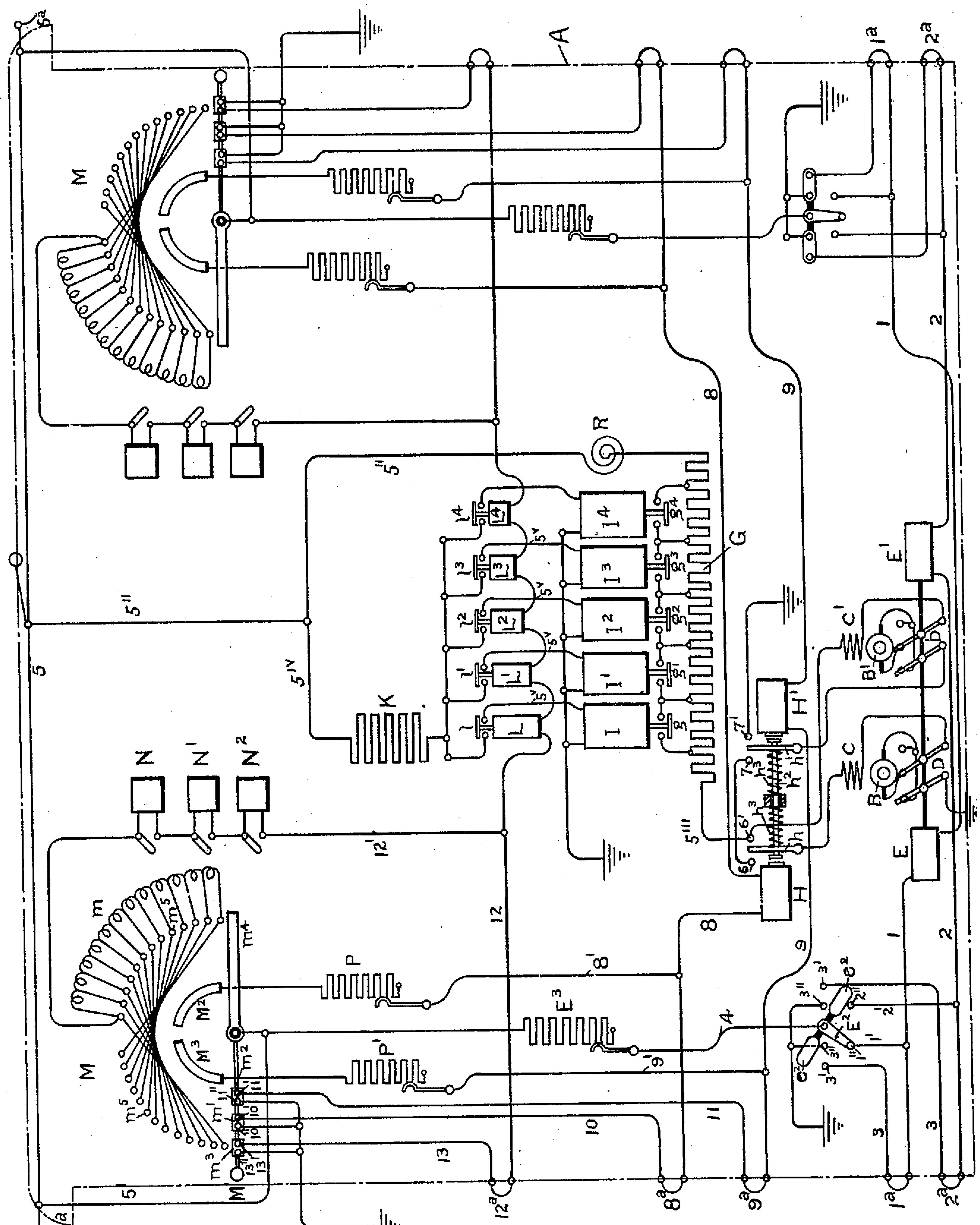
No. 678,861. Patented July 23, 1901.

F. E. CASE.

SYSTEM OF MOTOR CONTROL.

(Application filed Feb. 15, 1901.)

(No Model.)



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UNITED STATES PATENT OFFICE.

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SYSTEM OF MOTOR CONTROL.

SPECIFICATION forming part of Letters Patent No. 678,861, dated July 23, 1901.

Application filed February 15, 1901. Serial No. 47,413. (No model.)

