

POWER SUPPLY APPARATUS FOR ELECTRIC RAILROAD

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The present invention relates to a power supply apparatus for a direct-current type electric railroad, and more particularly to a power supply apparatus having a thyristor rectifier which rectifier performs powering and regenerating functions.

2. Description of the Prior Art

10 In general, a power supply apparatus for a direct-current type electric railroad is arranged to receive alternating-current electric power from a three-phase alternating-current electric source and transforms the alternating-current electric power to direct-current electric power. The power supply apparatus then supplies the direct-current electric power to electric railcars
15 through an electric-car line. Further, when an electric railcar is in a regenerating operation, the power supply apparatus controls the generative electric power from the electric railcar so as to be absorbed to the other powering electric railcar through the electric-car line, or so as to be returned to the alternating-current
20 electric source through an reverse electric-power inverting device. As shown in Fig. 2, a conventional direct-current type power supply apparatus is arranged to execute powering and regenerating by using a right-and-reverse inverter. This power supply apparatus is arranged to receive alternating-current
25 electric power from an electric transformer 21 to an alternating-current side of a right-and-reverse inverter 22, and to supply a direct-current output of the inverter 22 to an electric-car line 25 and a rail 26 through a direct-current reactor 23 and a powering-and-regenerating selector switch 24. The
30 selector switch 24 is constituted by a right-direction diode 241 installed to an positive-electrode output of the inverter 22, a right-direction diode 242 installed from the rail 26 to a negative-electrode end of the inverter 22, a right-direction thyristor 243 installed from the electric-car line 25 to a
35 negative-electrode output end of the inverter 22 and a

right-direction thyristor 244 installed from the positive-electrode output end of the inverter 22 to the rail 26. During a powering operation of the electric railcar 27, the thyristors 243 and 244 are put in an off condition, and therefore direct-current electric power is supplied from the inverter 22 through the diodes 241 and 242 to the electric railcar 27. During a regenerating operation of the electric railcar 27, the thyristors 243 and 244 are turned on. Therefore, at predetermined time, the regenerative electric power is supplied to the thyristor 243, the inverter 22 and the thyristor 244, and is regenerated in the alternating-current electric source through the electric source transformer 21 upon being reversely transformed at the inverter 22. This switching between the powering and regenerating is detected from an average value of the electric-car line voltage VG by a filter 28, a DC/DC converter 29 and an averaging circuit 30. When this average value becomes larger than or equal to a circuit selecting set-value of a selecting control circuit 31, it is judged that the regenerating operation should be executed and the thyristors 243 and 244 are turned on by means of the output of the selecting control circuit 31. Further, an output signal indicative of an execution of the regenerating operation is applied from the selecting control circuit 31 to an automatic voltage control circuit 32. A phase control signal corresponding to the average voltage value is applied from the automatic voltage control circuit 312 to a gate control circuit 33. The inverter 22 is reversely operated according to a gate pulse which is phase-controlled by the gate control circuit 33.

However, this powering-and-regenerating selector switch 24 and the circuits 31, 32 and 33 thereof complicates the conventional power supply system.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved power supply apparatus of a direct-current type railroad which apparatus is simplified in structure and eliminates

a momentary loss of the output voltage during the switching between powering and regenerating.

A power supply apparatus according to the present invention is for a direct-current type electric railroad. The power supply apparatus comprises an electric source transformer which is connected to an alternating-current electric source. A thyristor rectifier is connected to the electric source transformer and an electric railcar so as to perform functions of powering and regenerating of the electric railcar. A voltage ensuring rectifier is connected to the electric source transformer and to the electric railcar through the electric-car line. The voltage ensuring rectifier is arranged parallel with the thyristor rectifier and outputs a voltage lower than a direct-current voltage of the thyristor rectifier to the electric railcar.

With this apparatus, even if the output of the thyristor rectifier becomes zero at a moment of the switching between powering and regenerating, a momentary stoppage of the electric railcar is prevented by an operation of the voltage ensuring rectifier. Accordingly, a secure operation of the electric railcar is ensured.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit diagram which shows one-line wiring of an embodiment of the present invention; and

Fig. 2 is a circuit structural diagram of a conventional example.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, there is shown an embodiment of a power supply apparatus of a direct-current type railroad according to the present invention.

