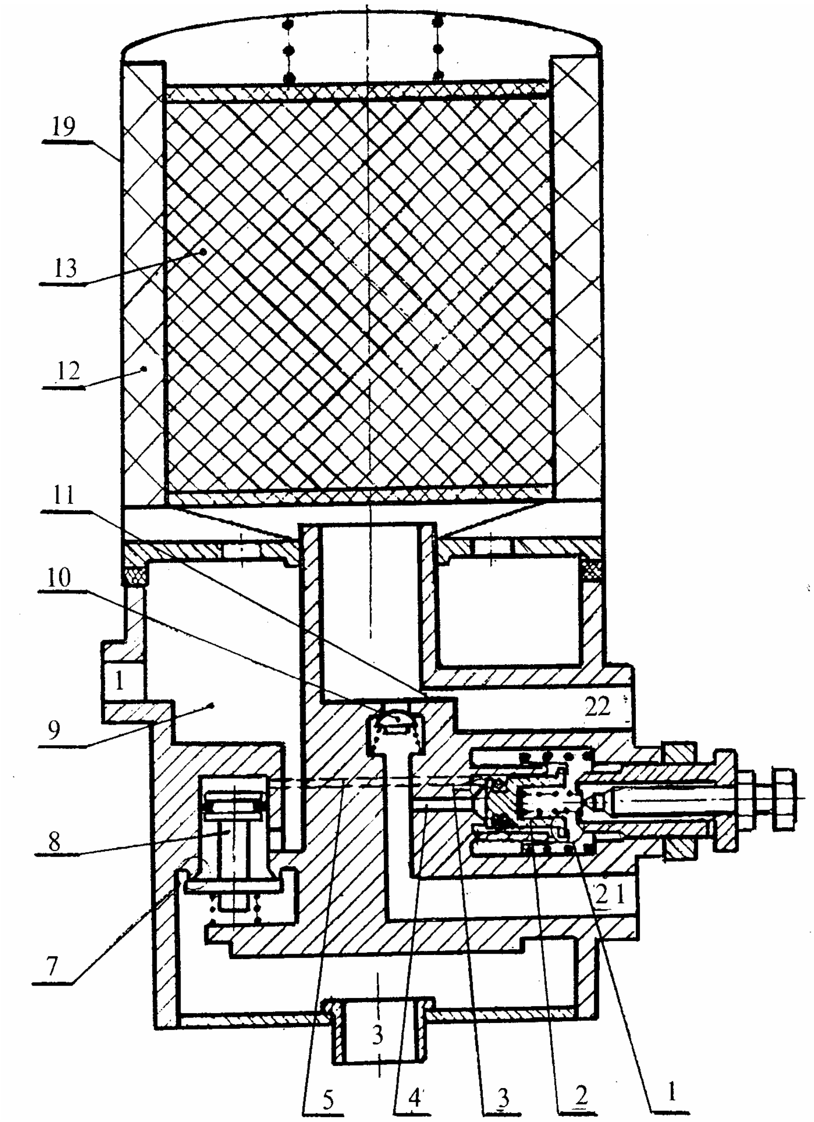
Fig. 13-4 Structure of Air Compressor

II. Air drier

It is extremely important to completely remove water content from the brake system, particularly water content from the air circuit for a vehicle running in an environment with much moisture, so as to ensure a safe brake system. In addition, for a vehicle equipped with air suspension, the air spring is sensitive to humidity and is prone to leakage. Therefore, air driers are commonly used on buses.

Molecular sieve is a kind of alumino-silicate with cellular structure. There are lots of cavity-shaped crystal cells in it. The crystal cells are connected by means of pores. Water molecules and other molecules will be absorbed in the cavities of crystal cells when they are passing the joint openings. Moreover, the molecules, in some specific conditions, may discharge the foreign matter and water content absorbed on the inner surface, which is called regenerative activation. The drier is just developed by utilizing this principle.

The King Long series buses are equipped with monobloc drier with built-in pressure regulating valve. This kind of drier is characterized by excellent pollution discharge effect and simple and compact structure. Before passing through the drier, compressed air is subject to two rough filtrations so as to remove oily stain and water drop, which extends service life of the drier. Furthermore, with screw-connected replaceable drying chamber, it is convenient to replace the desiccant.



1. Pressure regulating valve exhaust port 2. Pressure regulating valve piston 3. Pressure regulating valve air inlet 4. Pressure regulating valve inlet channel 5. Blow-off valve air channel 7. Blow-off valve 8. Unloading valve 9. Air inlet chamber 10. Check valve 11. Orifice 12. Filter 13. Drying cylinder 14. Drying chamber

Fig. 13-5. Structure Chart of Drier

The Fig. 13-5 shows the construction principle of this type of drier.

The Fig. 13-6 shows the installation of this type of drier in the air circuit.

As shown in Fig. 13-5, when the air compressor charges air to the loop, the compressed air from the compressor enters into the cavity 9 of drier from orifice 1. The condensed water due to drop in temperature flows through channel to valve 7. Compressed air passes through filter 12 and oily stain and large water drops are filtered first. Then compressed air reaches the upper end of drying cylinder 13. When the air passes through the drying cylinder containing the desiccant from the top down, the water content in the air is further absorbed by the desiccant. The dry, clean air flows to the four-loop protective valve through check valve 10 and interface 21, so as to charge the loop. On the other hand, it charges the recoil (regenerative) air tank through orifice 11 and interface 22.

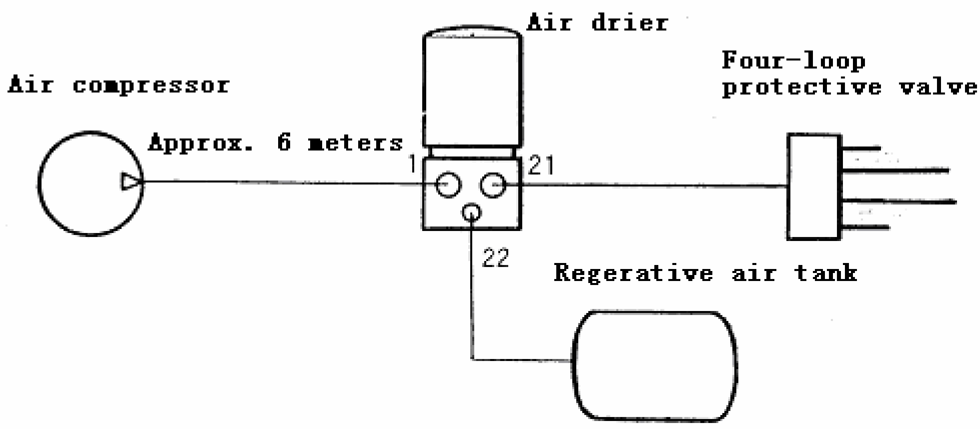


Fig. 13-6. Arrangement of Drier in Air Circuit

When pressure in the entire loop rises to the rated value, the compressed air will flow through channel 4 to push the piston 2 to overcome the spring force to shift rightwards so as to close the exhaust port 1 and open the inlet 3. The compressed air flows through the opened inlet 3 and channel 5 to apply on the unloading valve 8, which overcomes the force of release spring to move downwards so as to open the blow-off valve. The condensed water accumulated on the blow-off valve is discharged into the atmosphere through the exhaust port 3. At the same time, the air compressor is unloaded through 7. Since chamber 9 is unloaded and the check valve 10 is closed, compressed air in the recoil (regenerative) air tank flows through interface 22, orifice 11, drying cylinder 13 and filter 12 to the chamber 9. Since the chamber 9 is unloaded, compressed air expands rapidly through orifice 11 to form a large recoil air current so that the water content absorbed in the drying cylinder is discharged into the atmosphere together with the recoil air through the blow-off valve 7 and exhaust port 3. Thus the desiccant is regeneratively activated.

When pressure in the loop reduces to the level for closing valve 2, the valve 2 will move leftwards to close the air inlet 3 and open the air outlet 1 again. The air in the unloading valve 8 flows to the atmosphere through channel 5 and exhaust port 1. With the function of the release spring, the valve 8 goes up to close the blow-off valve 7. Then normal air charge process begins again.

An electric heater is equipped on the blow-off valve 7 for the air drier, in order to prevent freezing of blow-off valve in winter.

III. Four-loop Protective Valve

The function of the four-loop protective valve is to divide the air circuit on the complete vehicle into four loops, which are related to and independent from each other. If any one of the four loops is subject to a failure (e.g. disconnection or leakage), other loops may not be affected and can still operate and charge normally.

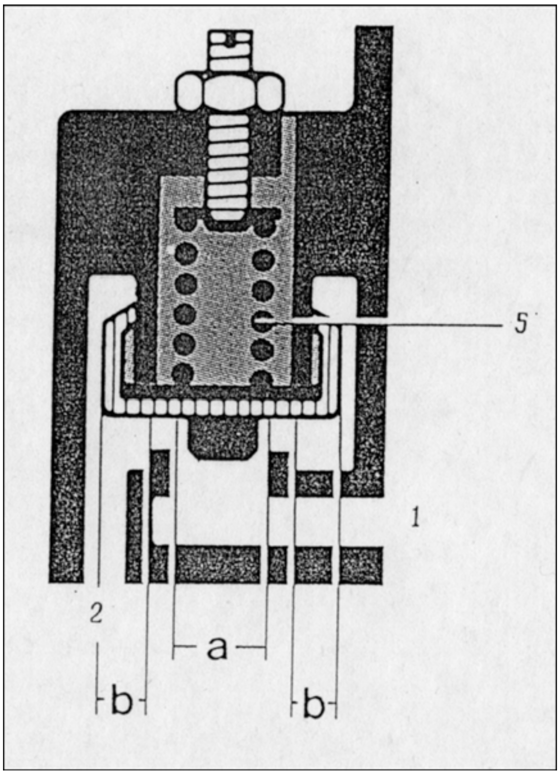


Fig. 13-7. Principle of One of Four-loop Valves

One of the four-loop protective valves is shown in Fig. 13-7. Compressed air from the drier enters into the protective valve through inlet 1. When inlet air pressure is low, the valve, with the function of spring, will close the valve base and the inlet air pressure is applied on the center area “a”. When the inlet air pressure rises to $0.7^{+0}_{-0.03}$ MPa, the pressure applied on the area “a” will produce upward thrust force to overcome the pretightening force of spring 5. Then the valve begins to go up to open the channel to charge air to loop 2. Since throttling is considered in making the valve, vibration due to opening and closing of valve from time to time during charging air to the loop will not happen, which extends the service life of the valve. As the loop is charged continuously, the pressure in the loop is applied again on the circular area “b” of the valve; therefore, as the loop circuit rises continuously and the charge opening pressure decreases continuously until the loop pressure reaches 0.45 MPa, the pressure of 0.45 MPa on the entire area of the valve produces a thrust force to the valve, which is equal to the spring pretightening force; then the valve opens formally and the opening of the valve increases with the loop pressure. When the loop consumes air and the pressure reduces again to 0.45 MPa, the valve will close again. $0.7^{+0}_{-0.03}$ MPa is called the opening pressure of protective valve and 0.45 MPa is called the closing pressure of protective valve.

Four such valves combined together will form a simple four-loop protective valve as shown in Fig. 13-8.

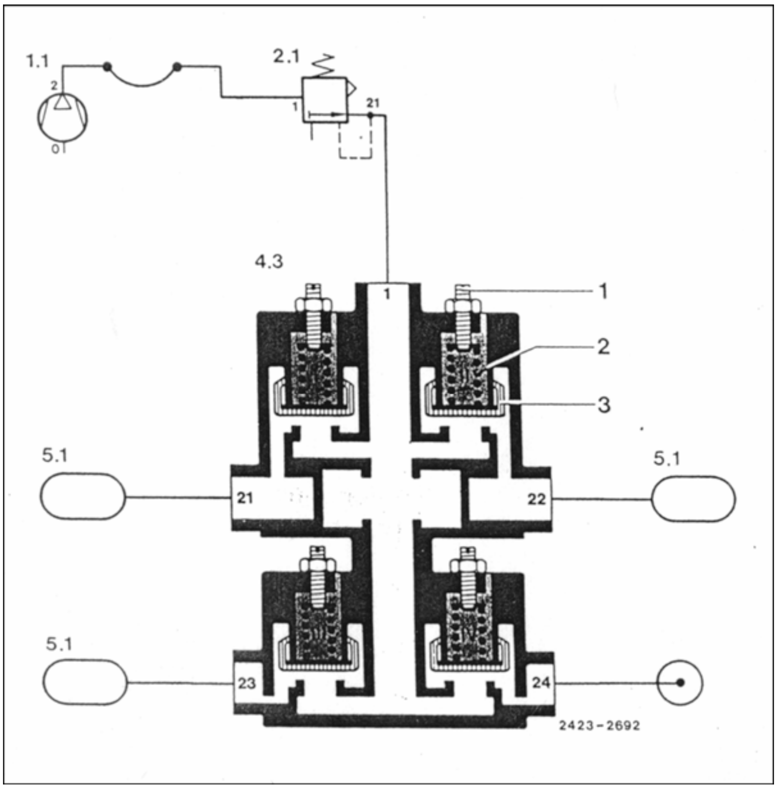


Fig. 13-8. Operating Principle of Four-loop Protective Valve

As shown in Fig. 13-8, when the air circuit on the complete vehicle is out of air, the four protective valves will all close and the compressed air from air pump enters into the protective valves through inlet "1". When the air pressure at the input end reaches $0.7^{+0}_{-0.03}$ MPa, the four valves begin to charge their respective loops. When loop pressure increases to 0.45 MPa, all valves will open until the pressure on the complete vehicle reaches 0.75 to 0.80 MPa as set by the pressure regulating valve. It is worthwhile to note that the four valves do not open at the same time during actual operation, since the springs of the four valves may not always be set consistently and in addition, the charging pressure of the four loops is not necessarily going up at the speed. The opening sequence depends on the spring pretightening force and increase of loop pressure. This point is not important for operation and is just the reason why the two pointers of the bi-pin barometer do not always indicate synchronously during charging.

When any of the loops is subject to disconnection or air leakage, e.g. the front brake loop is broken, the pressure of this loop reduces sharply, the circuit on the complete vehicle discharges air from outlet 21 and pressure goes down at the same time. When pressure of all loops reduces to 0.45 MPa, all the four valves will close. At this moment, the loops without failure is still at 0.45 MPa but the loop subject to air leakage will keep on leaking until the pressure reduces to zero. Then, as the air pump goes on supplying air and the supply pressure will increase back to 0.45 MPa, all valves except the one of the defective loop will open again to charge air until the pressure of loops increase to the opening pressure value $0.7^{+0}_{-0.03}$ MPa as set by the valve of the defective loop. This valve opens to become empty so that the maximum pressure of the remaining three loops is limited to $0.7^{+0}_{-0.03}$ MPa. Thus, normal operation and charge of the loops without failure are ensured.

