No. 608,302.

Patented Aug. 2, 1898.

E. W. RICE, Jr.

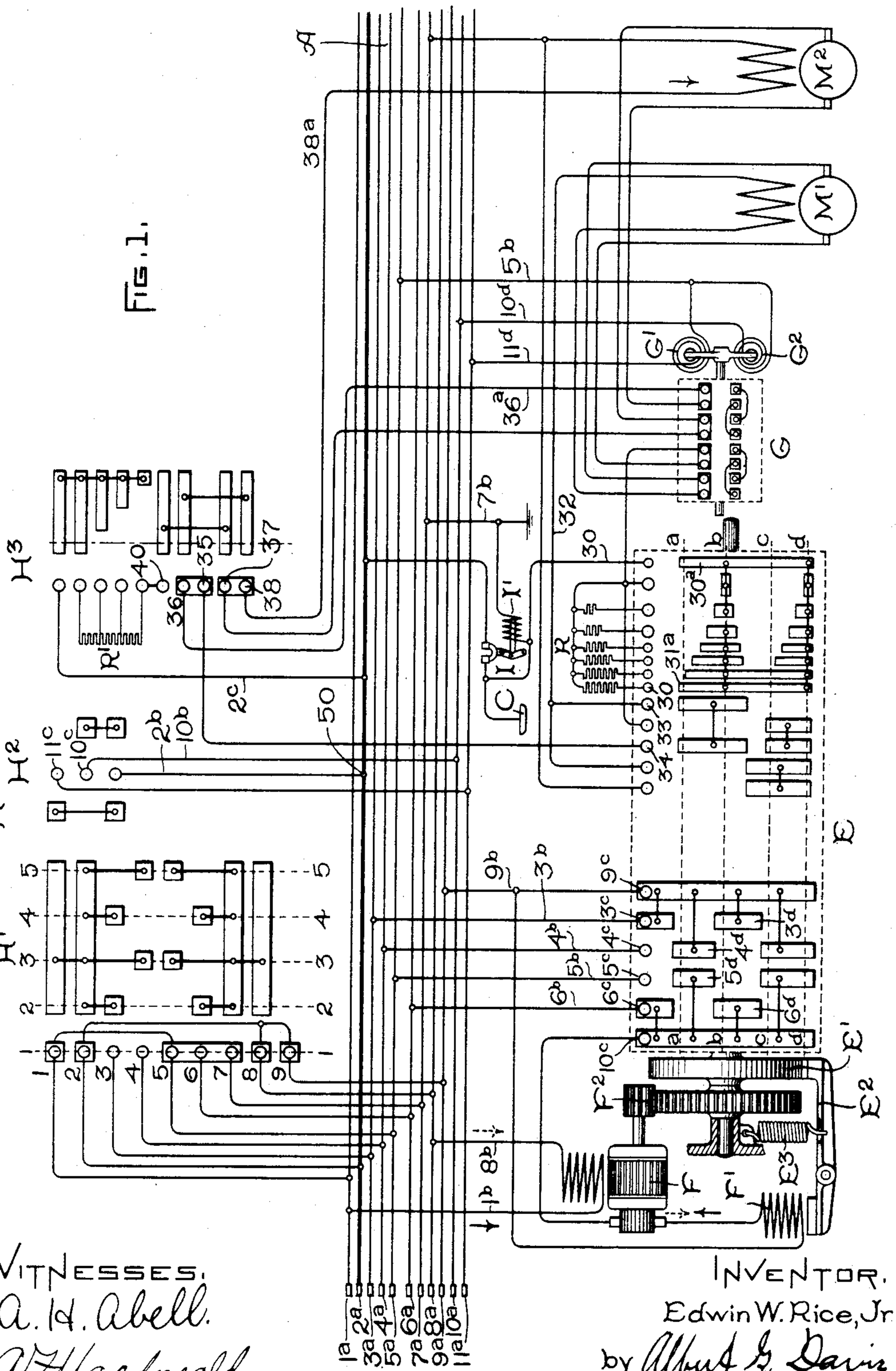
SYSTEM OF TRAIN CONTROL.

(Application filed Mar. 26, 1898.)

(No Model.)

2 Sheets—Sheet 1.

FIG. 1.



WITNESSES:

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2 Sheets—Sheet 2.

FIG. 2.