To all whom it may concern:

Be it known that I, FRANK E. CASE, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Motor Control, (Case No. 1,720,) of which the following is a specification.

This invention relates to systems for electric-motor control, especially those applicable to electric-railway motors, the object being to enable one or more motors to be controlled from a distant point, so that in case of a train of two or more motor-cars all the motors can be controlled from one or more points on any one of said cars. It has been heretofore proposed to accomplish this by means of a plurality of separately-actuated contacts or switches controlling a plurality of resistance-coils in series with the motor or motors, said switches being directly actuated by separate electromagnets responsive to successive increases in current strength in a circuit across the line parallel with the motor-circuit. It was also proposed to include in the control-circuit in series with the electromagnetic switches an electromagnet for actuating a switch comprising contacts arranged to connect the motors in series or in parallel; but such a system is impracticable, mainly for the reason that the electromagnets must be of such enormous dimensions as to prohibit their use and, further, because the control-circuit requires such a very large percentage of the line-current to operate it as to make it far too expensive for commercial service.

In the improved system which I have devised instead of operating the resistance cut-outs directly I interpose relays controlling said switches and operate the relays by a small current taken, preferably, from the trolley-line through a high-resistance rheostat. This reduces the excessive heating of the relay-coils and permits them to be made comparatively small and compact. The relay-coils may evidently be connected either in series or in multiple. The solenoids for actuating the series-parallel switch and the reversing-switch are in separate circuits. Compensating resistances are provided to keep the resistance of the relay-circuit constant for one, two, three, or more cars.

The accompanying drawing is a diagram of the circuits on an electric-railway car embodying my improvements.

The car, which is merely outlined at A, is shown as equipped with two motors, whose armatures B B′ are connected in series with their field-coils C C′ through reversing-switches D D′, both actuated by electromagnets E E′, one of which throws the switches into the forward position and the other into the reverse position. These electromagnets are connected by leads 1 2 with flexible couplings 1^a 2^a at each end of the car, whereby they can be put in connection with an adjoining car or with a lead 3, running to a contact 3′, adjacent to a grounded contact 3″. Branch leads 1′ 2′ lead to contacts 1″ 2″, adjacent to a hand-switch E^2, connected by leads 4 5′ with the trolley-lead 5 through an adjustable resistance E^3. The switch carries bridging contact-plates e^2, which when the switch is open and midway between the contacts 1″ 2″ connect both sets of contacts 3′ 3″. As soon, however, as the switch is swung one way or the other to cut in the electromagnet E or E′ the ground connection of both electromagnets is broken at that end of the car.

Current is supplied to the motor through a lead 5″, branching off from the trolley-lead 5, running through the car and having flexible couplings 5^a at each end for connection with another car, if desired. The branch lead 5″ includes a resistance G, divided into sections each adapted to be short-circuited by a switch g g' g^2 g^3 g^4 in order to supply an increasing amount of current to the motors. Between the resistance and the motors is a series-parallel switch composed of two electromagnets H H′, whose armature-levers h h' are connected by a rod h^2 so as to move in unison and make contact with buttons 6 7 or 6′ 7′. Springs h^3 keep the armature-levers in the off position when neither electromagnet is energized. The buttons 6 7 are looped together. Button 6′ is in the lead 5‴, running from the resistance G to the field-coil C′. Button 7′ is grounded. Armature-lever h is connected with the field-coil C, and lever h' connects with the reversing-switch D′ of the motor-armature B′, the other reversing-switch D being grounded. The electromagnet H gives the series connection and the electromagnet H′ the parallel connection of the motors, as is apparent from the diagram Fig. 1. Each electromagnet is connected by a lead 8 9 with flexible connections 8^a 9^a at the ends of the car, which can be connected with an adjacent car or with leads 10 11, running to contacts 10′ 11′, adjacent to grounded contacts 10″ 11″, controlled by the relay-switch handle, as hereinafter described. Current is supplied to said electromagnets through branch leads 8′ 9′ in a manner hereinafter set forth.

