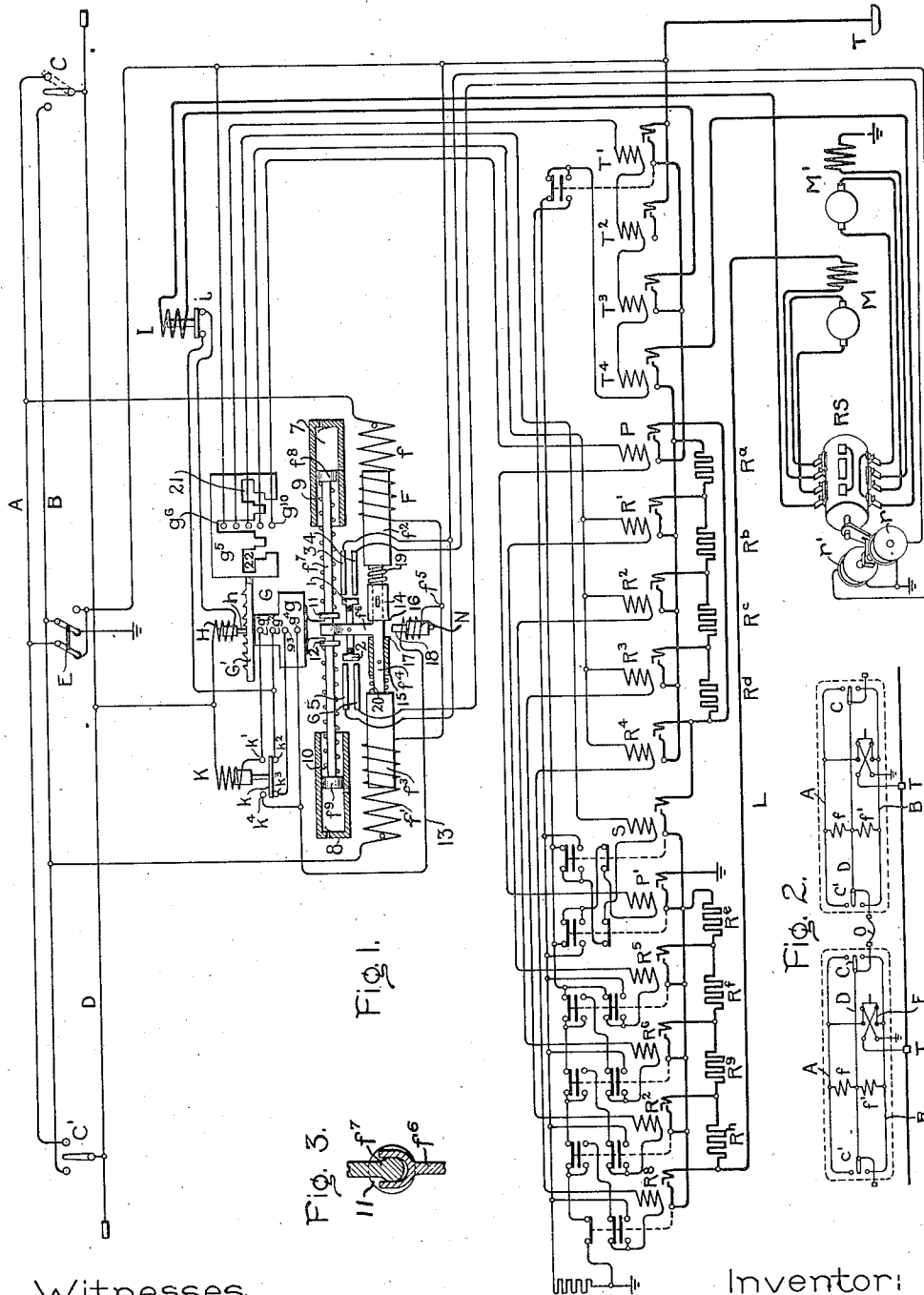


E. R. CARICHOFF.
MOTOR CONTROL SYSTEM.

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949,995.

Patented Feb. 22, 1910.



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Att'y.

UNITED STATES PATENT OFFICE.

EUGENE R. CARICHOFF, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MOTOR-CONTROL SYSTEM.

949,995.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, EUGENE R. CARICHOFF, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Motor-Control Systems, of which the following is a specification.

The present invention relates to control apparatus for motors and particularly to apparatus of the character designed to control a motor or a plurality of motors from a distant point.

