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DIRECT CURRENT HIGH TENSION GROUNDING PROTECTION CIRCUIT
FOR DIRECT CURRENT ELECTRIFICATION SYSTEM

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The present invention relates generally to a direct current high tension grounding protection circuit for a direct current electrification system.

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Subways, electrified conveyance systems and the like are commonly powered on a direct current at 1,500V or less at present. Such electrification systems supply direct current converted from a three phase alternating current (AC) source via a rectifier to provide current meeting the requirements of the conveyance in a manner such that the positive pole side of the rectifier is connected to a trolley wire, third rail, or the like, and the negative pole side is connected to a standard rail for applying the voltage. In this case, the current from the negative pole side returns to the negative pole side of the rectifier through the rail. However, since the rails are laid on the ground, a shunt current (sneak current, or stay current) may be present in addition to the current supplied to the rails. In the territories supplying the alternating current to the rail, direct grounding systems are employed line such that the current is allowed to flow positively through the ground in order to maintain the potential of the train at the same level as the ground, and a non-ground system (floating system) with which to minimize the current through the ground so as to avoid the possibility of electrolytic corrosion as much as possible.

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Generally, in the case of a subway, for example, the rails are not laid directly on the ground, but are fixed to concrete slabs, or sleepers. The slabs

are laid on the ground insulated by rubber pads which serve as vibration insulators. Therefore, the ground and the rails are in a state where they are insulated with high resistance. In a direct current electrification system for such a subway, a voltage detection system capable of detecting a potential difference between the rail and the ground is generally used for practical protection at present because it is not possible to practice current detection system to detecting grounding problems for the positive pole side connected to the third rail since the value is so small compared with the load current.

For example, when the positive pole side is grounded, the ground shows positive potential, as a result, a potential difference occurs between the negative pole potential of the rail and the ground (positive pole). With this value of potential difference, normal and troubled states may be discriminated.

A long distance subway, which is built with non-ground system with a high resistance between the rail and the ground is generally structured as shown in Fig. 2. The system includes a transformer 1 of a first alternating current receiving system 100 and a transformer 2 of a second alternating current receiving system 200. The secondary side of the transformer 1 is connected to direct current substations SS1, SS2 and SS3 of each direct current substation through a breaker 3 and an alternating current bus-bar 4. The secondary side of the transformer 2 is connected to each of the direct current substations SS4 and SS5 through a breaker 5 and an alternating current bus-bar 6. Each of the substations comprises breakers 7a to 7e, transformers 8a to 8e and rectifiers 9a to 9e.

The positive pole side of each of the foregoing

rectifiers 9a to 9e is connected to the trolley wire 10 and the negative pole side is connected to the rail 11. One-line ground discrimination relays (direct current high tension grounding relays) 12a to 12e are connected
5 respectively between the common contact point of the rail 11 and each of the rectifiers 9a to 9e and the ground. The alternating current bus-bars 4 and 6 are connected by an extension supply breaker 13.

In a circuit as structured above, the original
10 alternating current wires are arranged with several receiving points over a long-distance area, and the current thus received is supplied locally in each territory to each of the direct current substations in the territory. The direct current is fed over the entire
15 rail way by the rectifiers which are in parallel at all times, while, as mentioned, the alternating current side is independent per territory. If, for example, a first alternating current receiving system (on the side of AC bus-bar 4 side) is in suspended service, the extension
20 supply breaker 13 is closed to allow current to be supplied from the AC bus-bar 6 to the second alternating current receiving system to the AC bus-bar 4 territory so that no hindrance is given to train operation.

In such a system as described above, the one-
25 line discrimination relays 12d and 12e which exist outside the territory where the service is suspended conduct an unwanted activation at the moment an outage is caused to the first alternating current receiving system, that is the AC bus-bar 4 side. The cause of such
30 undesirable operation is because when a power is supplied from the rectifier 9e in the normal territory adjacent to the territory connected in parallel where the alternating current service is suspended, the negative pole current returning through the ground becomes great depending on the ratio of its shunt current due to the

rail resistance and the round resistance as shown in Fig. 3, so that the one-line ground discrimination relay 12e performs an unwanted activation where there is no trouble in the system at all. Thus the rectifier is caused to
5 conduct an acute locking trip to result in trouble where the breakers in the direct current substations in the entire territory are caused to trip one after another ultimately. In Fig. 3, the same elements are described by the same reference numerals.