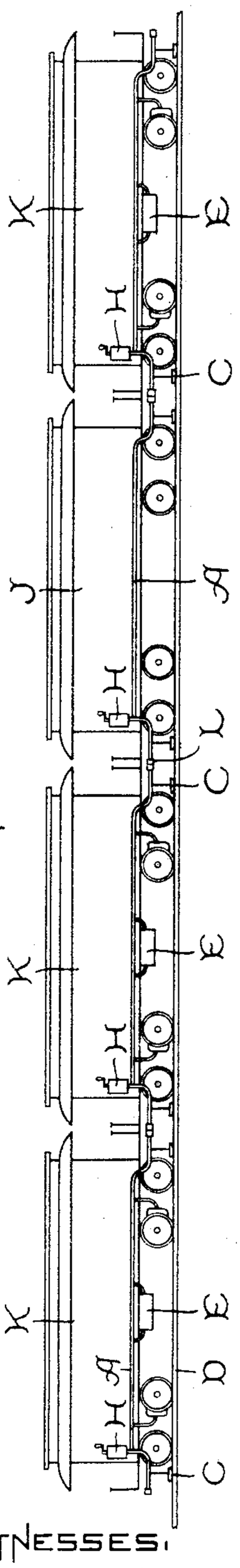


FIG. 4.

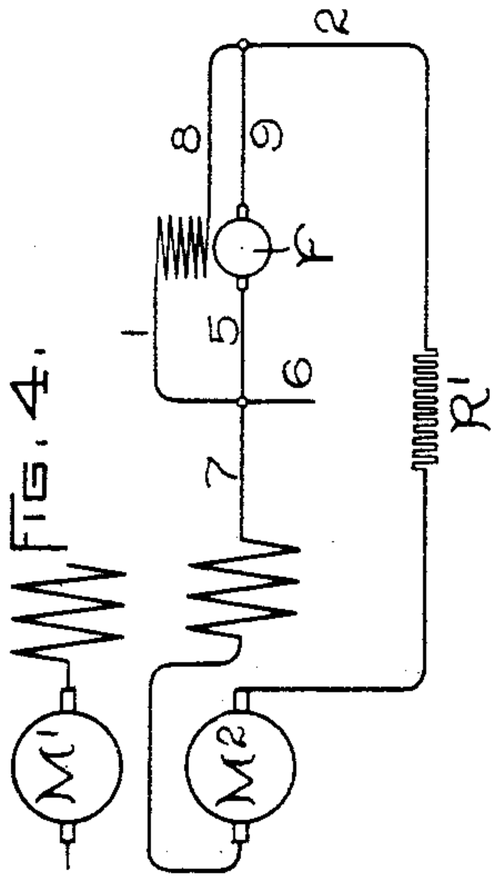
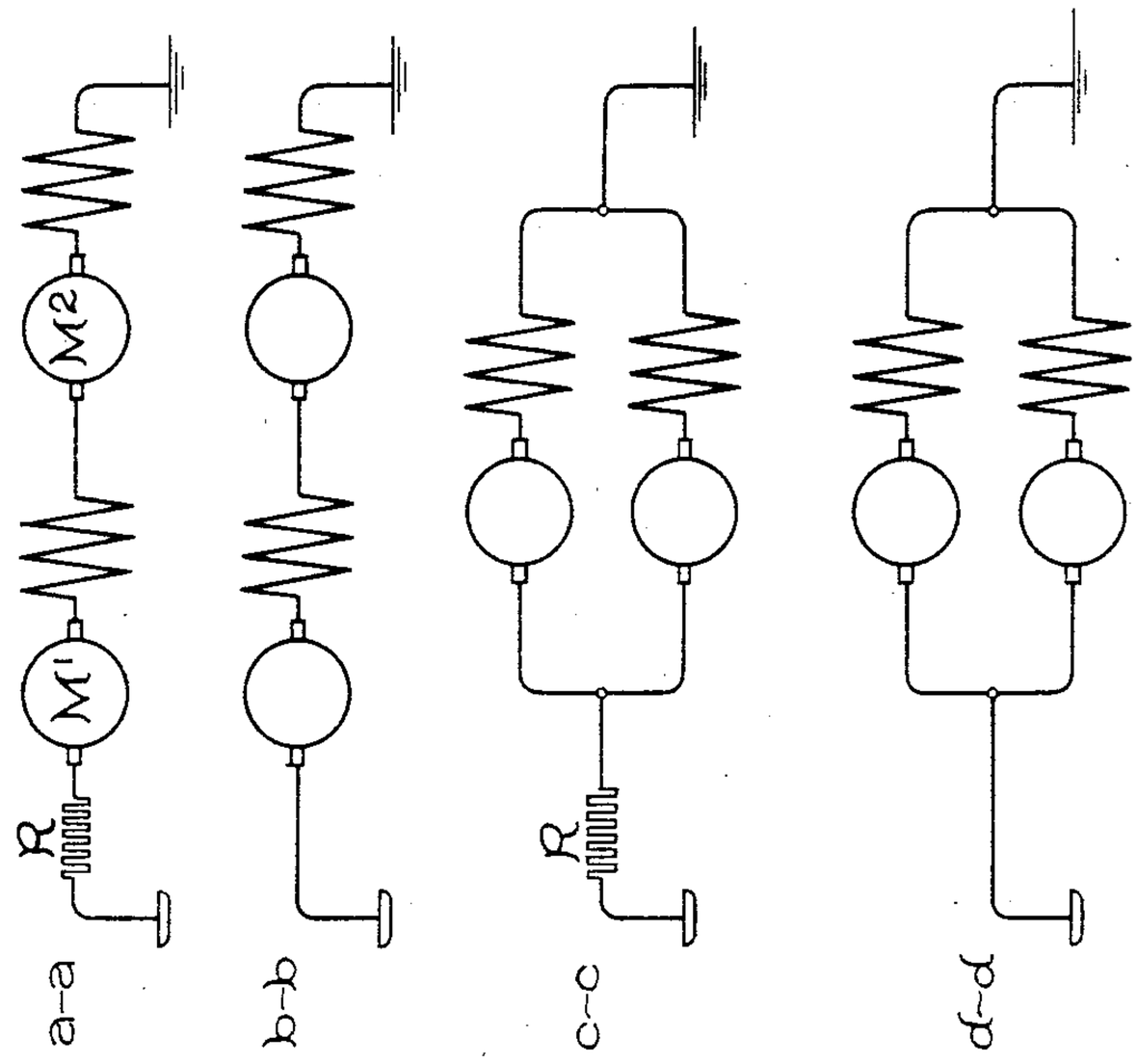


