No. 687,124. Patented Nov. 19, 1901.

F. E. CASE.

SYSTEM OF ELECTRIC CIRCUITS.

(Application filed June 29, 1901.)

(No Model.) 2 Sheets—Sheet 1.

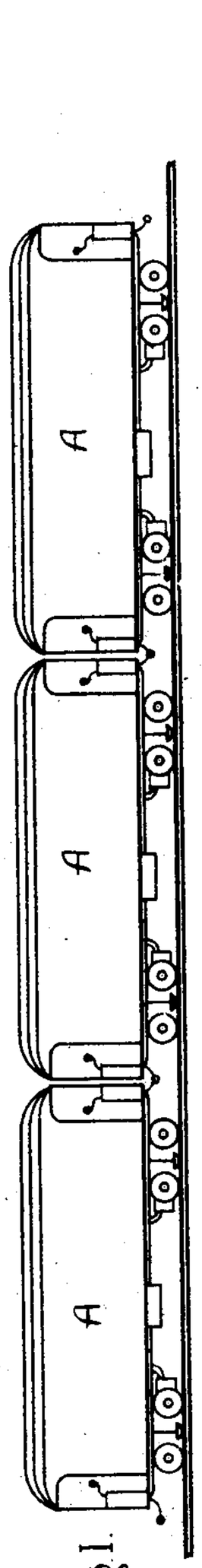


Fig 1.