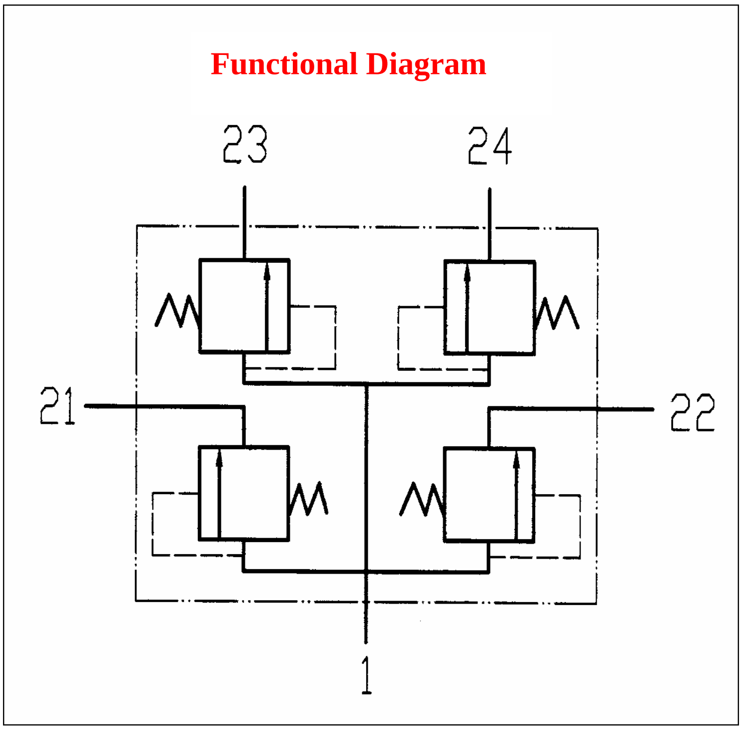


Fig. 13-9. Functional Diagram of Four-loop Protective Valve Air Circuit

Table 13-1 shows the performance parameters of four-loop protective valve.

Item	Parameter
Max. operating pressure	2.0 MPa
Opening pressure	0.559~0.588 MPa
Protective pressure	≥0.412 MPa
Operating temperature	-40℃ to +80℃
Weight	0.82 kg

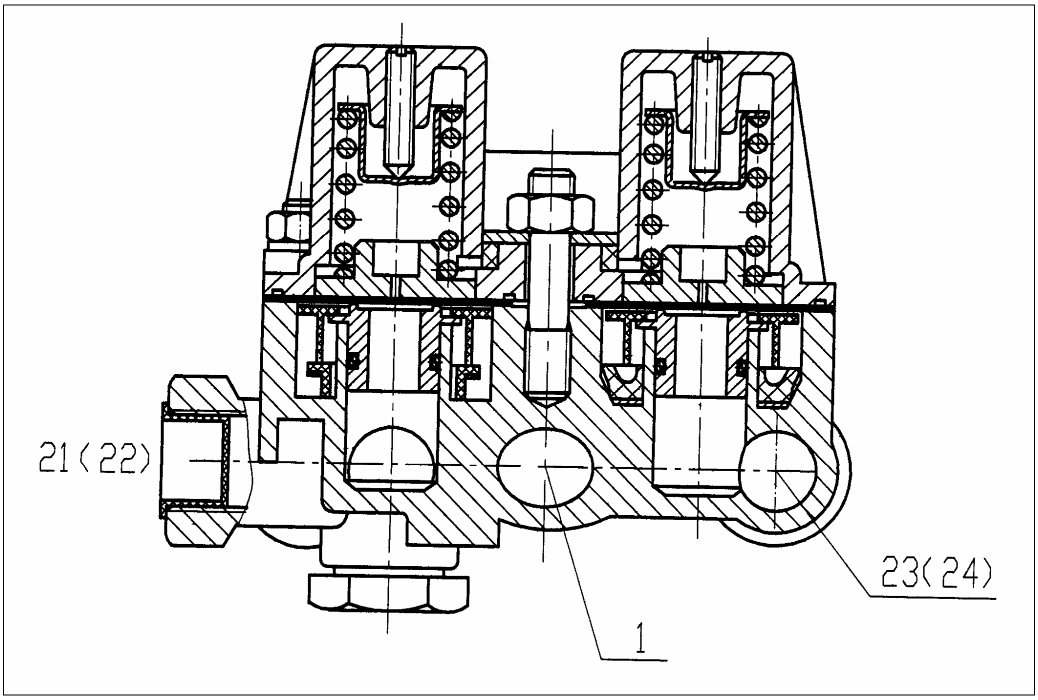


Fig. 13-10 Structure Chart of Four-loop Protective Valve

IV. Brake Master Cylinder (main brake valve)

Main brake valve is generally called brake master cylinder and is used to control the service brake system and make the brake pressure proportional to the brake operating force (or brake pedal stroke). Double-loop double-chamber main brake valve is used on the King Long bus.

As shown in fig. 13-11, the main brake valve consists of upper and lower chambers. Air from the rear brake air reservoir is connected with interface 11 and that from the front one is connected with interface 12. The outlet 21 of the upper chamber provides brake signal pressure to the rear brake relay valve and the 21 is connected to the front brake chamber.

During brake application, the brake pedal, through a set of connecting levers, makes the main brake valve push rod "a" move downwards. The rod push, by means of the rubber spring "b", forces the piston "C" to overcome the force of release spring to move downwards. When piston "C" contacts the valve handle e, the exhaust port "d" will be closed. The piston continues to move downwards and forces the valve handle "e" to move downwards with it so that air inlet I is opened. The air from air reservoir flows to the relay valve through the interface 21. Thus rear axle brake application is achieved. When the air inlet opens to charge the brake loop, the loop pressure is applied at the same time on the piston C. When the force of pressure to push the piston upwards is equal to the rubber spring pretightening force, the piston begins to go upwards until the balanced state with air "i" closed is achieved. The longer the brake pedal stroke is, the greater the spring pretightening force is and the higher the pressure delivered to the brake loop will be. Such a characteristic, in which the brake pressure varies with the pedal stroke at a certain proportion, is also called follow-up property.

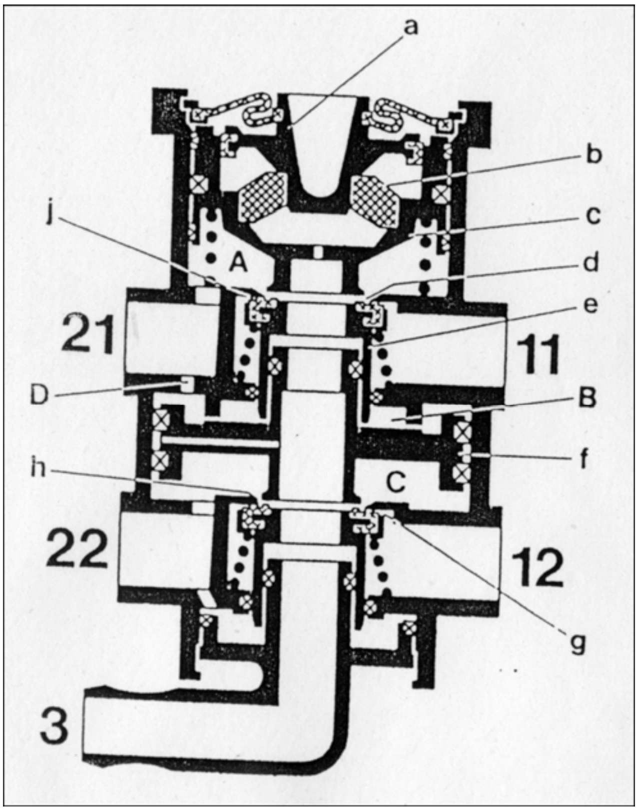


Fig. 13-11 Schematic Diagram of Brake Master Cylinder

As the upper chamber acts, the loop pressure leads to the chamber B through orifice D and applies on the piston f. The piston is forced to move downwards to close the exhaust port h and then open the air inlet g. The air from the front brake air reservoir flows through the 12, the inlet g and the outlet 22 to charge the front brake loop so that front brake application is produced. Thus, the loop pressure is applied on the underside of piston f. When the front brake loop pressure increases to a level equal to the pressure of chamber B, the piston f will rise to close the air inlet so that the brake loop pressure will not increase any longer. Therefore, a pressure synchronous with the rear axle brake application will be generated. The output pressure of the lower and upper chambers has some proportional relation and will increase or decrease synchronously. The only difference is that, at a specific moment, the output pressure of upper chamber is always higher than that of the lower one by $\triangle P=0.03$.

In other words, under the same output pressure, rear axle brake application happens earlier than the front.

The double-loop main brake valve must ensure normal operation of one loop without being affected in case of failure of the other. As shown in Fig. 13-11, it is obvious that operational failure of the lower chamber will not affect operation of upper chamber primary loop since the lower chamber is controlled by the upper chamber. If the primary loop is defective, e.g. the outlet 21 is subject to disconnection or leakage, when the push rod a moves downwards to open the inlet i, the interface 21 may not establish pressure so that there is no pressure signal in chamber B. However, the push rod forces the piston C and valve handle e to go on moving downwards, thus eliminating the gap of valve handle from piston rod f. Thereafter, downward movement of push rod will directly force piston f to move downwards so that the lower chamber air inlet is opened to achieve secondary loop brake application. At this moment, balanced state is produced between the upward force applied by the secondary loop brake pressure on the piston f and the rubber spring force.

When the brake is released, the force applied on the push rod is eliminated; the rubber spring pressure disappears; the piston C moves upwards with the function of the release spring and loop pressure to close the air inlet i and then open the exhaust port d. The control pressure of relay valve is emptied through the orifice 21 and exhaust port 3. The pressure in the brake chamber is emptied through the relay valve. Thus the rear axle brake is released. At the same time, with the function of loop pressure, the main brake valve lower chamber forces the piston f to move upwards to close the inlet g and open the exhaust port h. The pressure in the front brake chamber is emptied through the orifice 22 and exhaust port 3. Thus, the front brake is released.

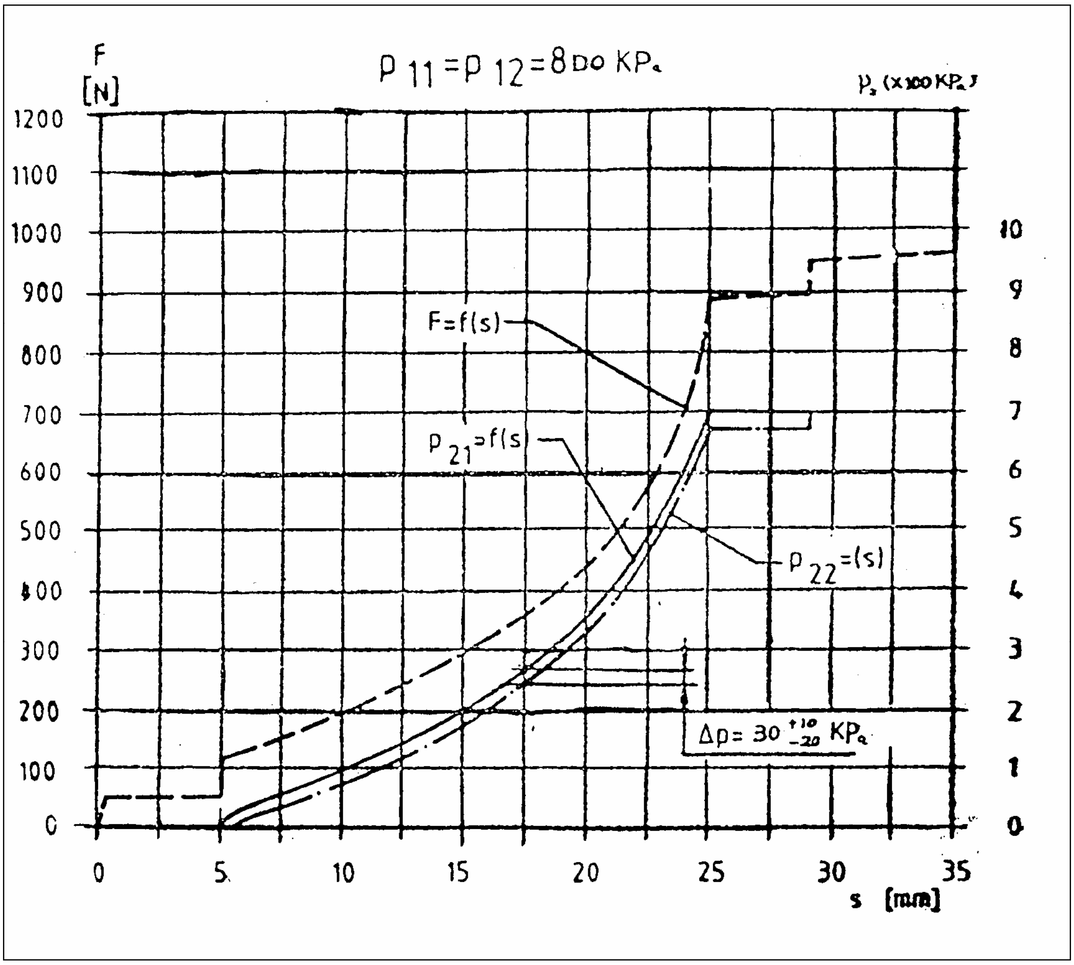


Fig. 13-12. Characteristic Curve of Main Brake Valve

Fig. 13-12 shows the characteristic curve of main brake valve. S is the stroke of brake pedal. F is brake control force. P_{21} is brake output pressure of upper chamber. P_{22} is brake output pressure of lower chamber.

Figure 13-2 shows the performance parameters of brake master cylinder.

