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(71) Applicant: **CRSC Research & Design Institute Group Co., Ltd.**
Beijing 100070 (CN)

(72) Inventors:
• **YANG, Yixuan**
Beijing 100070 (CN)
• **XU, Zongqi**
Beijing 100070 (CN)
• **LI, Wentao**
Beijing 100070 (CN)
• **SUN, Guoying**
Beijing 100070 (CN)
• **QIAO, Zhichao**
Beijing 100070 (CN)
• **REN, Guoqiao**
Beijing 100070 (CN)
• **LIU, Ruidong**
Beijing 100070 (CN)
• **XIE, Wenlei**
Beijing 100070 (CN)

- **WANG, Huachao**
Beijing 100070 (CN)
- **QU, Bo**
Beijing 100070 (CN)
- **YANG, Xiaofeng**
Beijing 100070 (CN)
- **CHEN, Yi**
Beijing 100070 (CN)
- **YIN, Huiyuan**
Beijing 100070 (CN)
- **YUAN, Cheng**
Beijing 100070 (CN)
- **WANG, Yong**
Beijing 100070 (CN)
- **WANG, Yuzhang**
Beijing 100070 (CN)
- **LIU, Qingjun**
Beijing 100070 (CN)
- **LI, Ming**
Beijing 100070 (CN)
- **SU, Bo**
Beijing 100070 (CN)
- **LI, Hailong**
Beijing 100070 (CN)

(74) Representative: **Meissner Bolte Partnerschaft mbB**
Patentanwälte Rechtsanwälte
Postfach 86 06 24
81633 München (DE)

(54) **TRACK CIRCUIT SYSTEM AND WORKING METHOD**

(57) Provided by the present disclosure are a track circuit system and an operating method. The track circuit system includes first transmitting equipment, second transmitting equipment, and receiving equipment. The first transmitting equipment and the second transmitting equipment are located on both ends of a track circuit section, respectively. The receiving equipment is located on a track between the first transmitting equipment and

the second transmitting equipment. The first transmitting equipment and the second transmitting equipment are configured to respectively transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time. The receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage

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detection on the track in the track circuit section according to the received first frequency signal and second frequency signal. The track circuit system provided by the present disclosure employs a track circuit structure for transmitting at both ends and receiving in the middle, thus achieving double-end code sending of tracks, switchless sections and switch sections of a high-speed railway and an ordinary-speed railway, and the system also has the function of bidirectional return.

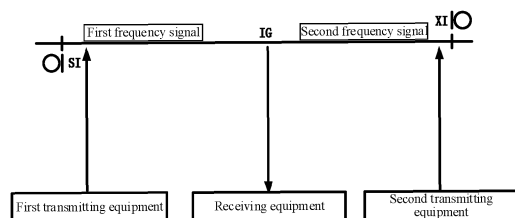


FIG. 3

Description

TECHNICAL FIELD

[0001] The present disclosure belongs to the field of rail traffic, in particular to a track circuit system, and an operating method.

BACKGROUND ART

[0002] The function of track circuit is to achieve train position inspection, and provide train control information through rails. The existing track circuit section is of a structure with one transmitting end, one or more receiving end, which is specifically as follows.

[0003] In high-speed railway, the station and the section adopt a ZPW-2000 track circuit section which includes a transmitting end, and a receiving end, as shown in FIG. 1a. In addition, the track circuit structure of the station track and the switchless section of the high-speed railway is limited by the structure with a transmitting end and a receiving end. In order to achieve double-end code sending when the train turns back, the section is divided into two, and each section is provided with a transmitting end and a receiving end, and the receiving end and the transmitting end are switched according to a running direction of the train, which is shown in FIG. 1b in receiving running. When the train turns back, it is necessary to change directions of the transmitting and receiving ends of the station section by designing external conditions, as shown in FIG. 1c. A switch section is provided with one transmitting end and one receiving end, in order to achieve double-end code sending when the train runs in both directions, it is necessary to change the directions of the transmitting and receiving ends of the switch section by designing external conditions (not shown in the figure), as shown in FIG. 1d. It should be noted that above external conditions include, but are not limited to, switching the directions of the receiving end and the transmitting end by using a bidirectional switch.

[0004] In ordinary-speed railway, the section is the same as that of the high-speed railway. The track circuit structure of the station track and switchless section is shown in FIG. 2a. In order to achieve double-end code sending on the track when the train turns back, two sets of coded code sending equipment are overlaid on the transmitting and receiving ends based on the track circuit. The switch section of the station is shown in FIG. 2b. The switch section of the station adopts a 25 Hz track circuit section, and the 25 Hz track circuit section has one transmitting end and at most three receiving ends. In order to achieve double-end code sending on the switch section when the train runs in both directions, two sets of coded code sending equipment are overlaid on the transmitting and receiving ends based on the track circuit.

[0005] In conclusion, the structure of the existing track circuit section has only one transmitting end. When the train runs in both directions, the double-end code sending

of the high-speed railway is achieved by cutting sections and adding external conditions to switch section directions, which leads to the increase of construction workload and brings some new faults in the switching process, such as the failure of switching function due to poor contact of a switching relay and inconsistent action of the switching relay. In the ordinary-speed railway, the double-end code sending is achieved by overlaying the coded code sending equipment, which not only increases the equipment investment, but also fails to perform the closed-loop inspection on the transmitted coded signal by the receiving end. Once the transmission of the coded signal fails due to channel failure, the track circuit cannot acquire the situation.

[0006] In addition, when the existing track circuit is applied in the station, it is necessary to take into account that the track circuit also need traction return current. Therefore, if all track circuits employ a double-choke track circuit, it is easy to form a circuitous circuit after midpoints are connected, thus forming a third rail effect. In order to avoid the track circuit from forming a "third rail", the midpoints of choke transformers at some insulation joints in the station are not connected, such that the traction current can only return from one side, and the a return current cutoff point is formed on the other side. Such a situation is commonly known as "one-end blocking" unilateral return, such that the signal of the track circuit can be returned to a receiver of this section from the neutral point of a matching unit through a transversely connected circuitous pathway. When the external circuitous length is equal to 0 m (that is, there are multiple lines in parallel on the track), the signal from the transmitting end on one side of the track will be directly transmitted to the receiving end on the other side of the track (that is, the signal is normally transmitted from the circuitous pathway to the receiving end in the case of rail breakage), which leads to the failure of detection after the rail is electrically disconnected.

[0007] Therefore, how to provide a track circuit system with bidirectional return current without cutting the station section, designing a switching circuit externally and overlaying coding equipment is becoming an urgent technical problem.

SUMMARY

[0008] For the problems above, an objective of the present disclosure is to provide a track circuit system, including first transmitting equipment, second transmitting equipment, and receiving equipment.

[0009] The first transmitting equipment and the second transmitting equipment are located on both ends of a track circuit section, respectively; and the receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment.

[0010] The first transmitting equipment and the second transmitting equipment are configured to respectively

transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time, where the first frequency signal and the second frequency signal have different frequencies.

[0011] The receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal.

[0012] Further, the receiving equipment is configured to determine a state of the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal; and

determining whether the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy a threshold requirement, and if the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, determining that the track circuit section is in an idle state, otherwise, determining that the track circuit section is in an occupied state.

[0013] Further, the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with those of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which makes a track circuit in the track circuit section operate normally.

