No. 837,037. PATENTED NOV. 27, 1906.

F. E. CASE.

# MOTOR CONTROL APPARATUS.

APPLICATION FILED APR. 17, 1905.

2 SHEETS—SHEET 1.

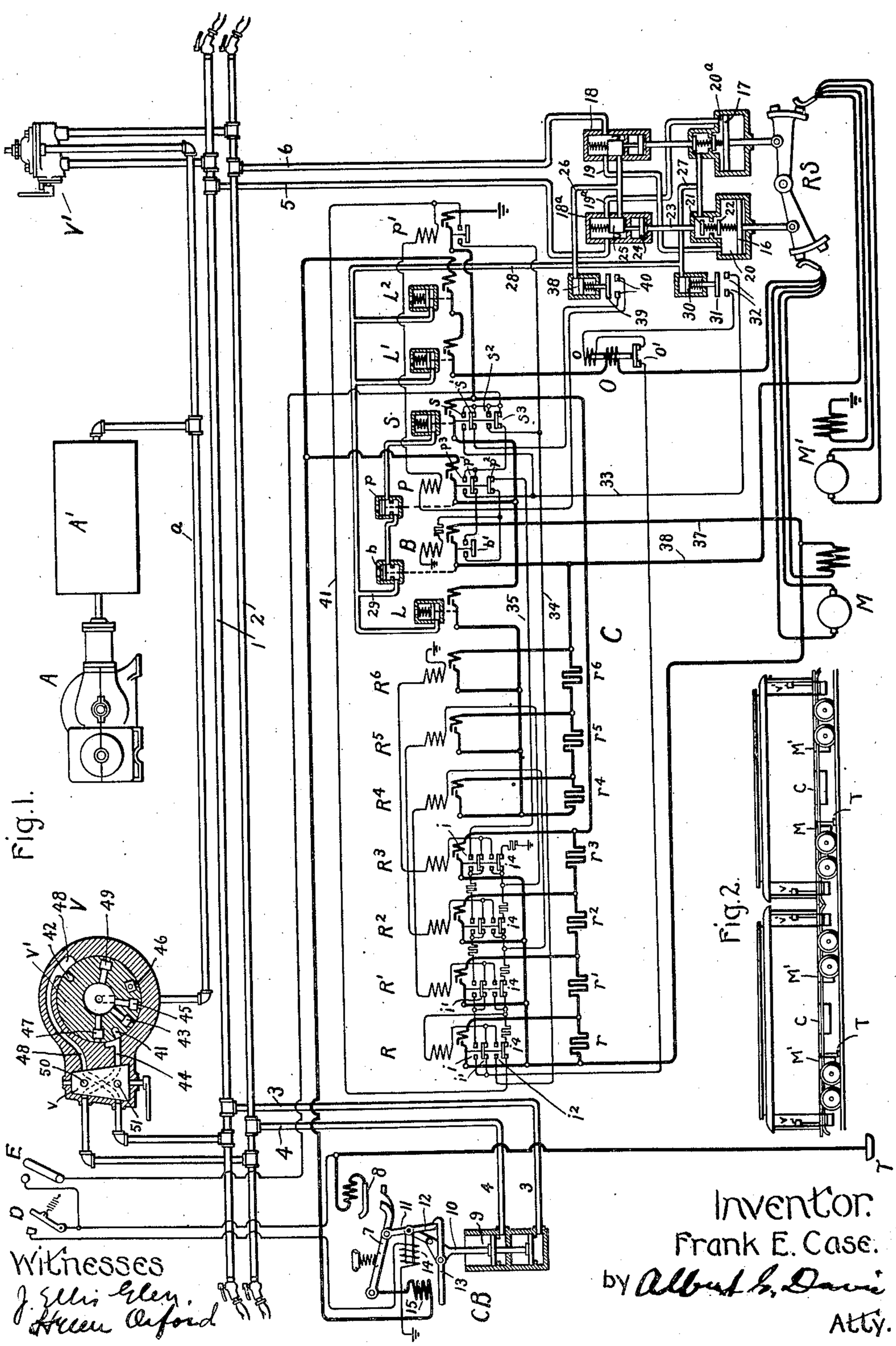


Fig. 1.