Fig. 13-2 Performance Parameters of Brake Master Cylinder

Item	Parameter
Max. operating pressure	1.0 MPa
Working temperature	-40℃ to +80℃
Weight	1.5 kg

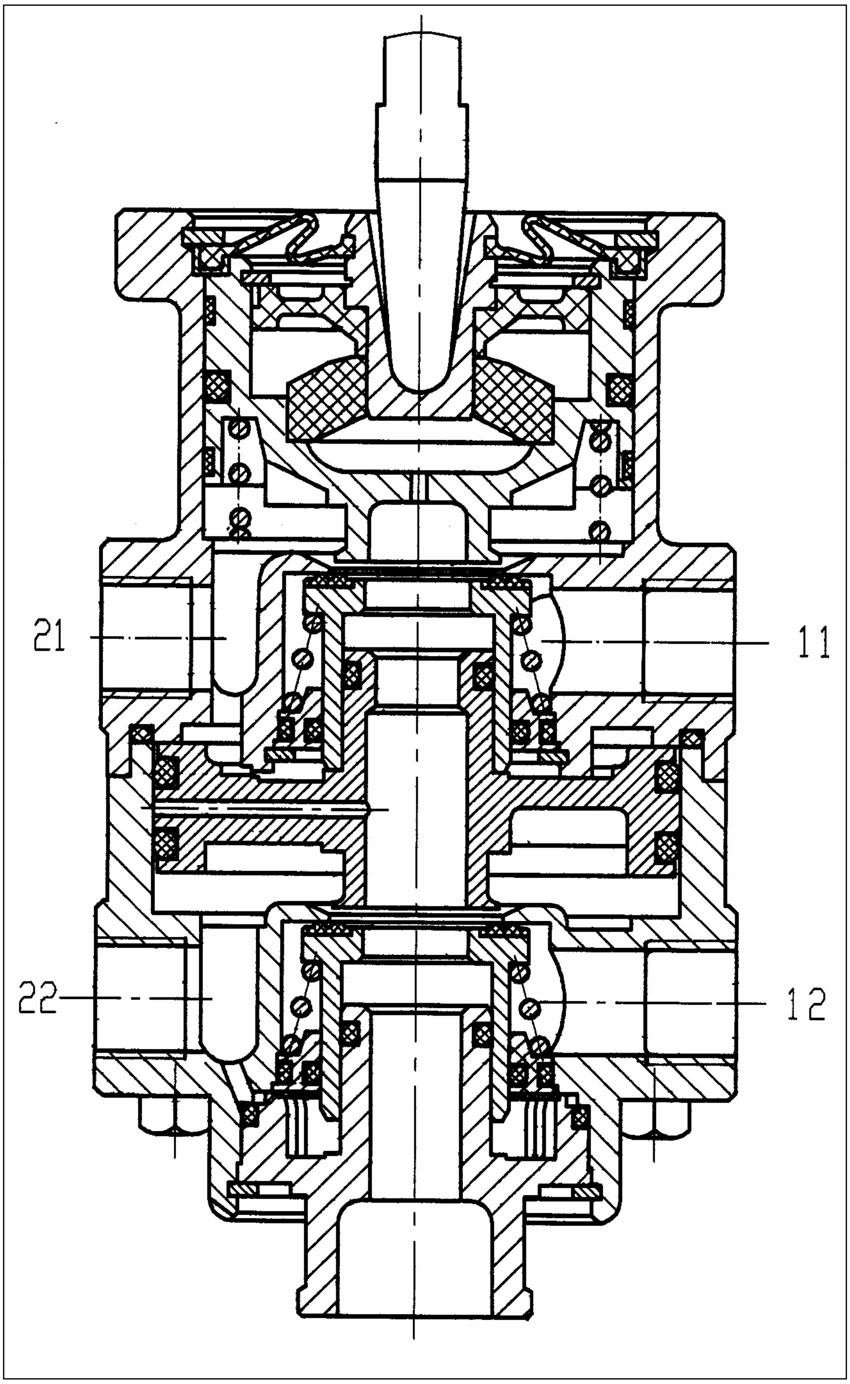


Fig. 13-13 Structure Chart of Brake Master Cylinder

Fig. 13-13 shows the Structure Chart of brake master cylinder. Fig. 13-14 shows the schematic diagram of brake master cylinder air circuit.

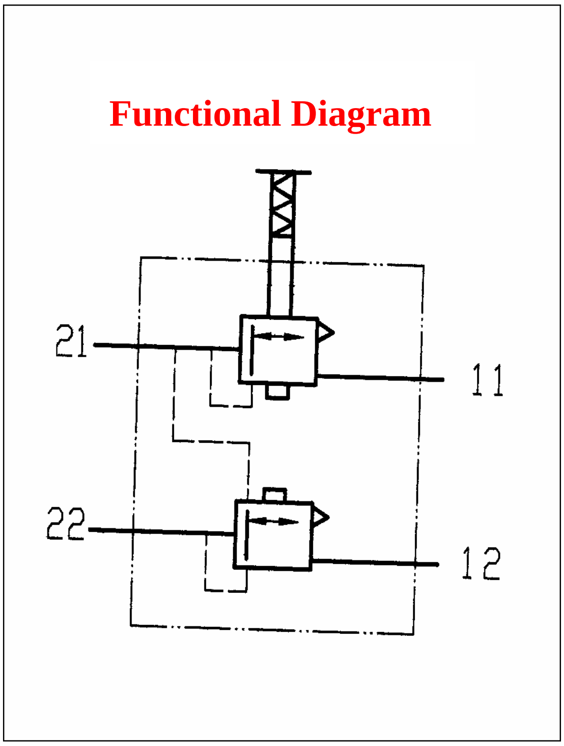


Fig. 13-14. Schematic Diagram of Brake Master Cylinder Air Circuit

V. Relay Valve

The relay valve of service brake aims at cutting down the brake reaction time and it performs the function of quick charge and quick discharge with regard to the service brake chamber.

As stipulated by the international standard, the brake reaction time of vehicle may not exceed 0.6 sec.

Since the King Long bus has a very long wheel base and the total capacity of rear axle brake chamber is large and far from the main brake valve, when the brake pedal is pressed, it take a long time for the pressure to the farmost chamber to reach the corresponding valve, so the brake reaction time is long. Accordingly, a relay valve is installed in a position nearest to the rear axle brake chamber. This relay valve is charged by the air reservoir by means of a thin main pipe and is controlled by the main brake valve by means of a thin pipe.

As shown in Fig. 13-15, when the brake master cylinder is operating, the upper chamber of the brake master cylinder sends out a pressure signal corresponding to the brake pedal stroke. This pressure signal enters into the control orifice 4 of the relay valve and makes the piston 1 move downwards to close the exhaust port 2 and press down the valve 3 to open the air inlet. The main loop compressed air, which has been waiting for a long time at the orifice 1, rapidly charges the brake chamber through the orifice 2. Thus, quick charge is achieved as shown in 13-15b. When the brake chamber pressure increases and becomes equal to the control pressure, the force applied by this pressure on the underside of piston 1 balances with that applied by the control pressure on the upside of the piston. The piston 1 rises to close the inlet again (as shown in 13-15a) so that the output pressure stops increasing and thus it is synchronous with the brake pedal stroke.

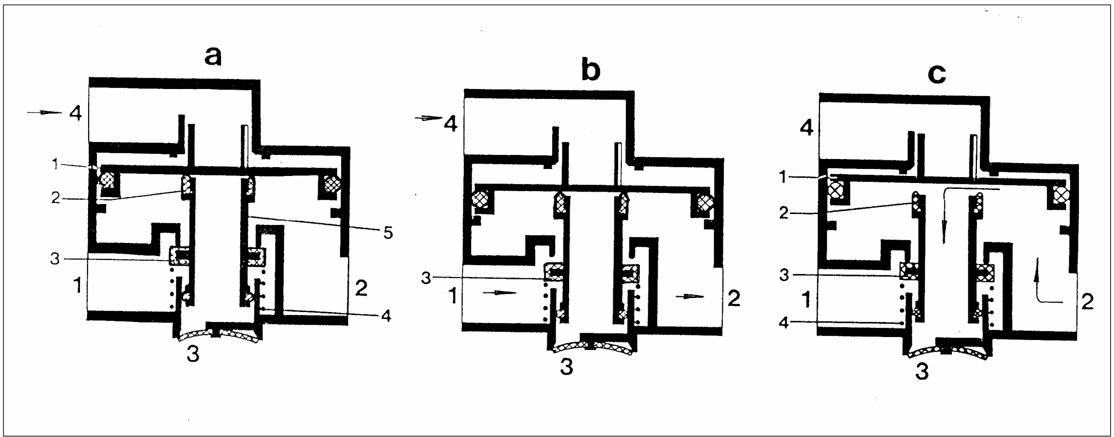


Fig. 13-15. Operating Principle of Relay Valve

When the brake master cylinder releases the brake application, the control pressure of relay valve is emptied through the brake master cylinder. The brake chamber loop pressure forces the piston to rises rapidly to open the exhaust port again. The chamber pressure is emptied through the relay valve exhaust port so that quick discharge is achieved (as shown in Fig. 13-15c）.

The relay valve only has the function to control a large air current by means of a small air current but does not change any brake performance.

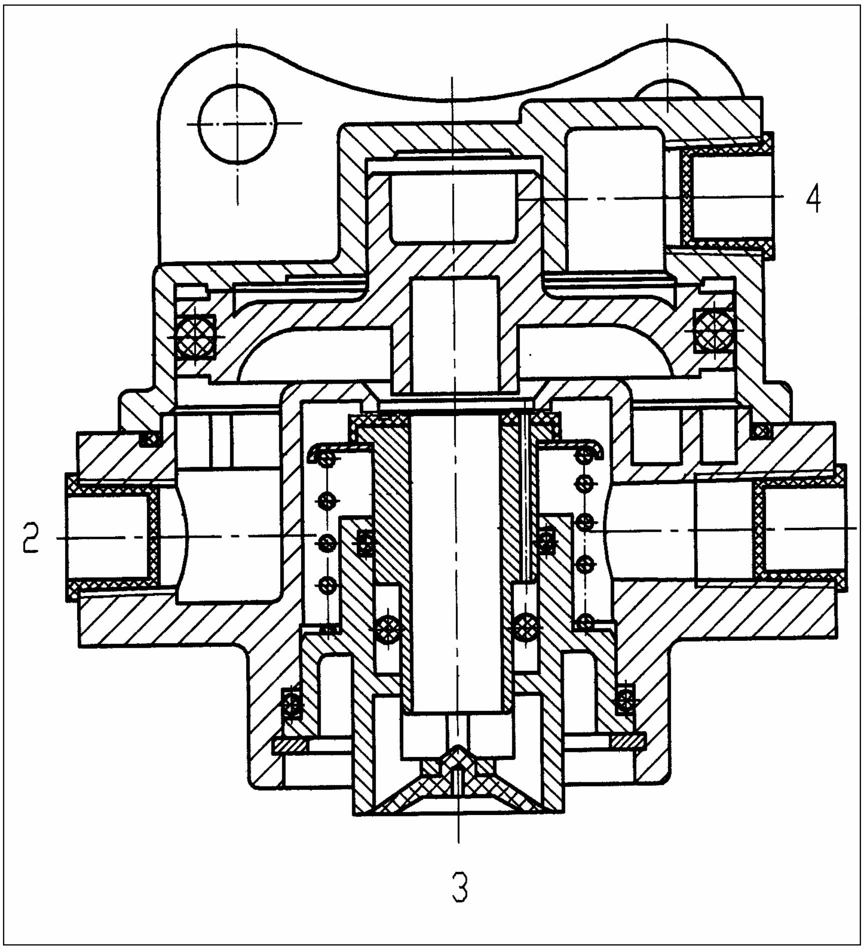


Fig. 13-16. Structure Chart of Relay Valve

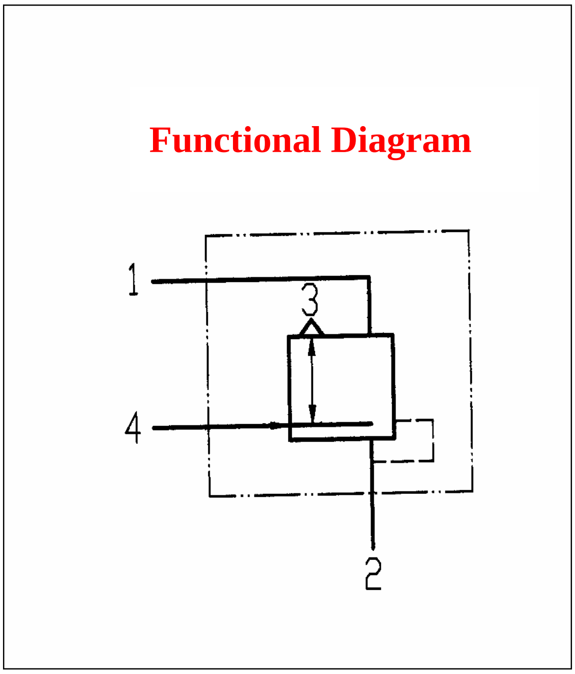


Fig. 13-17. Schematic Diagram of Relay Valve Air Circuit

Table 13-13 shows the performance parameters of relay valve.

Table 13-13. Performance Parameters of Relay Valve

Item	Parameter
Max. operating pressure	1.0 MPa
Operating temperature	-40℃ to +80℃
Weight	0.7 kg

VI. Front brake chamber

The function of front brake chamber is to deliver different pressure to generate different thrust force so as to produce brake application on the front axle with different strengths by means of brake cam, shoe plate and drums.

Connectional diaphragm type brake chamber is introduced for the King Long bus. The maximum stroke of push rod is 60 mm and can produce a thrust force of 9800 N max. See the Fig. 13-18 of its structure.

The brake strength of front brake chamber is in proportion to the input pressure.

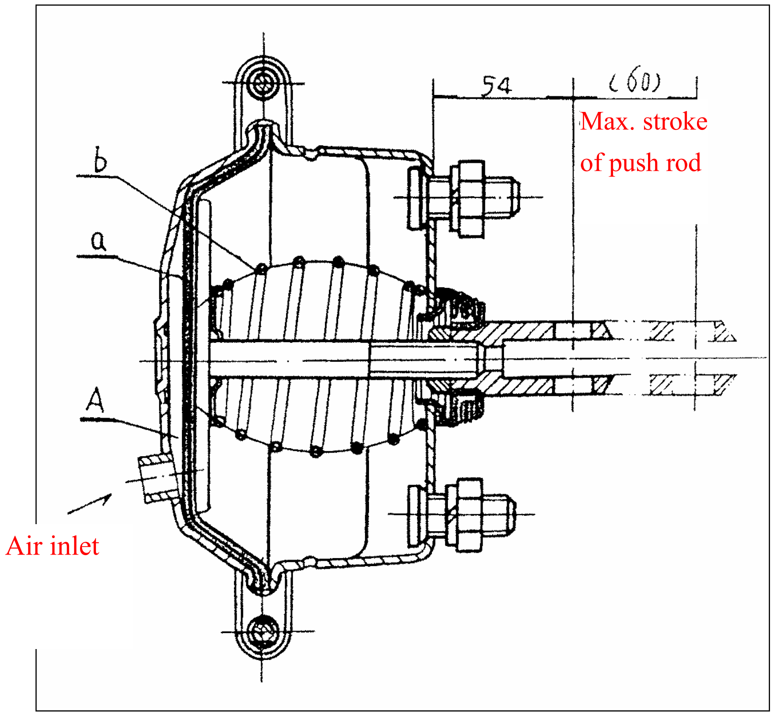


Fig. 13-18. Structure of Front Brake Chamber

VII. Combined type Rear Brake Chamber

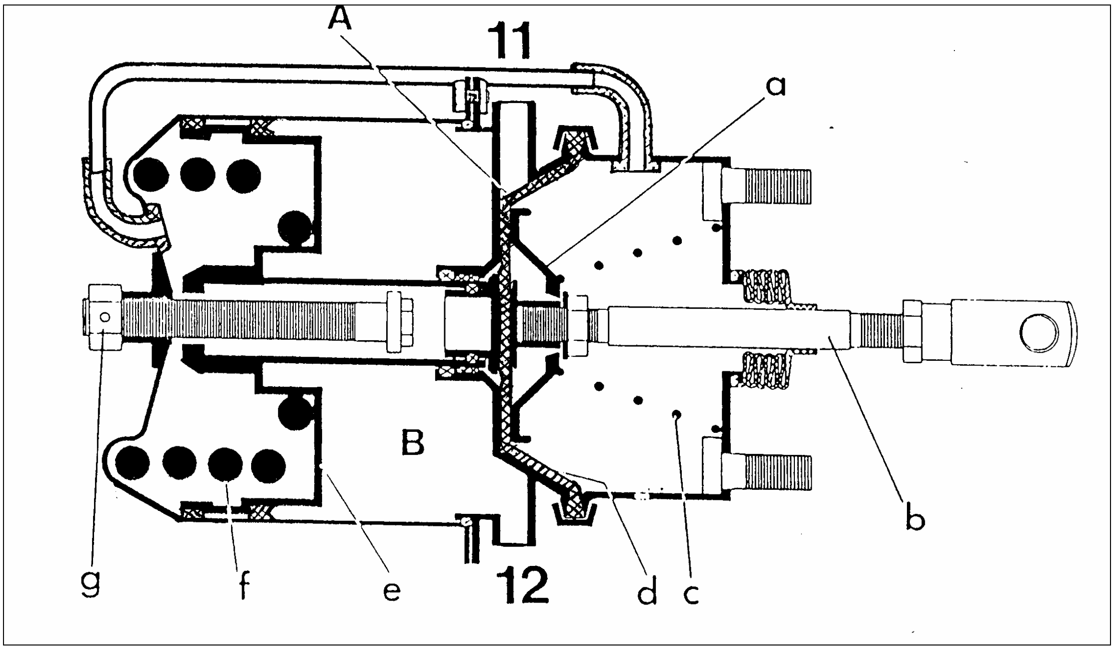


Fig. 13-19. Combined-type Brake Chamber

The function of combined-type brake chamber is not only to influence the rear axle service brake but also to implement parking brake and emergency brake application.