[0014] Further, the receiving equipment forms a circuitous pathway with each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks.

[0015] Further, the receiving equipment is configured to perform rail breakage detection on a track in the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal; and determining whether the voltages of the first frequency signal and the second frequency signal are both less than a first preset threshold, and if

the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, determining that rail breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

[0016] Further, the receiving equipment is configured to perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time, determining whether a voltage of a frequency signal in an adjacent section is received, and if the voltage of the frequency signal in the adjacent section is received, determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, otherwise, determining that the track in the track circuit section is normal; and

determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, if the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, determining that insulation breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

[0017] Further, if there are two adjacent track circuit sections, frequencies of frequency signals transmitted by the transmitting equipment at adjacent ends of the two adjacent track circuit sections are also different.

[0018] Further, each track circuit section is further provided with a first relay, and the first relay is connected to the receiving equipment.

[0019] The first relay is controlled to fall when the receiving equipment determines that the track circuit section is in an occupied state, detects that the rail breakage occurs on track in the track circuit section, or detects that the insulation breakage occurs on the track of the track circuit section, and is controlled to be sucked up when the receiving equipment determines that the track circuit section is in an idle state.

[0020] Another objective of the present disclosure is to provide an operating method of a track circuit system.

[0021] The track circuit system includes first transmitting equipment, second transmitting equipment, and receiving equipment. The first transmitting equipment and the second transmitting equipment are located on both ends of a track circuit section, and the receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment.

[0022] The first transmitting equipment and the second transmitting equipment are configured to respectively

transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time, where the first frequency signal and the second frequency signal have different frequencies.

[0023] The receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal.

[0024] Further, the determining a state of the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal; and

determining whether the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy a threshold requirement, and if the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, determining that the track circuit section is in an idle state, otherwise, determining that the track circuit section is in an occupied state.

[0025] Further, the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with those of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which makes a track circuit in the track circuit section operate normally.

[0026] Further, the receiving equipment forms a circuitous pathway with each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks.

[0027] Further, the performing rail breakage detection on the track in the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal; and determining whether the voltages of the first frequency signal and the second frequency signal are both less than a first preset threshold, and if

the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, determining that rail breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

[0028] Further, if there are two adjacent track circuit sections, frequencies of frequency signals transmitted by the transmitting equipment at adjacent ends of the two adjacent track circuit sections are also different. The performing insulation breakage detection on the track in the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal includes the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to determine whether a voltage of a frequency signal in the adjacent section is received, and

if the voltage of the frequency signal in the adjacent section is received, determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, otherwise, determining that the track in the track circuit section is normal; and determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, and if the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, determining that the insulation breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

[0029] Further, each track circuit section is further provided with a first relay, and the first relay is connected to the receiving equipment.

[0030] The first relay is controlled to fall when the receiving equipment determines that the track circuit section is in an occupied state, detects that the rail breakage occurs on track in the track circuit section, or detects that the insulation breakage occurs on the track of the track circuit section, and

the first relay is controlled to be sucked up when the receiving equipment determines that the track circuit section is in an idle state.

[0031] The track circuit system provided by the present disclosure employs a track circuit structure for transmitting at both ends and receiving in the middle, there is no need to cut the track, design a switching circuit externally and overlay coding equipment, such that the double-end code sending of the tracks, switch sections and switchless sections of a high-speed railway and an ordinary-speed railway can be achieved. Moreover, the transmitted signal can be subjected to closed-loop inspection in real time, thus achieving the determination of the state

of the track circuit section, the rail breakage detection, and the insulation breakage detection.

[0032] In addition, the receiving equipment forms a circuitous pathway with each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks. Compared with the traditional track circuit system, especially the traditional in-station track circuit, both ends of the track circuit section in the track circuit system of the present disclosure are not provided with return-current interruption points, the return current of all track circuit sections in the station is always kept smooth, the potential of the station to ground is greatly reduced, and the interference of traction current is reduced. Meanwhile, even if an external circuitous length at both ends of the track is 0 m (that is, multiple tracks (lines) are parallel), the first transmitting equipment and the second transmitting equipment at both ends are equivalent to being directly connected. The frequency signal, before entering the receiving equipment, still passes through the track with a certain distance, and the resistance and inductance characteristics of the track will form an impedance to the frequency signal, making the frequency signal satisfy rail breakage detection. Therefore, the track circuit of the present disclosure improves the safety and reliability of train operation.

[0033] Other features and advantages of the present disclosure will be set forth in the following description, and will be apparent in part from the specification, or may be learned by implementing the present disclosure. The objectives and other advantages of the present disclosure may be implemented and acquired from the structure pointed out in the specification, claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] To describe the technical solutions of the present disclosure or in the prior art more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present disclosure, and those of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. 1a shows a structural schematic diagram of a track circuit system used in a station and a section of a high-speed railway in the prior art;

FIG. 1b shows an operating schematic diagram of a track circuit system used in a station and a section of a high-speed railway in the prior art in the train running process;

FIG. 1c shows an operating schematic diagram of a track circuit system used in a station and a section of a high-speed railway in the prior art in the train running turn-back process;

FIG. 1d is shows an operating schematic diagram of a track circuit system used in a switch section of a high-speed railway in the prior art in the train running process;

FIG. 2a shows a structural schematic diagram of a track circuit used in a station track and a switchless section of an ordinary-speed railway in the prior art; FIG. 2b shows a structural schematic diagram of a 25 Hz track circuit used in a switch section of a station of an ordinary-speed railway in the prior art;

FIG. 3 shows a structural schematic diagram of a track circuit system according to an embodiment of the present disclosure;

FIG. 4 shows a structural schematic diagram of another track circuit system according to an embodiment of the present disclosure;

FIG. 5 shows a structural schematic diagram of a track circuit system used in a switchless section according to a third embodiment of the present disclosure;

FIG. 6 shows a structural schematic diagram of a track circuit system used in a switch section according to an embodiment of the present disclosure;

FIG. 7 shows a change trend of a locomotive signal current after a train enters a section with two pieces of transmitting equipment and one piece of receiving equipment from different ends according to an embodiment of the present disclosure;

FIG. 8 shows a change trend of a locomotive shunting voltage after a train enters a section with two pieces of transmitting equipment and one piece of receiving equipment from different ends according to an embodiment of the present disclosure;

FIG. 9 shows a schematic diagram of a circuitous pathway of a signal when rail breakage occurs on a right side of receiving equipment in a section according to an embodiment of the present disclosure;

FIG. 10 shows a change trend of a voltage of a right-side signal received by receiving equipment when rail breakage occurs on a right side of receiving equipment in a section according to an embodiment of the present disclosure;

FIG. 11 shows a schematic diagram of a circuitous pathway of a signal when rail breakage occurs on a left side of receiving equipment in a section according to an embodiment of the present disclosure;

FIG. 12 shows a flow diagram of an operating method of a track circuit system according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0035] To make the objectives, technical solutions and advantages of the present disclosure more clearly, the following clearly and completely describes the technical solutions in the embodiments of the present disclosure with reference to the accompanying drawings in the embodiments of the present disclosure. Apparently, the

described embodiments are merely a part rather than all of the embodiments of the present disclosure. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present disclosure without creative efforts shall fall within the protection scope of the present disclosure.