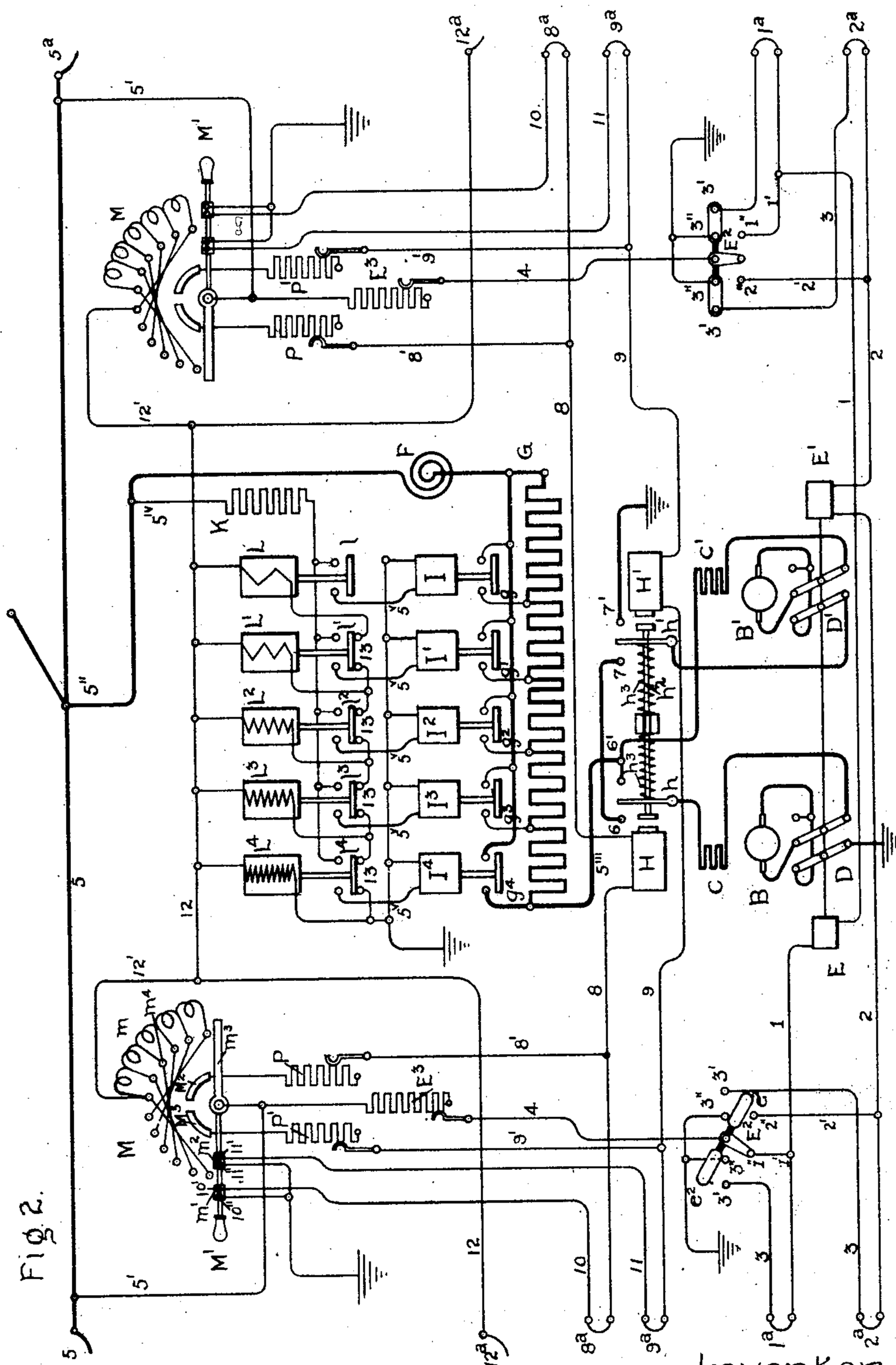


Fig 2.

Witnesses:
Robt. A. Chapman
Benjamin B. Tucker.

Inventor.
Frank E. Case.
by Albert G. Davis
Atty

No. 687,124. Patented Nov. 19, 1901.

F. E. CASE.

SYSTEM OF ELECTRIC CIRCUITS.

(Application filed June 29, 1901.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 3.

