A. J. HALL.

SYSTEM OF DISTRIBUTION.

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1,248,484. Patented Dec. 4, 1917.

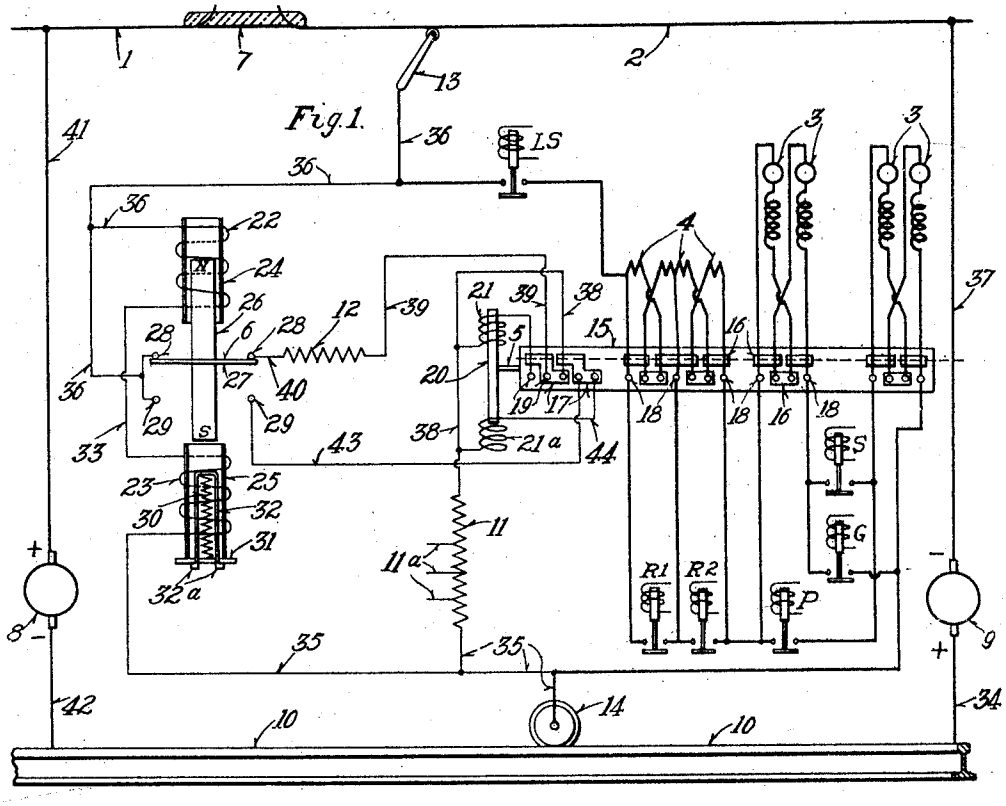


Fig. 1.

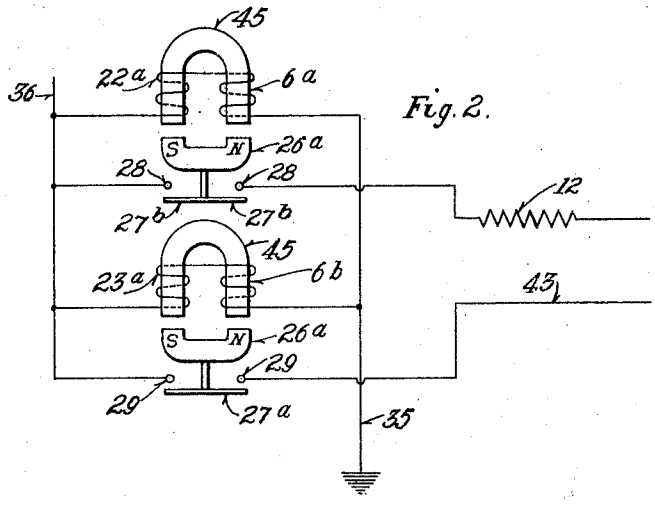


Fig. 2.