10 The present invention is designed in consideration of the above and it is an object of the invention to provide a direct current high tension ground protection circuit for a direct current electrification system capable of eliminating any unwanted activation of
15 the direct current high tension ground relays.

It is therefore a principal object of the present invention to overcome the drawbacks of the prior art.

20 It is a further object of the present invention to provide a direct current high tension ground protection circuit for a direct current electrification system capable of eliminating any unwanted activation of the direct current high tension ground relays.

25 In order to accomplish the aforementioned and other objects, a direct current high tension grounding protection circuit for a direct current electrification system is provided, comprising: at least first and second alternating current receiving means having first and
30 second alternating current bus-bars to which alternating current electric power is applied, an extension supply breaker separating the first and second alternating current receiving means, a plurality of rectifiers arranged in parallel between the first and second alternating current bus-bars and direct current feeder

lines, a plurality of direct current high tension grounding relays arranged in parallel between a non-grounded rail and ground to suspend operation of the rectifiers when a ground contact current is detected, first and second insufficient voltage detecting relays connected to each of the first and second alternating current bus-bars and active to output a signal indicative of insufficient alternating current reception, and a protection circuit suppressing operation of the direct current high tension grounding relays in accordance with operation signals from the first and second insufficient voltage detecting relays.

In the drawings:

Fig. 1 is a circuit diagram of a direct current high tension grounding protection circuit for a direct current electrification system according to a preferred embodiment of the invention;

Fig. 2 is a circuit diagram showing an example of a conventional direct current electrification system;

Fig. 3 is a schematic view describing a state where current is returning through the ground.

Referring now to the drawings, particularly to Fig. 1, wherein like elements to those of the previously described Fig. 2 will be referred to by like reference numerals, it can be seen that insufficient voltage relays 14 and 15 are provided for alternating current bus-bars 4 and 6 respectively. To the positive pole line of a direct current power source 16, a constantly open contact point 14a of the alternating current insufficient voltage relay 14 is inclusively inserted. Between the positive and negative poles of the direct current power source 16, coils 17 and 18 of the alternating current insufficient voltage relay 14 are connected in parallel. To the

positive pole line of alternating current power source 19, the constantly open contact point 15a of the alternating current insufficient voltage relay 15 is inclusively inserted. Between the positive and negative
5 poles of the direct current power source 19, coils 20 and 21 of the alternating current insufficient voltage relay 15 are connected in parallel.

Between the one-line ground discrimination relays 12a to 12d and the rail 11, diodes 22a to 22d
10 having polarities as shown in Fig. 1 are connected, respectively. Between both ends of each of the detecting coils of the one-line ground discrimination relays 12a and 12b, the constantly open contact points 20a and 21a of the coils 20 and 21 are connected, respectively.
15 Between both ends of each of the detecting coils of the one-line ground discrimination relays 12c and 12d, constantly open contact points 17a and 18a of the coils 17 and 18 are connected respectively.

In this respect, although not shown in Fig. 1,
20 the positive poles and negative poles of the rectifiers 9a to 9d are connected to the trolley wire 10 and rail 11, respectively, as shown in Fig. 2.

In the circuit structured as above, if, for example, the service of the first alternating current receiving system 100 is suspended, the current flows from
25 the positive pole side of the rectifiers 9c and 9d connected to the alternating current bus-bar 6 of the second alternating current receiving system 200 to the negative pole side of the rectifiers 9c and 9d through
30 the trolley wire 10, the train (not shown), ground, the one-line ground discriminating relays 12c and 12d, and the rail 11.

At this juncture, depending on the shunt ratio between the rail resistance and the ground resistance, the current returning to the negative pole side of the

rectifiers 9c and 9d through the ground is increased, and there is a possibility that the relays 12c and 12d will conduct unwanted activation. However, since the alternating current insufficient voltage relay 14 on the
5 alternating current bus-bar 4 side is allowed to operate during the period from the moment the service of the first alternating current receiving system 100 is suspended, to the moment the extension supply breaker 13 is closed, the contact point 14a becomes ON to excite the
10 coils 17 and 18.