As shown in Fig. 13-19, the service brake chamber and the parking brake chamber are integrated. Conventional diaphragm brake structure is introduced for service brake chamber and typical spring energy storage and discharging brake device is introduced for the parking brake chamber. When it enters into the chamber through 12, the charging pressure of parking brake chamber is applied on the piston e and counteracts the thrust force of spring f.

When the charging pressure is higher than 0.65 MPa, the piston will overcome the spring force to move leftwards to the limit position so that the brake is released. If the chamber pressure is emptied through 12, the piston will be forced by spring f to move rightwards. Then the hollow push rod will push out the service brake chamber push rod to generate brake force. The max. brake strength depends on spring pretightening force. The input pressure of 12 is lower than 0.65 MPa, the piston together with push rod will extend out to produce brake application. However, the brake strength is in reverse proportion to the input pressure value. Different input pressure may produce different brake strengths. Therefore, the parking brake chamber is also emergency brake chamber.

Inside the hollow push rod of parking brake chamber, there is a fine-thread bolt. When it is completely screwed out, this bolt allows the piston to overcome spring force to move to the left limit position. Thus, parking brake can be released when there is no compressed air.

Special care should be taken in case of disassembly of the combined-type brake chamber. The spring of parking brake chamber has great pretightening force so assembling and disassembling have to be done on a pressing machine. First, use the pressing machine to clamp and dismantle the fixing bolts of the chamber. Then dismantle the screw g. On completion of disassembling, loosen the pressing machine slowly. Never carry out decomposition until the spring is in the free state. Otherwise, an accident may possibly happen.

VIII. Hand Brake Valve

Hand brake valve performs two tasks, i.e. parking brake and emergency brake application.

The emergency brake herein refers to the backup brake that substitutes the service brake in case of defective service brake and has consistent performance with it.

As shown in Fig. 13-20, when the handle is placed between the range between 0° and 10°, the inlet A fully opens and the outlet fully closes. The pressure enters from orifice 11 and is exhausted from orifice 22. So the complete vehicle is in the normal running state.

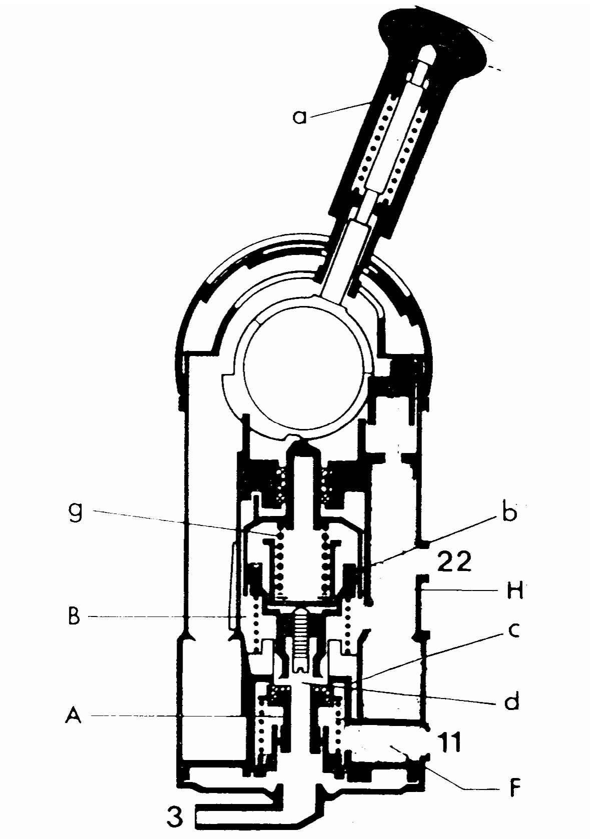
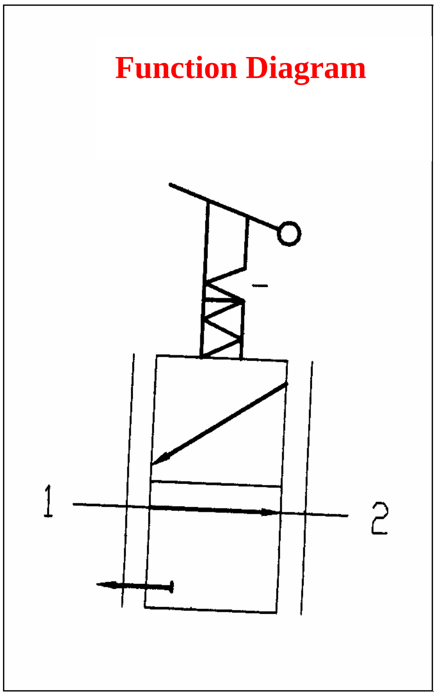


Fig. 13-20. Schematic Diagram of Hand Brake Valve

When the handle is placed between 10° and 55°, with the function of balance piston b and balance spring g, the output pressure P_{22} reduces in inverse proportional to the increase of handle angle. Thus, emergency brake application is achieved.

When it exceeds the thrust point to reach parking brake locking position, the handle will be locked. At this moment, the inlet closes and the outlet d fully opens. Thus, full-load parking brake application is achieved.



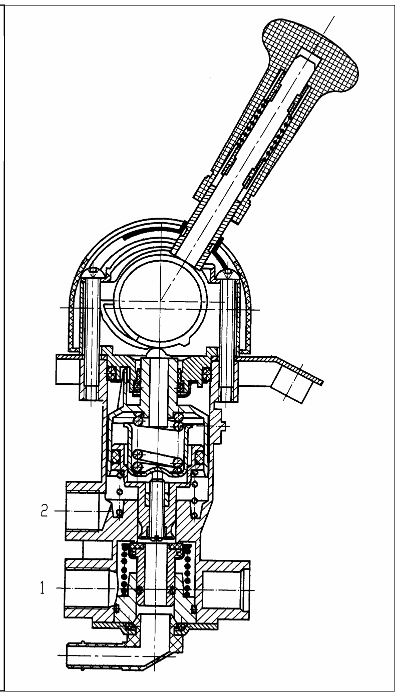


Fig. 13-21. Schematic Diagram of Hand Brake Valve Air Circuit

Fig.13-22 Structure of Hand Brake Valve

Table 13-4 shows the performance parameters of hand brake valve.

Table 13-4. Performance Parameters of Hand Brake Valve

Item	Parameter
Max. operating pressure:	1.0 MPa
Operating temperature:	-40℃ to +80℃
When handle angle α＜10°:	Input pressure ＝ Output pressure
Weight:	0.7 kg

IX. Quick-Release Valve

The function of quick-release valve is to allow the compressed air in the brake chamber to be discharged rapidly.

This valve is equipped in the position nearest to the rear brake chamber. When the hand brake handle is placed in the position “Driving”, the hand brake valve delivers the compressed air in the air reservoir to the quick-release valve through two-way valve. As shown in Fig. 13-23, the compressed air enters from the inlet of quick-release valve 1 and is applied on the one-way diaphragm E through the inlet P. Thus, the channels around the diaphragm are opened and the air is delivered from outlet 2 to the hand brake cylinder of the combined-type brake chamber. Therefore, the hand brake is released.

When the hand brake valve handle is placed in the position “Parking”, the compressed air at the quick-release valve inlet 1 is emptied through two-way valve and hand brake valve. The compressed air in the chamber jacks up the one-way diaphragm so as to open the exhaust port R. The air in the hand brake air cylinder is discharged rapidly through the exhaust port R and exhaust orifice 3. Thus parking brake is applied.

The function of quick-release valve is similar to that of relay valve. The relay valve performs not only quick release but quick charge. The quick-release valve, however, only performs quick release. The quick-release valve is equipped in the hand brake loop not mainly for the reason of parking brake application. Such installation is mainly to cut down the brake reaction time in case of emergency brake application so that the emergency brake has the same performance as the service brake.

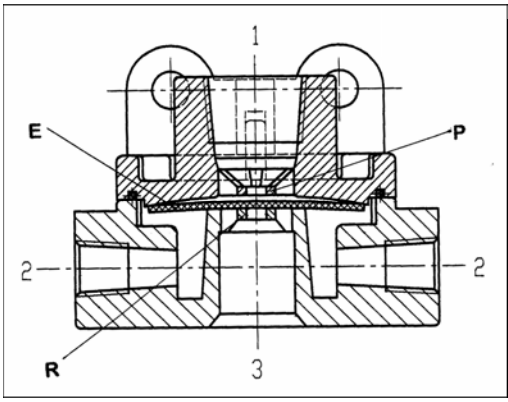


Fig. 13-23. Structure Chart of Quick-release Valve

Functional Diagram

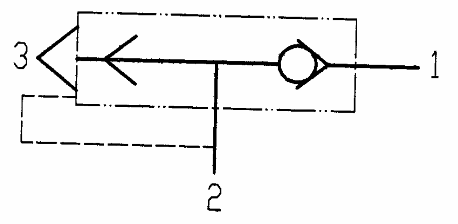


Fig. 13-24. Schematic Diagram of Quick-release Valve Air Circuit

X. Two-way Valve

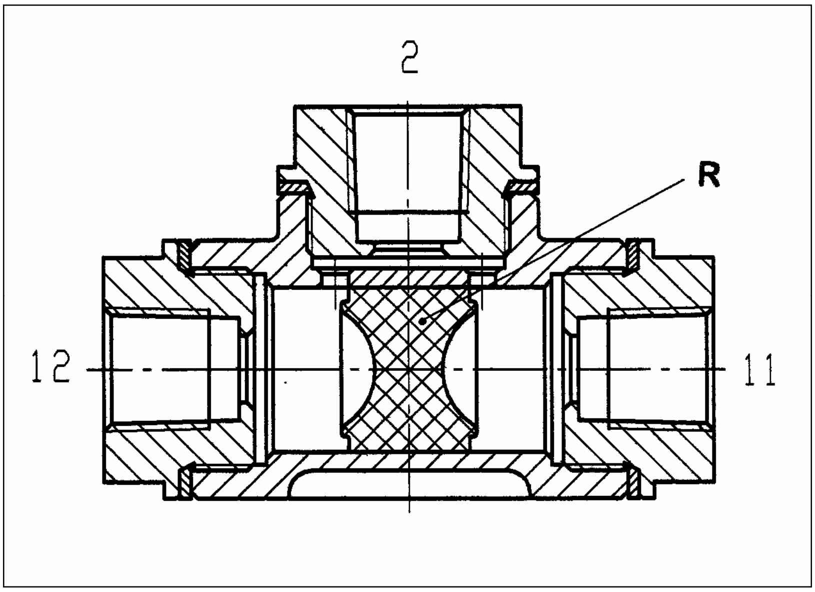


Fig. 13-25. Structure Chart of Two-way Valve

Functional Diagram

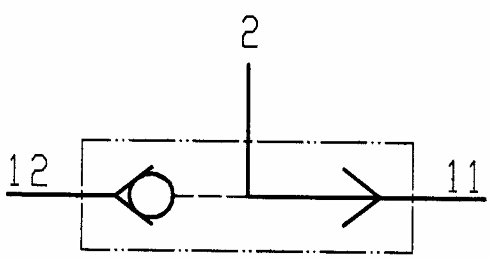


Fig. 13-26. Schematic Diagram of Two-way Valve Air Circuit

A two-way valve is also called two-way single-way valve.

The two-way valve is mainly equipped in the control loops of service brake and hand brake. As shown in Fig. 13-25, a two-way piston R is provided in the two-way valve. When the hand brake valve is placed in the position “Driving”, the compressed air from hand brake valve enters from inlet of two-way valve 11 and forces the piston R to the left. Thus the compressed air flows to the hand brake chamber air cylinder through quick-released valve from outlet 2. Now, parking brake is released.

When the hand brake valve is placed in the position “Parking”, the quick-release valve control pressure is emptied from hand brake valve through two-way valve. The large quantity of compressed air in the hand brake chamber air cylinder is emptied from the nearby quick-release valve. At this moment, the push rod of hand brake chamber pushes towards the push rod of service brake chamber and parking brake is thus applied.

At this moment, however, thrust force of service brake chamber and that of hand brake chamber will be added up, causing brake system overload if the service brake pedal is pressed, if without a two-way valve. With a two-way valve, the air pressure in the service brake loop is delivered to the two-way valve through relay valve. The compressed air enters from the two-way valve inlet 12 and forces the piston R to the right so as to open the two-way valve. Similarly the air enters into the hand brake chamber air cylinder through quick-release valve from outlet 2, causing the push rod of hand brake chamber to retract. Thus hand brake is released and only the brake force of service brake chamber is applied on the brake camshaft.

As shown in Fig. 13-2 and Fig. 13-3, a number symbol is available at the air circuit interface of every valve. Such a number symbol is also visibly marked at every interface of the actual valves. This symbol has the following meanings:

“1”— Inlet of the valve

“2”— Outlet of the valve

“3”— Exhaust port of the valve

“4”— Control orifice of the valve

A symbol with two digits indicates the sequence of a certain interface. For instance, “11” represents primary inlet of this valve, “12” represents secondary inlet, “21” represents primary outlet and “22” represents secondary outlet and so on.

