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——铁道机车运用与维护专业

Electric Locomotive Brake System

电力机车制动系统

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前　言

本书为亚吉铁路电力机车司机培训教材。亚吉铁路由埃塞俄比亚和吉布提共同组建，是中国“一带一路”倡议的重要组成部分。为了培养亚吉铁路非洲司机学员的制动机操纵、试验和故障处理能力，本书设计成教学做一体化教材。

制动系统是机车的重要组成部分，它的运行状态直接关系到列车运行的安全。要想成为一名合格的机车司机，首先要掌握制动机各部件的组成、各部件之间的相互控制关系，理解制动机的工作过程，会正确使用和操纵制动机，最后能够熟练掌握制动机性能试验的顺序和要求，通过制动机性能试验能够及时发现制动机的故障，并且会对故障进行处理。

本书以出口到埃塞俄比亚和吉布提的亚吉铁路的 HXD_{1C} 机车中的 DK-2 制动机作为主要讲述内容，系统讲述了制动系统认知、DK-2 制动系统的组成、DK-2 制动系统的综合作用、DK-2 制动系统的操纵、DK-2 制动系统的性能试验和 DK-2 制动系统的故障处理。

本书编写过程突出实际运用，只讲述了必要的制动系统的原理知识。原理知识包含了制动系统的基本概念、早期制动机的工作原理和现代制动机的基本控制逻辑。

在 DK-2 制动系统的讲述中，突出制动系统组成、操纵和故障处理。这些内容是以司机在机车运用中制动机使用时必备的知识和能力为基础，然后围绕知识和能力要求，与机务生产一线人员共同进行专业能力分析，最终选定相应教学内容。

本书由郑州铁路职业技术学院马金法、李书营、李孝坤编著。具体编写分工如下：马金法编写第 1、2、3 章，李书营编写第 4 章，李孝坤编写第 5、6 章。

由于编者水平有限，加之编写时间仓促，书中难免有疏漏和不当之处，恳请读者批评指正。

作　者
2021 年 11 月

PREFACE

This book is a training material for electric locomotive drivers of Addis Ababa Djibouti railway. Addis Ababa Djibouti railway is jointly established by Djibouti and the Ethiopia, it is also one important part of the belt and road of china. In order to cultivate the brake operation, test and fault handling ability of African driver trainees of Addis Ababa Djibouti railway, this book is designed as an integrated teaching material.

Braking system is an important part of locomotive, and its running state is directly related to the safety of train operation. To become a qualified locomotive driver, first of all, master the composition of various parts of the brake and the mutual control relationship between various parts, understand the working process of the brake, and be able to use and operate the brake correctly. Finally, be able to master the sequence and requirements of the brake performance test, and find the brake fault in time through the brake performance test, and then grasp the troubleshooting.

This book takes DK-2 brake in HXD_{1C} locomotive as the main content. This locomotive is exported from china to Ethiopia and Djibouti. It systematically describes the cognition of braking system, composition of DK-2 braking system, comprehensive function of DK-2 braking system, operation of DK-2 braking system, performance test of DK-2 braking system and fault treatment of DK-2 braking system.

In the process of compiling this book, the practical application is highlighted, and only the necessary principle knowledge of braking system is described. The principle knowledge includes the basic concept of braking system, the working principle of early brake and the basic control logic of modern brake.

DK-2 braking system highlights the composition, operation and fault handling of the braking system. These contents are based on the necessary knowledge and ability of the driver in the use of locomotive and brake, and then around this knowledge and ability requirements, conduct professional ability analysis with the front-line personnel of locomotive production, and finally select the corresponding teaching contents.

This book is edited by Ma Jinfa, Li Shuying and Li Xiaokun of Zhengzhou Railway Vocational and technical college. The specific compilation division is as follows: Chapters 1, 2 and 3 written by Ma Jinfa, Chapter 4 written by Li Shuying, and chapters 5 and 6 written by Li Xiaokun.

Due to the limited level of editors and the short preparation time, it is inevitable that there are omissions and inappropriateness in the book. I urge readers to criticize and correct.

Editor

November 2021

CONTENTS

Chapter 1

Brake System Cognition

nit 1 Cognition of basic concept of brake system

In everyday life, any means of transportation cannot be separated from the brake system. From small bicycles to space shuttles, the brake system plays an important role in ensuring transportation safety. For railway transportation, the running process of the train includes three basic working modes of traction, idle and braking. The key to the successful implementation of the braking mode is that the brake system works effectively and reliably.

So, what's the brake system?

What are the compositions of the brake system?

Here are two basic concepts-braking and braking force.

The braking refers to the process that artificially generating the train deceleration force and controlling its size to slow down， stop the train or prevent it from accelerating.

The braking force is the train deceleration force that can be artificially controlled during the braking process.

The moving train contains kinetic energy. To slow down or stop the train, the kinetic energy of the train must be reduced. According to the law of conservation of energy, kinetic energy needs to be converted into other forms of energy during braking process.

In the train operation, according to different actual conditions, the target after the implementation of braking is also very different. Braking is divided into emergency braking and service braking according to the braking target.

The goal of emergency braking is to stop in the possible shortest time, that is, to obtain the maximum braking force in the shortest time so that the train can stop suddenly. Because the emergency braking effect is relatively fierce, it will cause a relatively large impulse of the rolling stock, which will bring great discomfort or even injury to the passenger, so it can only be used in the event of an emergency.

The service braking is more moderate than the emergency braking. It is to get the specified braking force for the train within a certain period of time. Why does it need a specified braking force? Because the service braking has different targets in different situations, in most cases it is stop, but sometimes only for speed regulation. In particular, passenger trains, in order to improve passenger comfort, usually use the minimum effective braking force to make the train speed control or stop smoothly.

In order to obtain different braking results during in the process of braking, it is necessary to control the size and speed of the energy conversion.

In summary, the process of braking must have two basic conditions:

(1) Achieve energy conversion.

(2) Control energy conversion.

A brake system is a device or system that is capable of producing a controllable train deceleration force to achieve and control energy conversion.

The simple brake system performs energy conversion control while achieving energy conversion. For example, the brake of the bicycle completes the control of the braking force by the tightening of the hand while the brake is being applied.

Both the locomotive and the vehicle have their own brake system. When locomotives and vehicles are combined into the train, their respective brake systems are connected to each other to form a unified brake system-the train brake system.

With the development of rolling stock technology, the train running speed is getting higher and higher, the traction weight of the train is also increasing. Finally, the kinetic energy of the train is inevitable increasing, which puts forward higher requirements for the braking ability of the train brake system, so the structure and working principle of the train brake system is becoming more and more complex.

Modern train brake systems generally use compressed air as power to achieve braking, known as air braking. Depending on the relationship with the compressed air in the brake system, all equipment of the brake system can be divided into two parts. Among them, the device to control the change of compressed air pressure is usually called brake, which completes the control of energy conversion in the process of braking. Since the pressure change control of different brake is quite different, it is the focus of our future study. The device that uses compressed air as the power source to ultimately generate the corresponding braking force is called the brake rigging, which realizes the energy conversion in the braking process. Because all the brake riggings of locomotives and vehicles are pure mechanical transmission, the working principle is similar, so we only need to master the working principle of brake rigging of one type.

The main content of this course is the knowledge of the locomotive brake system. At the same time, the vehicle brake system involved is also briefly described.

The purpose of the brake system is to enable the train to slow down or stop accurately according to the will of the operator. The performance of the brake system not only affects the train braking effect, but also affects the railway transportation production. Measuring the performance of the brake system is mainly to measure the performance of the brakes. A brake with good performance has the following advantages in promoting railway transportation:

(1) Ensure train running safety.

(2) Give full play to the traction force, increase the traction weight of the train, and improve the running speed of the train.

(3) Improve the ability of the train to pass the section.

Unit 2 Cognition of the development of brake system

On September 27, 1825, the world's first railway was built between Stockton and Darlington, England, and the world's first steam locomotive-driven train began to operate. The brake used at that time was a manual brake, i.e. a hand brake. In the work, several brakemen are needed. When braking is needed in operation, the driver sends out a signal, and brakemen control the hand brakes on each vehicle separately for braking. It can be seen that manpower braking not only increases the labor intensity of brakemen working in harsh environments, but also greatly reduces the simultaneity of vehicle braking in trains, thus causing serious braking impact and affecting the braking effect of trains.

In 1869, American Engineer George Westinghouse invented the world's first air brake, the straight air brake. The straight air brake belongs to the pneumatic device and is operated by the driver alone. Compared with the manual brake, the straight air brake greatly improves the simultaneity of the train braking, reduces the braking impact and improves the braking effect of the train. However, due to the working principle of the straight air brake, there is a fatal weakness in its operation process-when the train is separated, the train will lose its braking function.

In 1872, George Westinghouse developed a new type of air brake, automatic air brake, on the basis of straight air brake. Automatic air brake overcomes the fatal weakness of straight air brake, so it has been widely used in railway transportation. Even today, with the high development of science and technology, air brake used by trains all over the world originates from automatic air brake.

In the 1960s, with the development of science and technology, electro-pneumatic brake technology was widely used in railway transportation, resulting in electro-pneumatic brake, which improved the working performance of brake and provided more reliable safety measures for railway transportation.