[0036] As shown in FIG. 3, the present disclosure provides a track circuit system. The system includes first transmitting equipment, second transmitting equipment, and receiving equipment. The first transmitting equipment and the second transmitting equipment are located on both ends of the track circuit section, respectively. The receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment. Further, the first transmitting equipment and the second transmitting equipment are configured to respectively transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time, and the first frequency signal and the second frequency signal have different frequencies. The receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal. By employing a track circuit structure for transmitting at both ends and receiving in the middle (hereinafter, it is also referred to as a structure with two pieces of transmitting equipment and one piece of receiving equipment), the double-end code sending of the tracks, the switchless sections and switch sections of the high-speed railway and the ordinary-speed railway can be achieved without cutting the track, designing a switching circuit externally and overlaying coding equipment. Moreover, the transmitted signal can be subjected to closed-loop inspection in real time, thus achieving the determination of the state of the track circuit section, the rail breakage detection, and the insulation breakage detection. That is, the rail electrical disconnection fault inspection and insulation breakage inspection of the track circuit are achieved by only using one set of equipment with two pieces of transmitting equipment and one piece of receiving equipment, and the reliability and safety of the track circuit system are improved. Further, the track circuit system provided by the present disclosure is suitable for high-speed railways and ordinary-speed railways, especially for track circuit sections in the high-speed railway and ordinary-speed railway stations.

[0037] In this embodiment, the track circuit system includes one or more track circuit sections, and one set of equipment with two pieces of transmitting equipment and one piece of receiving equipment is connected into each track circuit section.

[0038] In this embodiment, as shown in FIG. 4, the track circuit system with two pieces of transmitting equipment and one piece of receiving equipment correspond to a group of track circuit equipment, each group of track

circuit equipment includes indoor equipment and outdoor equipment (also called track-side equipment), and the indoor equipment is connected to the outdoor equipment by a cable. The indoor equipment includes a digital control unit, a redundancy switching unit, a lightning protection unit, a digital control cabinet, an integrated cabinet, and a first relay. The outdoor equipment includes an impedance matching unit, and a compensation capacitor. The first transmitting equipment, the second transmitting equipment and the receiving equipment are all arranged in the digital control unit, and the digital control unit is set redundantly. The digital control unit is connected to the impedance matching unit through the redundancy switching unit and the lightning protection unit, and the impedance matching unit is connected to a rail. The receiving equipment in the digital control unit is further connected to the first relay (GJ in the figure). Further, the digital control unit and the redundancy switching unit are all arranged in the digital control cabinet, and the lightning protection unit is arranged in the integrated cabinet.

[0039] In this embodiment, the receiving equipment is configured to determine a state of the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps: demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal; and determining whether the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy a threshold requirement, and if the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, determining that the track circuit section is in an idle state, otherwise, determining that the track circuit section is in an occupied state. Further, the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with the frequencies of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which makes a track circuit in the track circuit section operate normally. Preferably, the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage under the condition of the lowest ballast resistance, which makes the track circuit equipment operate reliably.

[0040] Further, each of the first frequency signal and the second frequency signal employs a carrier frequency of 1700-2600 Hz. As shown in FIG. 5, the carrier frequency signals of 1700 Hz and 2000 Hz are exemplified, but the present disclosure is not limited thereto, and other carrier frequency signals, such as a carrier frequency signal of 2600 Hz, are also applicable to the present

disclosure. The receiving equipment of the track circuit can be arranged at any position between the two pieces of transmitting equipment (the first transmitting equipment and the second transmitting equipment), and the two pieces of transmitting equipment (FS stands for a transmitting end in the figure) are arranged at both ends of a section IG and operate at the same time. As the frequencies of the first frequency signal (2000-1 carrier frequency signal) and the second frequency signal (1700-1 carrier frequency signal) transmitted are different, which can be simultaneously demodulated by the receiving equipment (JS in the figure stands for the receiving end). Further, when a train enters the section IG from the left side, the receiving equipment can only receive a signal of 1700-1 in front, and a signal of 2000-1 in the back is short-circuited by a train wheel set, so an antenna of the train installed at the front of the train cannot receive the signal. At this time, the receiving equipment cannot receive the signal of the 2000-1 due to the short circuit of the wheel set. Therefore, the receiving equipment can obtain a running direction and state of the train and the state of the track circuit section by demodulating the two frequency signals, thus adjusting and shunting the track circuit. In FIG. 7, the upper left side shows change curves of four frequency signals, such as left 1700 Hz- left 2600 Hz, and the lower left side shows the change curves of four frequency signals, such as right 1700 Hz- right 2600 Hz, while the upper right side shows change curves of four frequency signals, such as right 1700 Hz- right 2600 Hz, and the lower right side shows the change curves of four frequency signals, such as left 1700 Hz- left 2600 Hz. After the train enters the section with two pieces of transmitting equipment and one piece of receiving equipment, a locomotive signal current and a shunting residual voltage change with the movement of the train. If the train enters the section from the left side, a large current is generated by the first frequency signal on a left track of the receiving equipment due to the short circuit of the wheel set, which continues to decrease with the movement of the train. When the train passes through the receiving equipment, the locomotive current generated by the first frequency signal on the left track of the receiving equipment tends to be stable, and the generated stable locomotive signal current is small, while the change of the locomotive signal current generated by the second frequency signal is opposite to that of the first frequency signal, which is not described in detail here. The shunting residual voltage on the track is shown in FIG. 8, the upper left side shows change curves of four frequency signals, such as right 1700 Hz- right 2600 Hz, and the lower left side shows the change curves of four frequency signals, such as left 1700 Hz- left 2600 Hz. The abscissa is the length in m (meter). If the train enters the section from the left side, the track is in an occupied state due to the short circuit of the wheel sets, a shunting residual voltage generated by the first frequency signal on the left track of the receiving equipment is relatively stable. When the train passes through the receiving

equipment, the shunting residual voltage generated by the first frequency signal on the left track of the receiving equipment changes stably. The change of a shunting residual voltage generated by the second frequency signal on the right side of the receiving equipment is opposite to that of the first frequency signal, and will not be described in detail here. As can be seen from FIG. 7 and FIG. 8, the signal current and the shunting residual voltage of the train can satisfy application requirements under various frequency combinations.

[0041] In this embodiment, if the track circuit section is a switch section, the first transmitting equipment and the second transmitting equipment are located at both ends of the switch section, and the receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment. That is, the receiving equipment can be connected to the track where the switch is located, specifically as shown in FIG. 6.

[0042] In this embodiment, one end of each of all track circuit sections is not provided with a return interruption point, and a circuitous pathway is formed between the receiving equipment and each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks (one or more parallel lines). That is, the circuitous pathway formed between the receiving equipment and the first transmitting equipment through the parallel tracks is always in direct connection under the condition that the track between the receiving equipment and the first transmitting equipment is in rail breakage or the track is normal. The circuitous pathway formed between the receiving equipment and the second transmitting equipment through the parallel tracks is also applicable, and thus will not be described in detail in detail. In the track circuit system, both ends of all track circuit sections are not provided with return interruption points, so the smooth return of all track circuit sections of the station inner rail is always kept, the ground potential of the station is greatly reduced, and the interference of the traction current is reduced.

