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——铁道机车运用与维护专业

Train Operation Safety Equipment

列车运行安全装备

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PREFACE

Safety is the lifeline of railway transportation and the eternal theme of transportation production. Railway transport safety not only affects the production efficiency and economic benefits of enterprises, but also has a significant impact on society and economy. Track circuit, locomotive signal, Locomotive integrated radio communication equipment (CIR), and train tail device provide an effective guarantee for the safety of train operation.

Train operation monitoring and recording device is referred to as monitoring device, abbreviated as LKJ, which is a train speed monitoring device developed by Chinese railway to ensure the safety of train operation.

The device not only realizes the safe control of train speed, but also collects and records all kinds of locomotive running state information related to the safe operation of the train, which promotes the automation of locomotive running management.

LKJ operation record data processing system is the core subsystem of LKJ ground data processing and analysis system. Its main function is to record and process parameters in the form of files, such as the state information of LKJ and its related on-board equipment during train operation, the operation standardization of drivers and passengers and on-board equipment testing personnel. Its processing results are used for quality and safety analysis or grading, so as to prevent the occurrence of traffic safety accidents from the source, and provide important basis for post-analysis of train operation accidents.

Locomotive 6A system, namely, locomotive on-board safety protection system, is an important device for safety protection of key parts of locomotive operation.

This book as an integrated teaching textbook is written for the training of electric locomotive drivers of Yaji Railway. This book mainly contains the following contents: the composition, working principle and operation method of track circuit, locomotive signal, Locomotive integrated radio communication equipment (CIR) and train tail device; the functional composition of LKJ2000 monitoring device, the operation of LKJ monitoring

device and the necessary skills of locomotive crew, which is divided into several task modules and combines theoretical knowledge with practical training. 6A system is to expand knowledge and help students to establish a comprehensive knowledge system of train operation safety equipment.This book is edited by Zhang Qiongjie, Dang Jianmeng , Zhang Hongtao and Ma Zhuo of Zhengzhou Railway Vocational and technical college. Zhang Yuan, senior engineer of China Railway Zhengzhou Bureau Group Co., Ltd. The specific preparation division is as follows: Zhang qiongjie prepared chapters 1, 2 and 3 and the full text unified draft , DangJianmeng prepared chapters 4, 5, 6, 7, 8 and 9, and Zhang Hongtao prepared chapters 10, 11, 12 and 13. Ma Zhuo is responsible for the English translation of the full text of this book.Zhang Yuan is responsible for reviewing the manuscript of the book.

Due to the limited level of editors, irregularities are inevitable. I urge readers to criticize and correct them.

CONTENTS

Chapter 1

Track Circuit

1.1 Concept

Two rails are used as the conductor, rail insulations are installed on both ends of the rail in the certain length , rail bonds are used to connect the middle of the rail gap, fixture wires are used to connect power source and receiving device , this circuit is called track circuit.

Introduction of course+track circuit

The simplest track circuit, as shown in the figure, consists of rails, insulation joints, rail end connectors, transmitter and receiver (rail relay). The transmission end of the track power supply is the track power supply and the current limiter. The function of the current limiter is to protect the power supply from damage caused by overload, and to ensure that the track relay can fall reliably when the train occupies the track circuit. At the other end of the receiver, relay is generally used. We call it track relay, which receives the current signal of track circuit.

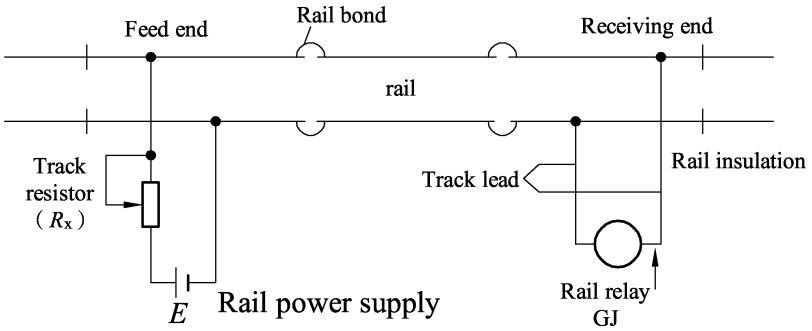

Fig.1-1 Composition of track circuit

Rail insulation is installed in the boundary of a track circuit to limit current to flow within the given section of track circuit and to ensure to have reliable electrical insulation

between adjacent track circuits without any affection to each other.