Fig. 2.

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2 SHEETS—SHEET 2

FIG. 4.

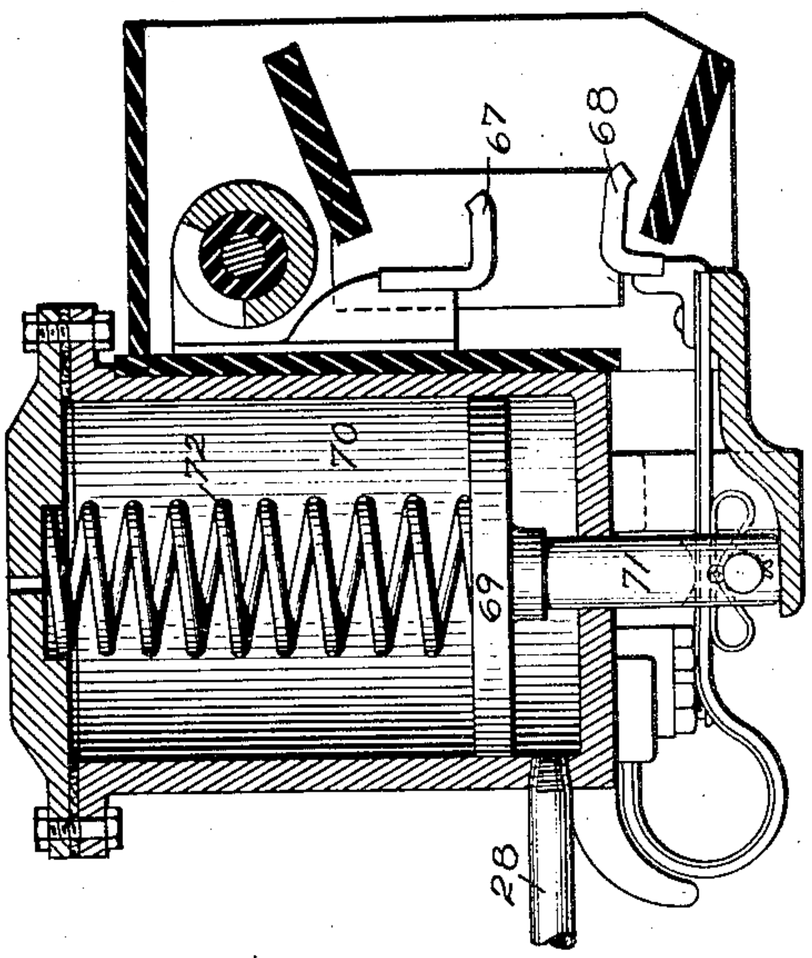


FIG. 3.




WITNESSES.

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# UNITED STATES PATENT OFFICE.

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

## MOTOR-CONTROL APPARATUS.

No. 837,037. Specification of Letters Patent. Patented Nov. 27, 1906.

Application filed April 17, 1905. Serial No. 255,868.

*To all whom it may concern:*

Be it known that I, FRANK E. CASE, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Motor-Control Apparatus, of which the following is a specification.

The present invention relates to motor-control apparatus adapted for controlling the direction of rotation and speed of the motors of one or more cars of a train, and has for its object the improvement of various features of detail in the type of apparatus employing two train-pipes through which the entire control apparatus is governed.

A further object of the present invention consists in improvements in the construction and operation of circuit-breakers adapted for use in connection with train-control systems.

The present invention in its various aspects will be more fully understood in connection with the following description thereof as embodied in a preferred form.

In the accompanying drawings, Figure 1 illustrates a single-car equipment arranged in accordance with the present invention. Fig. 2 indicates a train of two cars, each of which is provided with the apparatus shown in Fig. 1. Fig. 3 shows in cross-section an electromagnetically-actuated switch provided with a valve for controlling a second switch, and Fig. 4 shows in cross-section a pneumatically-actuated switch.