In the 21st century, with the development of computer technology and sensor technology, the instructions of electro-pneumatic brake are transmitted through computer control. The working state of the brake is supply back from the sensor to the computer in real time. Computer control realizing networked, informative and intelligent control, and improving the speed response and accuracy. At this time, these brakes can be called intelligent electro-pneumatic brakes.

nit 3 Classification cognition of brake system

The difference of power and control signal required in braking process is an important indicator to distinguish different brakes. For example, the power and control signal of air brake are all compressed air (also known as pressure air); the power of electro-pneumatic brake is also pressure air, but its control signal is electrical signal. Therefore, it is the basic premise for analyzing and mastering the working process of the brake to understand the power and control signals of the brake.

In theory, different mode brakes are often distinguished by braking modes. The braking mode refers to the transfer mode of train kinetic energy or the formation mode of braking force in the braking process. According to the different transfer modes of train kinetic energy, brake can be divided into two basic modes: heat dissipation and conversion of kinetic energy into useful energy, as shown in Figure 1-1.

- Heat dissipation
  - Friction braking
    - Solid friction braking
      - Wheels tread brake
      - Disc brake
      - Track electromagnetic brake
    - Liquid friction braking
  - Dynamic braking
    - Rheostatic braking
    - Rotary eddy current brake
    - Track eddy current brake
- Conversion of kinetic energy into useful energy
  - Regenerative braking
  - Flywheel energy storage brake

Figure 1-1 Braking modes (by train kinetic energy transfer mode)

According to the different forms of braking force, braking mode can be divided into adhesive braking and non-adhesive braking. The braking force is formed by the adhesion between the wheel and rail, which is called adhesive braking. On the contrary, the braking force without the adhesion between wheel and rail is called non-adhesive braking. The classification of adhesive brakes and non-adhesive brakes is shown in Table 1-1.

Table 1-1 Classification of adhesive brake and non-adhesive brake

Brake type	Classification		Remarks
Adhesion braking	1. Friction braking	Tread brake	Widely used
		Disc brake	
	2. Dynamic braking	Rheostatic braking	Commonly used on electric locomotives
		Regenerative braking	Used on electric locomotive
		Supplying rheostatic brake	Commonly used on electric locomotives
	3. Inertia braking	Flywheel energy storage brake	
Non-adhesion braking	4. Magnet track friction brake		Adopted on high-speed locomotives and EMUs, it is not yet popular
	5. Magnetic track eddy current brake		
	6. Air resistance brake and jet brake		

The brakes can be divided into locomotive brakes and vehicle brakes according to the action objects. They can be divided into air brakes, electric pneumatic brakes and vacuum brakes according to the control mode and power source.

Unit 4 The cognition of working principle of early brake system

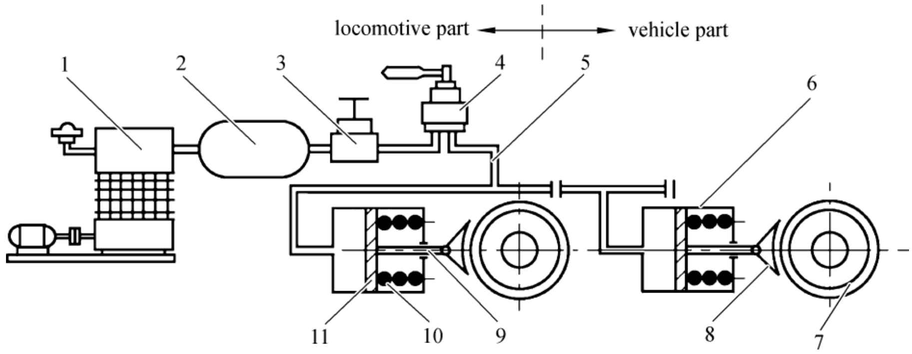
As mentioned above, the development of the early brake system has gone through two stages: the straight air brake system and automatic air brake system. Their basic working principles are discussed separately below.

4.1 The basic working principle of the straight air brake system

4.1.1 Basic structures

The composition of the straight air brake system is shown in Figure 1-2.

In the vehicle, the straight air brake mainly consists of brake pipe and brake cylinder. On the locomotive, the straight air brake includes not only brake pipe and brake cylinder, but also air compressor, main air reservoir and brake valve which controls the whole brake system. When the train is running, besides the coupler connection, the brakes of the locomotive and the vehicle should be connected with the hose through the brake pipe to form a unified brake system for the train. The driver manipulates the brake valve to achieve the corresponding control.



1—air compressor; 2—main air reservoir; 3—pressure regulating valve; 4—brake valve; 5—brake pipe; 6—brake cylinder; 7—wheel; 8—brake shoe; 9—brake cylinder piston rod; 10—brake cylinder restoring spring; 11—brake cylinder piston.

Figure 1-2 The structure schematic of the straight air brake system

4.1.2 Basic working principle

The working process of the brake system mainly includes three basic states: braking, release and pressure holding.

1. Braking state

When the train needs braking, the driver pushes the brake valve handle to be placed in the “brake” position, so that the pressure air stored in the main air reservoir is directly flowed into the locomotive brake cylinder and the vehicle brake cylinder through the pressure regulating valve, the brake valve and the brake pipe, and the piston of the brake cylinder is pushed to compress the spring, and then through the brake transmission device (e.g. The brake cylinder piston rod, brake lever, etc.) transfers this thrust to the brake shoe, so that the brake shoe presses the wheel tread and produces braking effect.

2. Release state

When the train needs to reduce or release braking, the driver pulls the brake valve handle to be placed in the “release position”, so that the pressure air in the brake cylinder of locomotive and vehicle flows through the brake pipe and the passage opened by brake valve, it is discharged into atmosphere. Under the force of the brake cylinder restoring spring, the piston of the brake cylinder moves backwards, and the brake shoe is driven by the brake transmission device, it leaves the wheel to release the brake system.

3. Pressure-holding state

When a train needs to maintain a certain braking force, the driver controls the brake valve handle to be placed in a “neutral position”, which not only close the air charging passage of the locomotive and vehicle brake cylinder, but also the air discharging passage, so as to maintain a certain pressure in the brake cylinder of the locomotive and vehicle to achieve pressure-holding effect.

In summary, the operation of the straight air brake has the following characteristics:

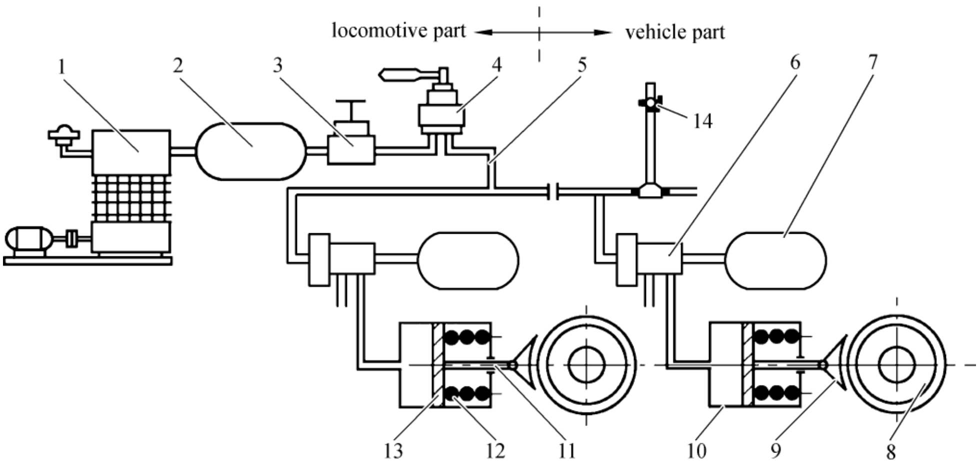
(1) Because the charging and discharging of the brake cylinder need to be completed through the brake pipe, it can be said that the brake pipe charging leads to brake, the brake pipe discharging leads to release. It is precisely this characteristic of the straight air brake that makes it have the fatal weakness of “when the train is separated, the brake system of the train loses its braking function”, which is also the crucial reason for the elimination of the straight air brake.

(2) Because the brake pipe is thin and long, it will inevitably lead to fast air charging and high pressure of the brake cylinder of the front vehicle while braking, while slow air charging and low pressure of the brake cylinder of the rear vehicle.This makes the braking simultaneity of the front and rear vehicles of the train poor, thus causing certain train braking impact, although it is much better than hand brake in this respect.

4.2 Basic composition and principle of automatic air brake

4.2.1 Basic composition

The automatic air brake is shown in Figure 1-3.



1—air compressor; 2—main air reservoir; 3—pressure regulating valve; 4—brake valve; 5—brake pipe; 6—triple valve (distributing valve); 7—auxiliary reservoir; 8—wheel; 9—brake shoe; 10—brake cylinder; 11—brake cylinder piston rod; 12—brake cylinder restoring spring; 13—brake cylinder piston; 14—emergency brake valve.