The power supply apparatus comprises an electric source transformer 1 whose primary coil 1a is connected to an alternating-current electric source AC. A secondary coil 1b of the electric source transformer 1 is connected to an input end of a thyristor rectifier 2 which transforms the alternating-current electric power to the direct-current electric power. A

positive-electrode of the thyristor rectifier 2 is connected to an electric-car line 4 through a direct-current bus 3 and direct-current high-speed breakers 6 and 7. The thyristor rectifier 2 is of a bridge type rectifier and is arranged to execute a α -control (a control of angle of retard) and a β -control (a control of angle of advance) which control a phase of the thyristor rectifier 2 for powering and regenerating, respectively. A section 5 is disposed in the electric-car line 4. A rail 8 is connected to a negative-electrode of the thyristor rectifier 2. An electric railcar 9 is provided with a direct-current motor (although not shown) and receives the electric power from the electric-car line 4. A voltage ensuring thyristor 10 is of a bridge type, and its alternating-current side is connected to a tertiary coil 1c of the electric source transformer 1. A direct-current side of the voltage ensuring thyristor 10 is connected with the direct-current output side of the thyristor rectifier 2 so as to be arranged parallel with the thyristor rectifier 2.

This voltage ensuring rectifier 10 is constituted for ensuring a voltage at a moment when the powering operation (regenerating operation) is moved to the regenerating operation (powering operation). This voltage ensuring rectifier 10 is a small capacity rectifier not taking account of electric current, and the output voltage of direct current is set to be lower than the direct-current output voltage of the thyristor rectifier 2.

For example, in case that the voltage of the electric-car line is 1500V and the capacity of the thyristor rectifier 2 is 300kw, if the direct-current voltage during converter (powering) is 1500V and the direct-current voltage during inverter (regenerating) is 1600V, the capacity of the voltage ensuring rectifier 10 is set at 100kw and the direct-current output voltage is set at 1300V.

Explaining the operation of the above-mentioned structure, during a normal powering operation, electric power is supplied to the electric railcar 9 by executing the α -control (0° - 90°) of a gate of the thyristor rectifier 2, as indicated by a solid line arrow.

Next, when the regenerating operation is executed, the gate of the thyristor rectifier 2 is moved to an inverter operation by executing the β -control (90° - 180°). At this time, the generated electric power of the electric railcar is converted into
5 alternating-current at the thyristor 2 as indicated by a dotted line arrow, and returned to a side of an alternating-current electric source AC through the electric source transformer 1.

With the thus arranged power supply apparatus, even if the output of the thyristor rectifier 2 changes so that the phase
10 control passes through zero point at a moment of a switching from the α -control to the β -control, an electric current indicated by a dot and dash line arrow is flowed in the electric railcar since the output voltage of the voltage ensuring rectifier 10 is always applied to the direct-current bus. Therefore, the electric railcar 9
15 is not put in non-voltage applied condition. Accordingly, the undervoltage relay in the electric railcar 9 is prevented from being operated, and the electric railcar 9 is prevented from being stopped during the switching.

Although the thyristor rectifier 2 and the voltage ensuring
20 rectifier 10 are operated in parallel, the voltage ensuring rectifier 10 is never put in an overload condition since the direct-current electric power is supplied from a high voltage side, that is, from a side of the thyristor rectifier 2.

Although the preferred embodiment has been shown and
25 described so that the alternating-current electric power to the voltage ensuring rectifier 10 is supplied from the tertiary coil of the electric source transformer 1, it will be understood that such alternating-current electric power is supplied from the secondary coil through a transformer for decreasing voltage.



WHAT IS CLAIMED IS:

1. A power supply apparatus of a direct-current type electric railroad comprising:

a electric source transformer connected to an alternating-current electric source;

a thyristor rectifier connected to said electric source transformer and to an electric railcar so as to perform functions of powering and regenerating of the electric railcar; and

a voltage ensuring rectifier connected to said electric source transformer and to the electric railcar through the electric-car line, said voltage ensuring rectifier being arranged parallel with said thyristor rectifier and outputting a voltage lower than a direct-current voltage of the thyristor rectifier to the electric railcar.

2. A power supply apparatus as claimed in Claim 1, wherein said electric source transformer has primary, secondary and tertiary coils, the primary coil being connected to the alternating-current electric source, the secondary coil being connected to said thyristor rectifier, and the tertiary coil being connected to said voltage ensuring rectifier and outputting a voltage lower than that of the secondary coil.

3. A power supply apparatus as claimed in Claim 1, wherein said thyristor rectifier and said voltage ensuring rectifier are connected to the electric railcar through a direct-current bus, a direct-current breaker and an electric-car line.

4. A power supply apparatus as claimed in Claim 1, wherein a capacity of said voltage ensuring rectifier is smaller than that of said thyristor rectifier.

5. A power supply apparatus as claimed in Claim 1, wherein a powering operation is executed by a α -control of a gate of said



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thyristor rectifier, and a regenerating operation is executed by a β -control of the gate of said thyristor rectifier.