The cut-outs or switches g g' g^2 g^3 g^4 are actuated by electromagnets I I′ I^2 I^3 I^4, each having one terminal grounded and the other connected by a lead 5^v with a branch lead 5^{iv} from the trolley-lead 5″, preferably through a resistance K. In each lead 5^v is a normally open circuit-closer l l' l^2 l^3 l^4, controlled by a relay-solenoid L L′ L^2 L^3 L^4, all connected in series and of successively-decreasing values—that is to say, the relay L has the greatest number of ampere-turns, so that it will be sufficiently energized by a comparatively small current to actuate its circuit-closer l, while the succeeding relays have a regularly-decreasing number of ampere-turns in order to require a successively-increasing current to properly energize them. The ratio between any two adjacent relay-coils should be the same throughout the series.

By means of one of the rheostats M, located at the ends of the car and having coils m of very high resistance, a small current can be sent through the branch lead 12′ from the trolley-lead 5′ to the lead 12, connecting the series of relay-solenoids with flexible connections 12^a at the ends of the cars, by which the current can be transmitted to adjacent cars or grounded through the lead 13, running to a contact 13′, adjacent to a grounded contact 13″, controlled by the relay-switch handle M′, which carries three insulated contact-plates m' m^2 m^3, the first serving to connect the contacts 10′ 10″, the second the contacts 11′ 11″, and the third the contacts 13′ 13″ when the rheostat is not in use, thereby grounding the leads 8, 9, and 12; but as soon as the handle is moved to send current through the relays the bridging contacts m' m^2 m^3 move off their terminals and break the grounds at that end of the car.

Each rheostat M comprises a handle M′, carrying, besides the bridging contacts m' m^2 m^3, a contact-arm m^4, adapted to sweep over the resistance-contacts m^5 and the segments M^2 M^3. There are two sets of contacts m^5, properly looped together, so that when the arm passes over segment M^2 it will also cut out the resistance successively, and when the arm passes to the other segment M^3 it will again successively cut out the resistance-coils. The segment M^2 is connected by lead 8′ and segment M^3 by lead 9′ with the series and parallel electromagnets H H′, respectively. The trolley-current is brought to the contact-arm m^4 by a lead 5′. In the lead 12′ are resistances N N′ N^2, in number equal to the greatest number of motor-cars ever made up into a train and each offering a resistance equal to the relay-coils on one car. When a car is taken off, one of the resistances N is cut into circuit to maintain the total resistance of the relay-circuit constant. In each lead 8′ and 9′ is an adjustable resistance P P′ to prevent too great a proportion of the current passing through the contact-arm m^4 from flowing to the electromagnet H or H′. A blow-out magnet R is included in the motor-circuit 5″.

The operation of my invention is as follows: The several flexible connections at the front end of the car are connected with their adjacent grounded leads. Those at the rear end of the car are similarly connected if the car is to run alone; but if another car is coupled to it then the flexible connections are coupled to those of the following car in order to preserve the series connection of each group of electromagnets. The proper number of compensating resistances N is cut into circuit with the relays L, and the resistances E^3 P P′ are set to correspond. The switch E^2 at the front end of the car or train is then moved to break the ground connections 3, energize the forward solenoid of the reversing-switch, and throw the switches D D′, as shown at the left hand of Fig. 1, which is assumed to be the front of the car. The left-hand rheostat-handle M′ is then moved downward, opening the ground connections, at the front end of the car, of the relays and the series-parallel electromagnets. The continued movement of the rheostat-handle sends trolley-current through the segment M^2 and leads 8′ 8 to energize the magnet H and connect the motors in series across the circuit with all resistance in. At the same time current passes through the resistance-coils m to the relays. When the rheostat-handle is moved to a certain point, depending upon the resistance of the rheostat, the solenoid L will be energized, thereby closing the circuit-closer l in the circuit of the solenoid I, which at once picks up the main switch g and cuts out the first section of the motor resistance G, permitting current to flow to the motors through the leads 5″ 5‴. As the arm m^4 continues to cut out the resistance-coils m the relay-current presently becomes strong enough to energize the coil L′, short-circuiting another section of the motor resistance, and so on until all the coils m have been cut out and the motors are running under full trolley-current. A reverse movement of the arm m^4 deënergizes the relays in reverse order and cuts in the motor resistance again. If the arm m^4 is carried over to the segment M^3, the motors are placed in parallel, with all the resistance G in circuit, which is gradually cut out by the movement of the arm over the second set of contacts m^5.