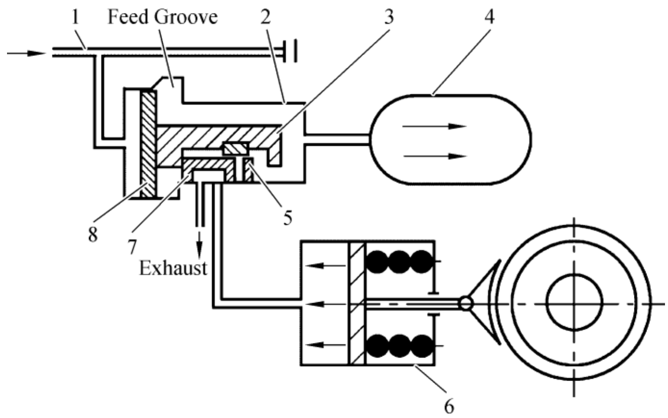
Figure 1-3 Schematic diagram of automatic air brake structure

The automatic air brake is composed of an auxiliary reservoir and a triple valve (or distributing valve) added on the basis of the straight air brake. Among them, the auxiliary reservoir is used to store the pressure air filled by the brake pipe and supply the pressure air to the brake cylinder during braking. The function of triple valve or distribution valve is to charge the auxiliary reservoir with the same pressure and exhaust the brake cylinder when the brake pipe is charged. When the brake pipe discharges, it stops the charge of the auxiliary reservoir and opens the flow path from the auxiliary reservoir to the brake cylinder at the same time.

4.2.2 Basic working principle

1. Release state

As shown in Figure 1-4, when the driver places the brake valve handle in the “release” position, the pressure air flows into the brake pipe through the passage opened by the brake valve. The piston of the triple valve loses balance and generates the right-facing pressure difference, which pushes the piston to drive the graduating valve and the sliding valve to the right. On the one hand, the Supply Groove is opened to make the brake pipe pressure air flow into auxiliary reservoir store for next braking. On the other hand, the right move slide valve opens the passage that the air in the brake cylinder is discharged into atmosphere, and finally the brake shoe is separated from the wheel to release.



1—brake pipe; 2—triple valve; 3—piston rod; 4—auxiliary reservoir; 5—graduating valve; 6—brake cylinder; 7—slide valve; 8—triple valve piston.

Figure 1-4 Schematic diagram of release state of automatic air brake

2. Braking state

As shown in Figure 1-5, the driver pulls the brake valve handle in the “brake” position. The pressure air in the brake pipe is discharged through the passage opened by the brake valve. The piston of the triple valve loses balance and forms a pressure difference to the left, which pushes the piston to move left and closes the Supply Groove so that the pressure air in the auxiliary air cylinder cannot flow back to the brake pipe. When the piston drives the graduating valve and the sliding valve to move left, the sliding valve covers the exhaust port to shut off the discharging passage of the brake cylinder, and the graduating valve opens the air passage which the auxiliary air flows to the brake cylinder. With the charging of the brake cylinder, the piston of the brake cylinder will move right, and finally the brake shoe will compress the wheel to brake.

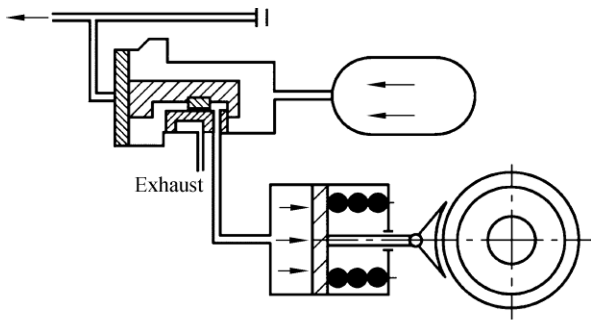


Figure 1-5 Schematic diagram of brake stage of automatic air brake

3. Pressure-holding state

As shown in Figure 1-6, the driver places the brake valve handle in a “neutral” position and cuts off the charging and discharging ventilation circuit of the brake pipe, that is, the brake pipe pressure stops changing. The pressure of the auxiliary reservoir is decreasing as the auxiliary reservoir charges the brake cylinder in braking state. When the auxiliary reservoir pressure drops to a little lower than the brake pipe pressure, the piston of the triple valve drives the graduating valve to move slightly to the right, thus cutting off the air passage of the auxiliary reservoir flowing to the brake cylinder, so that the brake cylinder is neither charged nor discharged, that is to say, the brake system is in a pressure-holding state. It can be seen that the automatic air brake has the working principle of “brake pipe charging leads to brake system release, brake pipe discharging leads to brake system braking”. Therefore, it overcomes the fatal weakness of the straight air brake that the brake system loses its braking function when the train is separated, thus it is widely used.

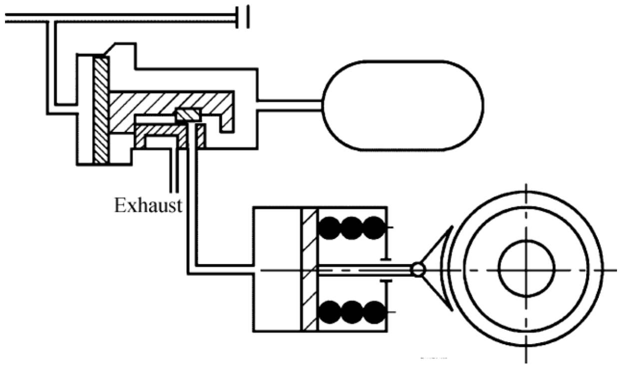


Figure 1-6 Pressure-holding state of automatic air brake

4. “Fail to safe”

Although the automatic air brake solves the fatal weakness of the straight air brake that “the braking system loses braking effect when the train is separated”, new problems have emerged. When the brake valve fails, the brake pipe cannot reduce pressure, so the brake system cannot brake. In order to solve this problem, the automatic air brake system is equipped with an emergency brake valve. When the brake valve fails and braking is required, pull down the handle of the emergency brake valve to quickly discharge the compressed air of the brake pipe to the atmosphere. This function is still retained in the current braking system. The emergency brake valve is called the last sort of brake system.

nit 5 Cognition of relay valve and the development of pressure control of brake pipe

5.1 Pressure control

In the previous study, we have already come into contact with the concept of pressure control. In the brake system, the so-called pressure control is to control the pressure of a pipe to change according to the requirements, specifically to control the pipe pressure to increase, decrease and maintain. Compressed air naturally has the characteristics of flowing from high pressure area to low pressure area. In fact, the pressure control of air pipe is to control opening and closing of the passage that the pipe connects with the external atmosphere or the pipe (general is air source) whose pressure is higher than it. The opening and closing of passage are controlled by valves. Valves need control commands when working. The control instructions can be position of valve handle, compressed air pressure change, and electrical signal etc. The opening and closing of passage can change the pressure of compressed air pipe. The output of the valve is the pressure change of corresponding pipe.

5.1.1 Pressure control of the brake pipe by brake valve

In early brake system, such as the straight and automatic air brake system, they use the same device which called brake valve to control the pressure of the brake pipe. The brake valve directly opens or closes the passage according to the handle position. That is, the handle position is the control instruction to the brake valve. When the handle position is "release", the brake valve opens the only passage that connect the regulating pipe and brake pipe. The brake pipe is charged and its pressure rises.

When the handle position is "braking", the brake valve opens the only passage that connects the exhaust and the brake pipe. The brake pipe is discharged and its pressure falls. When the handle position is "neutral", the brake valve closes all the passages. The brake pipe is neither charged nor discharged and its pressure maintains.

The direct control by brake valve is simple structure and working principle. It was widely use at that time.

5.1.2 Air wave and air wave velocity

In railway transportation, locomotives and vehicles are organized into trains. Brake pipes are slender and long, and air is an elastic substance. Therefore, when the driver controls the charging or discharging of brake pipes in the locomotive at the front of the train, the brake pipes of the whole train are not immediately and synchronously pressurized or decompressed. Taking braking as an example, first of all, the air pressure of the brake pipe near the front brake valve of the train began to decrease, which destroyed the original pressure balance. Then, the pressure drop gradually propagates backward along the brake pipe at a certain speed until the pressure at the closed part of the brake pipe at the rear end of the train begins to decrease. When the pressure drop propagates from front to back, the air pressure at the front end of the brake pipe continues to drop, and new pressure drop also propagates back. This kind of wave is known as air wave because it is formed by air pressure fluctuation propagation along the length direction of the brake pipe from forward to backward. Its propagation is a mechanical wave, just as the water surface ripple caused by throwing stones into the lake keeps spreading outward. However, it is an air wave propagating along the brake pipe, and its performance is similar to other air waves such as sound waves.

During the process of discharging air and decompression at the front end of the train and continuous backward propagation, the pressure air in the brake pipe expands continuously, and its pressure energy is continuously transformed into kinetic energy. Therefore, it continuously flows from the back to the front, and discharges to the atmosphere through the exhaust port of the brake valve. Obviously, the continuous flow of air is not the same as the propagation of pressure drop. Pressure drop propagation (air wave) belongs to a kind of vibration wave, which propagates in the medium according to the law of vibration, the continuous flow of air in the pipe is not a wave, but a continuous movement of the medium(air), so the resistance around (e.g. the pipe wall) has a great influence on it. In addition, the direction of airflow is opposite to that of pressure drop during decompression (although the direction of air wave propagation is the same as that of airflow, it is not the same thing in the case of air charging and pressurization).