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SYSTEM OF DISTRIBUTION.

1,248,484. Specification of Letters Patent. Patented Dec. 4, 1917.

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To all whom it may concern:

Be it known that I, ARTHUR J. HALL, a subject of the King of Great Britain, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Distribution, of which the following is a specification.

My invention relates to systems of distribution, and it has special reference to direct-current railway systems.

One of the objects of my invention is to provide a sectionalized trolley system having high and low-voltage trolley sections for supplying energy to vehicles that are provided with a reliable means, which shall be independent of variations in line voltage, for automatically rearranging the motor-circuit connections thereof, in passing from one section to another, to correspond to the voltage of the section upon which the vehicle is to be operated.

Since the introduction of the use of high-voltage direct-current energy on interurban railways, there have been many instances in which the same vehicles have been required to operate at full speed on both low-voltage city sections and high-voltage interurban sections. The above conditions require some means for so re-arranging the motor circuits that each motor will receive its rated voltage on each trolley section.

In some existing systems, the re-arrangement of the motors is automatically effected, in passing from one section to another, by means of selective voltage relays. However, because of the wide variations in line voltage on both sections, a system embodying the use of selective voltage relays is inherently uncertain in its operation.

According to my invention, I provide a system having successive high and low-voltage trolley sections of alternate polarity for delivering energy to electric vehicles that are provided with reverse-current relays for automatically governing the change-over of motor-circuit connections, in passing from one section to another, in accordance with the polarity and voltage of the section being entered, and entirely independent of any variations in line voltage.

My invention may be more readily understood by reference to the accompanying drawing, in which Figure 1 is a diagrammatic view of the apparatus and connections of a system embodying my invention, and Fig. 2 is a similar view of a portion of a modified system arranged in accordance with my invention.

Referring to Fig. 1, the system shown embodies positive and negative trolley-conductor sections 1 and 2 which, for the sake of explanation, are assumed to be supplied with direct-current energy at 600 and 1200 volts, respectively, a plurality of traction motors 3 associated with a vehicle (not shown), a sectionalized accelerating resistor 4, a switching device 5 adapted to re-arrange the motor and resistor connections for full-speed operations on the different voltage sections, and automatic means 6 for controlling the operation of the change-over switch 5, in passing from one section to another.

The trolley conductors 1 and 2 are suitably insulated, the one from the other, by a section-break insulator 7. The low-voltage trolley conductor 1 is energized from the positive side of a 600 volt direct-current source, such as a generator 8, and the high-voltage trolley conductor is energized from the negative side of a 1200 volt direct-current source, such as a generator 9. A track rail 10 conveniently completes the circuit for the system, the negative side of the 600 volt generator 8 and the positive side of the 1200 volt generator 9 being connected thereto.

A set of electrically operated unit-switches LS, R_1, R_2, P, S and G is provided for manipulating the connections of the motors 3 and resistor 4 during accelerating and transition periods, said switches being operated by low-voltage current from taps 11^a of a control resistor 11 through a suitable master controller (not shown). An additional control resistor 12 is provided for use in series with the resistor 11 to limit the current in the control circuit when operating on a high-voltage section.

A trolley 13 is provided on the vehicle for making traveling contact with the trolley conductors, and moving contact is made with the rail 10 through a wheel 14 of the vehicle.

The motors 3, in this instance, may be of any suitable type adapted for 600 volts, and four motors are used in order to form series and parallel groups to obtain full-speed operation on both 1200 and 600 volt trolley sections.

The switching device 5, which may be made of various forms, conveniently constitutes an electro-magnetically operated two-position drum-type change-over switch. The change-over switch embodies a two-position drum 15 that carries a plurality of main-circuit contact members 16 and a plurality of control-circuit contact members 17, while main contact fingers 18 and control contact fingers 19 are provided for making sliding engagement therewith. The drum 15 has, associated therewith, a plunger 20 that is adapted to be actuated in either direction by the one or the other of solenoids 21 and 21ª to effect either of the two-drum positions.