Section V. Removal of Common Failures of Brake System

The brake system of King Long bus is a typically standard bus brake system. The brake valves used give advanced performance and reliable operation.

However, there are many factors that can influence the operation of brake system since it consists of lots of air circuit components. Moreover, a symptom is sometimes a syndrome caused by two or more factors.

It is encouraged to shoot the trouble with scientific method in case of failure. Never dismantle or dismount randomly without analysis or judgment. A good troubleshooting method, which we call truncation method, is described in the following.

The core of truncation method is to find the "middle" position of the system and "cut" it from this position. Carry out tests to decide whether the failure is on this or that side of the system. This way, we can exclude half of the system components. Thereafter, "cut" the defective half from the middle. Carry out tests to decide whether the failure is on this or that side of the half system. Repeat this procedure for several times. The position of failure will be found out very quickly in this way. Then disassemble the components in the position of failure to find out the source of failure. Thus the failure can be removed quickly and we get twice the result with half the effort, having nine chances out of ten.

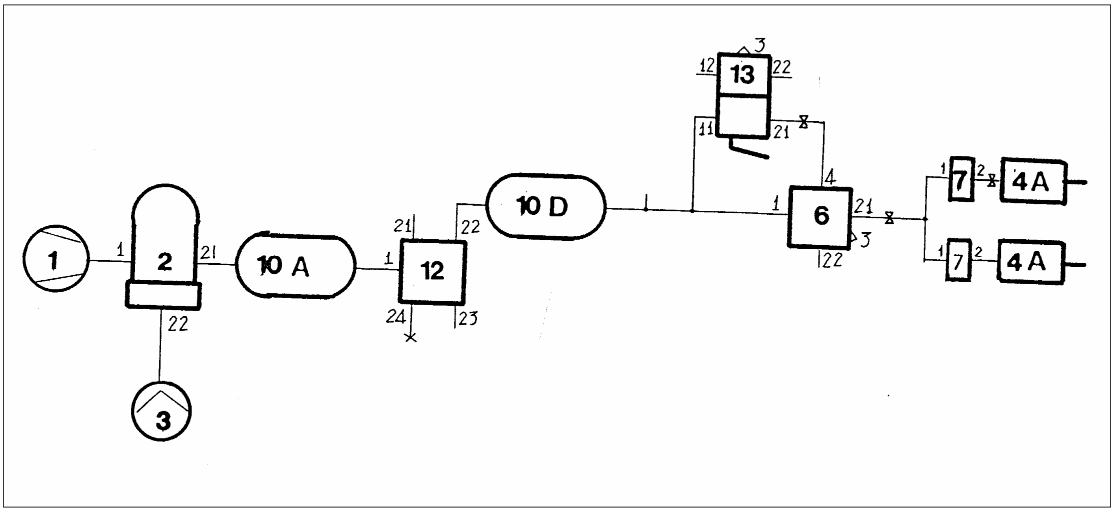
Let's take an example to describe the application of this method. Imagine such a failure: The rear brake chamber does not operate when the brake pedal is pressed.

First of all, we should judge which system is subject to a failure. Obviously the rear brake system.

Then we should check what components are included in this defective system and what the operational relations between those components are.

As shown obviously in Fig. 13-3 "Schematic Diagram of Brake System", the rear brake system consists of air compressor 1, drying chamber 2, recoil air reservoir 3, master reservoir 10A, four-loop protective valve 12, rear brake air reservoir 10D, brake master cylinder 13, relay valve 6, ABS solenoid valve 7 and rear brake chamber 4A, etc.

A schematic diagram is separately prepared to show the operational relations in this system. See Fig. 13-27.



1. Air compressor 2. Drier 3. Recoil air reservoir 10A. Master reservoir 12. Four-loop protective valve 10D. Rear brake air reservoir 13. Brake master cylinder 6. Relay valve 7. ABS solenoid valve 4A. Rear brake chamber

Fig. 13-27. Schematic Diagram of Rear Brake System

To begin with, we should find out the middle position of the system, e.g. outlet 21 of brake master cylinder. Disconnect the joint at this position and press the brake pedal. If air goes out normally from this outlet of brake master cylinder, obviously no valve of this cylinder was subject to a problem. So we can decide that the problem lies in a component behind the brake master cylinder. Connect the joint properly. Now three components still remain there, i.e. relay valve 6, ABS solenoid valve 7 and rear brake chamber 4A. Cut again from approximately the middle position of those three components. For instance, disconnect the joint of outlet 2 of an ABS solenoid valve 7 and press the brake pedal. If no air flows out from the outlet, obviously, the problem lies either in the relay valve 7 or in the ABS solenoid valve 7. Finally, disconnect the joint of outlet 21 of relay valve 6 and press the brake pedal. If no air flows out from the relay valve, it is obvious that the problem lies in the relay valve. Dismount and disassemble the relay valve and we consequently find out that the relay valve piston is seized by dirt and may not operate. Thus the cause of failure is found. Now carry out cleaning or replacement. The system resumes normal operation immediately.

The above is just description by an example. During practical work, we can shoot the trouble more quickly or accurately if such a scientific method is introduced and certain practical experience is used.

Some common failures and their causes are briefly described in the following:

1. Ineffective Brake

When discussing the failure of ineffective brake, we should first fully understand what ineffective brake means. As explicitly explained at the beginning of this chapter, it is extremely wrong for us to have judged the effectiveness of brake by the criteria of presence or absence of pulling trace. This is a conceptual mistake. It is shown by both theory and practice that brake effect is at its worst and stopping distance is the longest in case of pulling trace (Of course, it is better than no brake application at all). Therefore, various devices to improve brake effect have been developed. Among those devices, however, the electronic anti-lock brake system (ABS) is the most effective. Any vehicle equipped with ABS will not at all be subject to “pulling trace” in brake application in normal conditions. So only a brake tester can be used to test the brake effect in future. If you are going to test the brake effect by means of road test, then measure the stopping distance covered from the moment when brake pedal is pressed (it must be pressed to the end) to the moment when vehicle is stopped, in conditions specified by the international or national standards such as road surface, load (generally noload), vehicle speed and system pressure. This is the only way to test the brake effect by means of road test.

If it is shown by tester or road test that the brake is really ineffective, we should check, firstly, whether the system pressure meets the requirement and whether ABS operates normally. If there is nothing wrong with the abovementioned parts, the problem lies obviously in the brake actuating mechanism, i.e. brake shoe and brake drum. Generally speaking, the contact area of brake shoe with brake drum should be larger than 70％. In addition, as shown by practice, better result can be achieved by both ends of brake shoe engaging with the brake drum than the middle of brake shoe engaging with the brake drum. Therefore, if the brake shoe or drum is worn, sprained or out of round, polishing should be done. The brake drum can be polished on a special brake drum polisher or peeled directly on a lathe. The brake shoe had better be polished directly on the brake shoe on-board polisher (See the section regarding special tools), which not only allows simple dismounting and mounting but also importantly provides high accuracy of polishing, thus resulting in the best brake effect. In order to ensure the best state for both ends of brake shoe to engage with brake drum, the peeled brake shoe generally has a diameter larger than that of the brake drum by 0.2 mm. Generally, the max peeling amount of brake drum is 2 mm or so in diameter.

Sometime axle shaft oil seal is subject to oil leakage, causing contamination to the brake shoe lining, which is also a main possible cause of effective brake.

The abovementioned truncation method can be used to shoot the trouble when poor brake effect is caused by the brake control air circuit system.

2. Brake Deviation

For the problem of brake deviation, we sometimes emphatically inspect the clearance between brake shoe and drum. However, both front and rear brakes of King Long series buses are provided with an automatic clearance adjusting arm, which can adjust the brake clearance automatically to maintain it at the its best.

Therefore, do not consider the clearance any longer if it is of no use to inspect and adjust the clearance in case of serious brake steer. The contact area of brake shoe with brake drum of the left wheels is greatly different from that of the right wheels (especially among front wheels) (or splashing of oil causes brake block on any side oil stained), causing great difference of left side from right side in brake torque, which is sometimes the main factors causing brake steer. In this case, just polishing or placing the brake shoe and drum can solve the problem.

3. Brake Incomplete Release

Brake incomplete release refers to the phenomenon that one or all wheels are always subject to a bit brake application during running, causing heating up of brake drum. The causes of such a phenomenon may include the following: the automatic brake adjusting arm is defective; the brake master cylinder pedal has no free travel; the brake camshaft is rusted or deformed or the brake camshaft bracket is misaligned, causing camshaft non-returning, just to name a few.

If brake incomplete release happens to the rear wheel, maybe the hand brake chamber air cylinder, hand brake valve, quick release valve or two-way valve is subject to air leakage.

Another circumstance is that brake incomplete release happens to a wheel on completion of brake application and it releases completely after running of vehicle for a while. Such a failure is generally caused by slow returning of brake chamber or cam. In turn, slow returning is basically caused by poor lubricated brake camshaft and its bushing, misaligned bracket or rustiness. Readjusting the bracket or lubricate the camshaft bushing can facilitate trouble shooting.

Brake incomplete release sometimes may cause heating up of brake drum. For judgment of a failure, differentiation should be made between heating up of brake drum and heating up of wheel hub or axle head. Those two phenomena will be from different causes and should not be confused.

4. Valve Leakage

All valves of the brake system are generally provided with inlet and exhaust port. Therefore, air leakage, when the valve is not operated, is generally caused by foreign matter between inlet valve and its base or by a damaged sealing member. However, air leakage, when the valve is operated, is obviously caused by foreign matter between exhaust valve and its base or by a damaged sealing member. Sealing member repair kits are available for all valves and are special for maintenance purpose.

Section VI. Special Tools for Maintenance of Brake System

The main task of brake system maintenance is polishing of brake shoe and drum.

The brake drum can be peeled on a special brake drum boring machine or on a lathe. In order to ensure proper concentricity, the brake drum had better be mounted on a wheel hub to get peeled, with outer ring of wheel hub bearing as position reference. This not only ensures proper concentricity of brake drum with wheel hub but also improves accuracy of peeling.

Conventionally, polishing of brake block is carried out on a brake block polisher. When a brake shoe is to be polished, you not only have to dismount the brake drum but also remove the brake shoe from vehicle (it is troublesome to dismount or mount a brake shoe) and position it onto the clamping fixture of brake shoe polisher for peeling. On completion of peeling, dismount it from the fixture and mount it onto the brake disk support on vehicle. Form or position error of clamping fixture and brake disc sometimes may cause misalignment of brake shoe with wheel hub, resulting in poor brake effect. Such a problem is effectively solved by the brake shoe on-board polisher developed by Jinan Lanfa Industry Co., Ltd (Tel: 0531-5662004). Fig. 13-28 just shows the brake shoe on-board polisher and Fig. 13-29 shows polishing of a brake shoe by using the polisher.

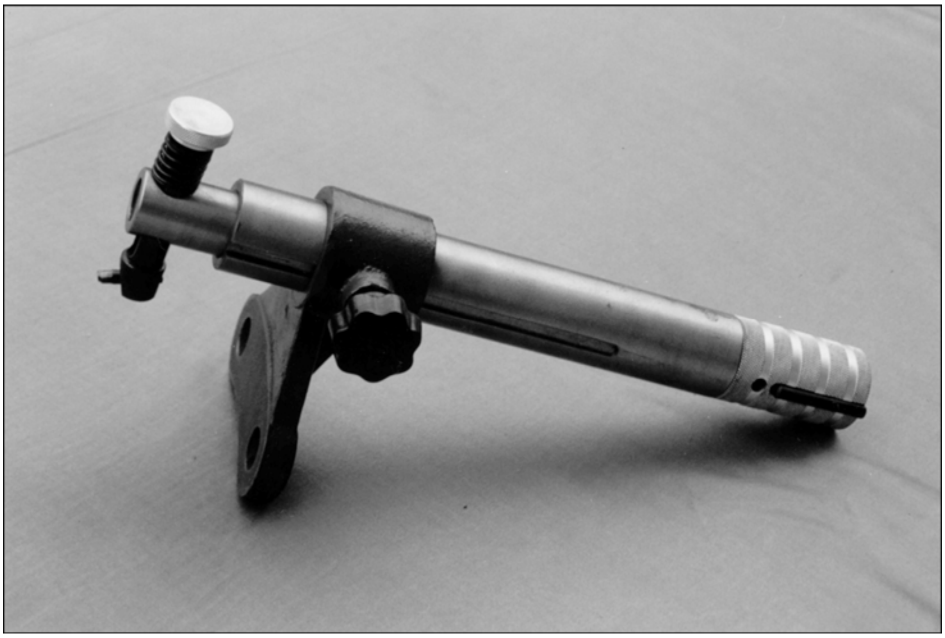


Fig. 13-28. Brake Shoe **On-board Polisher**

Fig. 13-29. Polishing of Brake Shoe **by a Polisher**

With this polisher, we only need to dismount the brake drum then use two tire screw caps to fix the polisher bracket on the axle head wheel hub. When polishing the brake shoe of the front wheel, hold the handle by hand and rotate it clockwise. When polishing brake shoe of the rear left wheel, only reserve gear is needed and when polishing brake shoe of the rear right wheel, only forward gear is needed. Then hold the polisher handle by hand slightly and rotate it by following the wheel hub.

Advance the tool while rotating the polisher handle. Thus the lining on brake shoe can be polished very fast. With this kind of polisher, dismounting and mounting can be done easily. More importantly, positioning is done by means of its own wheel hub so the polished brake block is certainly concentric with the axle, thus ensuring proper accuracy of polishing and optimum brake effect.

Section VII. Automatic Brake Clearance Adjusting Arm

As a rule, a brake chamber is charged (for service brake) or discharged (for parking brake and emergency brake), making the brake push rod to push the brake adjusting arm and thus the brake camshaft is rotated to open the brake shoe. The brake lining generates frictional resistance to the brake drum. This way, the brake is applied.

In free state, the brake shoe can brake drum must maintain a standard clearance. If this clearance is too small, brake incomplete release and heating up of brake drum may happen. However, a too large clearance may cause too long brake reaction time, resulting in brake delay.

As the vehicle runs and the brake shoe lining abrades, this clearance is getting increasingly large. Therefore, during maintenance of vehicle, the brake clearance should be often adjusted.