Rail bonds are used to connect two rails to reduce the resistance of the rail joint and to improve the electrical conductivity.

The power supply equipment (DC or AC) is used to supply power to track circuit at one end of the track circuit.

There is track resistor in the feed end of DC or AC track circuit, they are used to adjust the voltage value of track circuit.

Track relays are connected at the other end of track circuit to reflect the working state of track circuit.

1.2 Working principle

When the train does not enter the track section, the current will start from the positive pole of the power supply, and though the rail reach the coil of the track relay and then return to the other rail to reach the negative pole of the power supply. If there is enough current in the track relay coil, the relay will be up. The front node closes when the rear node of the relay is disconnected. The green light circuit is turned on to light the green light, indicating that the track circuit is idle. If a car occupies the track section, when the track circuit is occupied by the train, the track circuit will be divided by the wheels of the train. Because the wheel-to-wheel resistance is much smaller than the coil resistance of the track relay, the current flowing through the track relay will be greatly reduced. Most of the positive poles of the current track power supply start to flow through the wheel-to-rail to the negative poles of the power supply. At this time, the current in the track relay coil is relatively small, which is not enough for the track relay to suck up, so the armature is released. The release of armature disconnects the front node, closes the back node, turns on the red light circuit and lights the red light. The track circuit is occupied.

1.3 Function

（1）Supervise the occupancy of trains.

（2）Transmit the traffic information.

For example, frequency shift automatic block is to use the track circuit to transmit different frequencies to reflect the position of the forward train, determine the signal display, and provide commands for train operation. In addition, the traveling information transmitted in the track circuit directly provides the information of the position of the train ahead, the status of the signal in front of the train and the condition of the line for the

automatic train operation control system, determines the target speed of the train operation, and controls whether the train needs to stop or decelerate at the current running speed. Therefore, track circuit is widely used as a channel to transmit traffic information.

（3）Track breakage inspection.

1.4 Classification

（1）Classification by the nature of signal current, Track circuit can be classified into DC track circuit and AC track circuit.

（2）Track circuit can be classified into close type track circuit (shown in figure 1-2) and open type track circuit (shown in Figure 1-3)according to the connection mode (both are confirmed by the state of track circuit when there is no car occupancy at ordinary times).