FIG. 3.



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INVENTOR:
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UNITED STATES PATENT OFFICE.

EDWIN W. RICE, JR., OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

SYSTEM OF TRAIN CONTROL.

SPECIFICATION forming part of Letters Patent No. 608,302, dated August 2, 1898.

Application filed March 26, 1898. Serial No. 675,245. (No model.)

To all whom it may concern:

Be it known that I, EDWIN W. RICE, Jr., 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 Train Control, (Case No. 755,) of which the following is a specification.

My invention relates to the means employed for controlling one or more motor-cars, whether single or united to form a train.

It has been proposed in electric traction-work to provide each motor-car with a controller for its propelling motor or motors and with electromagnetic means—as, for example, an electric motor or one or more electromagnets receiving current from the main source of supply—for operating the controller or its contacts, the regulation of the electromagnetic means being accomplished by means of a master-controller located at any selected point. It has also been proposed to provide each motor-car with a suitable cable, to which is connected the means employed for operating the motor-controller, so that the various cars may be united in any suitable manner to form a train and the regulation of all the motor-controllers accomplished by any one of the master-controllers. Within certain limits this arrangement is satisfactory; but when for any reason the main source of supply fails it is impossible to return the motor-controllers to their off position until current is again restored to the line. This interruption is liable to occur at a time when the controllers are in their full-on position, and a sudden rush of current with the motors standing still or moving slowly is liable to injure them seriously. It has been proposed to obviate this difficulty by providing a separate source of energy—as a storage battery, for example—for furnishing current to return the controllers to their off position when the main source of current fails; but this arrangement necessitates the care and expense of maintaining a storage battery or like apparatus.