The reverse-current relay 6 comprises a pair of stationary solenoids 22 and 23 that are oppositely wound on spools 24 and 25 which are disposed the one above the other and a vertically movable polarized plunger 26 having a north pole at its upper end and a south pole at its lower end disposed between the solenoids 22 and 23 and adapted to be actuated in either direction in accordance with the direction of the energizing current. The plunger 26 carries a contact member 27 which bridges the upper relay contact studs 28 in its upper position and the lower relay contact studs 29 in its lower position. A compression spring 30 is provided to centrally position the plunger 26 between the solenoids 22 and 23 when the relay is deenergized. The spring 30 is disposed within the lower solenoid 23 and has a fixed lower stop 31 and a downwardly movable upper stop 32 consisting of a strap having its lower ends 32ª outwardly extended and adapted to engage the under side of the lower stop 31 to limit the upward movement of the upper stop 32.

The oppositely wound solenoids 22 and 23 are permanently connected in series relation by conductor 33.

With the trolley 13 on a high voltage trolley section, as in Fig. 1, the relay 6 is energized from the 1200 volt generator 9 through a circuit including conductor 34, rail 10, vehicle wheel 14, conductor 35, lower relay solenoid 23, conductor 33, upper relay solenoid 22, conductor 36, trolley 13, trolley conductor 2 and conductor 37 to the generator 9. The flow of current through the relay from the solenoid 23 to the solenoid 22 produces a south pole at the top of the lower solenoid 23 and a south pole at the bottom of the upper solenoid 22. As the lower portion of the polarized plunger 26 is a south pole and the upper portion is a north pole, the plunger will be attracted by the upper solenoid 22 and repelled by the lower solenoid 23, thus holding the plunger 26 in the upper or 1200 volt position, as indicated in the drawing. In the upper position, the contact member 27 bridges the contact studs 28, thus connecting the control resistors 11 and 12 in series across the line through a circuit from the 1200 volt generator 9 which traverses conductor 34, rail 10, vehicle wheel 14, conductor 35, control resistor 11, conductor 38, change-over switch control fingers 19, contact member 17, conductor 39, 1200 volt resistor 12, conductor 40, relay contact studs 28, contact member 27, conductor 36, trolley 13, 1200 volt trolley conductor 2, and conductor 37 to the generator 9.

With the change-over switch 5 in the 1200 volt position, as shown in the drawing, the four motors 3 are arranged in two sets of two series-connected motors, so that each motor will receive 600 volts when in the full parallel connection on the 1200 volt section. In the 1200 volt position of the change-over switch, the two halves of each of the two steps of the accelerating resistor 4 are connected in series to offer the highest resistance available for 1200 volt acceleration.

When the trolley 13 moves from the 1200 volt trolley section 2 to the section-break insulator 7, the relay 6 is deënergized and the plunger 26 drops by gravity to a neutral position limited by the stop 32 and the spring 30, the upward pressure of the spring 30 being slightly greater than the weight of the plunger 26. The dropping of the plunger 26 causes the contact member 27 to break contact with the studs 28, thus disconnecting the control resistors 11 and 12.

When the trolley moves from the section-break insulator 7 to the positive 600 volt trolley conductor 1, the relay coils are energized from the positive terminal of the 600 volt generator 8 through conductor 41, trolley conductor 1, trolley 13, conductor 36, upper relay solenoid 22, conductor 33, lower relay solenoid 23, conductor 35, vehicle wheel 14, rail 10 and conductor 42 to the negative side of the 600 volt generator 8. The flow of current through the relay 6 from the upper solenoid 22 to the lower solenoid 23 produces a north pole at the bottom of the upper solenoid 22 and a north pole at the top of the lower solenoid 23. As the top of the movable plunger 26 is a north pole and the bottom a south pole, the plunger will be repelled by the upper solenoid 22 and attracted by the lower solenoid 23, thereby compressing the spring 30 until the contact member 27 bridges the contact studs 29. The bridging of the studs 29 effects energization of the operating solenoid 21ª of the change-over switch 5, from the 600 volt generator through a circuit including

conductor 41, trolley conductor 1, troller 13, conductor 36, contact studs 29, contact member 27, conductor 43, change-over switch control fingers 19, contact member 17, conductor 44, operating solenoid 21^a, conductor 38, control resistor 11, conductor 35, vehicle wheel 14, rail 10 and conductor 42 to the generator 8.