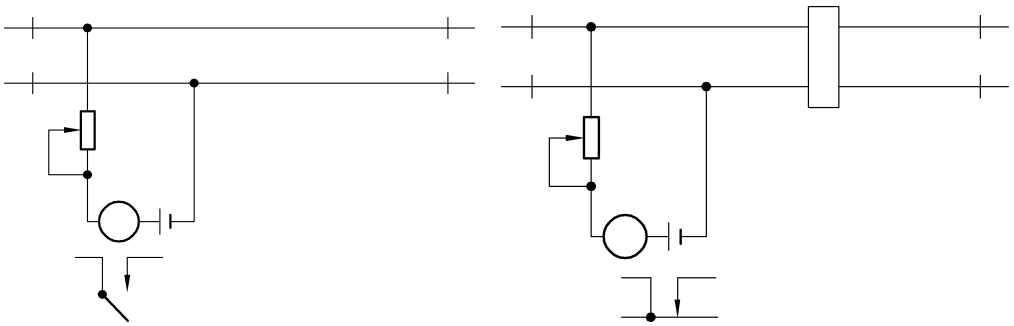

Fig.1-2 Close type track circuit

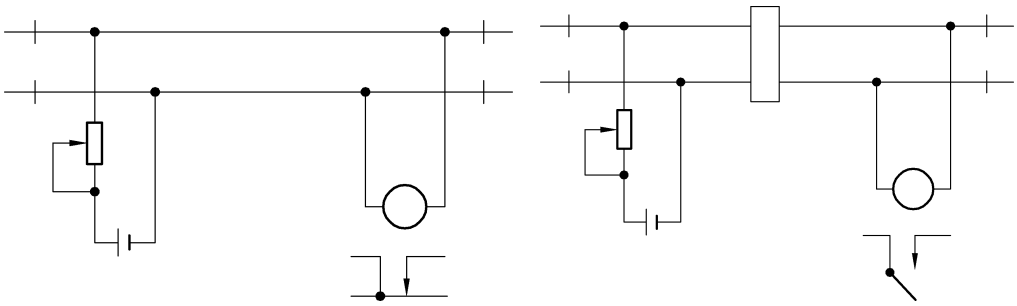

Fig.1-3 Open type track circuit

（3）According to the path of traction current in electric traction section, it can be classified into single rail track circuit and double rail track circuit, as shown in figure 1-4 and figure 1-5.

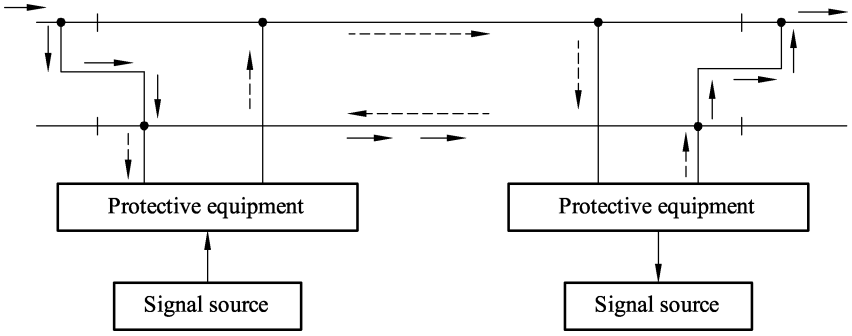

Figure 1-4 Single rail track circuit

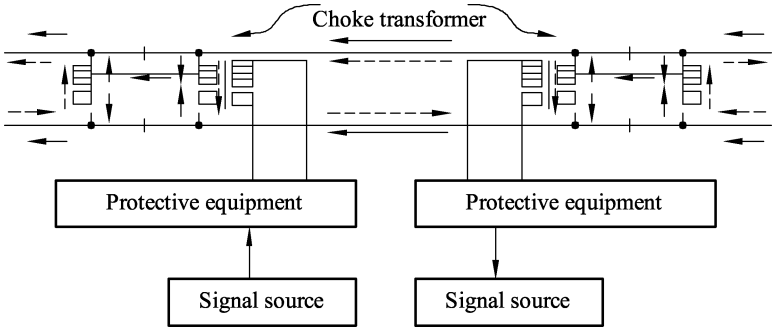

Fig.1-5 Double rail track circuit

（4）According to whether there are branches or not, it can be classified into single feeding and single receiving track circuit and single feeding and multiple receiving track circuit. The turnout sections are all single feeding and multiple receiving track circuit.

（5）According to the transmission characteristics of current, it can be classified into continuous track circuit, frequency-shift modulated track circuit and digital coding track circuit.

（6）According to the way of track circuit division, it can be classified as insulated track circuit and non-insulated track circuit, as shown in figure 1-6 and figure 1-7.