[0043] In this embodiment, the receiving equipment is configured to perform rail breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps: demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal; determining whether the voltages of the first frequency signal and the second frequency signal are less than a first preset threshold, and if the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, determining that rail breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal. The first preset threshold is, but is not limited to, 153 mV, and a value of the first preset threshold can be adjusted according to the requirements of the track circuit. Specifically, when one side of the

existing track circuit section is a transmitting end and the other side of the existing track circuit section is a receiving end, when an external circuitous length is 0 m (meter), a signal transmitted by the transmitting end at one end of the track will be directly transmitted to the receiving end at the other end of the track. As a result, after the rail is electrically disconnected, the received signal is the same as that under normal working conditions, and rail breakage detection cannot be carried out at the receiving end. When the track circuit system of the present disclosure has a rail electrical disconnection fault, as shown in FIG. 9, the second frequency signal flows into the circuitous pathway through the second transmitting equipment (assuming that the right side is the second transmitting equipment), and then flows into the receiving equipment through the first transmitting equipment and the track between the first transmitting equipment and the receiving equipment. Therefore, by adopting the track circuit system provided by the present disclosure, the receiving equipment is arranged on the track between the two pieces of transmitting equipment. Even if the external circuitous length is equal to 0 m and both ends of the track are directly connected, the frequency signal, before entering the receiving equipment, will still pass through the track with a certain distance after the rail breakage occurs, and the resistance and inductance characteristics of the track can form impedance to the frequency signal. In particular, impedances formed for different frequency signals are different, but all of which can make the signal amount loss, such that the voltage of the first frequency signal or the second frequency signal is lower than the first preset threshold when the rail breakage occurs on the track. Further, taking the first preset threshold as 153 mV for an example, as shown in FIG. 10, the ordinate corresponding to a dotted line in the figure is the first preset threshold, and the abscissa is the length in km (kilometer). The track on a right region of the receiving equipment is electrically disconnected (rail breakage). As can be seen from the figure that after the rail breakage occurs, the maximum residual voltage of electrical disconnection of the right rail is finally less than 153 mV, and thus it can be determined that rail breakage failure occurs on the right rail. Further, as shown in FIG. 11, when the rail breakage occurs, the whole circuitous pathway passes through three loss points, so there are more loss points compared with the traditional one. Under the most unfavorable conditions (infinite ballast resistance, optimal rail parameters, and the first transmitting equipment and/or the second transmitting equipment and the receiving equipment are circuitously and directly looped), the voltage of the broken rail can be reduced to below 153 mV through the loss point 3 in its own rail breakage circuit, thus achieving the inspection of inspection of broken rail fault. Preferably, the impedance of the loss point 3 to the frequency signal transmitted by the left transmitting equipment is different from that to the frequency signal transmitted by the right transmitting equipment. Therefore, compared with the traditional track circuit system,

the track circuit system of the present disclosure can achieve bidirectional return, that is, there are no return interruption points at both ends of the track circuit sections, so the smooth return of all track circuit sections of the station inner rail can be always kept, the station to ground potential is greatly reduced, and the interference of the traction current is reduced. In addition, the rail breakage detection can be achieved, and the safety and reliability of train running are improved.

[0044] In this embodiment, the first preset threshold is less than or equal to an upper limit voltage of a reliable shunt. Preferably, the upper limit voltage of the reliable shunt may be, but is not limited to, 153 mV, and a value of the upper limit voltage can be adjusted according to the application situation.

[0045] In this embodiment, the track with a certain distance may be half the track length, that is, the receiving equipment is arranged in the middle of the track circuit section, but it is not limited to this. Other distances, such as the distance from the transmitting equipment at one end to the receiving equipment is two thirds of the track length, are also applicable to the present disclosure. That is, the distances from the receiving device to the first transmitting equipment and the second transmitting equipment can be adjusted according to the impedances between the receiving equipment and the first transmitting equipment and the second transmitting equipment, respectively.

[0046] The receiving equipment is configured to perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which includes the following steps: demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time, determining whether a voltage of a frequency signal in an adjacent section is received; if the voltage of the frequency signal in the adjacent section is received, determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, otherwise, determining that the track in the track circuit section is normal; determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, and if the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, determining that the track in insulation breakage occurs on the track in the track circuit section, otherwise, determining that the track in the traction section is normal.

[0047] Specifically, if there are two adjacent track circuit sections, the frequencies of the frequency signals transmitted by the transmitting equipment at adjacent ends of the two adjacent track circuit sections are different. Further, after insulation breakage occurs, a signal of the adjacent section may invade the present section (the section where the receiving equipment is located). Because the frequency of the adjacent section is different

from that of the present section, the signal can form a signal voltage with the frequency different that of the present section at the receiving equipment after passing through the rail, the track-side equipment, the cable and the indoor equipment. Whether the voltage of the signal of the adjacent section exceeds the insulation threshold voltage is determined. If the voltage of the signal of the adjacent section exceeds the insulation threshold voltage, it is determined that the insulation breakage occurs, the present track circuit section is set as an occupied state, otherwise, the present track circuit section is set as an idle state. There is an insulation joint between the track circuit sections. In the traditional track circuit, if the transmitting equipment in the track circuit sections on the left and right sides of the insulation joint is transmitting equipment A and transmitting equipment B, respectively (running in opposite directions, and B is at an end far away from A). Once the insulation breakage occurs, a signal transmitted by A may invade the receiving equipment on the right side of the insulation joint very closely, and the transmitting equipment B in the section on the right side of the insulation joint is at one end close to A, then a signal of A needs to pass through the whole track circuit section and be transmitted to the receiving equipment. The receiving equipment, after receiving a signal a with a certain magnitude, can determine that the section is occupied. If the transmitting equipment on both sides of an insulation joint of adjacent ends of two adjacent track circuit sections in the track circuit is the second transmitting equipment C and the first transmitting equipment D, the frequency signals transmitted by C and D are different. In this time, if the insulation joint is broken, the frequency signals in the adjacent track circuit sections can be directly received in the track circuit sections on both sides of the insulation joint, respectively. The receiving equipment of the track circuit sections on both sides of the insulation joint may determine that the sections are occupied at the same time, thus achieving the insulation breakage inspection of the rail.

[0048] In this embodiment, when it is detected that the rail breakage occurs on the track in the track circuit section or the insulation breakage occurs on the track in the track circuit section, the receiving equipment determines that the present track circuit section (the track circuit section where the receiving equipment is located) is in an occupied state. When the track circuit section is in the idle state, and no rail breakage or insulation breakage occurs in the track circuit section, the receiving equipment determines that the present track circuit section (the track circuit section where the receiving equipment is located) is in the idle state.

[0049] Preferably, the receiving equipment is configured to determine the state of the track circuit section, perform rail breakage detection on the track in the track circuit section or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which includes: executing the determination of

the state of the track circuit section, the rail breakage detection of the track in the track circuit section, and the insulation breakage detection of the track in the track circuit section in turn, thus finally determining the state of the track circuit section. That is, when the state of the track circuit section is determined to be idle, and no rail breakage and insulation breakage occurs in the track circuit section, and the receiving equipment determines that the present track circuit section is in the idle state (the track circuit section where the receiving equipment is located). When the track circuit section is determined to be in the occupied state, and no rail breakage or insulation breakage occurs in the track circuit section, the receiving equipment determines that the present track circuit section (the track circuit section where the receiving equipment is located) is in the occupied state. When it is detected that the rail breakage occurs on the track in the track circuit section or insulation breakage occurs on the track in the track circuit section, the receiving equipment determines that the present track circuit section (the track circuit section where the receiving equipment is located) is in the occupied state.