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

The present invention, broadly considered, consists of a motor-controller of the separately-actuated-contact type and a pneumatically-actuated reversing-switch, some of the separately-actuated contacts being operated electrically and others pneumatically and all being controlled by a master-valve through the mechanism of the reversing-switch.

The circuit-breaker of each car is arranged to be closed pneumatically when the train-pipes are energized and to be tripped upon overload in the respective motor-circuits in which they are situated. Provision is also made for rendering the pneumatic actuating means inoperative to close the circuit-breakers after they have been tripped on account of overload until a manually-operated handle of some kind local to each car is operated. By this arrangement it is impossible to close any motor-circuit which has been overloaded without first deënergizing the train-pipes and therefore bringing the motor-controllers to their inoperative or "off" positions.

Reference being had to the drawings, M and M′ represent a pair of motors.

C is a motor-controller of the separately-actuated-contact type for connecting the motors either in series or in parallel and for regulating the amount of resistance in circuit with the motors.

CB is the circuit-breaker; RS, the reversing-switch; V V′, master controlling-valves arranged one at each end of the car in the usual manner.

A is an air-compressor supplying air to a storage-reservoir A′. A pipe *a* connects the reservoir A′ to the two master-valves V V′. The valves V V′ are connected to the two train-pipes 1 and 2. Branch pipes 3 4 and 5 6 connect the train-pipes to the circuit-breaker-actuating mechanism and to the reversing-switch mechanism, respectively.

The motor-controller C consists of a series of contacts or switches R to $R^6$, which control resistance-sections *r* to $r^6$, respectively, switches L, L′, and $L^2$ for connecting the motor-circuit to line, a series switch S, a bridging switch B, and parallel switches P P′. Certain of the resistance-controlling switches, the series switch, the bridging switch, and the parallel switches are provided with auxiliary contacts and interlocks similar to those shown and described in my previous application, Serial No. 226,755, filed October 1, 1904.

The circuit-breaker mechanism consists of a movable switch member 7, arranged to connect the local motor-circuit to the current-collecting device T when in engagement with the coöperating fixed contact 8. The member 7 is arranged so that when otherwise free it moves out of engagement with its complementary fixed contact, thereby breaking the motor-circuit. The pneumatically-actuated means for closing the circuit-breaker may take various forms—as, for instance, the double-piston arrangement 9, which is moved upwardly when air is admitted either to pipe 3 or pipe 4. The stem 10 of the actuating

device is not secured rigidly to the switch-arm 7, but is connected thereto by means of a toggle 11, which is so arranged that normally the arm 7 is allowed to drop sufficiently to prevent the pneumatic closing device from closing it. One arm of the toggle is extended, as at 12, and is adapted to be engaged by a pivoted catch 13, carried upon the stem 10. When the catch is in engagement with the projection 12, as illustrated, the switch-arm 7 is locked to the operating mechanism in such a manner that the switch is closed upon admission of air to either pipe 3 or 4. The engagement of the catch with projection 12 is effected by means of an electromagnet 14, the core of which is secured to the toggle 11 at its middle point and which is energized by current flowing from trolley through a normally open switch D to ground. It is evident that the momentary closing of the switch D serves to energize the magnet 14 and draw the projection 12 inward past the end of the catch 13. The electromagnet 14 is not made powerful enough to straighten the toggle sufficiently when the pneumatic actuating means is energized to bring the projection 12 into locking position. Therefore when the circuit-breaker is tripped while the pneumatic actuating means remains energized it is impossible to close the circuit-breaker and maintain it closed without first deënergizing the actuating means—namely, exhausting the air from the train-pipes. The circuit-breaker may be tripped in case the local motor-current exceeds a predetermined value by means of an overload-coil 15, arranged in the motor-circuit and serving to attract the end of the catch 13, thereby releasing the projection 12 and allowing arm 7 to be retracted. Instead of the electromagnet 14 any other form of setting device for the toggle may be employed, it being only essential that the device be arranged to become deënerzgied as soon as the manual control therefor is discontinued. Moreover, in case train-wires instead of train-pipes are employed in the control system an electromagnetic closing device may be used in place of the pneumatic apparatus.