In control apparatus in which the direction of rotation and the speed of electric motors are determined by motor control apparatus governed by a master-switch located at a distant point, it is desirable to have the motor control apparatus automatic or semi-automatic in character and at the same time simple in construction and certain in action. It is furthermore desirable that the system be so arranged that the master-switch device may be simple in form and in operation and so arranged as not to necessitate an auxiliary source of current supply for energizing the control system.

The objects of the present invention are to so construct and arrange the parts of a control system that the system shall embody the features heretofore mentioned.

To the above ends, I so construct and arrange the parts of a control system that the master-switch device consists of a simple switch comprising a single arm engaging with a plurality of contacts and but a single wire is necessary to connect the master-switch to the motor control apparatus. Where the present system is used in connection with multiple unit railway control, the single wire extends throughout the train and serves to control the motors on the several motor cars of the train.

The present invention will be more clearly understood in connection with the following description of one embodiment thereof illustrated in the accompanying drawing, in which—

Figure 1 illustrates diagrammatically a control system arranged in accordance with the present invention; Fig. 2 shows a train of two cars and the wiring thereof; and Fig. 3 is a detail of a portion of the master-controller.

Similar reference characters will be used throughout the specification and drawing to indicate like parts.

Reference being had to Fig. 1, M and M' indicate the motors of a two-motor car equipment; L is a motor controller of the separately-actuated type; RS is a reversing-switch; A and B represent two car wires; C and C' are two master-switches adapted to connect either car wire to the train-wire D.

T is a trolley or other current-collecting device carried by the car and this trolley may be connected permanently to one of the car wires, and the other car wire may be connected permanently to the ground. However, in order that the cars may be turned end for end in making up a train, a switch E is provided for connecting either wire to ground or to trolley, and the other to trolley or to ground.

F is a master controller-actuating device having two actuating coils f and f^1 connected in series between wire A and wire B. Consequently, when the switch E is in one of its operative positions coils f and f^1 will both be energized. Arranged within the coils f and f^1 are magnetic core pieces f^2 and f^3 , respectively, connected together by means of the rod or stem f^4 . It is evident that so long as both coils f and f^1 are energized no movement of the cores will result. Train-wire D is connected to the coils f and f^1 at a point intermediate the adjacent terminals of the coils, as at f^5 . If one of the master-switches is connected to car-wire A, one of the coils f , f^1 will be short-circuited, while if the master-switch is placed in connection with car wire B the other coil will be short-circuited, thereby providing for operating the connected cores in either direction and for connecting the motors for propelling the car in the forward or in the reverse direction.

Extending from the stem f^4 is an arm f^6 provided with contact members 1 and 2 which are suitably insulated from the arm f^6 and from each other. These contacts are arranged to engage respectively with elongated fixed contacts 3 and 4, and 5 and 6, respectively, for energizing the reverser switch actuating coils r and r' in order to throw the reverser-switch in the proper direction as determined by direction of movement of the magnetic cores. The arm f^6 is also operatively associated with a rod f^7

provided at its opposite ends with pistons f^8 f^9 moving in cylinders 7 and 8. Springs 9 and 10 surround the rod f^7 and extend from the pistons to points adjacent the middle of the rod, at which points they bear against collars 11 and 12, loosely surrounding the rod and with which the arm f^6 is adapted to engage. A movement of the connected cores in one direction or the other tends to move the rod f^7 and, if this rod is not free to be moved, then compresses the spring 9 or 10, depending upon the direction of movement of the cores. As soon as the rod f^7 is free to move, the compressed spring expands and forces the rod axially, subject to the retarding effect of the dash-pots. The rod f^7 carries the member G constituting the movable member of the master-controller, a movement of the rod f^7 producing a corresponding movement in the controller member G. The member G comprises a movable plate g adapted to cooperate with fixed contacts g^1 , g^2 , g^3 and g^4 , together with the contact plate g^5 which cooperates with fixed contacts g^6 to g^{10} , these two contact plates being insulated from each other. The member G of the master-controller is provided with a rack G^1 with which a pin h actuated by electromagnet H cooperates in order to lock said member G in any one of several running positions. The plate g and cooperating fixed contacts serve simply to stop the master controller in its full series position until the operator desires to connect the motors in parallel, while the plate g^5 controls the control circuits of the motor-controller L.

I is a throttle relay, the actuating coil of which is energized by motor current, and this relay, together with a second relay K controls the electromagnet H. The arrangement of parts is such that the circuits for the reversing switch are completed prior to the closing of the circuits for the motor-controller in order to insure the proper operation of the reversing switch before the motor-controller switches are actuated.