Because of the loss of energy in the process of air wave propagation, the intensity of air wave is actually gradually weakening, just as the water wave caused by throwing stones in the lake expands outward and weakens gradually, so the pressure reduction speed is lower as the distance longer from the front part.

Usually, the speed of air wave propagation is measured by physical quantity-air wave velocity. The so-called air wave velocity refers to the speed of air wave propagation. The following formula can be used to calculate:

$$v_{\mathrm{aw}} = L_{\mathrm{aw}} / t_{\mathrm{aw}} \tag{1-1}$$

Where:

v_{aw} —air wave velocity;

L_{aw} —the distance of the air wave propagation;

t_{aw} —the time of the air wave propagation.

Generally, the air wave velocity is about 330 m/s.

5.1.3 Pressure control of brake pipe by relay valve

With the increasing number of train formation, the brake pipe is getting longer and longer, but the air wave velocity is relatively stable, so the time for the pressure change of the brake pipe from locomotive to the last vehicle is also getting longer and longer, and the driver directly controls the pressure change of the brake pipe by the brake valve is becoming more and more inadequate.

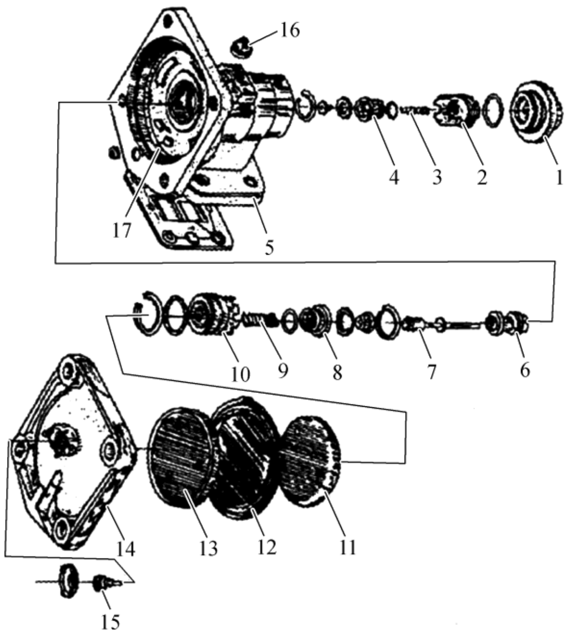
In order to control the brake pipe pressure reduction accurately and to control the braking force of train, the equalizing reservoir (volume 4 L) is set as the standard parameter to control the brake pipe pressure reduction accurately.

All of modern brakes are equipped with equalizing reservoir and relay valve. According to the pressure change of equalizing reservoir, the relay valve can automatically control the brake pipe to achieve the same pressure change that the equalizing reservoir has completed. The driver can control the pressure change of brake pipe conveniently and accurately.

5.2 The structure and working principle of relay valve

5.2.1 Structure

Dual-passage relay valves are mainly composed of the following components, as shown in Figure 1-7.



1—screw cap; 2—supply valve sleeve; 3—supply valve spring; 4—supply valve; 5—valve body; 6—valve seat; 7—drive rod; 8—exhaust valve; 9—exhaust valve spring; 10—exhaust valve sleeve; 11—inner piston; 12—rubber diaphragm; 13—outer piston; 14—overcharge cap; 15—overcharge spool; 16—exhaust choke plug; 17—choke plug.

Figure 1-7 The structure diagram of dual-passage relay valve

1. Main diaphragm piston

The sensing component is used to sense the pressure different between its two sides, thus driving the left or right movement of the drive rod to open or close the exhaust or supply valve ports, and ultimately to connect or cut off the discharging and charging air passages. It is mainly composed of inner and outer piston and rubber diaphragm.

2. Supple valve outfit

The actuating parts connecting or cutting off the air supply passage. It is mainly composed of supply valve, supply valve sleeve, supply valve spring and O-ring rubber seal (O-ring for short).

3. Exhaust valve outfit

Connecting or cutting off the executing parts of the exhaust air passage. It is mainly composed of exhaust valve, exhaust valve sleeve, exhaust valve spring and O-ring.

4. Drive rod

Follow the main piston to move and open the air supply valve port or exhaust valve port.

5. Valve seat

It is a two-way seat structure. It can respectively form a supply and exhaust valve ports with the supply and exhaust valves.

6. Overcharged spool

When overcharged spool is rapidly filled with air, additional force is produced and acted on the diaphragm piston plate to realize rapid air filling of brake pipe and to obtain overcharged pressure of brake pipe.

7. Other parts and components

Including valve body, end cap, choke plug, exhaust choke plug and rubber seals etc.

8. Connected Pipe of relay valve

As shown in Figure 1-8, each internal space of the dual-passage relay valve is connected respectively with one of the five air pipes (i.e. tube):

(1) The space on the left side of the overcharge spool is connected to the overcharge reservoir pipe.

(2) The space on the left side of the diaphragm piston (called the middle average chamber) is connected to the equalizing reservoir pipe.

(3) The space on the right side of the diaphragm piston is connected with brake pipe through a choke plug (ϕ1.0 mm), and the intermediate space of the valve seat is in communication with the brake pipe.

(4) The exhaust chamber is connected to the atmosphere.

(5) The air supply chamber is in communication with the main reservoir pipe that passes through the main reservoir cut-off valve.

5.2.2 Working principle

The basic principle of the double-valve relay valve is that the difference of forces acting on both sides of the diaphragm piston is changed according to the change of the pressure of the equalizing reservoir, so that the diaphragm piston drives the drive rod to move left and right, and opens the air supply valve orifice or exhaust valve orifice to connect or cut off the discharging or air supply circuit of the brake pipe, so as to realize the brake pipe charging and discharging. At last its pressure is equal to the pressure of equalizing reservoir. Dual-passage relay valves have four operating positions.

1. Charging position (as shown Figure 1-8)

As the pressure of the equalizing reservoir increase, the pressure on the left side of the diaphragm piston plate increase, causing it to exert a force to the right. Therefore, the diaphragm piston plate drives the drive rod to move to the right, and compresses the spring of the supply valve to push the supply valve to move to the right, thus opening the supply valve port, the pressure air of the main reservoir coming from the main reservoir cut-off valve (hereinafter referred to as the main air, the pressure ranges from 700 kPa to 900 kPa). The main air flows to the brake pipe through the opened supply valve port, and the air of brake pipe flows to the right side space of the diaphragm piston plate through the choke plug (ϕ1 mm).

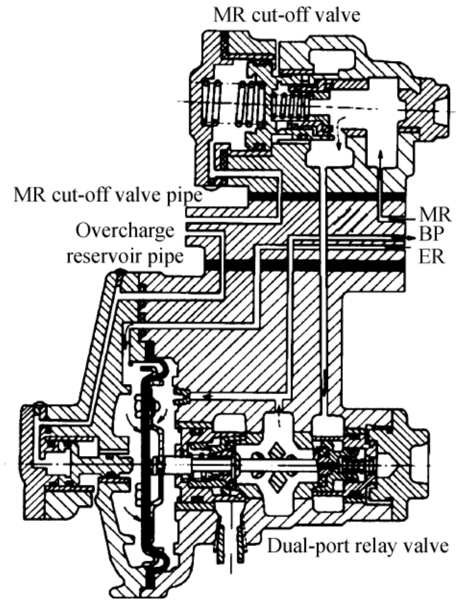


Figure 1-8 Schematic diagram of charging position of relay valve

2. Maintaining position after charging

When the equalizing reservoir is filled to specified pressure (500 kPa or 600 kPa), its pressure is stability. With the pressure increasing of brake pipe and the right side of diaphragm piston plate for their charging, the pressure on the left side of diaphragm piston plate is gradually balanced. Under the action of supply valve spring, the supply valve pushes the drive rod and diaphragm piston plate to the left and gradually reduces the air supply valve port opening until it closes. At the same time, the drive rod and diaphragm piston plate stop moving left and cannot open the exhaust valve port, so that it is in the pressure-maintaining state that the supply and exhaust valve ports are all closed.

When the brake pipe leaks, the pressure on the right side of the diaphragm piston plate of the double-port relay valve decreases, and the pressure difference on the diaphragm piston plate produces a force to the right. Therefore, the diaphragm piston plate drives the drive rod to the right and opens the air supply valve port to charge the brake pipe, while the right side of the diaphragm piston plate pressure increases too. When the brake pipe pressure is balanced with the pressure on the left side of the diaphragm piston plate, under the force of the supply valve spring, the valve port is closed to complete the air charging process. It can be seen that the air supply function is automatically carried out with the leakage of the brake pipe.

3. Braking position (as shown Figure 1-9)

As the decrease of equalizing reservoir pressure, the pressure of the left side of diaphragm piston decrease, the pressure difference on the diaphragm piston produces a left direction force, so that the diaphragm piston drives the drive rod to move left, it pulls the exhaust valve to move left by overcome the force of exhaust valve spring, the exhaust valve port is opened, the brake pipe is discharged, at the same time the air in the right side of diaphragm piston is discharged through the choke plug and the exhaust valve port.