Fig.1-6 Insulated track circuit

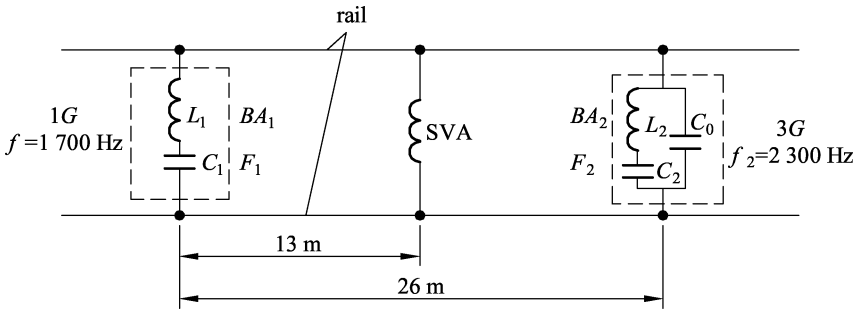

Fig.1-7　Non-insulated track circuit

Chapter 2

Locomotive signal

2.1 Overview of locomotive Signal

Locomotive signal (shown in figure 2-1) is a locomotive on-board system that can automatically reproduce the display of the ground signal machine in front of the train. It can reflect the running conditions of the train. By processing the received ground signal, the display information of the signal machine in front of the train can be obtained, and the information can be displayed through the corresponding display mechanism.

locomotive signal

Fig. 2-1 Locomotive signal

2.2 Function

1. Reducing Driver's Labor Intensity

Ground signal is limited by curve, tunnel and other terrain, which makes some trouble for the driner during observation.

2. Ensuring driving safety and improving driving efficiency

With the development of high-speed trains, the braking distance continues to increase. It is difficult for the driver to take measures calmly when the ground signal machine located one kilometer ahead shows the stop signal.

3. Provide information for other train control systems

The locomotive signal is gradually changed from auxiliary signal to main signal.

2.3 Component

The composition of locomotive signal is shown in figure 2-2. The information comes from the ground equipment. It is sensed by the locomotive through the channel. The information sensed by the locomotive is sent to the vehicle part of the locomotive to process the information, and then the corresponding display is given.

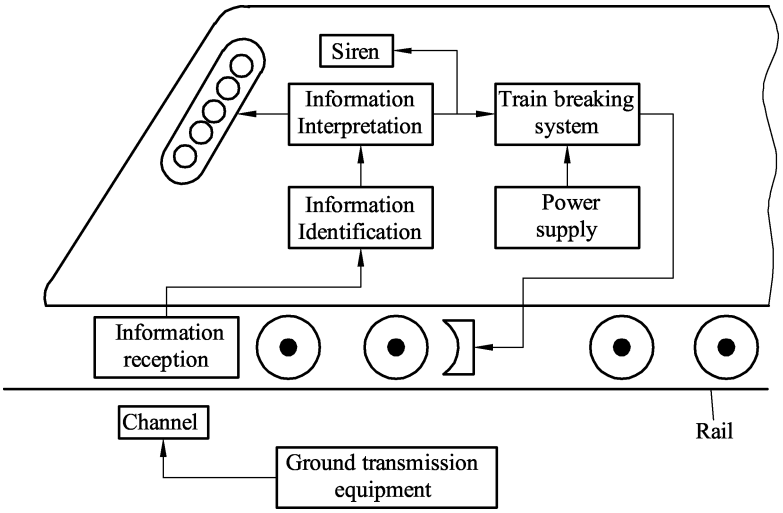

Fig. 2-2 Composition of locomotive signal

Information Source: Ground information transmitting equipment transmits information such as frontal block partition status to locomotive.

Information reception: It is an important part of the locomotive signal control system. The electromagnetic induction method is generally used in China.

Information identification: It can identify not only interference or information, but also the characteristics of information.

Siren: Audio equipment for locomotive signal alarm, prompting drivers to take

measures.

Information Interpretation: According to the identified information characteristics, it can be directly interpreted into locomotive signal display or speed indication according to the design requirements.

Train braking system: It is the executive part of controlling train operation, through which the alarm siren can be controlled and the measures to be taken by drivers can be taken.

Power supply: It uses locomotive generator and locomotive battery floating charge to provide DC 50 V power supply.

2.4 Basic technical requirements for iocomotive signals

（1）The equipment should work steadily and reliably in the prescribed climatic conditions and train vibration environment.

（2）A sufficient number of locomotive signals should be installed to visually reflect the display of ground signals.