[0050] In this embodiment, each track circuit section is also provided with a first relay, which is connected to the receiving equipment. The first relay is controlled to fall when the track circuit section is in the occupied state, rail breakage on the track in the track circuit section is detected, or insulation breakage on the track in the track circuit section is detected. That is, the first relay is in an off state, such that a signal indicator light is red to show occupation, and when the track circuit section is in the idle state, the first relay is sucked up. That is, the first relay is in a closed state, such that the signal indicator light is green to show idleness. The state of the track circuit section can be controlled by using only one relay, which makes the track circuit system more concise.

[0051] As shown in FIG. 12, an embodiment of the present disclosure further provides an operating method of the track circuit system. The track circuit system includes first transmitting equipment, second transmitting equipment, and receiving equipment. The first transmitting equipment and the second transmitting equipment are located on both ends of the track circuit section, respectively. The receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment. The first transmitting equipment and the second transmitting equipment are configured to respectively transmit a first frequency signal and the second frequency signal to a track in the track circuit section at the same time. The receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal.

[0052] In this embodiment, the receiving equipment is configured to determine the state of the track circuit

section according to the received first frequency signal and second frequency signal. First, the receiving equipment demodulates the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal, and determines whether the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy a threshold requirement. If the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, it is determined that the track circuit section is an idle state; otherwise, it is determined that the state of the track circuit section is in an occupied state. Further, the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with those of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which makes a track circuit in the track circuit section operate normally.

[0053] In this embodiment, the receiving equipment forms a circuitous pathway with each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks.

[0054] In this embodiment, the receiving equipment is configured to perform rail breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal. First, the receiving equipment demodulates the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal, and determines whether the voltages of the first frequency signal and the second frequency signal are lower than a first preset threshold. If the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, it is determined that rail breakage occurs on the track in the track circuit section, otherwise, it is determined that the track in the track circuit section is normal.

[0055] In this embodiment, if there are two adjacent track circuit sections, the frequencies of the frequency signals transmitted by the transmitting equipment at adjacent ends of the two adjacent track circuit sections are also different, and the receiving equipment is configured to perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal. The receiving equipment demodulates the first frequency signal and the second frequency signal at the same time to determine whether a voltage of a frequency signal in the adjacent section is received. If the voltage of the frequency signal in the adjacent section is received, the receiving equipment determines whether the voltage of the frequency signal in the adjacent section exceeds the

insulation threshold voltage, otherwise, the track in the track circuit section is normal. The receiving equipment determines whether the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage. If the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, it is determined that insulation breakage occurs on the track in the track circuit section, otherwise, it is determined that the track in the traction section is normal.

[0056] In this embodiment, each track circuit section is further provided with a first relay, and the first relay is connected to the receiving equipment. The first relay is controlled to fall when the receiving equipment determines that the track circuit section is in the occupied state, detects that rail breakage occurs on the track of the track circuit section, or detects that insulation breakage occurs on the track of the track circuit section, and is controlled to be sucked up when the receiving equipment determines that the track circuit section is in the idle state.

[0057] By employing a track circuit structure for transmitting at both ends and receiving in the middle, the double-end code sending of the tracks, the switchless sections and switch sections of the high-speed railway and the ordinary-speed railway can be achieved without cutting the track, designing a switching circuit externally and overlaying coding equipment. Moreover, the transmitted signal can be subjected to closed-loop inspection in real time, thus achieving the determination of the state of the track circuit section, the rail breakage detection, and the insulation breakage detection. That is, the rail electrical disconnection fault inspection and insulation breakage inspection of the track circuit are achieved by only using one set of equipment with two pieces of transmitting equipment and one piece of receiving equipment, and the reliability and safety of the track circuit system are improved.

[0058] It should be noted that although the present disclosure has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that it is still possible to modify the technical solutions described in the foregoing embodiments, or to replace partial technical features with equivalents. However, these modifications or replacements do not make the essence of the corresponding technical solutions deviate from the spirit and scope of the technical solutions of various embodiments of the present disclosure.

Claims

1. A track circuit system, comprising first transmitting equipment, second transmitting equipment, and receiving equipment, **characterized in that**

the first transmitting equipment and the second transmitting equipment are located on both ends of a track circuit section, respectively, and the

receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment;
 the first transmitting equipment and the second transmitting equipment are configured to respectively transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time, wherein the first frequency signal and the second frequency signal have different frequencies; and
 the receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal.

2. The track circuit system according to claim 1, **characterized in that** the receiving equipment is configured to determine a state of the track circuit section according to the received first frequency signal and second frequency signal, which comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal; and
 determining whether the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy a threshold requirement, and if the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, determining that the track circuit section is in an idle state, otherwise, determining that the track circuit section is in an occupied state.

3. The track circuit system according to claim 2, **characterized in that** the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with those of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which is able to make a track circuit in the track circuit section operate normally.
4. The track circuit system according to claim 3, **characterized in that** the receiving equipment forms a circuitous pathway with each of the first transmitting

equipment and the second transmitting equipment through one or more parallel tracks.

5. The track circuit system according to any one of claims 1 to 4, **characterized in that** the receiving equipment is configured to perform rail breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal; and
 determining whether the voltages of the first frequency signal and the second frequency signal are both less than a first preset threshold, and if the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, determining that rail breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

6. The track circuit system according to any one of claims 1 to 4, **characterized in that** the receiving equipment is configured to perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal, which comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to determine whether a voltage of a frequency signal in an adjacent section is received; if the voltage of the frequency signal in the adjacent section is received, determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, otherwise, determining that the track in the track circuit section is normal; determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, and if the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, determining that insulation breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

7. The track circuit system according to claim 6, **characterized in that** if two adjacent track circuit sections

exist, frequencies of frequency signals transmitted by transmitting equipment at adjacent ends of the two adjacent track circuit sections are also different.

8. The track circuit system according to any one of claims 1 to 4 and 7, **characterized in that** each track circuit section is further provided with a first relay, and the first relay is connected to the receiving equipment; the first relay is controlled to fall when the receiving equipment determines that the track circuit section is in an occupied state, detects that the rail breakage occurs on track in the track circuit section, or detects that the insulation breakage occurs on the track of the track circuit section, and is controlled to be sucked up when the receiving equipment determines that the track circuit section is in an idle state.

9. An operating method of a track circuit system, **characterized in that**

the track circuit system comprises first transmitting equipment, second transmitting equipment, and receiving equipment, wherein the first transmitting equipment and the second transmitting equipment are located on both ends of a track circuit section, respectively, and the receiving equipment is located on a track between the first transmitting equipment and the second transmitting equipment; the first transmitting equipment and the second transmitting equipment are configured to respectively transmit a first frequency signal and a second frequency signal to a track in the track circuit section at the same time, wherein the first frequency signal and the second frequency signal have different frequencies; and the receiving equipment is configured to determine a state of the track circuit section, perform rail breakage detection on the track in the track circuit section, or perform insulation breakage detection on the track in the track circuit section according to the received first frequency signal and second frequency signal.

10. The operating method of a track circuit system according to claim 9, **characterized in that** the determining a state of the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire frequencies and voltages of the first frequency signal and the second frequency signal; and determining whether the frequencies and vol-

tages of the first frequency signal and the second frequency signal both satisfy a threshold requirement, and if the frequencies and voltages of the first frequency signal and the second frequency signal both satisfy the threshold requirement, determining that the track circuit section is in an idle state, otherwise, determining that the track circuit section is in an occupied state.