Consequently the constantly open contact points 17a and 18a become ON to cause the detecting coils (not shown) of the one-line ground discriminating relays 12c and 12d to be short circuited, thus suppressing
15 unnecessary activation. In this way, it is possible to avoid any situation where the unwanted operation of the one-line ground discrimination relays 12c and 12d is conducted to cause activation of the rectifiers 9c and 9d.

20 Then, when the extension supply breaker 13 is closed by an extension supply instruction from a control source (not shown), the alternating current insufficient voltage relay 14 on the alternating current bus-bar 4 side is restored to cause the suppressed operation of the
25 one-line ground discrimination relays 12c and 12d to be released. Hence, the original state is restored.

In this respect, there is a method where instead of employing the foregoing method, a delay timer (not shown) may be added to that of the one-line ground
30 discrimination relays 12a to 12d. By this, while the operation is being delayed, the extension supply breaker 13 is closed. However, if such a method is adopted, the protection level is lowered because an amount of delay of the timer is also added even in a case where grounding trouble takes place for the trolley wire 10 while

receiving the current normally, therefore, preferable protection is obtained by the previously described method.

5 The suppression of the operation of the one-line ground discrimination relays 12a to 12d according to the present invention is confined to a case where alternating current receiving is suspended. Consequently, it is possible to reliably detect any grounding troubles at the time of normal current
10 receiving and suitable protection is provided.

According to the present embodiment, a pilot wire (not shown) is used as a means to detect any outage of adjacent systems. However, the present invention is not limited to such an arrangement and any other means of
15 communicating the information may also preferably be used.

Thus, according to the invention as set forth above, there is provided a protective circuit capable of suppressing the operation of the direct current one-line
20 ground discrimination relays 12 by means of first and second alternating current insufficient voltage relays 14 and 15 which are respectively connected to the first and second alternating current bus-bars 4 and 5 of the direct current electrification system, which operate at the time
25 of suspension of alternating current reception in accordance with operating signals from the first and second alternating current insufficient voltage relays 14 and 15. Therefore, it is possible to prevent any unwanted operation of the direct current one-line ground
30 discrimination relays 12 (high tension grounding relays) in territories where current is being normally received, and to avoid any suspended operation of the rectifiers 9 in territories where current is being normally received.

While the present invention has been disclosed in terms of the preferred embodiment in order to

facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood
5 to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.

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CLAIMS:

1. A direct current high tension grounding protection circuit for a direct current electrification system, comprising:

5 at least first and second alternating current receiving means having first and second alternating current bus-bars to which alternating current electric power is applied;

10 an extension supply breaker separating said first and second alternating current receiving means;

a plurality of rectifiers arranged in parallel between said first and second alternating current bus-bars and direct current feeder lines;

15 a plurality of direct current high tension grounding relays arranged in parallel between a non-grounded rail and ground to suspend operation of said rectifiers when a ground contact current is detected;

20 first and second insufficient voltage detecting relays connected to each of said first and second alternating current bus-bars and active to output a signal indicative of insufficient alternating current reception; and

25 a protection circuit suppressing operation of said direct current high tension grounding relays in accordance with operation signals from said first and second insufficient voltage detecting relays.

2. A direct current high tension grounding protection circuit for a direct current electrification system as set forth in claim 1, wherein said protection circuit is connected to first and second coils which are respectively excited according to operation of said first and second insufficient voltage detecting relays, said protection circuit further connected between both ends of



coils of each of said direct current high tension grounding relays, a constantly open contact thereof becoming on when said first and second coils are excited.

5 3. A direct current high tension grounding protection circuit for a direct current electrification system as set forth in claim 1, further including a delay timer connected with said direct current high tension grounding relays such that, while operation of said
10 direct current high tension grounding relays is delayed said extension supply breaker of said electrification system is closed.

15 4. A direct current high tension grounding protection circuit for a direct current electrification system as hereinbefore described with reference to Figure 1.

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