My invention has for one of its objects to overcome the objections above pointed out and to provide means whereby the propelling-motors themselves may be employed to return the motor-controllers to their off position. It has been proposed in trainwork to operate the motor-controllers in the forward direction by pilot-motors and in the backward direction by springs, acting at once upon failure of current in the pilot-motors. Various other suggestions have been made for bringing the motor-controllers to the off position either upon interruption of the main current or immediately after its restoration. All such devices are open to the objection that they operate when for any reason one car of the train loses current for a small fraction of a second—as, for example, when its contact-shoe passes over a piece of paper or dirt on the third rail. The instantaneous withdrawal of current from any car may itself cause that car to drag behind the others and to cause a bumping; but this effect is greatly magnified by the action of the various safety devices above described. To avoid all such difficulties and to equalize the torque in all of the motors of the train, I provide a "train-wire" connected to all of the contact-shoes or other collecting devices of the train and also to all of the translating devices of the various cars. This train-wire neutralizes the effect of a merely instantaneous interruption of the current-supply to any particular car, while allowing the safety devices, if any are provided, to act at once and in all of the cars upon a general interruption of the current.

My invention also has for its object to improve the construction and arrangement of the various controllers whereby the regulation of the train may be rendered more positive and the motor-controllers actuated in a synchronous step-by-step manner.

In the accompanying drawings, which show an embodiment of my invention, Figure 1 represents in diagram the circuits of a single motor-car. Fig. 2 represents diagrammatically a four-car train comprising three motor-cars and one trail-car. Fig. 3 is a diagram illustrating the various motor combinations, and Fig. 4 is a diagram of the circuit combination when one of the propelling-motors is employed to return the motor-controller to its off position.

Extending through the cars of the train is a cable A, containing a number of wires for completing the circuit of the several master-

controllers, also containing the train-wire 2^a, to which all the contact-shoes C on the train are connected in multiple, as above explained.

As the car-wiring of all the motor-cars is similar, a detail description of the circuits of only a single car will be given.

The train-cable A consists of a number of wires having reference-numerals from 1^a to 11^a, inclusive. Connected with the wiring of the cable are wires leading to and from various switches, which will be described more in detail hereinafter. Mounted under the car or at any other convenient point is a motor-controller E, provided with the usual contacts for regulating the circuits of the propelling-motors and, in addition, with a set of contacts shown on the left-hand end for regulating the step-by-step action of the pilot-motor F. The contacts on the controller are shown developed in a single plane for the purpose of illustration; but in practice they are mounted on a cylinder or other support and the support actuated in a step-by-step manner by a pilot-motor or other electromagnetic means. The pilot-motor may be of any desired type and is shown as geared to the shaft of the motor-controller by suitable reducing-gear F^2. Mounted on the shaft of the controller is a brake-disk E′ in operative relation with a brake-shoe, which, as shown, is carried by a pivoted arm E^2, and is held in engagement with the brake-disk by tension-spring E^3, except when, by the action of current flowing through the armature-circuit of the pilot-motor, the coil F′ is so energized as to cause it to attract its armature and withdraw the brake-shoe from the disk.

The motor-reversing switch consists of a pivoted insulating-support which is actuated by solenoid-magnets G′ G^2. In the present instance magnet G^2 is supposed to have been energized and to have moved the upper row of contacts into engagement with the stationary brushes.

To control the action of the pilot-motor and motor-controller, a master-controller H is provided, which consists of three separate switches, switch H′ being employed to regulate the action of the pilot-motor forward and back, switch H^2 to control the action of the motor-reversing switch G, and switch H^3 to regulate the action of one or more of the propelling-motors when acting to generate current for the pilot-motor or other electrical apparatus employed to actuate the motor-controller E. The switch H^3 is not used in the normal operation of the system, but is intended for use only when the main source of energy fails.

In the circuit with the contact-shoe C is an automatic circuit-breaker I, which under ordinary running conditions is held in the position shown by a shunt-coil I′; but as soon as the main source of supply fails coil I′ is de-energized and the circuit-breaker opens. This prevents the motor from feeding current back to the line after it has been converted into a generator.

In Fig. 2 my invention is shown as applied to a four-car train in which a trail-car J is placed between the motor-cars K. Each car, including the trail-car, is provided with a cable A, the wires of which are connected to the cars in advance and in the rear by suitable couplings L. In circuit with the cable and mounted in any suitable manner on the car (as many cars as may be desired and preferably each) is a master-controller H, each master-controller being connected in circuit in such manner that the entire train may, if desired, be controlled therefrom.

Switch H′ is provided with a double set of contacts, which are mounted for simultaneous movement, one set being arranged to establish the proper circuit connections to cause the armatures of the pilot-motors to revolve in a clockwise direction and the second set to cause them to rotate in an anticlockwise direction.