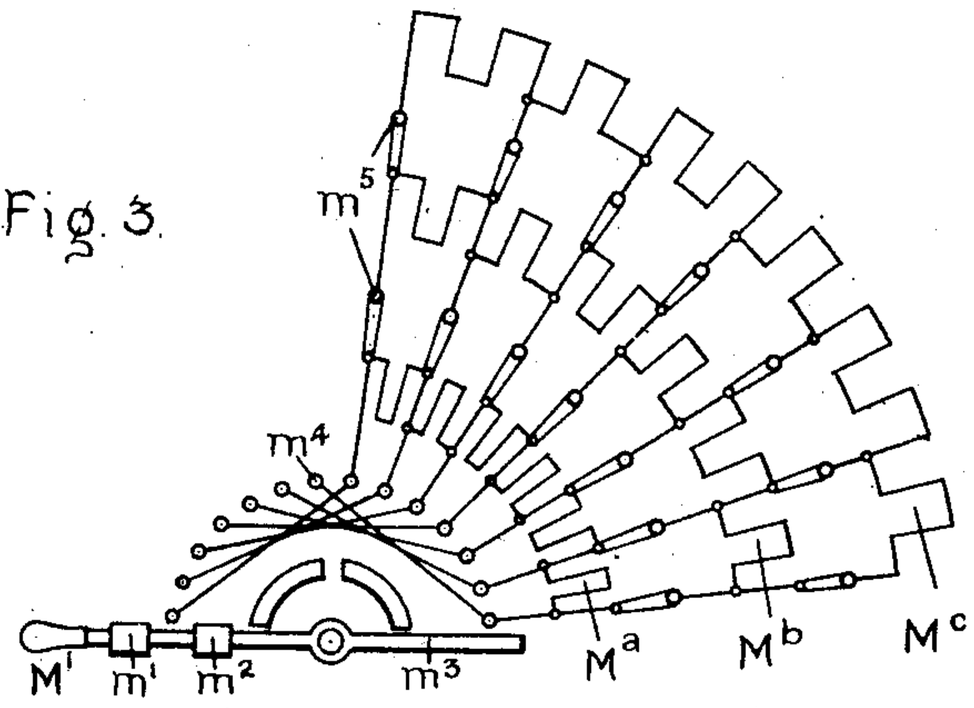
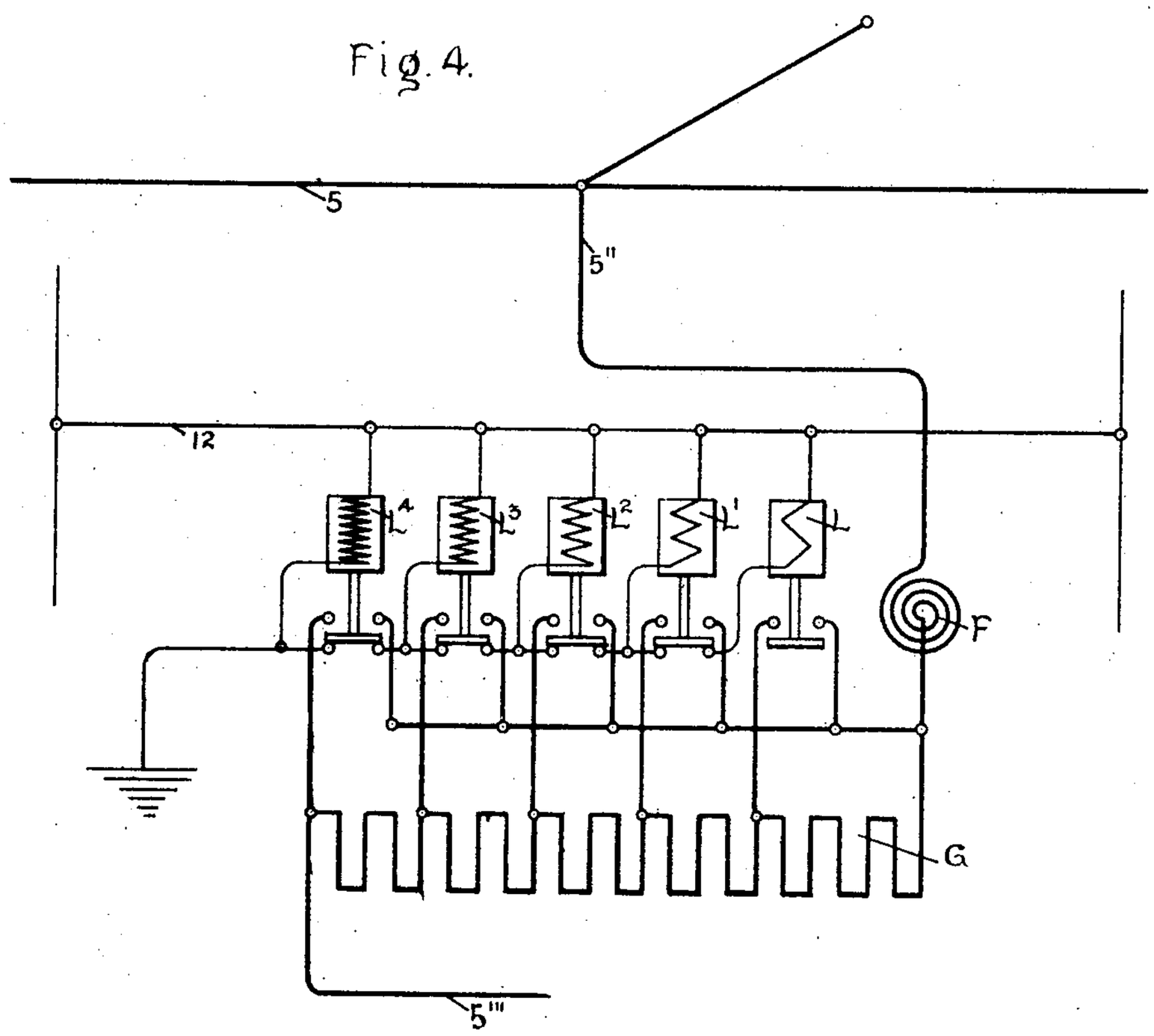


Fig. 4.



Witnesses:
Robt L. Chapman.
Benjamin B. Bruce.

Inventor.
Frank E. Case.
by Allen & Davis
Atty.

UNITED STATES PATENT OFFICE.

FRANK E. CASE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYSTEM OF ELECTRIC CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 687,124, dated November 19, 1901.