Assuming the master switch C to be placed in the position shown in dotted lines, namely, so as to connect car-wire A to train-wire D, coil f of the reverser is short-circuited by reason of its terminals being connected together through car-wire A; one terminal being connected directly to this wire as shown, and the other terminal being connected thereto through the wire 13, contact g^4 , contact plate g to contact g^1 , coil of relay K, train-wire D and master-switch C. Current flows from wire A, through the circuit just traced, to the point f^6 , thence through coil f^1 , car-wire B, to ground; the cores f^2 and f^3 will therefore be drawn toward the left. Current also flows through the coil of electromagnet H, through the contacts i of throttle relay I and thence to contact g^2 , con-

tact plate g , and contact g^4 , in parallel with the circuit through the coil of relay K. Consequently, at the same time that the coil f^1 is energized, electromagnet H will also be energized and the rod f^7 and movable portion G of the master-controller become free to move with the cores f^2 f^3 . In case the motor current becomes too strong, throttle I will be actuated breaking the circuit of electromagnet H and allowing the pin h to engage with the teeth of the rack G^1 , thus checking the movement of the controller member G and permitting the cores f^2 and f^3 to compress the spring 10 upon the rod f^7 . When the motor current falls to a normal value the magnet H is again energized and the spring 10, in expanding, continues the movement of the master-controller.

The motor-controller L may be of any usual or preferred type, that illustrated being similar to the controller shown and described in my Patent No. 763,658, granted June 28, 1904. The number of teeth in the rack G^1 will, of course, depend upon the character of the motor-controller L. If, for instance, there are a large number of resistance steps in the motor-controller, a corresponding number of teeth may be formed in the rack, while if the resistance steps are few the number of teeth in the rack may be small. In addition to the locking action produced by the throttle relay, a further locking action results from the action of the relay K. The plate g is so constructed that when the master-controller has caused the motor controller to connect the motors in series with no resistance in circuit, contact is broken at g^1 and g^2 , which are connected respectively with contacts k^1 k^2 associated with the relay K. It is evident that when contact is broken at g^2 the circuit of electromagnet H is interrupted, therefore permitting the pin h to drop into engagement with the rack and thereby locking the master controller against further advancement. In order that the master controller may be enabled to continue its movement it is necessary to break circuit at the master-switch C, thereby deenergizing relay K and causing its movable member k to engage with contacts k^2 k^3 , thus connecting the coil of electromagnet H to wire 13 through contacts k^2 , k^3 , g^3 and g^4 . Upon again closing the master-switch relay K does not become energized, since its circuit is interrupted at k^4 , and also at g^4 ; but electromagnet H is energized and releases the controller member G, which then continues its movement subject to the influence of throttle relay I, until a full parallel position is reached.

In order to bring the master-controller to its "off" position it is necessary to throw the master-switch C to reverse, namely, so as to connect train-wire D to car-wire B. Coil f will now be energized and the controller

will be returned to its normal position without being interrupted by electromagnet H since the teeth on the rack bar G^1 are inclined on one face to permit the pin to ride over them. Means must be provided for positively stopping the master controller at its "off" position, and for this purpose a pair of sliding catches 14 and 15 are mounted upon the stem f^1 . These catches are provided with shoulders 16 and 17 which are adapted to engage with a pin 18 actuated by an electromagnet N having its coil in series with the wire 13. When the master-switch is placed in either operative position, electromagnet N is energized and tends to raise the pin 18. Assuming that the master controller has been thrown to the left and is being reversed, the cores f^2 and f^3 will move toward the right and the shoulder 16 on the catch 14 will depress the pin 18 sufficiently to enable the catch to pass, but as soon as the catch passes the pin it rises, abuts against the square face of the catch 15, preventing any further movement of the master controller. The introduction of the catches 14 and 15 and the locking pin 18 necessitates a slightly different mode of operation in starting the car or train from that just described. It is evident that when the master-controller is in its "off" position and the master-switch is thrown to one of its operative positions, the pin 18 will prevent the connected cores f^2 and f^3 from axial movement except within limits determined by the catches 14 and 15. The catches 14 and 15 are yieldingly mounted and held in their normal positions by springs 19 and 20. As soon as the coil f is short-circuited, the cores move laterally until the catch 14 engages the pin 18, whereupon the catch is moved slightly against the tension of the spring 19. If now the master-switch C is moved to its "off" position, breaking contact with both wires A and B, the electromagnet N will become deenergized and the pin 18 will drop. As soon as the pin drops the catch 14 will be forced to its normal position by the spring 19, namely, to such a position that when electromagnet N is again energized upon the closing of the master-switch, the shoulder on the catch is free from the pin 18 and the connected cores are enabled to move uninterruptedly.