Assuming that it is desired to propel the car or train in a forward direction, the master reversing-switch H^2 is moved to a position where the contacts now situated on the right will engage with the vertical row of stationary brushes. As soon as the reversing-switch has been moved to this position a circuit is created from the contact-shoe C to train-wire 2^a, to point 50, by wire 2^b to the reversing-switch, by cross-connected contacts to brush 10^c, by wire 10^b to cable-wire 10^a, to wire 10^d, through the solenoid-magnet G^2 to wire 5^b, cable-wire 5^a, to brush 5 of the master-switch H′, to brush 7, to cable-wire 7^a, to wire 7^b, and to ground. This energizes the solenoid-magnet G^2, which attracts its core and moves the motor-reversing switch G to the position shown. The switch H′ is then moved to a position where the brushes 1 to 9, inclusive, rest on line 2 2 and the circuit is as follows: Current enters at contact-shoe C and passes to train-wire 2^a and to brush 2, where the current divides, one path being by cross-connected contacts to brush 1, to cable-wire 1^a, through the field of the pilot-motor in the direction indicated by the full-line arrow to wire 8^b, to cable-wire 8^a, to brush 8, by cross-connected contacts to brush 7, to wire 7^b, and to ground. Returning to brush 2, a second path is by way of cross-connected contacts to brush 3, to cable-wire 3^a, by wire 3^b to brush 3^c on the motor-controller E, by cross-connected contacts to brush 9^c, thence through the magnet-coil F′ in the direction indicated by the arrow, through the armature of the pilot-motor F to brush 10^c on the motor-controller, by cross-connected contacts to brush 6^c, by wire 6^b to cable-wire 6^a, to brush 6 on the master-controller, by cross-connected contacts to brush 7, cable-wire 7^a, wire 7^b, and to ground. This completes the circuit of the pilot-motor and at the same time raises the brake-shoe E^2 out of engagement with the brake-disk E′, and motion is imparted to the

motor-controller by the gearing F^2. The motor-controller will continue to run until the brushes rest upon the line *a a*, which will cause the circuit of the pilot-motor to be interrupted at brushes 3^c and 6^c, the brake-shoe E^2 to be automatically applied to the controller, and contacts 4^d and 5^d to be moved to a point where they engage with brushes 4^c and 5^c and are in a position to complete the circuit of the pilot-motor as soon as the master controller-switch H′ has been advanced to position 3 3. By arranging the circuits of the pilot-motor in such manner that the interruption takes place at a plurality of points—as at brushes 3^c and 6^c, for example—I am enabled to interrupt the circuit without destructive arcing. The brushes of the motor-controller E are thus caused to rest on the line *a a*, and the circuit through the propelling-motors is as follows: Current enters the contact-shoe C and passes by wire 30, contact 30^a, by cross-connected contacts to 31^a, to brush 30, thence through the first section of resistance R to the motor-reversing switch G, to the armature of motor M′, to the reversing-switch G, through the field of motor M′, by wire 32 to brush 33, by cross-connected contacts on the cylinder to brush 34, to brush 35 on the master controller-switch H^3, to brush 36, by wire 36^a to the motor-reversing switch G, through the armature of motor M^2 to the reversing-switch G, to brush 37 on the master-switch H^3, to brush 38, by wire 38^a, through the field of motor M^2 to cable-wire 7^a, wire 7^b, and to ground. With the connections as above described the propelling-motors are connected in series with full resistance, as shown in Fig. 3.

If it is desired to increase the speed of the propelling-motors, the master-switch H′ is moved to a point where the vertical row of stationary brushes rests on the line 3 3 and the circuit is as follows: Current enters at trolley C and passes to train-wire 2^a, thence to brush 2, where the circuit divides, one path being by cross-connected contacts to brush 1, to cable-wire 1^a, and thence, as before, through the field of the pilot-motor and to ground. The second circuit from brush 2 leads by the cross-connected contacts to brush 4, cable-wire 4^a, wire 4^b to brush 4^c, by cross-connected contacts to brush 9^c, through the magnet-coil F′ and armature of the pilot-motor to brush 10^c, by cross-connected contacts to brush 5^c, to cable-wire 5^a, brush 5, by cross-connected contacts to brush 7, to cable-wire 7^a, to wire 7^b, and to ground. With the circuits arranged as described the magnet-coil F′ will attract its armature and withdraw the brake-shoe E^2 from engagement with the brake-disk and motion will be imparted to the motor-controller E from the pilot-motor by means of the gearing F^2. The motor will continue to run at a speed suitable to cause proper acceleration of the car-motors until contacts 4^c and 5^c leave the brushes 4^d and 5^d. As soon as this occurs the circuit is interrupted; but brushes 3^c and 6^c are in engagement with the contacts 3^d and 6^d and in readiness to complete the circuit of the pilot-motor as soon as the master-switch H′ is advanced to its next position. It will be seen that brushes 3^c and 6^c and 4^c and 5^c are connected in such manner that they work in pairs—that is to say, for the first step brushes 3^c and 6^c are in operation. For the second position they are open-circuited; but brushes 4^c and 5^c are in electrical connection with the circuit. With the brushes resting upon the line *b b* of the motor-controller, which represents the conditions of the circuit corresponding to the position 3 3 of the master-controller, all of the graded sections of resistance R are cut out of circuit and the motors are connected in series between the trolley and ground without any resistance, as shown at *b b*, Fig. 3.