（3）If the driver fails to take timely braking measures after receiving the alarm when the train must stop and reduce its speed, the train should be braked.

（4）The equipment shall be installed within the specified limits for locomotives and rolling stock and construction.

（5）It can satisfy the requirement of the “fail-safe” principle. When the equipment fails, it should not display more permissible signals and show something when the locomotive signal equipment stops using(white light) .

（6）With the sound signal, when the locomotive signal is converted to a more limited display, the driver will be more attentive.

2.5 Classification

According to the information sources of locomotive signals, they are mainly classified into three categories: intermittent type locomotive signaling, approach continuous locomotive signaling and continuous type locomotive signaling.

（1）Intermittent type locomotive signaling refers to the system that sets up ground equipment to transmit information to locomotive at some fixed points on the line, as shown in figure 2-3. It includes two types: dual-frequency point type and variable-frequency point type, which are mainly used in non-automatic block section.

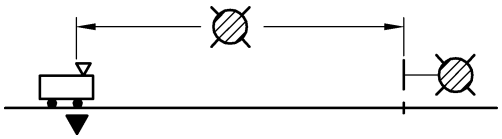

Fig. 2-3　Intermittent Type Locomotive Signal

（2）Approach continuous locomotive signaling is most used in non-automatic block section. A section of track circuit and locomotive signal transmitting equipment are set up in the 1200 m range outside the station signal generator to make the train enter the approaching section. When the train enters the approaching section, the transmitting device continuously transmits the information of ground signal to the locomotive, so that the locomotive signal generator can continuously repeat the display of the station signal generator, as shown in figure 2-4.

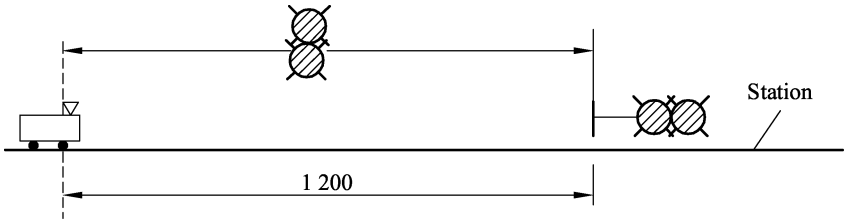

Fig. 2-4　Approach Continuous Locomotive Signal

（3）Continuous type locomotive signaling is mainly used in automatic block section. Corresponding track circuit and locomotive signal transmission equipment are installed in each block section, so that the ground signal display can be continuously transmitted to locomotive.

Locomotive signal display when the second train runs to each section as shown in figure 2-5 and figure 2-6.

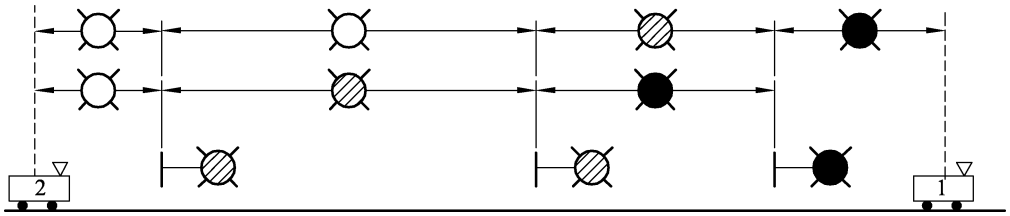

Fig. 2-5　Repeating signal and approaching signal

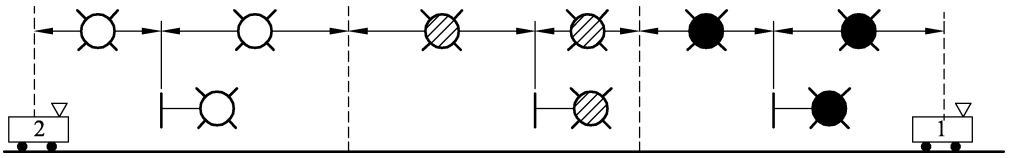

Fig. 2-6 Repeating and approaching signal

According to the universality of locomotive signal, it can be divided into special type, general type, subjectivity and integration.