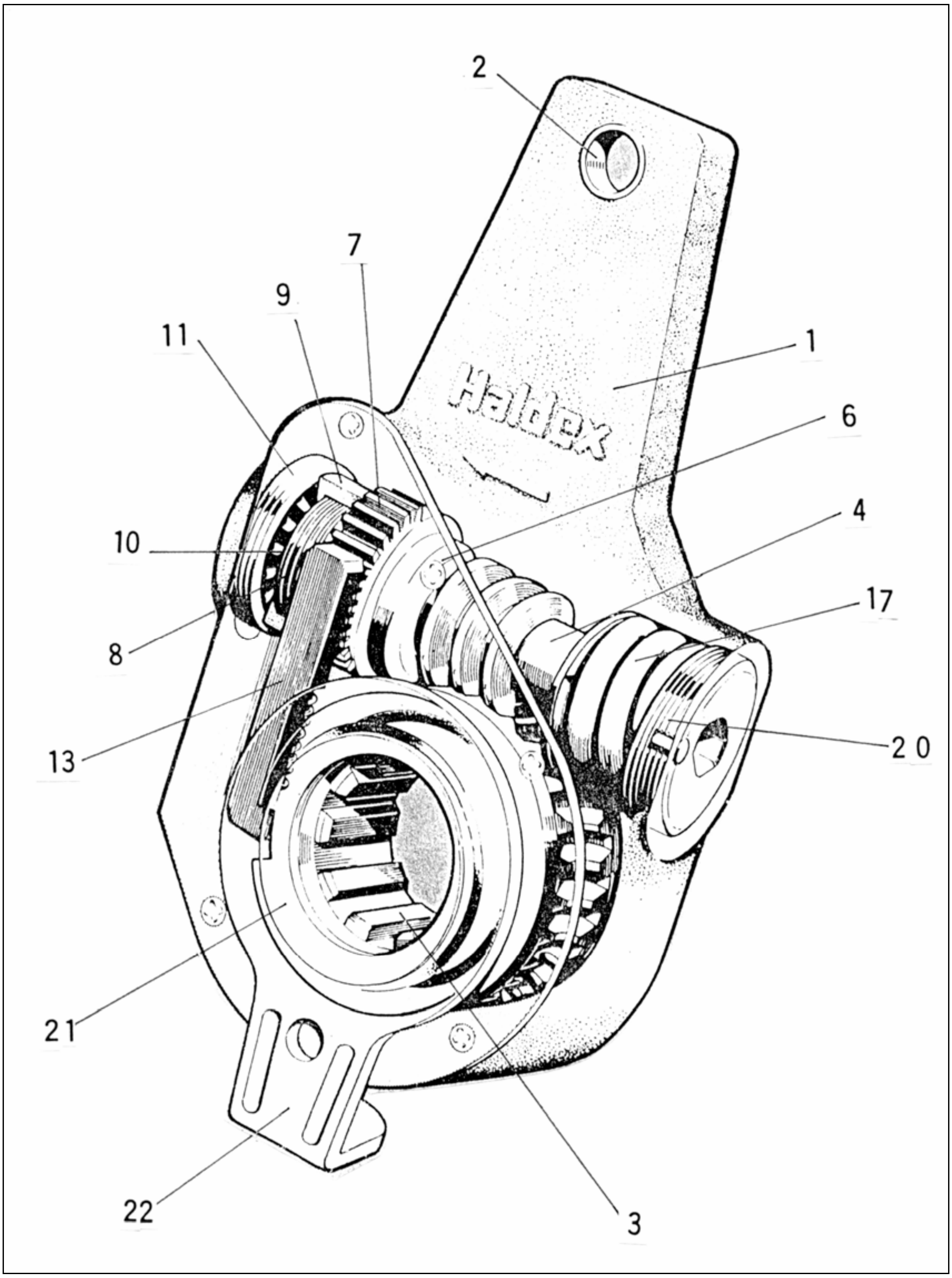
The brake adjusting arms in the past were all adjusted manually. With a manual adjusting arm, adjustment must be done frequently. Besides it could not be adjusted accurately.

The structure and maintenance of the automatic adjusting arm is described in the following, taking the automatic adjusting arm manufactured by Haldex, Sweden as an example.

Automatic adjusting arms are simply structured, work reliably and are widely mounted on the chassis of heavy-duty vehicles or buses.

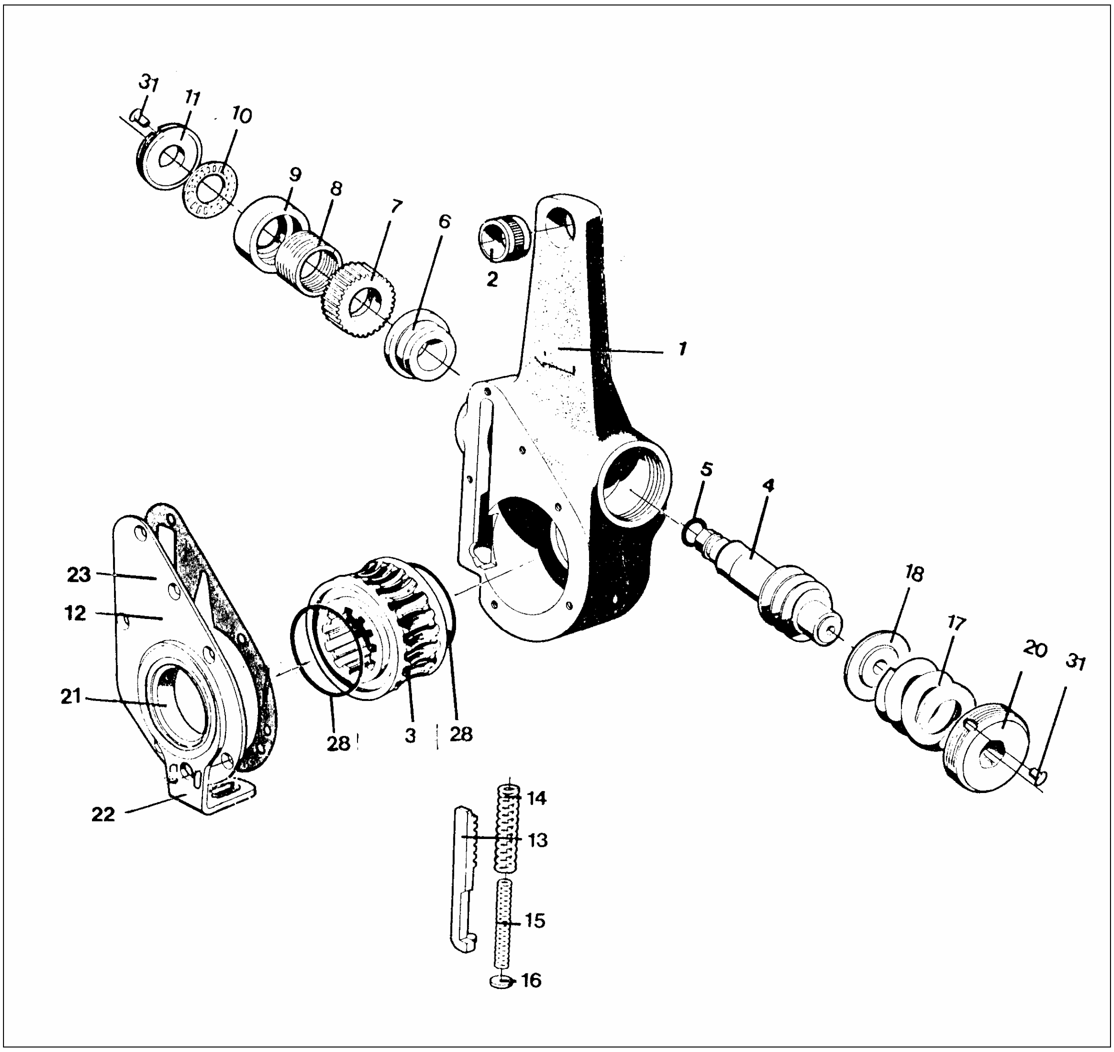
For the King Long series buses, Dongfeng EQR13 type of front and rear axles are equipped with the automatic adjusting arms manufactured by Haldex. DANA (USA) front and rear axles are also provided with such automatic adjusting arm.

Fig. 13-30 shows the structure chart of automatic adjusting arm and Fig. 13-31 shows the structure decomposition.



1. Automatic adjusting arm body 2. Pin hole bushing 3. Worm wheel 4. Worm shaft 6. Worm bearing 7. Gear 8. Clutch spring 9. Clutching ring 10. Plane bearing 11. Casing cap 13. Gear rack 17. Main spring 20. Casing cap 21. Control disc 22. Control arm

Fig. 13-30. Structure Chart of Automatic Adjusting Arm



1. Automatic adjusting arm body 2. Pin hole bushing 3. Worm wheel 4. Worm shaft 5. Sealing ring 6. Worm bearing 7. Gear 8. Clutch spring 9. Clutching ring 10. Plane bearing 11. Casing cap 12. Adjusting arm side plate 13. Gear rack 14.15. Gear rack springs 16. Casing cap 17. Main spring 18. Spring seat 20. Casing cap 21. Control disc 22. Control arm 23. Side plate 28. Sealing ring 31. Pin hole

Fig. 13-31. Decomposition Chart of Automatic Adjusting Arm

I. Operating Principle of Automatic Adjusting Arm

Let's make a study of the structure and operating principle of automatic adjusting arm.

As shown in Fig. 13-30 and Fig. 13-31, an automatic adjusting arm basically consists of four parts, i.e. worm shaft with one-way clutch clutching ring and main spring, rack and pinion gear with rack spring, lock gear positioned by control arm and worm wheel interlocked with brake cam.

As shown in Fig. 13-32, during brake application, the deviation angle of brake adjusting arm is divided into three sections, i.e. deflection angle "C" corresponding to the normal brake clearance, outer angle "Ce" corresponding to excessive clearance resulting from friction lining wearing and deviation angle "E" due to elastic deformation of driving members caused by the thrust force of push rods of brake chambers after contacting of brake shoe with brake drum.

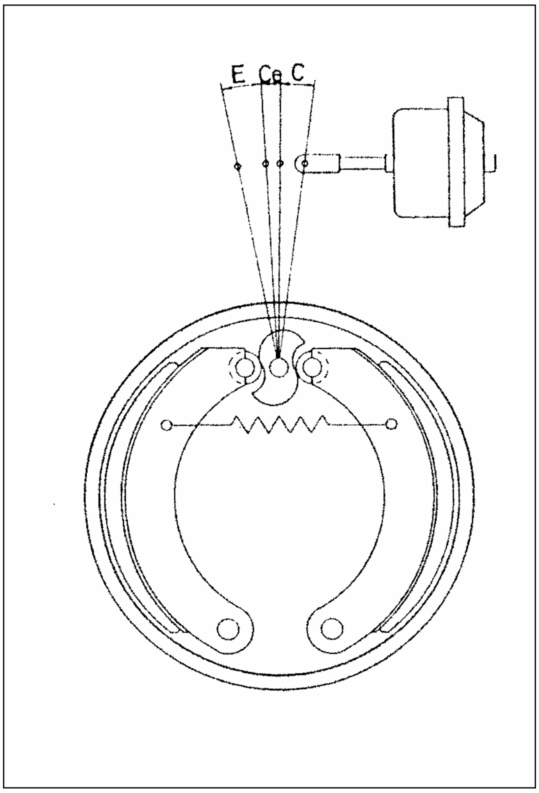


Fig. 13-32. Angle of Adjusting Arm in Brake Application

Please refer to Fig. 13-31 when studying the operating principle of automatic adjusting arm.

1. As shown in Fig. 13-33, there is a notch on the control disc 21 and the connecting lever at the lower end of the rack is inserted into this notch. Before application of brake, the rack connecting lever is at the lower end of the control disc 21. The clearance angle of rack connecting lever and control disc notch just corresponds to the angle “C” taking place for the automatic adjusting arm to eliminate the normal clearance between brake shoe and drum.

2. As shown in Fig. 13-34, when brake is applied, the push rod of brake chamber forces the adjusting arm body to rotate counterclockwise. At this moment, the worm screw 4 forces the worm wheel 3 and the worm wheel 3 drives brake camshaft through spline to rotate counterclockwise synchronously. At the same time, the worm screw 4, gear 7 and rack 13 rotate as a whole counterclockwise towards the connecting lever at the lower end of rack and contact the lower end of notch of control disc 21. Now, the angle “C” of automatic adjusting arm just corresponds to elimination of brake normal clearance and the brake block should just happen to contact the brake drum.

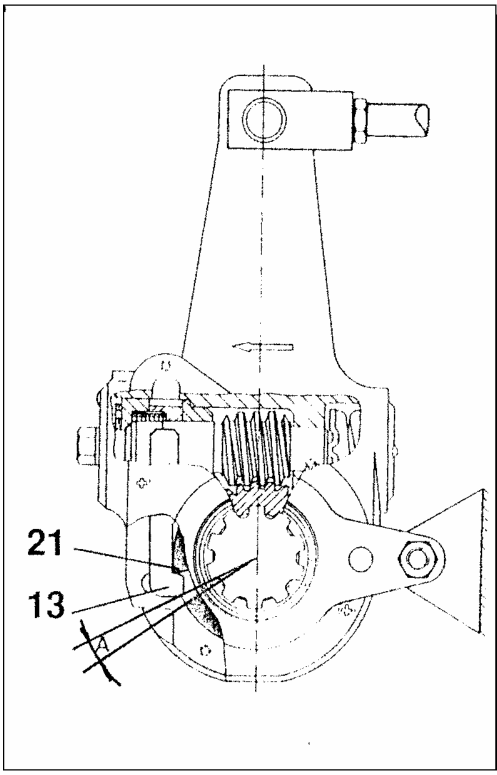


Fig. 13-33. Before Brake Application

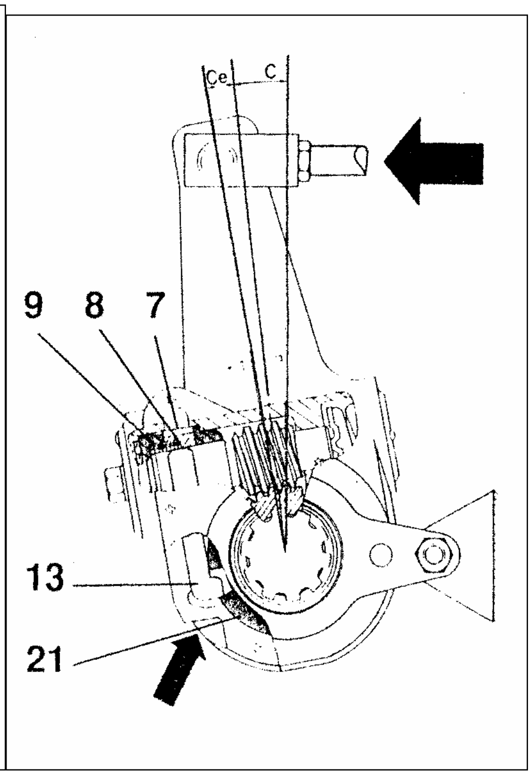
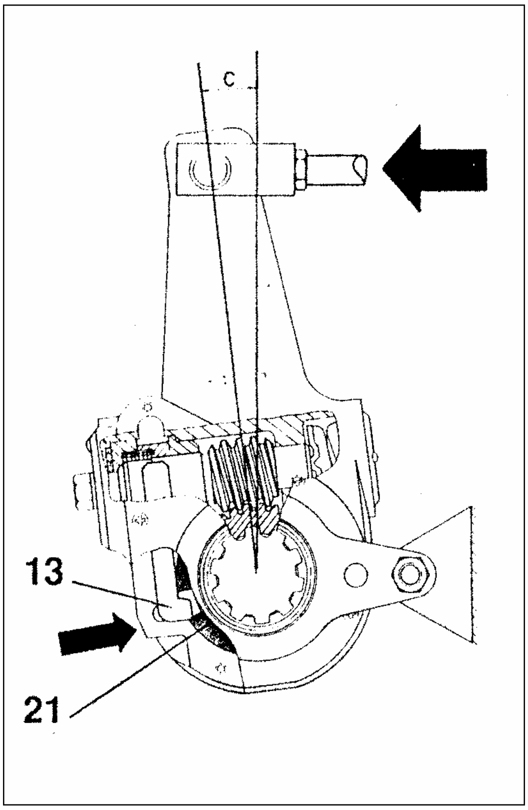