If it is desired to still further increase the speed of the propelling-motors, the master-switch H′ is moved to a position where the brushes rest upon line 4 4. This completes the circuit of the pilot-motor, and the motor-controller E will advance to a position where the brushes rest upon the line *c c*, which interrupts the circuit of the pilot-motor at brushes 3^c and 6^c, and the propelling-motors will be connected in parallel with full resistance, as shown at *c c* in Fig. 3. By advancing the master-controller to a point where the brushes rest upon the line 5 5 the motor-controller C is advanced to a position where the brushes rest upon the line *d d*, and the two motors are connected in full parallel, as shown at *d d* in Fig. 3, as will be readily seen by tracing the connections. Assuming that the motor-controller switch E is in other than its off position and that it is desired to return it to its off position, switch H′ of the master-controller is moved to the position shown in the drawings, and the circuit is as follows: Current enters at contact-shoe C and passes to the train-wire 2^a, to brush 2, by cross-connected contacts to brush 8, to cable-wire 8^a, to wire 8^b, through the field of the pilot-motor in the direction shown by the dotted arrow to cable-wire 1^a, to brush 1, by cross-connected contacts to brush 7, to cable-wire 7^a, to wire 7^b, and to ground. This completes the circuit of the field of the pilot-motor.

The armature-circuit is from train-wire 2^a to brush 2, by cross-connected contacts to brush 9, to wire 9^b, through the magnet-coil F′ in the direction of the arrow, through the armature F of the pilot-motor to brush 10^c, by cross-connected contacts to brush 5^c or 6^c, depending upon the position of the motor-controller E, (in this case it is assumed that brush 5^c is in contact,) to wire 5^b, cable-wire 5^a, brush 5, by cross-connected contact to brush 7, cable-wire 7^a, to brush 7^b, to ground. This completes the armature-circuit and at the same time energizes magnet F′, which attracts its armature and raises the brake-shoe E^2 out of engagement with the brake-disk E′. As soon as this is accomplished the pilot-mo-

tor starts into operation and drives the motor-controller to its off position, since when the contact 5^d leaves the brush 5^c the brush 6^c, also connected through the contact on H′ to contact 7, is energized by one of its proper contacts. A suitable stop is provided at the off position to limit the movement of the motor-controller. If the master-controller is allowed to remain in the position shown in the drawings, current will continue to flow through the pilot-motor after it has driven the motor-controller to its off position; but as soon as the motor-controller has reached its off position the master controller-switch H′ should be moved to a point where the brushes 1 to 9, inclusive, are situated between the lines 1 1 and 2 2. This interrupts all the circuits of the pilot-motor, so that no energy is being consumed during the time that the motor-controller is at its off position.

Assuming that for some reason the main source of supply fails and the motor-controller E is standing, for example, at the full-on position, with the ordinary arrangement of the pilot-motor or other electric apparatus for actuating the motor-controller it would be impossible without the use of some separate source of power to return the motor-controller to its off position. In order to provide means for returning it to its off position under such circumstances, I provide a switch H^3, which is normally in the position shown, but which when thrown converts one or more of the propelling-motors into generators and supplies current to the pilot-motor for driving the motor-controller.