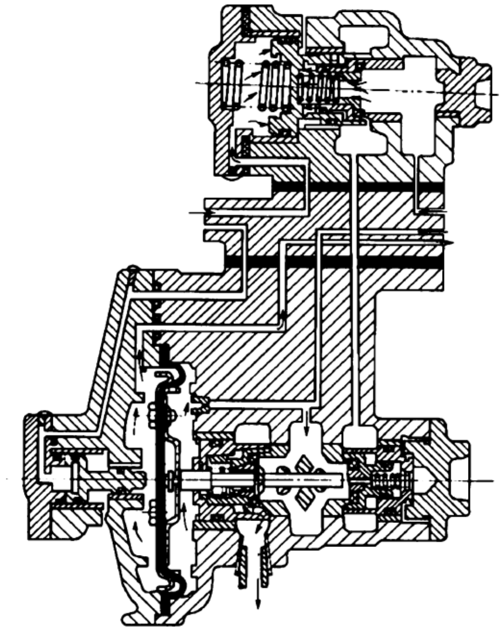


Figure 1-9 Schematic diagram of braking position of relay valve

4. Maintaining after braking

When the equalizing reservoir pressure maintains for complete the prescribed pressure reduction, the pressure on the left side of the piston remains unchanged. With the pressure decrease of the brake pipe and the right side of diaphragm piston plate, the pressure on the left side of diaphragm piston plate is gradually balanced. Under the force of exhaust valve spring, the exhaust valve pushes the drive rod and diaphragm piston plate to the right, until the pressure on both sides of diaphragm piston plate is balanced, the exhaust valve port is closed, thus cutting off the discharging air passage of brake pipe. At the same time, the drive rod and diaphragm piston plate stop moving to the right, and cannot open the air supply valve port, so that it is in the pressure-maintaining state without opening the exhaust valve port and the air supply valve port.

Similarly, when the brake pipe leaks, the dual-passage relay valve will also perform the automatic air supply function. At present, most of the locomotive brakes in our country use two pressure mechanism distribution valves, which have only direct release performance. Therefore, in actual operation, the automatic air supply function is removed through the main reservoir cut-off valve to avoid the occurrence of natural release and endanger the operation safety.

Further analysis shows that if the diaphragm piston plate of the dual-passage relay valve is communicated on both sides, i.e. the equalizing reservoir and the brake pipe, the difference of effective force cannot be formed on the diaphragm piston plate, thus the supply and exhaust valve ports of the dual-passage relay valve cannot be opened. It is customarily said that the dual-passage relay valve is in the self-locking state at this time. Obviously, the condition for the self-locking status of the dual-passage relay valve is to make the brake pipe communicate with the balanced air cylinder.

Unit 6 The development of brake cylinder pressure control

6.1 The inadequacy of triple valve

With the development of locomotive and vehicle braking technology, the requirement of brake cylinder pressure control is becoming higher and higher. Mainly manifested in the following aspects:

(1) Establish brake cylinder pressure as quickly as possible to shorten idling braking time and idling stopping distance.

(2) When the brake cylinder leaks, it should be able to replenish the air in time to keep the pressure of the brake cylinder unchanged so as to ensure that the locomotive and vehicle have enough braking force.

(3) In emergency braking, the brake cylinder should be charged in the shortest time to the maximum pressure of 450 kPa that the brake system can allow, so as to make the locomotive and vehicle stop quickly.

(4) Some trains, especially passenger trains, want to adopt graduated release to reduce impulse and improve comfort.

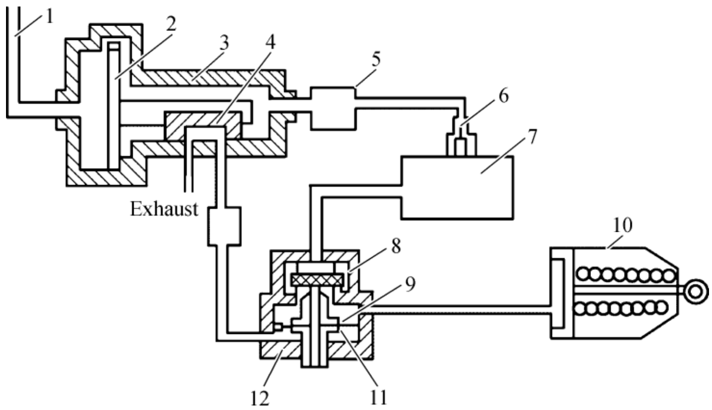
(5) Realize the multi-control of the brake cylinder pressure of locomotive, so as to

make the braking and release of locomotive and vehicle different when necessary.

We review the working principle of the triple valve and find that the above requirements correspond to the shortcomings of the triple valve one by one. Firstly, the feel groove opened at the charging position of the triple valve cannot be closed after the completion of air filling. Keeping the feed groove open has two consequences, one good and the other bad. On the one hand, it guarantees the stability of the brake, but it has little significance for the control of the relay valve which can be supplemented at any time for the leakage of the brake pipe. The bad one is that it prolongs the time that the piston of the triple valve changes to the brake position, that is, it prolongs the idling braking time and the idling stopping distance. Because the piston of the brake cylinder is pushed to the left by the restoring spring of the brake cylinder piston at the charging position, when the compressed air from the auxiliary reservoir pushes the piston of the brake cylinder to the right, the pressure of the brake cylinder is equivalent to the vacuum, so the speed of establishing the pressure of the brake cylinder is relatively slow, and the idling braking time and idling stopping distance are also prolonged. Secondly, because all the passages are cut off at pressure maintaining position, the leakage of the brake cylinder cannot be compensated, that is to say, with the leakage of the brake cylinder, the braking force will gradually decrease. Thirdly, due to the limited volume of the auxiliary reservoir, even if it is balanced with the pressure of the auxiliary reservoir, the maximum pressure that the brake cylinder can get is less than 450 kPa which needed in emergency. Fourthly, the triple valve can only direct release, as long as the brake pipe is charged in the maintaining position after braking, the brake cylinder will exhaust and completely release. Finally, the triple valve controls the brake cylinder directly, so it cannot realize the multi-control of the brake cylinder pressure of locomotive.

6.2 Overview of air distributing valve

In order to solve the above problems, similar to the relay valve controlling the pressure change of brake pipe according to the pressure change of equalizing reservoir, the modern brake system first changed the pressure control of brake cylinder to indirect control. As shown Figure 1-10.



1—brake pipe; 2—main piston; 3—distributing valve; 4—slide valve; 5—working reservoir; 6—check valve; 7—auxiliary reservoir; 8—balance valve; 9—balance piston; 10—brake cylinder; 11—volume chamber; 12—relay valve.

Figure 1-10 The schematic diagram of air distributing valve structure

Compared with the triple valve, which directly controls the pressure change of the brake cylinder according to the pressure change of the brake pipe, indirect control adds the working air cylinder, volume chamber and relay valve, as shown in the Figure 1-10. The triple valve controls the pressure change of the volume chamber according to the pressure change of the brake pipe. Its working principle is similar to that of the automatic air brake, except that the pressure of the volume chamber is established from the atmospheric pressure, and its air source is replaced by the working reservoir. Because of the function of the check valve, the auxiliary air cylinder does not participate in the pressure control of the volume chamber, but only acts as the pressure air source of brake cylinder. According to the pressure change of the volume chamber, the relay valve finally controls the pressure of the brake cylinder to be equal to the volume chamber, and the leakage of the brake cylinder can be supplemented at any time. At this time, although the brake cylinder is still built up from the vacuum, because the volume chamber is built up from the atmospheric pressure, the pressure of the brake cylinder and the volume chamber is equal quickly through the large flow of the relay valve, which improves the speed of the brake cylinder pressure establishment. Because the pre-control pressure of the relay valve can be controlled by multiple channels, it can realize the multi-control of locomotive brake. This basically solves 1, 2 and 5 of the above problems.

Later, the triple valve was evolved into an air distributing valve. Some of the distributing valves were designed as three-pressure mechanism, which could realize the graduated release function. Distributing valves are designed with main valve part, balance part and emergency part. Main part is similar to triple valves, but with quick service position. When the charging release position changes to the braking position, the brake pipe is opened to fill the air in the quick service chamber, which causes an additional pressure drop of the brake pipe, accelerates the service braking speed, and partially solves the braking delay caused by the opening of the supply groove. The balance part is equivalent to the relay valve. The emergency booster part can charge the volume chamber to 450 kPa when the emergency braking is happened. From the above, the distributing valve basically solves the problems mentioned earlier.

Modern computer control brakes use electronic distributing valves to control the pressure change of the volume chamber according to the pressure change of the brake pipe. Because the high-speed solenoid valves respond to the change of electronic instructions quickly to open and close the air passage, the delay of service braking is reduced to the greatest extent. Furthermore, it controls the pressure more accurately than the air distributing valve. It becomes the general device when normal running. That is the performance of brake is focus on the electronic distributing valve. The air distributing valve is not important for modern brake system. But for the sake of fail-safe, the triple valve or air distribution valve must be installed on the locomotive as a safe backup of the electronic distributing valve.

We will introduce the electronic distributing valve in the next project.