When the operating solenoid 21^a of the change-over switch 5 is energized, the plunger 20 is drawn into the solenoid, thus moving the drum 15 from the 1200 volt position to the 600 volt position. As the drum 15 assumes the 600 volt position, the contact member 17 breaks connection with the conductor 44 to effect deënergization of the solenoid 21^a and connects conductor 43 directly to conductor 38, thus energizing the control resistor 11 directly from the line voltage to supply low-voltage current for the operation of the control unit switches.

In the 600 volt position of the change-over switch 5, the four motors 3 are arranged in two sets of two parallel-connected motors, so that each motor will receive 600 volts in the full parallel position on the 600 volt section. The two halves of each of the two steps of the accelerating resistor 4 are paralleled to decrease the resistance and increase the capacity of the resistor for 600 volt acceleration.

The reverse of the operations just described are performed by the apparatus in passing from a 600 volt section to a 1200 volt section, whereby the main and control-circuit connections are re-arranged automatically in passing from one section to another, to conform to the voltage of the section being entered.

In Fig. 2, two separate oppositely wound polarized relays 6^a and 6^b, which may be substituted for the single double-acting relay 6 in Fig. 1, are employed.

Each of the relays 6^a and 6^b comprises an inverted U-shaped electro-magnet 45 and a polarized armature 26^a that is mounted in a vertically movable relation thereto, and carries a contact member 27^a. The relay 6^a is also provided with contact studs 28 and an energizing winding 22^a, and the relay 6^b has, in addition, contact studs 29 and an energizing coil 23^a which is wound oppositely to the coil 22^a of the relay 6^a. The coils 22^a and 23^a are so wound and the armatures 26^a are so polarized that the relay 6^a will operate on the negative 1200 volt trolley section 2 to bridge the control studs 28 by the member 27^a, and the relay 6^b will operate on the positive 600 volt trolley section 1 to bridge the contact studs 29 by the contact member 27^b. The operation of the system is otherwise identical with the operation described in connection with Fig. 1.

The system and structural details set forth above have been selected merely for the purpose of illustration, and various modifications in the circuit connections and apparatus may be made without departing from the spirit and scope of my invention, as set forth in the appended claims.

I claim as my invention:

1. In a system of distribution, the combination with a plurality of successive trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said sections, and electro-responsive means mounted on said vehicle and actuated by the reversal of current in passing from one section to another for connecting the vehicle to the trolley sections in accordance with the polarity thereof.

2. In a system of distribution, the combination with a plurality of successive trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said sections, circuit-changing means, and electro-responsive means associated with said vehicle and actuated by the reversal of current in passing from one section to another to control the operation of said circuit-changing means.

3. In a system of distribution, the combination with a plurality of successive trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said sections, a plurality of motors associated with, and adapted for driving, said vehicle, a circuit-changing device for manipulating the motor circuits, and electro-responsive means actuated by the reversal of current in passing from one section to another for controlling the operation of the circuit-changing device.

4. In a system of distribution, the combination with a plurality of successive trolley conductor sections of alternate polarity and different voltage, of a vehicle adapted to receive energy from said sections, a plurality of motors associated with, and adapted for driving, said vehicle, a switching device for re-arranging the grouping of said motors, and a reverse-current relay actuated by the reversal of current in passing from one section to another and adapted to control the operation of said switching device.