Assuming that the main source of supply has failed, the shunt-coil I′ will be deënergized and the circuit-breaker I will automatically open, either by a spring or gravity, as desired. The switch H^3 should then be thrown so that its brushes rest upon the position indicated by the broken and dotted line, those of switch H′ being as shown in the drawings, when the circuit will be as follows: from the brush on the left-hand side of the armature of the motor M^2 to the motor-reversing switch G, by wire 36^a to brush 36 on the switch H^3, by cross-connected contacts to brush 38, by wire 38^a through the field of the motor in the direction indicated by the full-line arrow to cable-wire 7^a, to brush 7, where the circuit divides, one path being to brush 5, to cable-wire 5^a, to wire 5^b, by cross-connected contacts on the switch E to brush 10^c, through the armature of the pilot-motor in the direction indicated by the dotted arrow, through the magnet-coil F′ to wire 9^b, to cable-wire 9^a, to brush 9, by cross-connected contacts to brush 2, train-wire 2^a, to wire 2^c, to switch H^3, by cross-connected contacts to resistance R′, through the several sections of resistance to brush 40, by cross-connected contacts to brush 37, to reversing-switch G, to the armature of motor M^2. Returning to brush 7, a second path is by cross-connected contacts to brush 1, to cable-wire 1^a, through the field of the pilot-motor to cable-wire 8^a, to brush 8, where it unites with the current from the armature of the pilot-motor.

With the circuits as above described the motor M^2 and pilot-motor are arranged as shown in Fig. 4, motor M′ being open-circuited. The motor M^2 is thus caused to act as a generator to supply current to the pilot-motor, and the pilot-motor will drive the motor-controller E to its off position, the speed of the pilot-motor being controlled by varying the resistance R′ in any desired manner by further manipulation of the switch H^3. By this arrangement it will be seen that the action of the pilot-motor can readily be controlled irrespective of the condition of the main source of supply. This is a very important feature, as it renders the action of the pilot-motors certain at all times.

The method of actuating the reversing-switch G from the master-switch H^2 has been already described. Its operation and functions are the same as in an ordinary series-parallel controller and need not be more fully described.

One important result of the improvements described is that I am able with a small number of train-wires to secure any desired number of positions of the motor-controllers owing to the arrangement of the contacts 3^d 4^c 4^d, &c. I am also able to stop the motor-controllers at sharply-defined points entirely independent of the current flowing in the main motors. Further, the motor-controllers can stop only on points at which their brushes are in full contact with their respective segments. I thus avoid the danger of stopping the controllers with certain fingers in bad contact, which would tend to cause injurious heating.

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

1. In a system of control for electric motors, the combination of a motor-controller, a pilot-motor for driving the motor-controller, a set of contacts for regulating the pilot-motor, which are so arranged that the circuit of the armature of the pilot-motor is automatically interrupted only after it has made a predetermined number of revolutions, and a second set of contacts which are brought into operative relation as soon as the circuit of the first set of contacts is interrupted.

2. In a system of control for electric motors, the combination of a motor-controller, a pilot-motor for actuating the motor-controller, a master-controller for regulating the pilot-motor, a set of contacts on the motor-controller for completing the circuit of the pilot-motor, and a second set of contacts also mounted on the motor-controller, which are employed to complete the circuit of the pilot-motor, the arrangement of contacts being such that when the first set of contacts is energized,

the second set is inactive, the two sets being arranged to come successively and alternately into action.

3. In a system of control for electric motors, the combination of a motor-controller, a pilot-motor for moving the motor-controller in a step-by-step manner, and two sets of contacts which are employed to complete the motor-circuits, one set being in service while the controller advances a step, and the second set while the controller advances a second step, the two sets being arranged to come successively and alternately into action.

4. In a system of electric-motor control, the combination of a controller for regulating the motor, and means actuated by the motor when acting as a generator for operating the controller.

5. In a system of electric-motor control, the combination of a controller for regulating the motor, and means actuated by the motor when acting as a generator for moving the controller to a predetermined position.

6. In a system of electric-motor control, the combination of a controller for regulating the motor, and electromagnetic means receiving current from the propelling-motor when acting as a generator for returning the controller to the off position.

7. In a system of electric-motor control, the combination of a motor-regulating controller, a pilot-motor which is geared to the controller, and means for supplying the pilot-motor with current from the main motor when it is acting as a generator to return the controller to the off position after the failure of the main-line current.

8. In a system of control for electric motors, the combination of a controller for regulating the propelling-motors, electromagnetic means for actuating the motor-controller, and a switch arranged to convert one or more of the propelling-motors into generators and to supply the current thus received to the electromagnetic means for actuating the controller.