The motor-controller L consists of line contacts T^1 to T^4 , resistance contacts R^1 to R^8 , controlling resistance sections R^a to R^b , series contact S, and parallel contacts P and P^1 , together with the usual auxiliary interlocks. The various contacts of the motor-controller act to connect the motors first in series with all resistance in circuit; then to cut out the resistance section by section; then to connect the motors in parallel with all the resistance in circuit; and finally to remove the resistance again, section by section.

The circuits for actuating the controller contacts are connected to trolley through contacts g^6 to g^{10} and plate g^5 . Slots 21 and 22 are cut in the plate g^5 in such a manner that as the plate moves to the right or to the left the various circuits are successively energized so as to produce the proper motor connections. The various circuits through the motor-controller will not be described in detail since they may readily be traced on the drawing and since, furthermore, the controller L forms specifically no part of the present invention.

In Fig. 2, two cars are shown coupled together in the form of a train, the train-wires D being united by a jumper O. When one of the master-switches is in service the others are left in their "off" position; the wire D on the second car being then connected to ground or to line by the master-switch on the leading car in unison with the wire D on the leading car. Any number of cars may be coupled together and controlled from any one of the master-switches.

While I have described in detail the best form of the present invention now known to me, I do not desire to limit the present invention to the particular form shown, since in its broader aspects it may be embodied in various other forms, for instance, the master-controller may operate directly as a motor-controller without the intervention of a separate motor-controller.

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

1. In a system of motor-control, a source of current supply, a plurality of motors or groups of motors, controllers for said motors or groups of motors arranged to connect said motors or groups of motors to said source of current supply for either direction of rotation, actuating means for said controllers, a master-switch connected to said source of current supply, a single electrical connection between said master-switch and the several controller-actuating means.

2. In a system of train-control, a source of current supply, a motor or group of motors on each of a plurality of cars, local controlling apparatus upon each of said cars arranged to connect the motors to said source of supply for either direction of rotation, a master-switch connected to said source of current supply, and a single electrical connection between the controlling apparatus on the several cars and the master-switch.

3. In a system of motor-control, a source of current supply, a plurality of motors or groups of motors, controllers for connecting said motors or groups of motors to said source of current supply for either direction of rotation and for varying the speed of the said motors or groups of motors, actuating means for said controllers, a master-switch connected to said source of current supply,

and an electrical connection between said controller-actuating means and said master-switch comprising a single wire.

4. In a system of train-control, a source
5 of current supply, a motor or motors upon
each of a plurality of cars, local controlling
apparatus upon each of said cars for con-
necting said motors to said source of cur-
rent supply, actuating means for said con-
trollers, a master-switch connected to said
10 source of current supply, an electrical con-
nection between said master-switch and said
controller-actuating means comprising a sin-
gle train wire, and means upon each of said
15 cars for maintaining the proper direction of
rotation of the motors irrespective of the
end for end position of the cars in the train.

5. In a system of motor-control, a source
of current supply, a plurality of motors,
20 resistances, control apparatus for connect-
ing said motors to said source of current
supply for either direction of rotation and
for varying the amount of said resistances
in the motor-circuits, a master-switch, and
25 an electrical connection between said mas-
ter-switch and said control apparatus com-
prising a single wire.

6. In a system of motor-control, a source
of current supply, a motor or group of mo-
tors, a controller for connecting said motor
or group of motors to the source of current
supply and for varying the speed of said mo-
tor or group of motors, actuating means for
said controller, means for bringing said con-
35 troller to rest in an intermediate position, a
master-switch connected to said source of
current supply, and an electrical connection
between the master-switch and said control-
ler-actuating means comprising a single train
40 wire.

7. In a system of motor-control, a source
of current supply, a motor or group of mo-
tors, a motor-controller for connecting said
motor or group of motors to said source of
45 current supply and for varying the speed of
the motor or group of motors, actuating
means for said controller including means
for bringing said controller to rest in an in-
termediate position, a master-switch for con-
50 trolling the operation of said controller, and
means including a single wire between the
master-switch and the controller-actuating
means for supplying said controller-actuat-
ing means with current at the potential of
55 the said source of supply.

8. In a system of motor-control, a source
of current supply, a plurality of motors, a
series parallel controller, actuating means
for said controller, means for bringing said
60 controller to rest in full series position, a
master-switch, and a single wire connecting
said master-switch and said controller-act-
uating means.