ıit 7 Multi-control of locomotive brake cylinder pressure

7.1 Multi-control of locomotive brake

When we control the locomotive brake to braking and release, it is required not only to synchronize braking and release with vehicle, but also to realize locomotive braking and release individually. With the development of rolling stock technology, the train requires multiple locomotives to improve traction force and braking force. Because of the strong braking capacity of locomotives, the smaller pressure difference between the brake cylinders between locomotives will lead to greater impulse, and may even cause the coupler to break. In order to avoid this situation, the trail locomotives must have the same brake cylinder pressure with the lead locomotive. All these require that the pressure control of locomotive brake cylinder should realize multi-control.

7.1.1 Automatic braking action

According to the change of brake pipe pressure to control the change of volume chamber pressure and then to control the braking and release of locomotives and vehicles is called automatic braking function.

7.1.2 Independent braking action

In order to control the braking and release of locomotives individually, an independent application pipe is added to the locomotive brake system. The driver controls the pressure change of the independent application pipe through different positions of the independent brake valve handle, and then controls the braking and release of the locomotive individually. In the brake system, it is generally called the independent braking function.

7.1.3 Multiple locomotive brake cylinder control

When multiple locomotives traction, that is, there are two or more sets of brakes. There must be one set as operating brake, i.e. lead brake system, others as non-operating brake, i.e. trail brake system. In order to minimize the braking and release impulse among the multiple locomotives, the trail locomotives should achieve the same brake cylinder pressure with lead locomotive through the brake cylinder equalizing pipe.

From above, the pressure of pre-controlled brake cylinder (general called application pipe) is determined by three aspects. They are volume chamber, independent application pipe and brake cylinder equalizing pipe. Generally speaking, braking priority is adopted. That is, the highest pressure among the three aspects will be the pressure of application pipe. The brake system uses the double check valve to achieve it.

At last, the brake system uses relay valve to control the pressure of brake cylinder to maintain the same pressure with application pipe. The brake cylinder can be replenished as soon as leakage. This causes conveniently use of the anti-slip device.

(1) The principle of control pressure of brake cylinder of lead locomotive is shown in Figure 1-11.

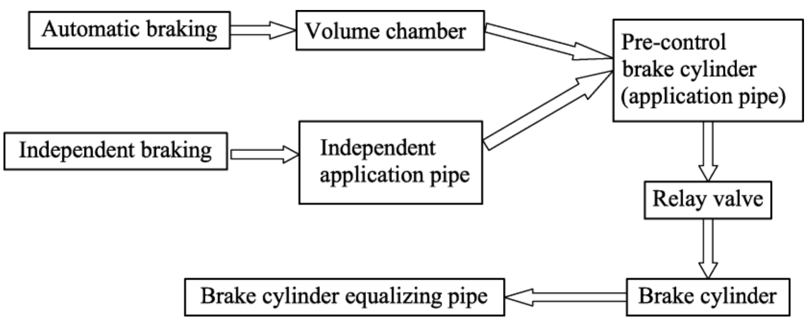


Figure 1-11 The block diagram of lead locomotive brake cylinder pressure control

(2) The principle of control pressure of brake cylinder of trail locomotive is shown in Figure 1-12.

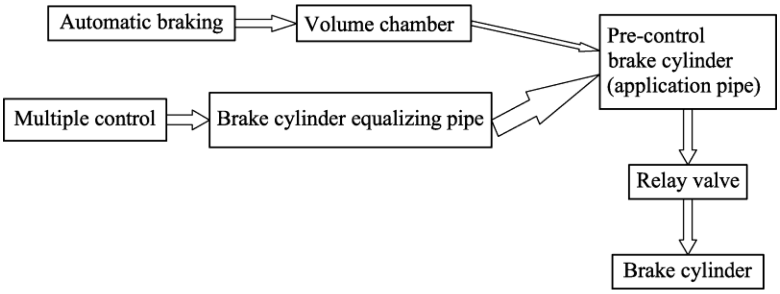


Figure 1-12 The block diagram of trail locomotive brake cylinder pressure control

(3) The pressure control of brake cylinder equalizing pipe.

To realize the same pressure control of brake cylinder of multiple locomotives, the multiple valve is adopted in the brake system. The action of the multiple vale is shown in Figure 1.13.

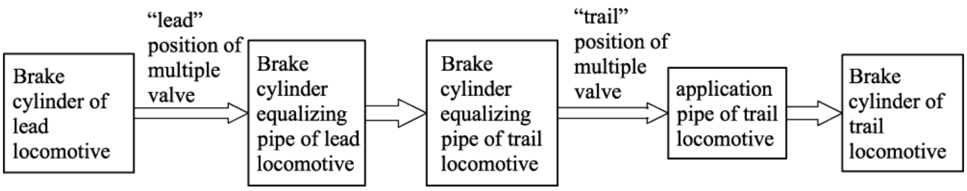


Figure 1-13 The schematic diagram action of the multiple vale

7.2 The structure and working principle of multiple valve

7.2.1 Structure of multiple valve

Multiple valve mainly consists of lead-trail changeover part, multiple part, the shutoff valve part of brake cylinder, valve body and pipe seat etc. Its external connection pipe includes action pipe, brake cylinder equalizing pipe, main reservoir multiple pipe and brake cylinder pipe. As shown Figure 1.14.

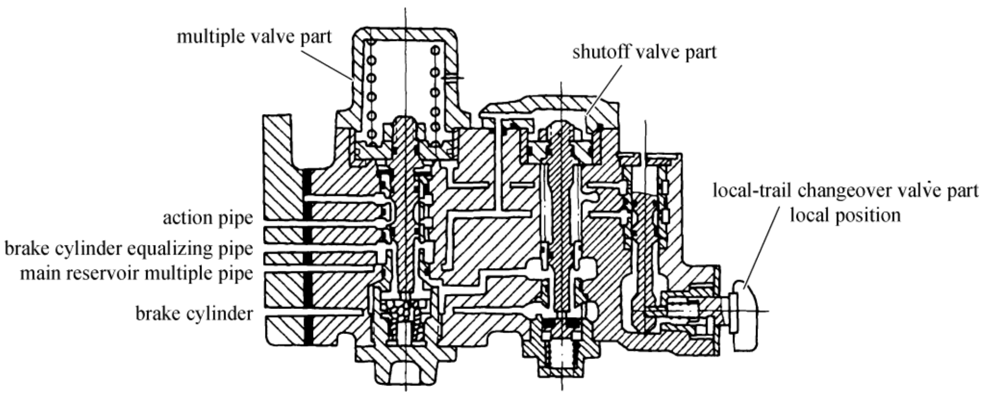
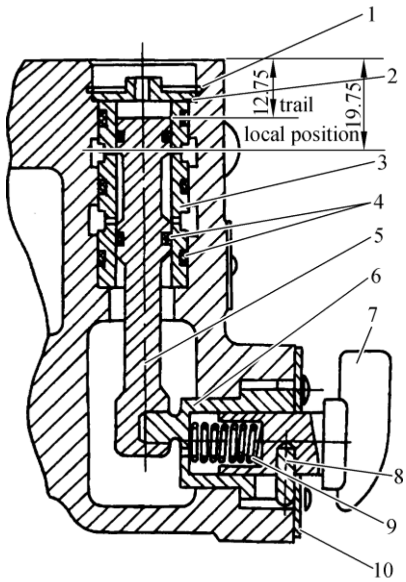


Figure 1-14 Structure schematic of multiple valve(lead position)

1. Lead-trail changeover valve part

The lead-trail changeover valve is a manual control valve, which is mainly composed of changeover button, eccentric rod, spring, valve sleeve, spool, O-ring, sign plate and elastic stop collar, cover and positioning pin, as shown in Figure 1-15.



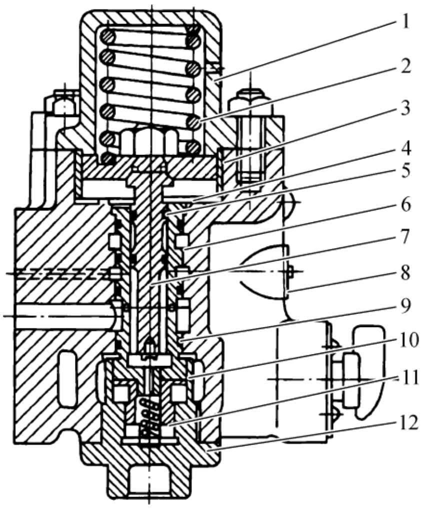
1—elastic stop collar; 2—cover; 3—valve sleeve; 4—O-ring; 5—spool; 7—changeover button; 8—positioning pin; 9—sping; 10—sign plate.

Figure 1-15 Structure diagram of lead-trail changeover

There are two working positions that includes of “lead position” and “trail position” in the lead-trail changeover valve part. Under the function of spring and positioning pin, the changeover button is kept in a fixed position. If the working position is to be changed, the changeover button must be pushed inward first, then rotated 180 degrees to the target position, and then loosened. The switch button drives the eccentric rod to rotate, thus driving the spool to move up and down in the valve sleeve to connect or cut off the corresponding air passage. Among them, at the lead position the spool moves down and cuts off the air passage between the main air multiple pipe and the lower side of the piston of the multiple valve part, and connects the air passage between the lower side of the piston of the multiple valve and atmosphere. At the trail position the spool connects the air passage between the main air reservoir multiple pipe and the lower side of the piston of the multiple valve.