9. In a system of control for electric motors, the combination of a controller for regulating the propelling-motors, a pilot-motor which is geared to the motor-controller, a switch for controlling the action of the pilot-motor under normal conditions, and a second switch for converting the propelling-motor into a generator, and supplying the current thus generated to the pilot-motor.

10. In a system of control for electric motors, the combination of a controller for regulating the propelling-motors, electromagnetic means for actuating the controller, a master-controller for regulating the action of the motor-controller, and a switch for converting the propelling-motor into a generator, supplying the current thus produced to the electromagnetic means, and regulating the current flowing in said means.

11. In a system of train control, the combination of a plurality of cars united to form a train, one or more dynamo-electric machines on certain of the cars for propelling the train, controllers for regulating the dynamo-electric machines, a master-controller for regulating the action of the said controllers, and means actuated by the dynamo-electric machines for driving the first-mentioned controllers.

12. In a system of train control, the combination of a plurality of motor-cars united to form a train or a portion of a train, controllers for regulating the propelling-motors of various cars, on each car, electromagnetic means for actuating the motor-controllers, a master-controller for regulating the said means, and a switch for converting one or more of the propelling-motors into generators and supplying the current to the electromagnetic means for actuating the motor-controller.

13. In a system of train control, the combination of a plurality of motor-cars united to form a train, controllers for regulating the propelling-motors of various cars, a pilot-motor for driving each motor-controller, a master-controller located at any selected point for regulating the action of the pilot-motors, and a switch for converting one or more of the propelling-motors into generators, supplying the current thus generated to the pilot-motors, and regulating the current flowing therein.

14. In a system of electric-motor control, the combination of a motor-regulating controller, electromagnetic means for actuating the controller in a step-by-step manner, and a switch for interrupting the circuit of the electromagnetic means, at a plurality of points after the completion of each step.

15. In a system of electric-motor control, the combination of a motor-regulating controller, a pilot-motor for actuating the controller in a step-by-step manner, and a switch for interrupting the circuit of the pilot-motor at a plurality of points each time the motor-controller advances a definite amount.

16. In a system of electric-motor control, the combination of a motor-regulating controller, a pilot-motor for driving the controller both forward and back, and a plurality of contacts carried by the motor-controller, for simultaneously interrupting the circuit of the pilot-motor at a number of points each time the motor-controller advances a step.

17. In a system of electric-motor control, the combination of a motor-regulating controller, a pilot-motor for driving the controller, a magnetically-controlled brake for stopping the motor-controller at the various steps, and a coil for actuating the brake included in the circuit of the pilot-motor, the whole being so arranged as to stop the motor-controller only at the off position or at a definite running position.

18. In a system of train control, the combination of a number of motor-cars united to form a train, one or more motor-controllers each driven by a pilot-motor, a master-controller for regulating the operation of the motor controller or controllers, a collecting device for each motor-car, and a train-wire ex-

tending through the train, to which all of the contact devices of the motor-cars are connected in multiple.

19. In a system of control for electric motors, the combination of a motor-controller, electromagnetic means for actuating the same, and a master-controller for regulating its action, provided with a double set of contacts, one set being arranged to produce rotation of the motor-controller in a clockwise direction, and the second set to produce rotation in an anticlockwise direction.

20. In a system of control for electric motors, the combination of a motor-controller, electromagnetic means for actuating the same, and a master-controller for regulating its action, and a double set of contacts on the master-controller, one set being arranged to produce a step-by-step rotation of the motor-controller in a forward direction, and the second set to produce a continuous movement of the motor-controller toward its off position.

21. The combination with a master-controller, of a motor-controller, a pilot-motor driving the motor-controller, and electrical means, controlled by the master-controller, for interrupting the supply of current to the pilot-motor in such a way that the motor-controller can stop only in the off position or in some definite running position.

22. The combination in a train system, of a plurality of motor-cars each equipped with a motor or motors, a motor-controller therefor, and a pilot-motor for driving the motor-controller, one or more motor-controllers situated upon the train, and electrical means controllable by each master-controller for interrupting the supply of current to the pilot-motors in such a way that the motor-controllers can stop only in the off position, or on some definite running position, and with the segments and fingers in good contact.

In testimony whereof I have hereunto set my hand this 25th day of March, 1898.

EDWIN W. RICE, JR.

Witnesses:
B. B. HULL,
C. L. HAYNES.