Fig. 13-34. Elimination of Normal Clearance

3. As shown in Fig. 13-35, if the brake shoe does not contact the brake drum at this moment, i.e. excessive clearance exists, continued forward pushing of brake chamber push rod will cause the adjusting arm body to rotate counterclockwise by a angle equal to the excessive clearance outer angle “Ce”. After elimination of normal clearance, gear connecting lever has contacted the lower end of control disc notch and the control disc 21 and the control arm 22 have integrated and in addition, the control arm 22 is fixed on the brake chamber bracket, i.e. the control disc 21 is immobilized by the control arm 22. Therefore, while the adjusting arm body is rotating across the excessive clearance angle “Ce”, the rack 13 is held by the lower end of the notch of control disc 21. This makes the rack 13 to move upwards in relation to the adjusting arm body and to push the gear 7 to rotate backwards. However, clutching ring 9, spring 8 and gear 7 make up the one-way clutch, i.e. gear 7 is in a skidding state in relation to clutching 9, so rack 13 has not changed the relative position of worm screw 4 and screw wheel 3. As shown in Fig. 13-36, there is an outer cone ring on the inner end face of clutching ring 9 and there is an inner cone axle end on the front end face of worm screw 4. There is a main spring 17 at the rear end of worm screw; during the abovementioned procedure, the resilience of this main spring 17 is applied on the inner cone end surface of worm screw 4 so that the clutching 9 may not rotate in relation to the worm screw 4.



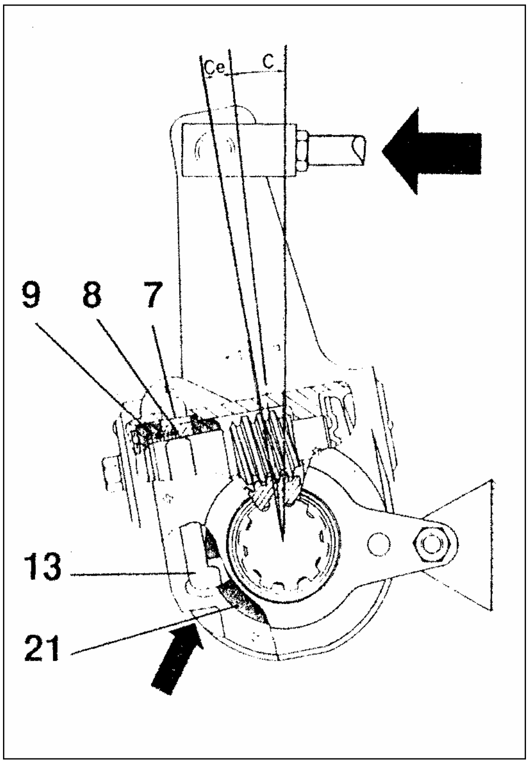


Fig. 13-35 Elimination of Excessive Clearance

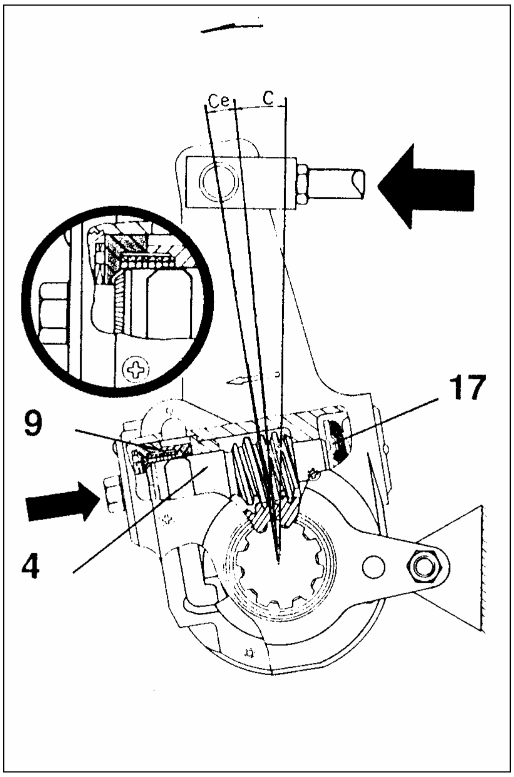


Fig. 13-36 Bevel Gear Clutch

After the adjusting arm rotates across the excessive clearance outer angle “Ce”, the brake shoe formally contacts the brake drum surface and the brake clearance is eliminated.

4. As shown in Fig. 13-37, due to thrust force of brake chamber push rod, the elastic deformation of all actuator linkages makes the adjusting arm produce forwards an outer angle “E”. During this procedure, the adjusting arm body 1 drives the worm screw 4

through the main spring 17 and consequently drives the worm wheel 3. The reacting force of worm wheel 3, through worm screw 4, compresses the main spring 17 so that the worm screw 4 shifts backwards, which disengages worm screw 4 from clutching 9. Thus, during this deflection procedure, the rack 13 at the lower end of control disc notch, the contact wheel 7 of rack 13 and the clutching ring 9 rotate backwards for an angle in relation to worm screw 4. At this moment, the relative position of worm screw to worm wheel is still unchanged.

5. As shown in Fig. 13-38, on completion of brake application, the thrust force of automatic adjusting arm disappears gradually. To begin with, the adjusting arm rotates clockwise to eliminate the outer angle "E" generated by elastic deformation. During this procedure, the thrust force reduces graduate as the elastic deformation outer angle is removed little by little, so the worm screw 4 still compresses the main spring 17. This allows the worm screw to remain disengaged with clutching ring 9; the rack 13 may still disengage with the worm screw to rotate the gear 7 and clutching ring 9; and the relative position of worm screw 4 to the worm wheel 3 is still unchanged.

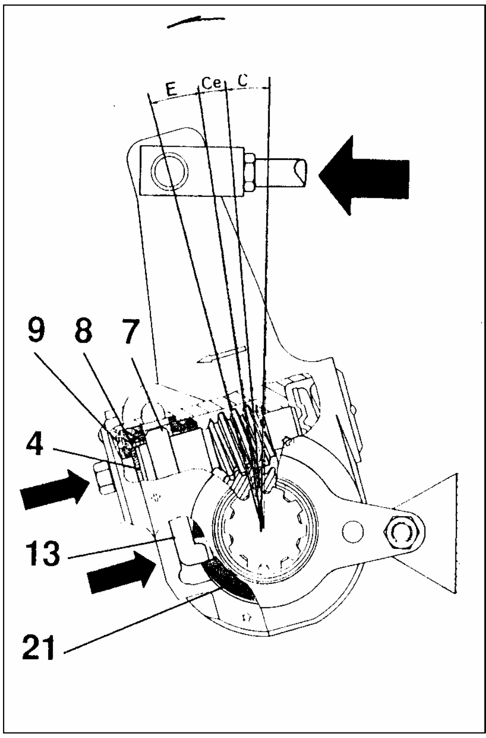


Fig. 13-37. Elimination of Elastic Clearance

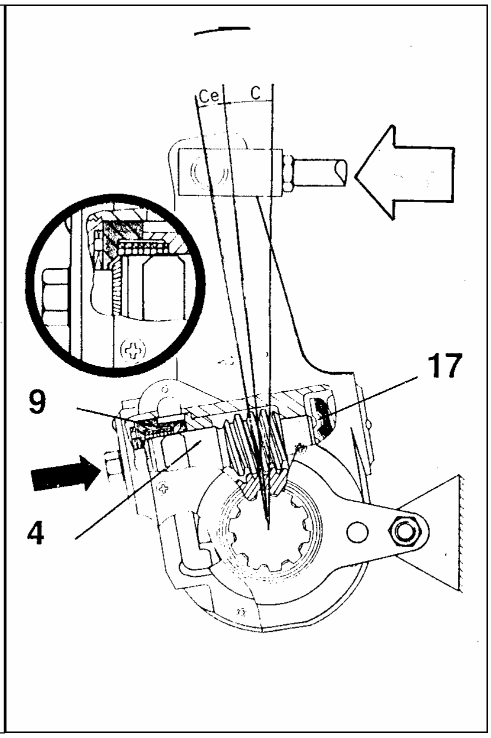
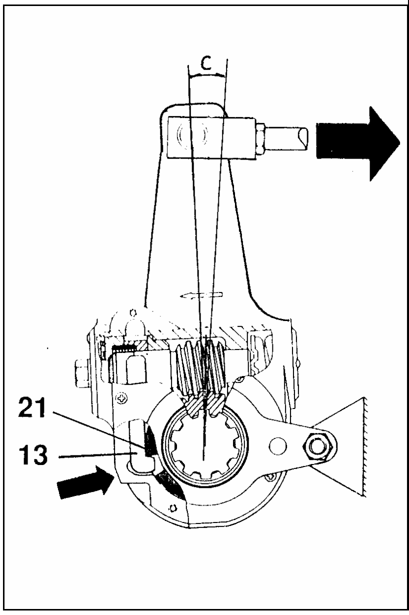


Fig. 13-38. Brake Release in Elastic Deformation Area



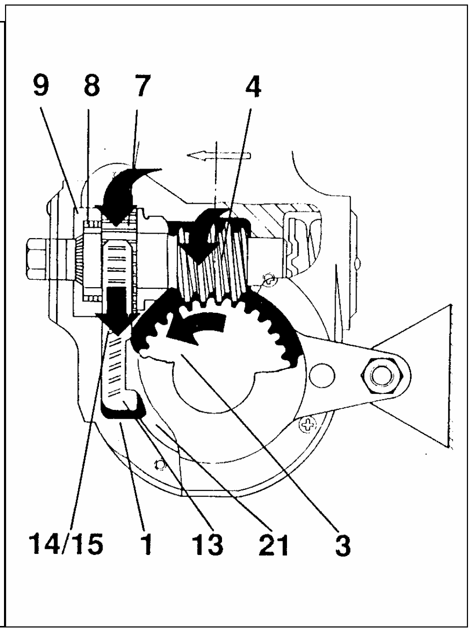


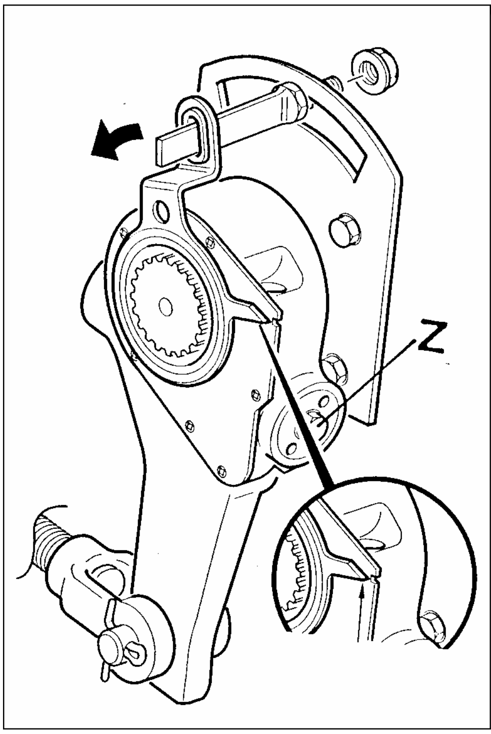
Fig. 13-39. Rotation Drawing of Normal Clearance　　Fig. 13-40. Adjustment of Excessive Clearance

6. As shown in Fig. 13-39, when the thrust force of brake chamber push rod is eliminated completely and elastic outer angle of adjusting arm also finishes rotating, the main spring 17 forces the worm screw 4 to be compressed together with the clutching ring 9. While the adjusting arm rotates clockwise, the connecting lever of rack 13 moves upwards to the upper end from the lower end of the notch of control disc 21. In corresponding to this procedure, the adjusting arm just rotates by an outer angle “C” to eliminate normal clearance.

7. As shown in Fig. 13-40, due to wear of friction lining, excessive clearance exists between brake shoe and drum. Therefore, after elimination of normal clearance, excessive clearance is still available, allowing the adjusting arm to rotate. At this moment, when the adjusting arm rotates clockwise again, the rack 13, due to limiting by the upper end of notch of control disc 21, will drive the rack, clutching ring 9 and worm screw 4 to rotate forwards (right-hand) in relation to the worm wheel 3. The worm screw will prod the worm wheel to eliminate the excessive clearance. Thus automatic adjustment of brake clearance is completed. Thereafter, the adjusting arm will rotate within the normal clearance outer angle. Automatic adjustment should not be done again until the brake shoe lining is worn again and excessive clearance is produced. Therefore, such adjustment is carried out continuously and automatically. Thus, use of such an automatic adjusting arm can save much manual service or maintenance.

From the above procedure, we can come to a conclusion: Adjustment with such an automatic adjusting arm is carried out in the no-load operating condition after brake application, so adjustment accuracy is high. In addition, the size of control disc notch defines that size of normal clearance between brake shoe and drum, so automatic adjusting arms with different standard of brake clearance have different control discs.

In order to meet the requirement of chassis structures of various vehicle models, Haldex has developed many fixing types of control arm. For instance, in Fig. 13-41, the control arm is fixed on the control arm bracket by an offset pin shaft; in Fig. 13-42, the control arm is fixed on the bracket by a screw; in Fig. 13-43, a groove-shaped tail fin is made for the arm, and then insert the other groove-shaped tail fin fixed on the bracket into the control arm tail fin so as to position the arm; in Fig. 13-44, the control arm is fixed by a clip type bracket and so on.