5. In a system of distribution, the combination with a plurality of successive trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said conductors, a plurality of motors associated with said vehicle, and electro-responsive means actuated by the reversal of current for re-arranging the grouping of said motors in passing from one section to another.

6. The combination with a plurality of conductor sections of relatively low voltage, and a plurality of successively interposed conductor sections of alternate polarity and relatively high voltage, of a vehicle adapted

to receive energy from said conductors, a plurality of motors associated with said vehicle, a switching device for re-arranging the grouping of the motors for full-speed operation on either high or low-voltage sections, and electro-responsive means actuated by the reversal of current in passing from one section to another for controlling the operation of said switching device.

7. The combinatiotn with a plurality of conductor sections of relatively low voltage, and a plurality of successively interposed conductor sections of alternate polarity and relatively high voltage, of a vehicle adapted to receive energy from said conductors, a plurality of motors associated with said vehicle, a switching device for re-arranging the motor grouping to give full-speed operation on either high or low-voltage sections, and a reverse-current relay actuated by the reversal of current in passing from one section to another and adapted to control the operation of the switching device in passing from one section to another of different voltage and polarity.

8. In a system of distribution, the combination with a plurality of successive conductor sections of alternate polarity, of a vehicle adapted to receive energy from said conductors, a plurality of motors associated with said vehicle, a switching device for rearranging the motor circuits, and a reverse current relay comprising a pair of oppositely wound operating coils and a movable polarized plunger disposed between said coils and carrying a contact making member, said relay being operated by the reversal of current in passing from one section to another for controlling the operation of the motor switching device.

9. In a system of distribution, the combination with a plurality of successive conductor sections of alternate polarity, of a vehicle adapted to receive energy from said conductors, a plurality of motors associated with said vehicle, a switching device for rearranging the motor circuits, and a pair of reverse-current relays severally comprising oppositely wound electro-magnets and similarly polarized armatures associated therewith and carrying auxiliary contact-making members, said relays operating selectively in passing from one section to another for controlling the operation of the motor circuit switching device.

10. In a system of distribution, the combination with a plurality of successive high and low-voltage trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said sections, a plurality of groups of motors for driving the vehicle, a plurality of motor-accelerating resistor steps, a two-position switching device adapted to connect the motors of each group in series and the two halves of each resistor step in series in one position and to connect the motors of each group in parallel and the two halves of each resistor step in parallel in the other position, and electro-responsive means actuated by reversal of current for controlling the operation of said switching device.

11. In a system of distribution, the combination with a plurality of successive high and low-voltage trolley conductor sections of alternate polarity, of a vehicle adapted to receive energy from said sections, a plurality of driving motors for said vehicle, an electro-magnetically controlled switching device for manipulating the motor connections, a pair of control-circuit resistors, and a three-position reverse-current relay adapted to control the operation of said switching device and to connect the two control resistors in series on a high-voltage trolley section in one position, to disconnect both resistors from the line in the neutral position, and to connect one resistor directly to the line on a low-voltage trolley section.

12. In a system of distribution, the combination with a plurality of trolley-conductor sections of different polarities, a vehicle connected to said trolley conductor and adapted to receive energy from the sections thereof, of controlling means for governing the operation of the vehicle and means responding to different polarities for governing the operation of said controlling means in accordance with the trolley section to which the vehicle is connected.

13. In a control system for an electric vehicle, the combination with a plurality of driving motors, and means for controlling the operation of said motors, of means for governing the operation of said controlling means in accordance with the polarity of the energy supplied to the motors.

14. In a control system for an electric vehicle, the combination with a plurality of propelling motors, and switching means for disposing the motors for operation by currents of various voltages, of means for controlling the operation of said switching means in accordance with the polarity of the energy supplied to the motors.

In testimony whereof, I have hereunto subscribed my name this 10th day of Feb. 1915.

ARTHUR J. HALL.

Witnesses:
H. T. MORRIS,
B. B. HINES.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."