To obtain a successful operation of the relays, their relative values must be the same throughout the series. For instance, if one one-hundredth of an ampere is sufficient to magnetize the first coil, and the second should require four one-hundredths of an ampere, then the third must take sixteen one-hundredths of an ampere, the fourth sixty-four one-hundredths, and the fifth two hundred and fifty-six one-hundredths. These small currents are insufficient to properly actuate the main cut-outs g, but are ample to control the circuits of the main-switch solenoids I. The total resistance of the relays must be high enough to give only the required small maximum current when all the resistance-coils m are cut out, and the total resistance of the coils m must be exceedingly high to give the required range in current down to the minimum.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, relay-coils responsive to different current strengths for energizing said electromagnets, and means for sending a current of varying strength through said relay-coils.

2. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, high-resistance relay-coils responsive to different current strengths, for energizing said electromagnets, and means for sending a current of varying strength through said relay-coils.

3. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, relay-coils connected in series and responsive to different current strengths, for energizing said electromagnets, and means for sending a current of varying strength through said relay-coils.

4. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, relay-coils responsive to different current strengths, for energizing said electromagnets, and a rheostat for sending a current of varying strength through said relay-coils.

5. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, relay-coils responsive to different current strengths for energizing said electromagnets, and a rheostat of exceedingly high resistance for varying the current flowing through said relay-coils.

6. In an electric-railway system, the combination with one or more electric motors, of a plurality of separately-actuated contacts for varying the motor speed, separate electromagnets for actuating said contacts, high-resistance relay-coils responsive to different current strengths for energizing said electromagnets, and a rheostat of high resistance for varying the current flowing through said relay-coils.

7. In an electric-railway system, the combination with one or more electric motors, of a controller comprising a plurality of electromagnetic switches, a series of high-resistance relays successively responsive to successively-increasing current strengths for controlling the actuating-circuits of said switches, and means for supplying current to said relays.

8. In an electric-railway system, a controller having a plurality of separately-actuated contacts, electromagnets for actuating said contacts, relay-coils, responsive to different current strengths, for controlling the operation of said electromagnets, and means for controlling the flow of current to said relay-coils.

9. In an electric-railway system, a controller having a plurality of separately-actuated contacts, actuating devices for said contacts, relay-coils, responsive to different current strengths, for controlling the operation of said actuating devices, and means for controlling the flow of current to said relay-coils.

10. In an electric-railway system, a controller having a plurality of separately-actuated contacts, actuating devices for said contacts, relay-coils, responsive to different current strengths, for controlling the operation of said actuating devices, a circuit to which all the relay-coils are connected, and means for regulating the current strength in said circuit.

11. In a train system, one or more motor-cars, a controller, having a plurality of separately-actuated contacts mounted on each of said motor-cars, actuating means for said contacts, relays responsive to different current strengths for controlling the operation of said actuating means, a train-circuit to which all of said relays are connected, and a master-controller, located at any desired point on the train, for regulating the current strength in the train-circuit.

12. In a train system, one or more motor-cars, a controller, having a plurality of separately-actuated contacts, mounted on each of said motor-cars, actuating means for said contacts, relays responsive to different current strengths for controlling the operation of said actuating means, a train-circuit to which all of said relays are connected, a mas-

ter-controller, located at any desired point on the train, for regulating the current strength in the train-circuit and resistances on each motor-car adapted to be cut into or out of the train-circuit in accordance with the number of motor-cars in the train.

13. In a train system, a motor-car provided with a plurality of separately-actuated resistance-controlling contacts, actuating means for said contacts, relays responsive to different current strengths for controlling the operation of said actuating means, a train-circuit to which all of said relays are connected, other contacts for controlling the circuit connections of the motors, electromagnets for actuating said contacts, and a separate train circuit or circuits to which the said electromagnets are connected.

14. In a train system, a motor-car provided with a plurality of separately-actuated resistance-controlling contacts, actuating means for said contacts, relays responsive to different current strengths for controlling the operation of said actuating means, a train-circuit to which all of said relays are connected, other contacts for controlling the circuit connections of the motors, relays for actuating said contacts, a separate train circuit or circuits to which said latter relays are connected, and adjustable resistances included in all of said train-circuits.

In witness whereof I have hereunto set my hand this 11th day of February, 1901.

FRANK E. CASE.

Witnesses:
BENJAMIN B. HULL,
MARGARET E. WOOLLEY.