11. The operating method of a track circuit system according to claim 10, **characterized in that** the threshold requirement is as follows: the frequencies of the first frequency signal and the second frequency signal received by the receiving equipment are consistent with those of the first frequency signal and the second frequency signal respectively output by the first transmitting equipment and the second transmitting equipment, and the voltages of the first frequency signal and the second frequency signal received by the receiving equipment are the lowest voltage which is able to make a track circuit in the track circuit section operate normally

12. The operating method of a track circuit system according to claim 11, **characterized in that** the receiving equipment forms a circuitous pathway with each of the first transmitting equipment and the second transmitting equipment through one or more parallel tracks.

13. The operating method of a track circuit system according to claim 12, **characterized in that** the performing rail breakage detection on the track in the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to acquire voltages of the first frequency signal and the second frequency signal; and

determining whether the voltages of the first frequency signal and the second frequency signal are both less than a first preset threshold, and if the voltage of the first frequency signal or the second frequency signal is less than the first preset threshold, determining that rail breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal.

14. The operating method of a track circuit system according to claim 13, **characterized in that** if two adjacent track circuit sections exist, frequencies of frequency signals transmitted by transmitting equip-

ment at adjacent ends of the two adjacent track circuit sections are also different; and the performing insulation breakage detection on the track in the track circuit section by the receiving equipment according to the received first frequency signal and second frequency signal comprises the following steps:

demodulating, by the receiving equipment, the first frequency signal and the second frequency signal at the same time to determine whether a voltage of a frequency signal in an adjacent section is received; 10
if the voltage of the frequency signal in the adjacent section is received, determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds an insulation threshold voltage, otherwise, determining that the track in the track circuit section is normal; and 20
determining, by the receiving equipment, whether the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, and if the voltage of the frequency signal in the adjacent section exceeds the insulation threshold voltage, determining that insulation breakage occurs on the track in the track circuit section, otherwise, determining that the track in the track circuit section is normal. 30

15. The operating method of a track circuit system according to claim 14, **characterized in that** each track circuit section is further provided with a first relay, and the first relay is connected to the receiving equipment; 35

the first relay is controlled to fall when the receiving equipment determines that the track circuit section is in an occupied state, detects that the rail breakage occurs on track in the track circuit section, or detects that the insulation breakage occurs on the track of the track circuit section; and 40
the first relay is controlled to be sucked up when the receiving equipment determines that the track circuit section is in an idle state. 45

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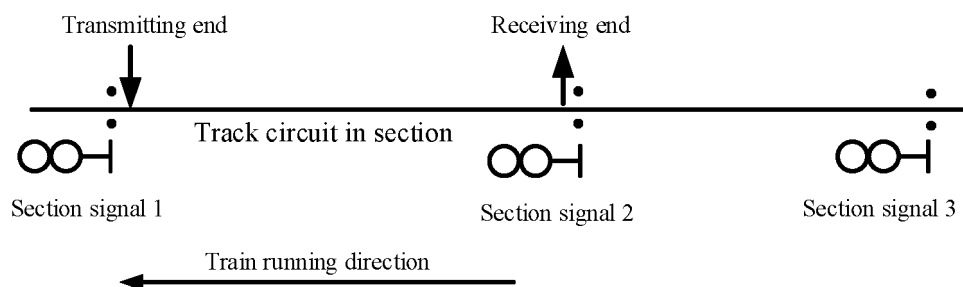