（1）Special-purpose: only one type of ground signal can be received.

（2）Universal: It can receive many kinds of ground signals.

（3）Subjectivism: It can receive many kinds of ground signals with high security and reliability. It has data recording function. locomotive signal is the main signal.

（4）Integration: The principle and function are the same as the main body of locomotive signal. The host box contains the junction box.

According to the number of locomotive signal display, it can be divided into 6 displays, 8 displays and 11 displays.

6 displays: L、U、UU、HU、H、B.

8 displays: L、U、UU、HU、H、B、LU、U2.

11 displays: L、U、UU、HU、H、B、LU、U2、UUS、U2S、HUS.

The basic technical conditions of locomotive signal require that the locomotive signal should have a sufficient number of displays, which is determined according to the situation of the ground signal and can display all the information of the ground signal. The first display is green, yellow, double yellow, red yellow, red and white. The red light and white light are displayed when there is no information, which is mainly to meet the three display mode of ground signal. When four displays appear on the ground in the later stage, the locomotive signal will turn into 8 displays correspondingly, which adds two display modes, green yellow light and yellow 2 light. Later, there were 11 displays, the number of light bits did not increase, or 8 bits. Three flash lights were added, mainly with the appearance of large number turnout above No. 18. The red and yellow flashes show the signal to guide the car to pick up.

2.6 Integrated locomotive signal

The composition of integrated locomotive signal on-board system, jt1-cz2000 integrated locomotive signal on-board system equipment mainly consists of the following

parts: locomotive signal host (also its main part), locomotive signal, two-way receiving coil. There are other parts, such as monitoring device, TAX2 box (locomotive safety information monitoring device), which do not belong to locomotive signal system, but are related to locomotive signal, and they have information exchange with locomotive signal system.

The working principle of the system is that the two-way receiving coil senses the ground track circuit signal, the analog-to-digital conversion circuit of the main board completes the analog-to-digital conversion of the signal, the main CPU processes the data digitally, controls the output of the signal, ensures the safety of the output, and conforms to the “fault safety” principle. Finally, it is displayed by the signal. The principle as shown in figure 2-7.

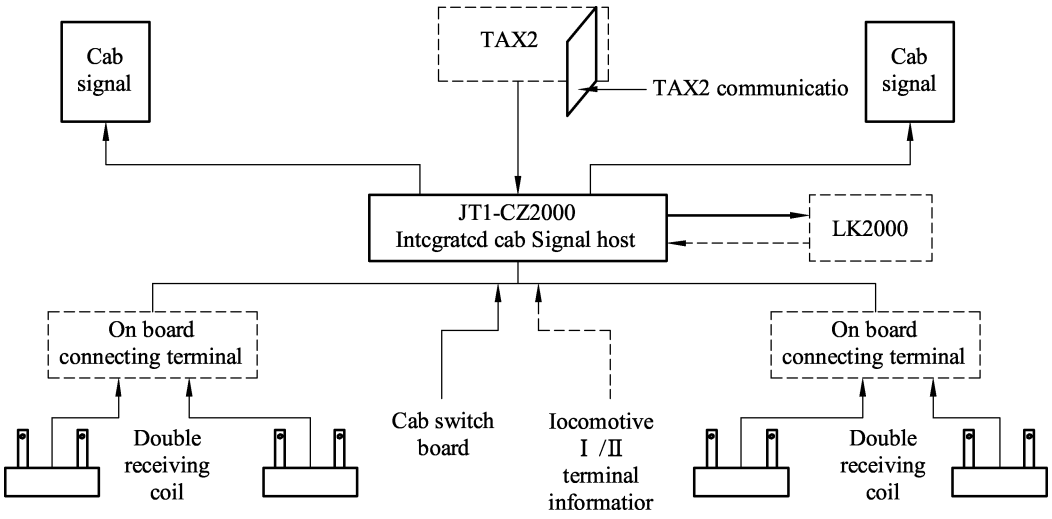

Fig. 2-7 The composition of integrated locomotive signal on-board system

Equipment

The main engine of locomotive signal, which is the core part of the integrated locomotive signal system, its main function is to carry out digital to analog conversion, decoding analysis and processing of the information received by the receiving coil, and output to the backward equipment to control the corresponding output display. As shown in figure 2-8 and figure 2-9, this is the appearance of the host, which consists of six plates, from left to right are the recording board, two host boards, connecting board, power board 1 and power board 2.