Application filed June 29, 1901. Serial No. 66,480. (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 Electric Circuits, (Case No. 2,071,) of which the following is a specification.

This invention relates to systems of electric circuits for controlling electric motors, and especially electric railway-motors, the object being to enable one or more motors to be controlled from a distant point, so that in the 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.

The invention herein set forth is a modification of the system disclosed in my prior application, filed February 15, 1901, Serial No. 47,413. In that case the switch-controlling relays are connected in series, so that the actuating-current must be strong enough to overcome the combined resistance of all the relay-coils in the final position. In the present invention the relays are arranged in multiple and the coils are so wound that each requires a different current to energize it. The relays are arranged in the order in which a successively-increasing current will cause them to operate, and the connections are such that each coil in the series as it becomes energized cuts out those preceding it, so that only one coil need be energized at a time, thereby enabling me to reduce to a minimum the amount of current required to operate the control system, and thus effecting a considerable saving in expense of operation over certain systems heretofore proposed.

In the accompanying drawings, Figure 1 is a side elevation of a train of three motor-cars equipped with my invention. Fig. 2 is a diagram of the circuits on each of the said cars. Fig. 3 shows a divided rheostat. Fig. 4 is a modification.

Each car A is provided 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 motors through a lead 5″, branching off from the trolley-lead 5, which runs through the car and has 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. Adjacent to the switches is a blow-out magnet F. 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′ I² I³ I⁴, 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′ L² L³ L⁴ of successively-increasing values—that is to say, it requires a successively-increasing current to cause the coils to pick up their armatures. The ratio between any two adjacent relay-coils must be the same throughout the series. The zigzag lines on the coils do not indicate the number of turns of wire, but the relative current strengths required to energize them, coil L having the least resistance and coil L⁴ the greatest. The relay-solenoids all have one terminal connected with a lead 12, running to flexible connections 12^a at each end of the car, by which the current can be transmitted to adjacent cars, if desired. The other terminal of the coil L⁴ is grounded, while the corresponding terminals of the coils L L′ L² L³ are connected, respectively, with one of a pair of contact-buttons 13, on which the circuit-closers l' l^2 l^3 l^4 normally rest. Adjacent buttons of the several pairs are connected, and the second button under the circuit-closer l^4 is grounded. The relays are thus connected in multiple, with one terminal normally grounded.

At each end of the car is a rheostat M, having coils m of very high total resistance and a handle M′, carrying insulated bridging contacts m' m^2 and a contact-arm m^3, adapted to sweep over the resistance-contacts m^4 and the segments M² M³. Each trolley-lead 5′ connects with its respective handle M′, so that current will pass through it and the resistance-coils and the lead 12′ to the lead 12. As soon as the handle is moved to effect this the bridging contacts m' m^2 move off their respective contacts 10′ 10″ and 11′ 11″ and break the grounds of the series-parallel switch at that end of the car. At the same time the arm m^3 passes over the contacts m^4, cutting out the resistance-coils successively and admitting an increasing current to the leads 12′ 12. The arm at the same time makes contact with the segment M², which is connected by leads 8′ and 8 with the "series" magnet H. An adjustable resistance P governs the proportion of current flowing to the magnet H. When the arm m^3 passes over to the segment M³, it meets a duplicate set of contacts m^4, properly looped to the first set, so that the resistance-coils will be again successively cut out. The segment M³ is connected by the lead 9′ through an adjustable resistance P′ with the lead 9, running to the "parallel" magnet H′.

Inasmuch as the coupling on of one or more additional motor-cars puts the active relays on the several cars in multiple, the current supplied to the control system must be doubled for two cars, trebled for three, and so on, in order to supply a constant current for the relays on each car. This can be accomplished by halving or trisecting the total resistance of the rheostat M.

In order to permit the rheostat-handle to be moved to the same position irrespective of the number of motor-cars in the train, the resistance may be divided, as shown in Fig. 3, into as many portions M^a M^b M^c as the greatest number of cars ever made up into a train, each portion being subdivided into the same number of sections. Suitable means, such as small switches m^5, are provided for connecting one or both portions M^b M^c in multiple with the portion M^a in order to reduce the total resistance in the circuit to one-half or one-third or any other desired fraction of that required for one car.