FIG. 1a

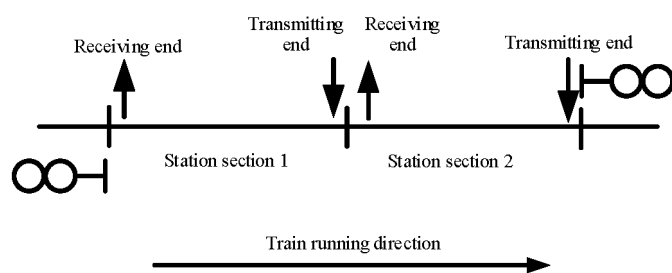


FIG. 1b

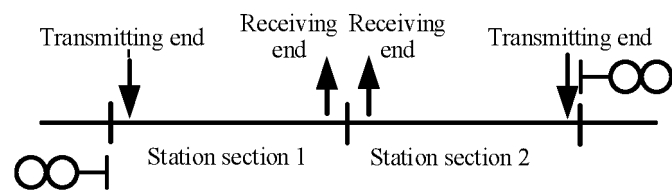


FIG. 1c

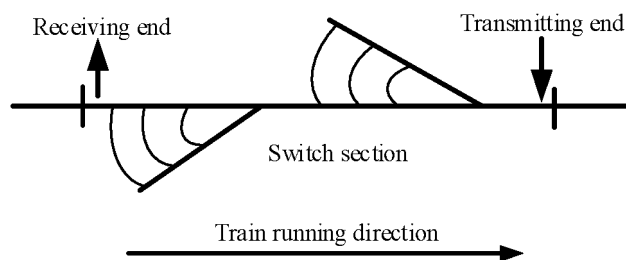


FIG. 1d

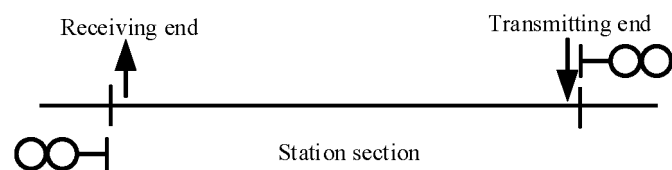


FIG. 2a

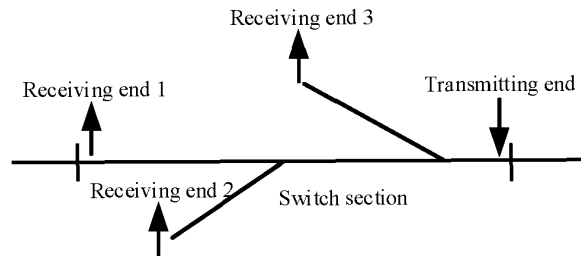


FIG. 2b

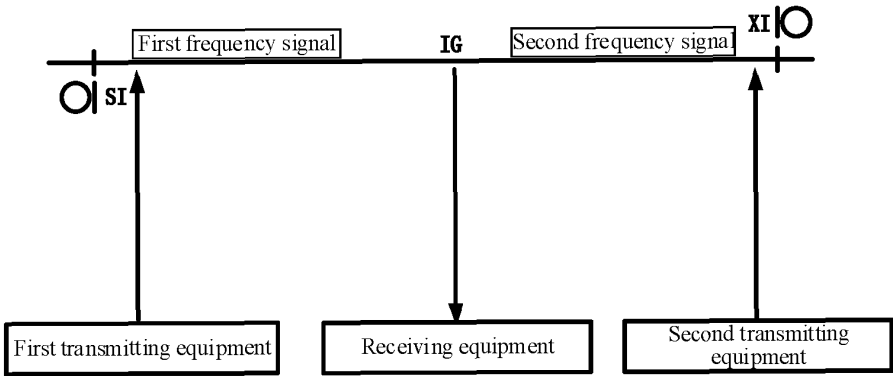


FIG. 3

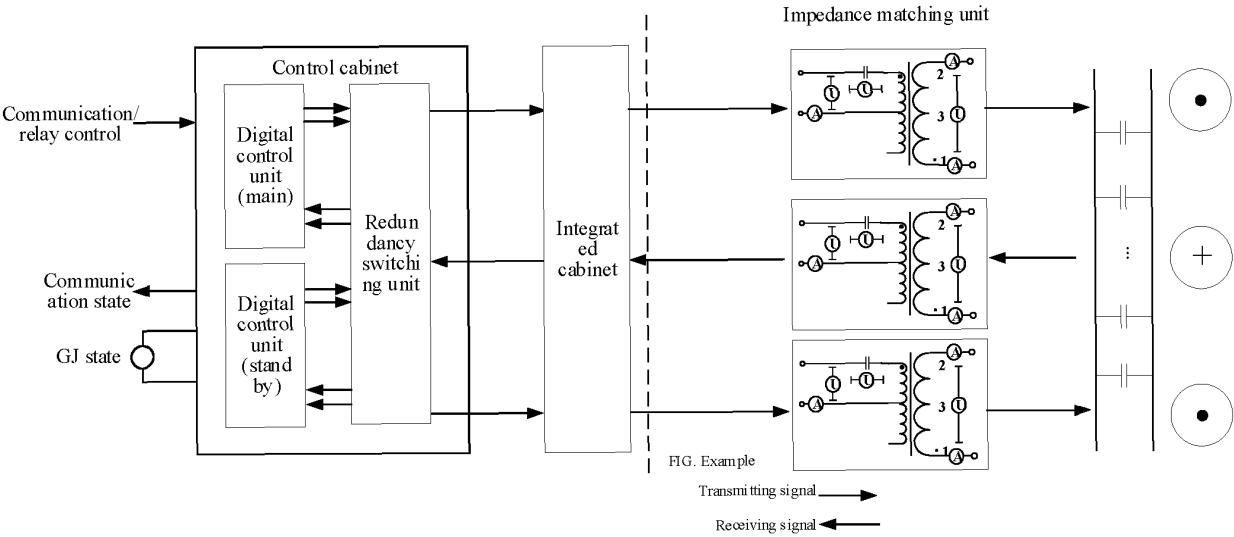


FIG. 4

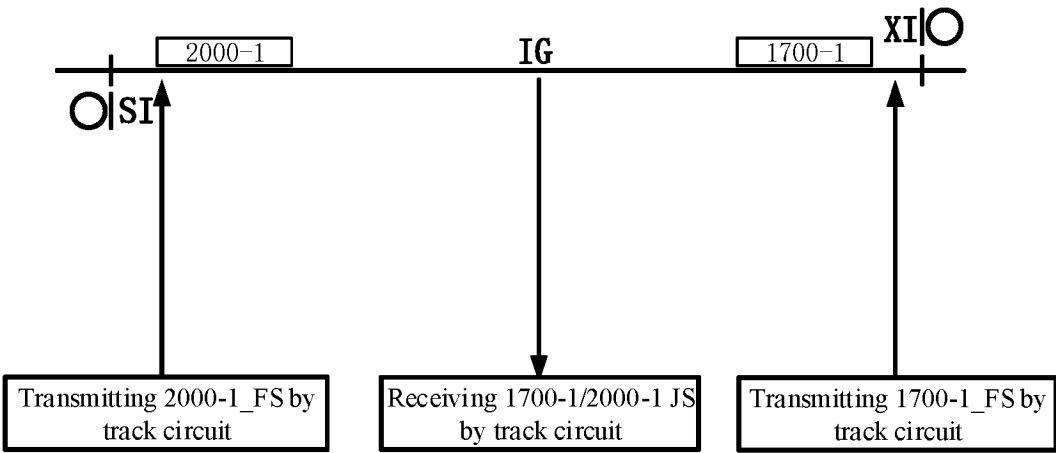


FIG. 5

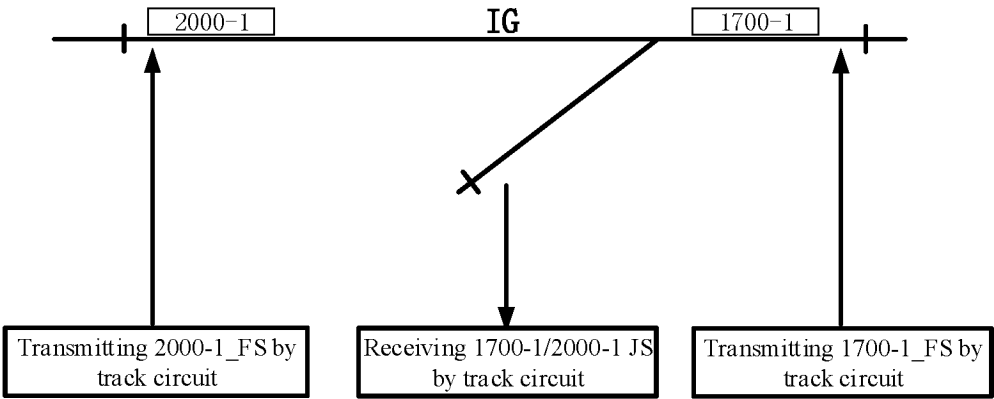


FIG. 6

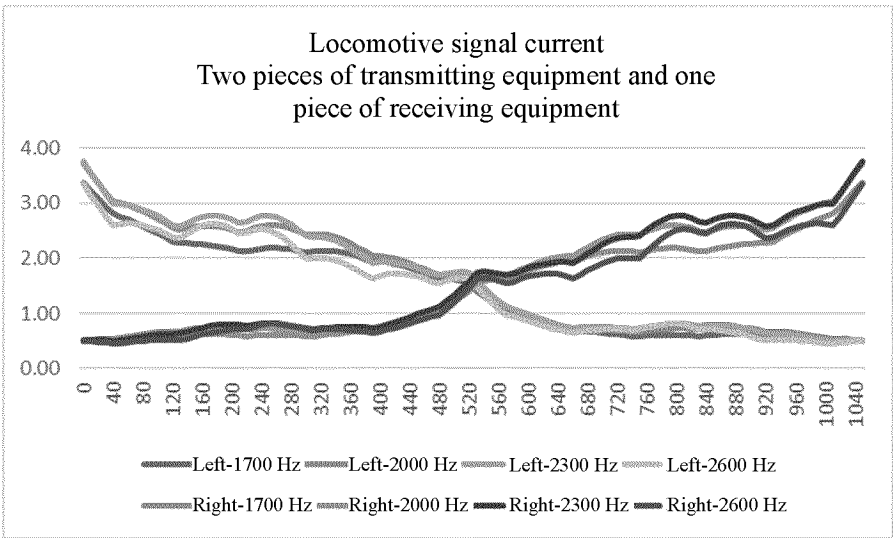


FIG. 7

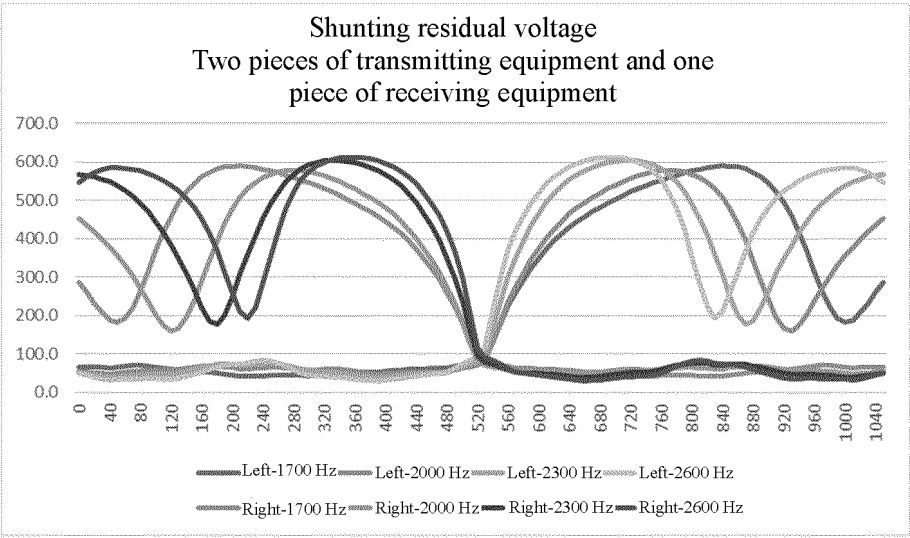


FIG. 8

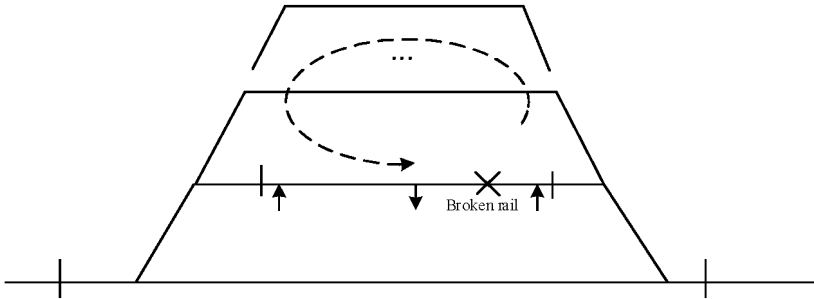


FIG. 9

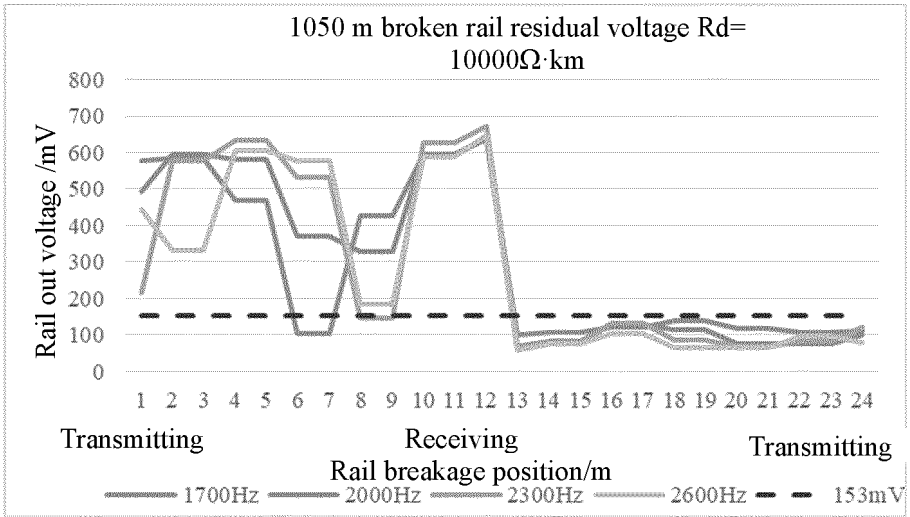


FIG. 10

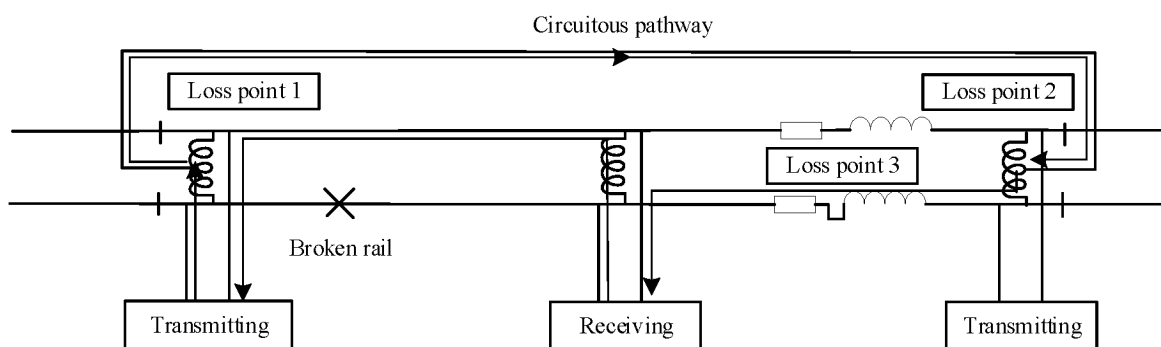


FIG. 11

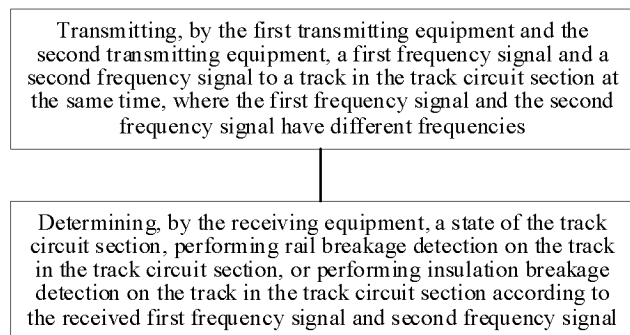


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/122251

A. CLASSIFICATION OF SUBJECT MATTER

B61L 23/04(2006.01)i; B61L 27/70(2022.01)i; B61K 9/08(2006.01)i; B61L 25/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:B61L B61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; GBTXT; JPTXT; EPTXT; Web of Science: 