Fig. 2-8 Locomotive signal host

Fig. 2-9 Integrated host and cab light box

The main function of the recording board is to record the locomotive signal information. There is a USB interface on the board, through which the recorded information can be copied down.

The main board is the core component, which is responsible for processing the received ground track circuit information and completing the parallel and serial port output control of the backward equipment. The existing mature dual machine hot standby switching circuit is reserved, and it will automatically switch to the standby machine in case of host failure. There are up and down indicator lights on the panel to reflect the current running direction.

The connection board uses two relays to realize the master-slave switching control of two sets of host computers. Six indicators are set on the front panel to indicate the working status of the A and B host computers. The first group of indicators indicates whether the two host computers are working normally. The second group only lights one, and the illuminated host computer is in the working status, and the corresponding host computer is

in the hot standby status when the lights are off. The third group is the power light of the host computer It indicates the power supply status. In addition, two indicators are added to indicate the up and down signal input. The A and B buttons on the panel are used to force the A and B mainboard to become working mainframes.

Two power boards in the host constitute hot standby redundancy. Each power board has a DC 110 V to 48 V power module, which outputs a common DC 48 V power supply for the main board and recorder board to work, and another DC 48 V dynamic lighting power supply controlled by the dynamic signal output from the main board. When the dynamic signal disappears, the lighting power is off, and the dynamic power meets the fault safety principle.

The host is installed in the third-party equipment cabinet, which needs to leave some space for installation to ensure better ventilation and convection for heat dissipation and improve the reliability of the system.

Cab light box (shown in the figure 2-10) is the display part of locomotive signal, which is double-sided eight display. From top to bottom: Green, semi green and semi yellow, yellow, yellow 2, semi red and semi yellow, double semi yellow, red and white. Among them, yellow 2, half red and half yellow and double half yellow can also show flashing status, with 11 kinds of displays. The weight is about 2 kg, which is installed in the middle or both sides of the front windshield in the cab to ensure convenient observation by the driver.

Fig. 2-10 Cab light box

Double way receiving coil (as shown in figure 2-11), the integrated locomotive signal receiving coil adopts double set design, double line double out, concealed outgoing line, ladle hose cable protection design, to avoid the weak link of the cable outside the vehicle which is easy to be damaged and improve the reliability. The weight of a single receiving coil is about 12 kg, and the installation position is between the rear of the locomotive cowcatcher and the first wheelset. When the horizontal distance from the axle center of the

first wheelset is more than 1.5 m, the mounting frame provided by the locomotive must be ensured that the distance between the bottom of the receiving coil and the rail surface is (155 ± 5) mm, and the deviation between the center of the receiving coil and the rail surface is less than ± 5 mm, which cannot be too high or too low, which will affect the receiving effect, and it is too low It is easy to be damaged by collision. There shall be no large volume of metal objects in the space of 300 mm around the receiving coil to prevent interference.

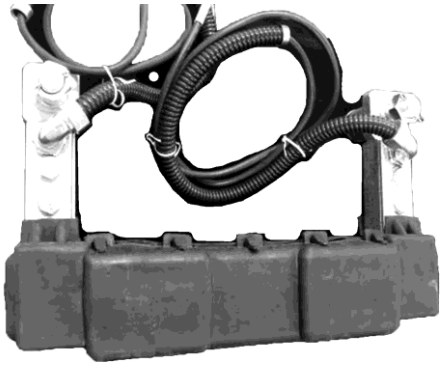

Fig. 2-11 Double receiving coils