2. Multiple valve part

The multiple valve part is mainly composed of piston, piston rod, spring, sleeve, O-ring, check valve and check valve spring, as shown in Figure 1-16.



1—Top cover of multiple valve; 2—multiple valve spring; 3—multiple valve piston; 4—elastic stop collar;
5, 9—O-ring; 6—multiple valve sleeve; 7—piston rod; 8—factory name plate;
10—check valve; 11—check valve spring; 12—lower cover.

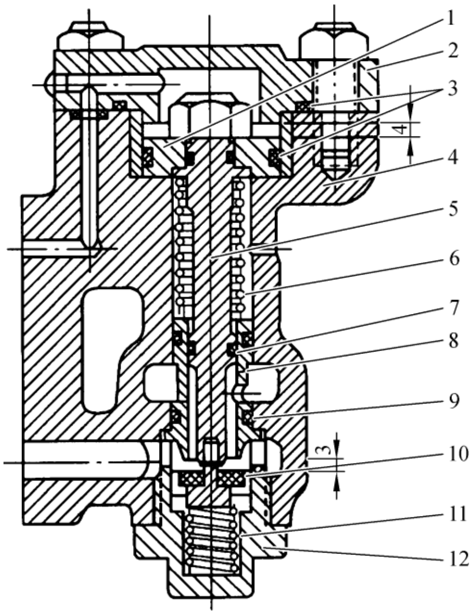
Figure 1-16 Structure diagram of multiple valve

The working position of the multiple valve part is controlled by the lead-trail changeover valve part. When its changeover button is placed in different positions, the multiple valve's piston rod moves up and down according to the force difference between the upper and lower sides of the piston, closes or opens the check valve, and connects or cuts off the corresponding air passages by the check valve or O-rings.

3. Brake cylinder shutoff valve part

Brake cylinder shutoff valve part is mainly composed of piston, piston rod, spring, valve sleeve, O-ring and check valve, check valve spring and so on, as shown in Figure 1-17.

Under normal operation, it means that the pressure of the main reservoir multiple pipe is 750 kPa to 900 kPa. The piston and piston rod of the brake cylinder shutoff valve move down to eject check valve to open the passage between the brake cylinder and the corresponding pipe. Once the separation occurs that caused by couplers broken between the locomotive, the main air reservoir multiple pipe is pulled to break and exhaust, its pressure decreases to zero quickly, due to the low pressure of the main air reservoir multiple pipe, the piston rod moves upward under the action of the shutoff valve spring, and the check valve closes, which cuts off the air passages between the brake cylinder and the corresponding pipe, and maintains the pressure of the locomotive brake cylinder.



1—brake cylinder shutoff valve piston; 2—top cover; 3, 7, 9—O-Ring; 4—multiple valve body;
5—piston rod; 6—shutoff valve Spring; 8—shutoff valve sleeve; 10—check valve;
11—check valve spring; 12—shutoff valve lower cover.

Figure 1-17 Structural diagram of brake cylinder shutoff valve (normal Position)

7.2.2 Working principle of multiple valve

When a locomotive is used as a lead locomotive, the changeover button shall be placed in the "lead" position, when a locomotive is used as a trail locomotive, the changeover button shall be placed in the "trail" position. Under the pure air mode, the same is true.

1. Lead position (see Figure 1-18)

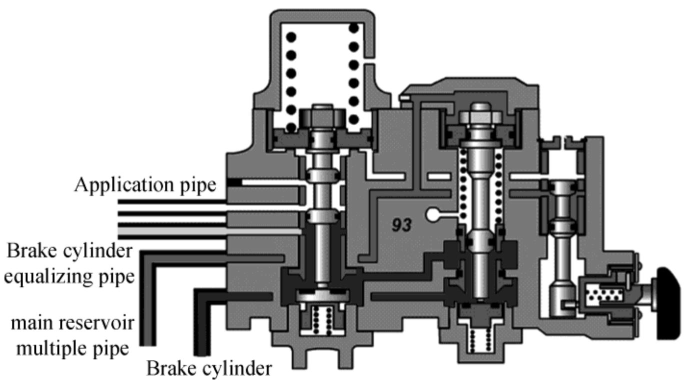


Figure 1-18 Lead position

When the changeover button is placed in the lead position, the valve spool connects the air passage between the lower side of the piston and atmosphere, under the action of the multiple valve spring, the piston of the multiple valve drives the piston rod down and ejects the check valve to open the air passage between the brake cylinder equalizing pipe and the upper side of the check valve of the brake cylinder. At the same time, the air from main air reservoir multiple pipe (750-900 kPa) flows to the upper space in the piston of the shutoff valve of the brake cylinder, so that the piston drives the piston rod down to compress the spring and ejects the check valve to open, thus connecting the air passage between the brake cylinder and the upper side of the check valve of the shutoff valve part of the brake cylinder. Therefore, in lead position, the air passage between the brake cylinder and the brake cylinder reservoir pipe is connected to prepare for the same change of the brake cylinder pressure of the multiple locomotives.

When the lead locomotive brake is braked or released, the pressure change of the brake cylinder is transferred to the brake cylinder equalizing pipe of the multiple locomotive through the passage connected by multiple valve, brake cylinder equalizing pipe of lead locomotive, the cock and the hose of brake cylinder equalizing pipe.

In operation, once the separation caused by coupler broken occurs, the connecting hoses such as brake pipe, main air reservoir multiple pipe and brake cylinder pipe are pulled off, and the locomotive does emergency braking. At the same time, due to the rapid drop of pressure in the main air reservoir multiple pipe, the piston of the brake cylinder shutoff valve drives the piston rod up and closes the check valve orifice under the action of its spring, thus cutting off the passage between the brake cylinder pipe and the upper space of check valve, so as to prevent the pressure air of the brake cylinder from exhausting to the atmosphere through the check valve and the broken brake cylinder equalizing pipe, and ensure the reliable implementation of emergency braking of the lead locomotive.

2. Trail position (see Figure 1-19)

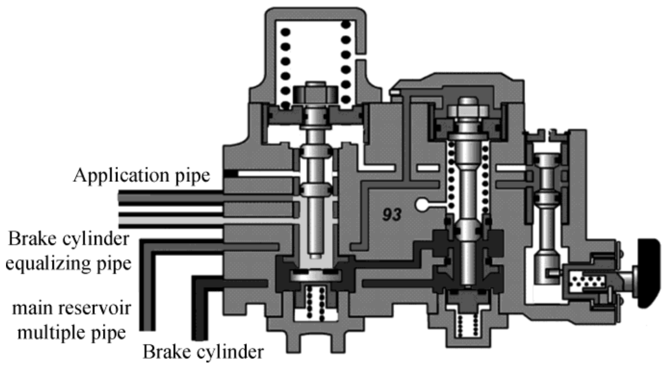


Figure 1-19 Trail position

When the changeover button is placed in the trail position, the lead-trail changeover valve part connects the air passage between the main air reservoir multiple pipe and the lower side of the piston of the multiple valve, enables the piston of the multiple valve part to compress spring of and drive the piston rod upward, closes the check valve port, and connects the air passage between the action pipe and the brake cylinder equalizing pipe. Under the action of pressure air of main air reservoir pipe (750-900 kPa), the shutoff valve piston drives the piston rod down by compress spring and ejects the check valve to open, which connects the brake cylinder with the upper side of the check valve. However, because the check valve in the multiple valve part is closed, the brake cylinder air passage in the multiple valve is closed by the check valve in multiple valve part. Therefore, at the trail position, the communication between the action pipe and the brake cylinder reservoir pipe makes the pressure change of the brake cylinder of the lead locomotive pass through the brake cylinder equalizing pipe to the action pipe of the trail locomotive. After the action of the equalizing part of the distribution valve of the trail locomotive, the pressure change of the brake cylinder of the trail locomotive is ensured to be same with the pressure change of the lead locomotive brake cylinder.

In operation, once the separation caused by coupler broken occurs, the connecting hoses such as brake pipe, main air reservoir multiple pipe and brake cylinder equalizing pipe are pulled off, and the lead locomotive does emergency braking. Due to the rapid drop of pressure in the main air reservoir multiple pipe, the piston of the shutoff valve part of the brake cylinder of the trail locomotive, under the action of its spring, drives the piston rod upward, closes the check valve port, and cuts off the passage between the brake cylinder pipe and the brake cylinder equalizing pipe, at the same time, the multiple valve piston drive the piston rode down under the force of spring, which cuts off the passage between the brake cylinder reservoir pipe and action pipe, moreover, the distributing valve of the multiple locomotive will automatically produce an emergency braking because the pressure air of the brake pipe is rapidly exhausted.

Unit 8 Control logic of modern brake

8.1 The role of modern brake system

With the development of the brake, especially the locomotive development, the function of the brake is more and more perfect. Of course, the structure and working principle of the brake are more and more complex. For the typical locomotive brake at present, the following functions need to be completed mainly:

(1) Provide compressed air for locomotive and vehicle brakes.