Fig. 4 shows the solenoids L to L⁴ used in the main switches instead of as relays.

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 each flexible connection is coupled to the corresponding one on the following car in order to connect in series the electromagnets in the series-parallel and reversing switches and in multiple the groups of relays L to L⁴. If two cars compose the train, the portion M^c of the rheostats is cut out and the resistances E³ P P′ are properly adjusted. The switch E² at the front end of the car or train is then moved to break the ground connections 3 and energize the forward solenoid of the reversing-switch, which throws the switches D D′ into the proper position for forward movement of the car, as shown at the left hand of Fig. 1. The handle M′ of the front rheostat is then moved downward, which opens the adjacent ground connections of the series-parallel-switch magnets and brings the arm m^3 in contact with the segment M², thereby energizing the magnet H and putting the motors in series. Further movement of the handle M′ brings the arm m^3 over the resistance-contacts m^4, sending a small current through the leads 12′ 12 sufficient to energize the relay L, and thereby close the circuit-closer l in the circuit of the switch-magnet I, which at once picks up the switch g and shunts the first section of the motor resistance G, permitting current to flow to the motors and start the car or train. If there are two cars, as assumed above, the current in the lead 12 divides equally between the two cars and energizes the relay L on each car. As the movement of the arm m^3 continues to cut out the resistance-coils m, the relay-current presently becomes strong enough to energize the relay L′. The movement of the circuit-closer l' first opens the ground-circuit of the relay L, and as this sends all the

relay-current through the relay L′ its power is suddenly increased, which causes the contact l' to close the circuit of the switch-magnet I′ very quickly and strongly. The picking up of the switch g' shunts another section of the motor resistance. In the same way the relay L^2 open-circuits both the relays L L′, and so on, thereby confining the relay-current to only one relay. A reverse movement of the rheostat-handle deënergizes the relays in reverse order and cuts in the motor resistance. If the arm m^3 is carried over to the segment M^3, the motors are placed in parallel, with all the resistance in circuit, which is gradually cut out as before by the movement of the arm over the second set of rheostat-contacts.

In the modification shown in Fig. 4 the relay-current is used to close the main resistance-switches directly without the interposition of the switch-magnets I I^4. The circuits are otherwise the same as in Fig. 2, each relay-magnet when energized breaking the circuit of the preceding coils.

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 coils connected in multiple and responsive to different current strengths for effecting the actuation of said contacts, means for sending a current of varying strength through said coils, and means for cutting out preceding coils as each coil becomes energized.

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 coils connected in multiple and responsive to different current strengths for effecting the actuation of said contacts, means for sending a current of varying strength through said coils, and means whereby each coil on becoming energized will open-circuit all preceding 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 coils connected in multiple and responsive to different current strengths for effecting the actuation of said contacts, means for sending a current of varying strength through said coils, and a ground connection for each coil controlled by the next succeeding coil.

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 coils connected in multiple and responsive to different current strengths for effecting the actuation of said contacts, means for sending a current of varying strength through said coils, and a ground connection common to some of said coils and independently controlled by some of said 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 coils connected in multiple and responsive to different current strengths for effecting the actuation of said contacts, means for sending a current of varying strength through said coils, and a circuit with which said coils are connected and containing breaks normally closed by the armatures of all but the first coil.

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, relay-coils connected in multiple and responsive to different current strengths for energizing said electromagnets, means for sending a current of varying strength through said relay-coils, and means for cutting out preceding coils as each coil becomes energized.

7. In an electric-railway system, a controller comprising a plurality of electromagnetic switches, a set of high-resistance relays connected in multiple and successively responsive to successively-increasing current strengths for controlling the actuating-circuits of said switches, means for supplying current to said relays, and means whereby each relay controls the circuit of all preceding ones.

In witness whereof I have hereunto set my hand this 27th day of June, 1901.

FRANK E. CASE.

Witnesses:

BENJAMIN B. HULL,

MARGARET E. WOOLLEY.