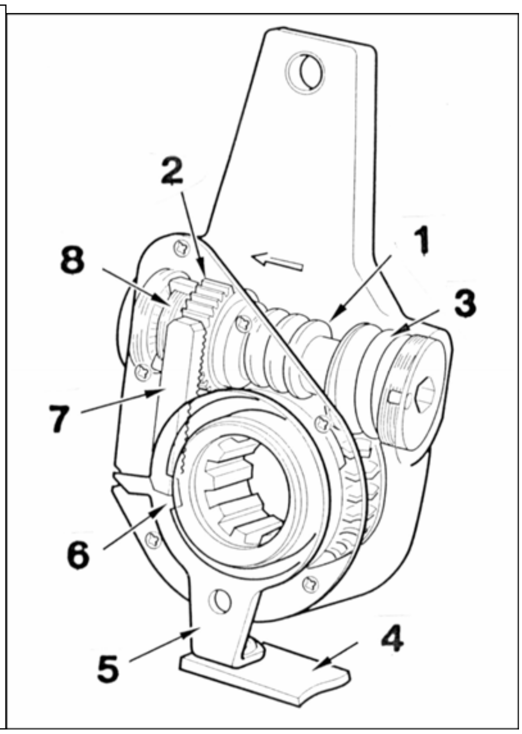
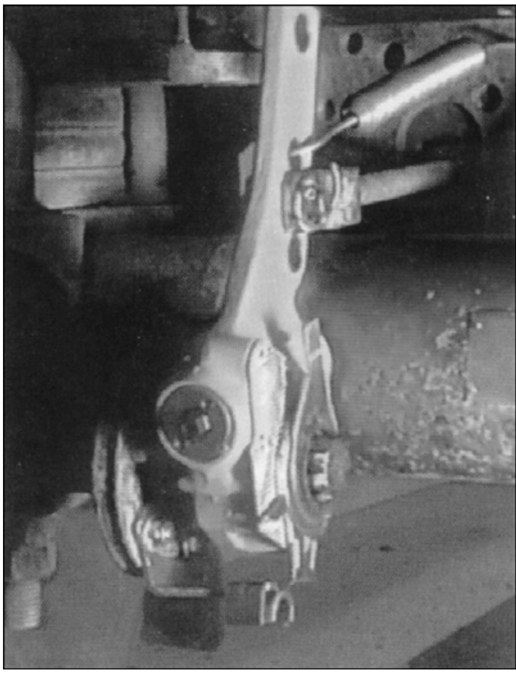


Fig. 13-41 Control Arm Fixed by Offset Pin Shaft   Fig. 13-42. Control Arm Fixed by Screw



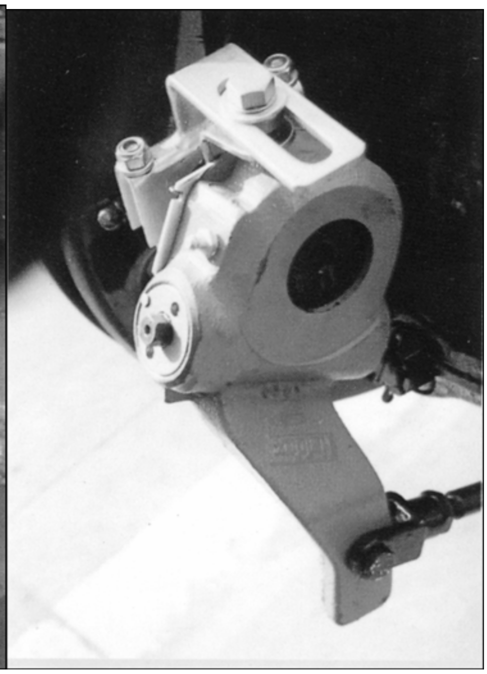


Fig. 13-43 Control Arm Fixed by Groove-shaped Tail Fin   Fig. 13-44 Control Arm Fixed by Clip

In addition, an indication mechanism is provided on the control arm as shown in Fig. 13-41. The pointer of the indicator will point to the notch on the side cover of adjusting arm when brake clearance is within the standard range. The farther the pointer is from the notch, the larger the brake excessive clearance is indicated.

Take Fig. 13-41 as another example, just the same as a usual adjusting arm, a hexagonal adjusting nut “Z” is provided at the end of each adjusting arm worm shaft. With such a nut, initial adjustment of large excessive clearance can be done manually in case of initial installation of the adjusting arm.

II. Dismounting and Mounting of Automatic Adjusting Arm

The structures of front and rear axle automatic brake adjusting arms are largely identical but with minor differences. The difference is generally in the fixing method of the control arms. Dismounting and mounting of an adjusting arm are described in the following, taking as an example an adjusting arm with control arm fixed by groove-shaped tail fin.

(I) Dismounting of Automatic Adjusting Arm from Vehicle Frame

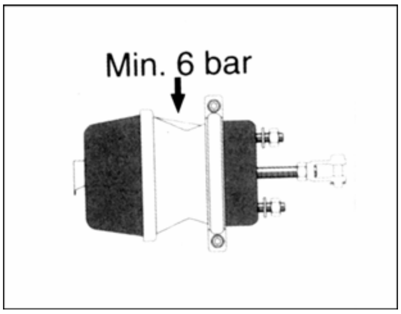
1. To begin with, dismount the cotter pin and straight pin from brake chamber push rod hitch yoke so as to detach the chamber from the adjusting arm.

2. Unscrew the attachment bolts of control arm bracket and vehicle frame.

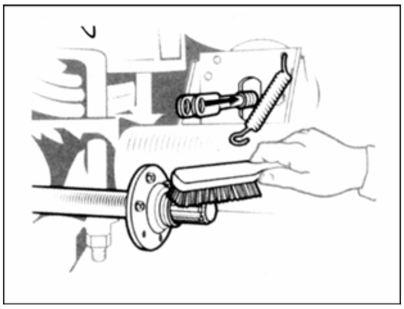
3. Remove the locating circlip (or fixing nut) from the end of brake camshaft.

4. Use a box wrench to rotate counterclockwise the hexagonal adjusting nuts on the adjusting arm so that the adjusting arm can be shifted out smoothly (large torque is needed during moving and “click-click” can be heard). Finally dismount the adjusting arm from the camshaft.

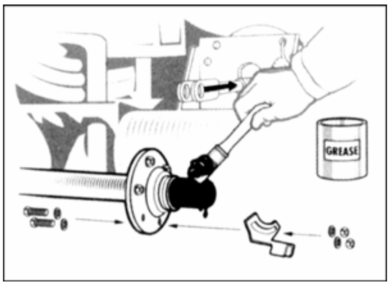
(II) Mounting of Automatic Adjusting Arm onto Vehicle Frame



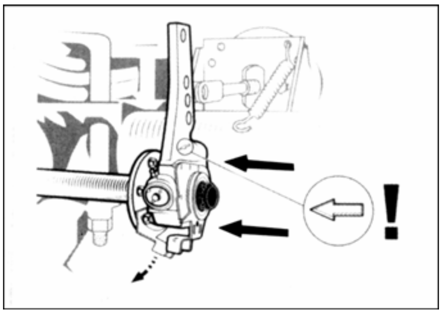
1. First of all, release the brake. As for the rear axle combined-type brake chamber, air needs to be charged to the hand brake chamber air cylinder and the charging pressure may not be lower than 0.6 MPa so as to ensure that the push rod of the chamber is in the initial position.



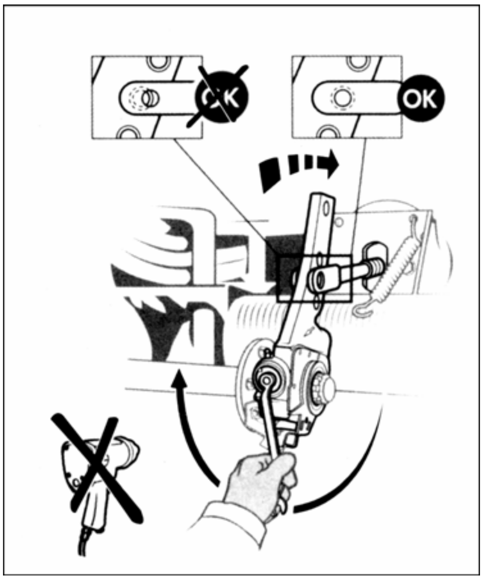
2. Use a wire brush to remove oil stain from camshaft spline.



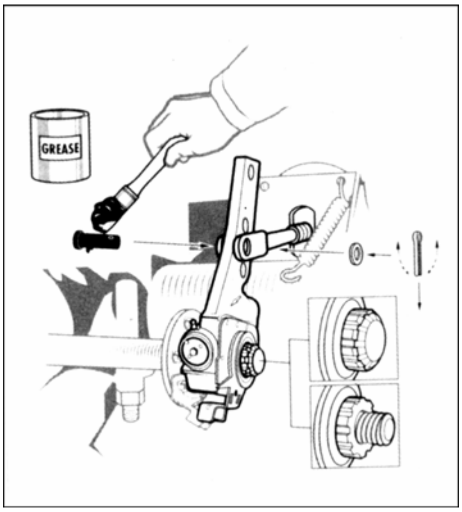
3. Apply lubricating grease onto the camshaft spline shaft.



4. Mount the adjusting arm onto the camshaft and make sure that the arrowhead direction on the adjusting arm casing is consistent with the brake application direction of the push rod of cylinder.

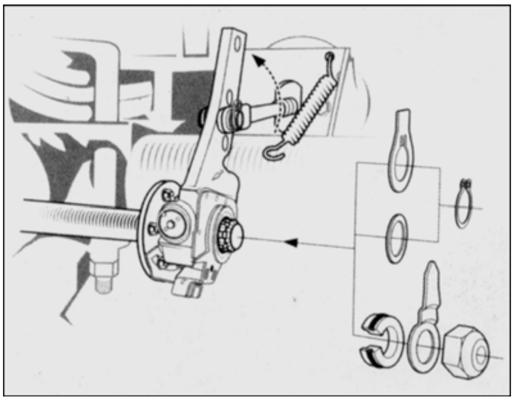


5. Use a wrench to rotate clockwise the hexagonal nuts of the adjusting arm to screw the adjusting arm into the U-fork of the brake chamber push rod until the U-fork hole is naturally aligned with the location hole on the adjusting arm.

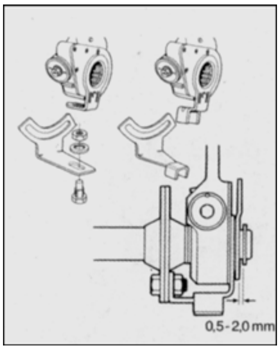


6. Apply lubricating grease onto the straight pin and insert it into the pin hole smoothly. Lock the cotter pin.

NOTE: The pin hole on the adjusting arm must be naturally aligned with that on the U-fork.

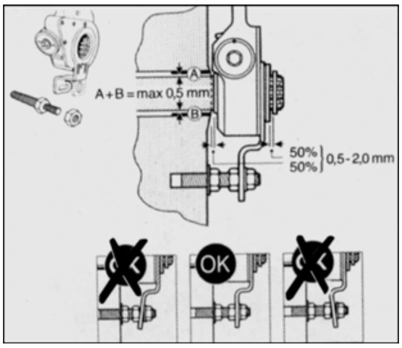


7. Use washer and circlip (or washer and nut) to fix the adjusting arm on the camshaft.

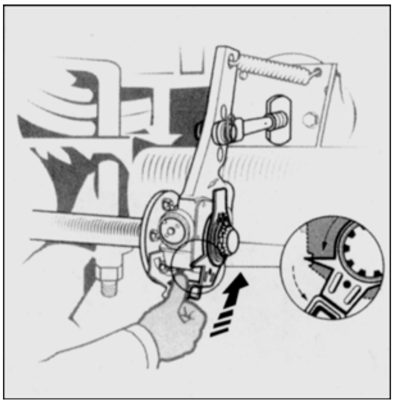


8. Check that the axial clearance of adjusting arm should be between 0.5 and 0.20 mm. Adjustment can be done by means of adding a washer if the deviation is large.

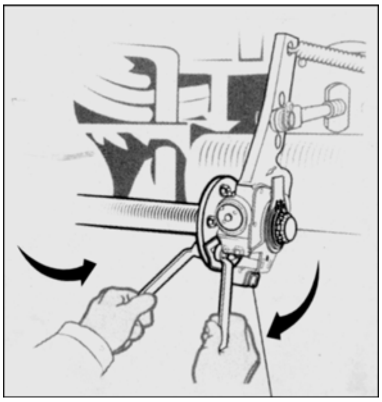
Insert the groove-shaped tail pin of the control arm bracket into that of the control arm (or attach the bracket to the control arm by means of a bolt).



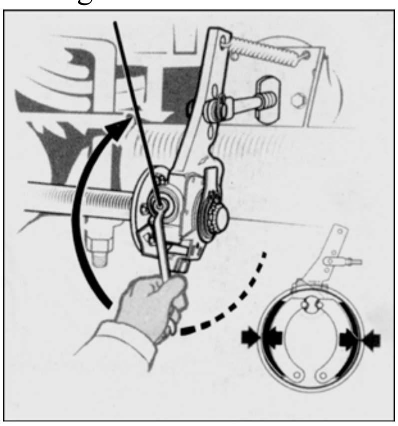
9、If the control arm is fixed by means of end face bolt, note that the control arm should be fixed on the fixing bolt vertically.



10. Push the control arm as per the arrowhead direction indicated on the adjusting arm casing until it is immovable. Then fix the control arm bracket together with the axle.

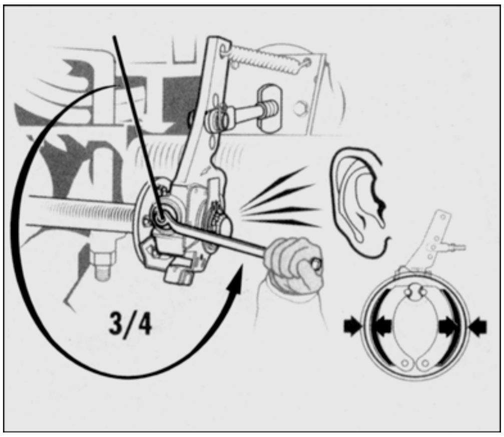


11. Tighten the control arm bracket fixing bolt to 20 N・m.



12. Rotate clockwise the adjusting nut on the adjusting arm by a wrench (small torque is needed, so no “click-click” can be heard) until it is immovable. At this moment,

clearance between brake shoe can drum is zero.



13. Then rotate counterclockwise the adjusting nut by 3/4 turn (270°) (large torque is needed, so “click-click” can be heard). Thereafter, apply the brake several times (press the brake pedal several times). Mounting and commissioning of automatic brake clearance adjusting arm is finished. At this moment, the pointer on the control arm should point to indicating position of the notch of side cover.

III. Maintenance of Automatic Adjusting Arm

If a lubricating nipple is provided on the automatic adjusting arm, lubricating grease should be filled up every 10,000 km. If a lubricating nipple is not available, the adjusting arm is a long acting one and it is unnecessary to often fill up lubricating grease during running.

Every 20,000 km, use an indication-type torque wrench to rotate the adjusting nut counterclockwise and check whether its rotating torque is larger than 18 N • m. Check it three times repeatedly. If the measured torque is smaller than 18 N • m, the adjusting arm is defective, cannot attain the purpose of automatic adjustment and should be replaced.