(2) Control the braking and release of the locomotive itself.

(3) Provide and transmit control signals and pressure air required for braking and release of vehicles through brake pipe to the vehicle brake.

8.2 The composition and control relationship of modern brake systems

In order to accomplish the above functions, the brake system mainly includes the brake rigging to realize energy conversion and the brake to control energy conversion. Because the brake rigging is a pure mechanical structure, its working principle is similar to the early automatic air brake system. With the development of brake, the pressure control of brake cylinder has also made great progress. Therefore, when learning the brake system, we should focus on the brake cylinder pressure change control. Modern brakes are generally composed of operating parts, control parts and executive parts. Operating parts are the command parts of drivers and maintenance personnel. By moving the handle of the operating parts in different positions, the target commands for brake operation are output. According to the fed back of actual state of the brake from the executive part and the target command, the control part outputs the corresponding control instructions to executive part. The executive parts work according to the control instructions, and ultimately realize the pressure change control of all pipes of the brake. Because there are many pipes in the brake, it is difficult to learn the brake. In order to solve this problem, first of all, we need to know the name of each pipeline and its functions in the brake. Then, taking the pressure change control of each pipeline in the brake as the main line, we draw the control logic block diagram of the brake as shown in the figure.

The main pipes in modern brakes are as follows: brake cylinder pipe, main air reservoir pipe, brake pipe, equalizing reservoir pipe, volume chamber, independent application pipe, brake cylinder equalizing pipe and application pipe.

8.2.1 Brake cylinder pipe

It is the intermediate link between the brake and the brake rigging to form the brake system. The final control object of locomotive brake is to control the energy conversion of brake system through its pressure change. The braking force formed by compressed air acting on the piston of the brake cylinder is the basis of the work of the brake rigging.

8.2.2 Main air reservoir pipe

It is the output of locomotive air supply system. It is the air source of train brake system. It is produced, dried, purified and stored by the air supply system, and the pressure is controlled at 750-900 kPa. The maximum pressure of main reservoir shall not exceed 950 kPa.

8.2.3 Brake pipe

It distributes along the train length direction, is connected to a thin and long pipe through the brake hose and opened cock to make the whole train coordinated braking and release. The locomotive brake transmits control instructions and compressed air for braking and release to the vehicle brake by controlling its pressure change, thus realizing the control of vehicle braking and release. At the same time, the locomotive brake controls the pressure change of the volume chamber by the distributing valve according to its pressure change, and finally realizes the automatic braking function of the locomotive brake.

8.2.4 Equalizing reservoir pipe

It is set for locomotive brake to make the driver control the pressure change of brake pipe conveniently and accurately. The relay valve controls the pressure change of brake pipe according to its pressure change. The main purpose is to solve the shortage of direct control of brake pipe pressure change.

8.2.5 Volume chamber

It is an intermediate control pipe for solving the shortage of directly control of brake cylinder by triple valve. Its pressure is a part of the pressure control of application pipe to ensure the automatic braking function of locomotive brake.

8.2.6 Independent application pipe

It is designed to realize the independent braking and release of locomotive. The pressure change of the independent application pipe is directly controlled by the independent brake valve, and its pressure is also a part of the pressure control of the application pipe.

8.2.7 Brake cylinder equalizing pipe

To ensure that the pressure of the brake cylinder of the trail locomotive is the same as that of the lead locomotive, so that all locomotives braking and release performance are synchronized and the impulse between locomotives is reduced.

8.2.8 Application pipe

It is an important intermediate variable of locomotive brake system. Its pressure is determined by three pipes: volume chamber, independent application pipe and brake cylinder equalizing pipe. The locomotive brake keeps the pressure of the locomotive brake cylinder same as the pressure of the application pipe through the relay valve (or valve parts similar to its working principle). Therefore, by controlling the pressure of the application pipe, the pressure of the locomotive brake cylinder can be controlled, thus realize the multi-control of locomotive brake.

8.3 Control relations of pipes in brake system

(1) The braking and release of locomotive are controlled by the pressure change of brake cylinder in the brake rigging of locomotive. At the same time, the realization and control of energy conversion in braking process are completed.

(2) The braking and release of vehicles are controlled by the pressure change of the vehicle brake cylinder.

(3) The pressure change of the vehicle brake cylinder is controlled by the vehicle brake according to the pressure change of the brake pipe controlled by the locomotive.

(4) The pressure change of locomotive brake cylinder is controlled according to the pressure change of locomotive application pipe.

(5) There are three kinds of control modes in locomotive brake: the first one is automatic braking controlled by pressure change of volume chamber, the second is individual braking controlled by pressure change of independent application pipe, and the third is pressure change of brake cylinder equalizing pipe as the trail locomotive.

(6) The pressure change of brake pipe is controlled according to the pressure change of locomotive equalizing reservoir when service braking and release. When emergency braking, the pressure change of brake pipe is controlled by the emergency vent valve and emergency valve, in this situation, brake pipe is quickly discharged to 0 with 3 s.

(7) The pressure change of the equalizing reservoir is directly controlled by the driver.

(8) The pressure change of the main air reservoir is controlled by the locomotive’s air supply system.

8.4 The control logic of locomotive brake

(1) The control logic of lead locomotive brake is shown in Figure 1-20.

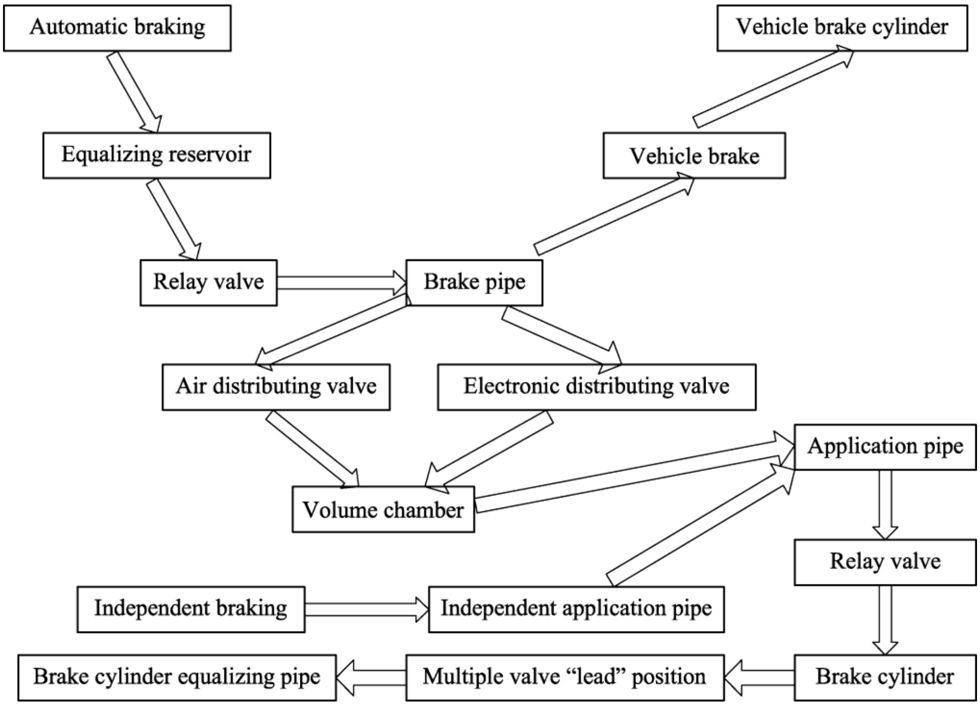


Figure 1-20 Logic block diagram of lead locomotive brake control

(2) The control logic of trail locomotive brake is shown in Figure 1-21.

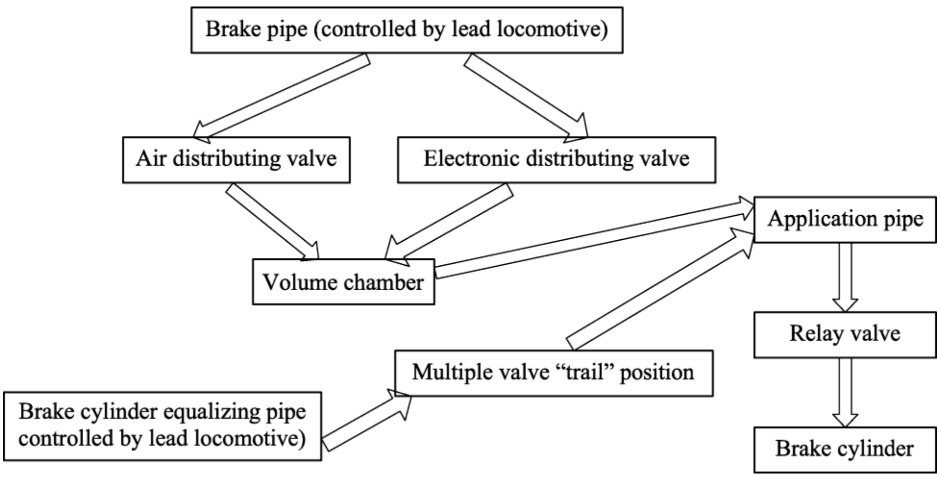


Figure 1-21 Logic block diagram of trail locomotive brake control