北京全路通信信号研究设计院, 杨铁轩, 徐宗奇, 李文涛, 孙国营, 轨道电路, 发送端, 发送单元, 发送器, 接收端, 接收单元, 接收器, 受端, 频率, 绝缘破损, 断轨, track circuit, receiver, transmitter, frequency, broken, break+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101973287 A (BEIJING NATIONAL RAILWAY RESEARCH & DESIGN INSTITUTE OF SIGNAL & COMMUNICATION) 16 February 2011 (2011-02-16) description, paragraphs [0029]-[0086], and figures 1-6	1, 8, 9, 15
A	CN 114348048 A (CRSC RESEARCH & DESIGN INSTITUTE GROUP CO., LTD. et al.) 15 April 2022 (2022-04-15) entire document	1-15
A	CN 206255024 U (CRSC RESEARCH & DESIGN INSTITUTE GROUP CO., LTD.) 16 June 2017 (2017-06-16) entire document	1-15
A	CN 105946900 A (XI'AN SIYUAN KECHUANG RAIL TRANSIT TECHNOLOGY DEVELOPMENT CO., LTD.) 21 September 2016 (2016-09-21) entire document	1-15
A	GB 1349651 A (M.L. ENGINEERING (PLYMOUTH) LTD.) 10 April 1974 (1974-04-10) entire document	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)
China No. 6, Xitucheng Road, Jimenqiao, Haidian District,
Beijing 100088

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/122251

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