9. In a system of train-control, a motor-
65 circuit upon each of a plurality of cars, local

controlling apparatus for determining the
direction of rotation of the motor or motors
and the resistance in the motor-circuit, a
master-switch, and a single train-wire con-
necting said switch to said controlling appa- 70
ratus.

10. In a system of motor-control, a motor-
circuit, a motor-controller, a lock for said
controller, electromagnetic means for releas-
ing said lock, and contacts associated with 75
said controller for deenergizing said electro-
magnetic means at a predetermined point in
travel of the controller.

11. In a system of motor-control, a motor-
circuit, a motor-controller, a lock for said 80
controller, electromagnetic means for releas-
ing said lock, means controlled by motor cur-
rent for deenergizing said electromagnetic
means, and means associated with the con-
troller for deenergizing said means when the 85
controller has reached a predetermined point
in its travel.

12. In a multiple-unit control system,
magnetic devices within the several cars hav-
ing differential or opposed windings, a sin- 90
gle pilot-wire extending throughout the
train, and connections from said pilot-wire
to said magnetic devices at points between
the opposed windings.

13. In a multiple-unit control system, 95
magnetic devices upon the several cars hav-
ing opposed or differential windings, means
for normally impressing a continuous cur-
rent in series through said opposed wind-
ings, a pilot-wire extending throughout the 100
train, and branch connections from said
pilot-wire to said magnetic devices at points
between the opposed windings.

14. In a system for controlling a plurality
of motors, the combination of a master-con- 105
troller, motor reversing and speed-control-
ling mechanisms governed thereby, and a
single conductor connecting said master-con-
troller and said mechanisms.

15. In a system for controlling a plurality 110
of motors, the combination of a master-con-
troller, motor reversing and motor resistance
controlling mechanisms governed by said
master-controller, a single conductor con-
necting said master-controller and said 115
mechanisms, and means at the master-con-
troller for reversing the direction of the cur-
rent through the said single conductor.

16. In a system for controlling a plurality 120
of motors, the combination of motor revers-
ing switches, a pair of solenoids for operat-
ing each switch, the windings of each pair
of solenoids being connected in series across
the supply mains, a master-controller, a sin-
gle conductor connected to said master-con- 125
troller and a point between each pair of so-
lenoids, and means at the master-controller
for connecting said conductor to one or the
other of the supply mains.

17. In a system for controlling a plural- 130

ity of motors, the combination of motor reversing switches, two solenoids for operating each switch, the windings of each pair of solenoids being in series across the supply
 5 mains, and means independent of said switches for supplying one or the other solenoid of each pair of solenoids with an excess of current over that supplied to the other solenoid of the pair sufficient to cause
 10 it to operate the said switch.

18. The combination with a plurality of motors, of means for controlling the forward, reverse and stop conditions of said motors from a distance, said means including
 15 one wire only between the controlling point and the motors.

19. In a multiple-unit-train-control system, the combination with a plurality of cars, of driving motors for the cars, and
 20 means for suitably controlling the forward, reverse and stop conditions of the motors upon all the cars of the train from one car, said means including one wire only between the various cars of the train.

20. In a multiple-unit-train-control system, the combination with a plurality of cars connected together to compose the train, of driving motors for the cars, controlling
 25 devices upon each car to control the forward, reverse and stop conditions of the motors of the respective cars and means for controlling the operation of said devices from one car only, said latter means including
 30 a train wire connected between the cars and extending throughout the train.

21. In a multiple-unit-train-control system, the combination with a plurality of cars, of driving motors for the cars, electro-magnetic switches upon each of the cars
 40 for suitably controlling the forward, reverse and stop operation of the motors of the same car, and means for controlling the operation of said electro-magnetic switches from one car of the train, said means including
 45 one wire only extending throughout the train and between the various cars.

22. In a multiple-unit-train-control system, the combination with a plurality of cars, of driving motors therefor, a controlling circuit extending throughout the train
 50 and comprising a single train wire between the cars, and means for controlling forward, reverse and stop conditions of said motors from said single train wire.

23. In a multiple-unit-train-control system, the combination with a plurality of cars, of driving motors for the cars, electro-magnetic switches upon each car to suitably control the direction and speed of operation of
 55 the motors of the respective cars, a controlling circuit consisting of a single train wire extending throughout the train and between the cars, and means for controlling said circuit to suitably control said switches.

In witness whereof, I have hereunto set
 65 my hand this 26th day of January, 1905.

EUGENE R. CARICHOFF.

Witnesses:

FRANK N. MURRAY,
 LEO C. FOSS.