The reversing-switch is provided with a pair of operating-pistons 16 and 17, arranged to set the switch for forward and reverse operation of the motors, respectively. Assuming that compressed fluid is admitted to train-pipe 2, it passes through branch pipe 6 into the casing 18, through pipe 19 and into the casing 20 above the piston 16, and if the reversing-switch is not already in the forward-running position the piston 16 will be depressed until such position is reached. If, on the other hand, air is admitted to train-pipe 1, it flows through branch pipe 5 into casing $18^a$, which is a duplicate of casing 18, through branch pipe $19^a$ and into the casing $20^a$ above piston 17, thereby forcing piston 17 downwardly and throwing the reverse-switch to its reverse operative position. The direction of movement of the car or train is therefore determined by the train-pipe which is first energized.

Assuming that train-pipe 2 alone has been energized and the reverse-switch to be thrown into the position shown, it will be seen that the valves 21 and 22, arranged within the casing 20, serve to uncover their respective ports, so that air is free to flow from the interior of casing 20 through pipe 23 and beneath piston 24, arranged within casing $18^a$. Piston 24 is moved upwardly, carrying with it the valve 25, which by its movement serves to uncover the port leading to pipe 26 and at the same time close the port leading to pipe $19^a$. Air also passes from casing 20 into pipe 27 and from thence to pipe 28. A series of branches leading from pipe 28 connect with suitable operating-pistons for the line-contacts L L′ $L^2$, which are arranged to be closed at the same pressure as that required to operate the reversing-switch. An additional branch pipe 29, leading from pipe 28, serves to energize the actuating mechanism for the series switch S. Within the pipe 29 are arranged a pair of valves *b p*, each of which is adapted to place the actuating means for the switch S either in open communication with pipe 28 or with atmosphere. The valves *b p* are connected, respectively, to the switch B and the switch P, the arrangement being such that when either of the switches B or P is closed the actuating means for the series switch is deënergized by being placed in open communication with the atmosphere. The series switch, like the line-switch, is arranged to be closed at the lowest working pressure. Consequently the admission of compressed fluid to train-pipe 2 serves to throw the reversing-switch to forward-running position, close the circuit-breaker, the line-switches, and the series switch, and by tracing the motor connections at this stage it will be seen that the motors are connected across the line in series with all resistance in circuit. If now the pressure in train-pipe 2 is increased—for example, to forty pounds, if the lowest pressure is twenty-five pounds—the increased pressure in pipe 27 will force the piston of the accelerating-relay 30 downwardly, bringing contact 31 into engagement with the fixed contacts 32. A control-circuit can now be traced from trolley through switch E, which must be closed, through the upper of the auxiliary contacts *s* of the series switch S, through wire 33, contacts 32 and 31 of the accelerating-relay, coil *o* of throttle-relay O, contact *o′* of the throttle-relay, auxiliary contact *i′*, associated with resistance-switch R, through the actuating-coil of this switch, through the lowermost auxiliary contacts $I^4$ of the switches R′, $R^2$, and $R^3$, to ground. Switch

R is thereby closed and the resistance-section *r* cut out of the motor-circuit. The closing of switch R breaks the actuating-circuit at auxiliary contact *i'*; but a maintaining-circuit is established by reason of the branch circuit passing through auxiliary contact $s^2$, associated with the series switch S, wire 34, auxiliary contact $i^2$, associated with switch R, through the actuating-coil of switch R, and to ground, as before. It will be noted that when the switch R closes the actuating-circuit is transferred from auxiliary contact *i'* to auxiliary contact *i* of switch R' and then passes through auxiliary contact *i'*, associated with switch R', thence through the actuating-coils of switches R' and $R^4$, to ground, as before. The closing of switches R' and $R^4$ breaks the actuating-circuit and establishes a maintaining-circuit in the same manner that the maintaining-circuit of switch R was established. Similarly switches $R^2$ and $R^5$ and $R^3$ and $R^6$ are closed, thereby cutting out all the resistance from the motor-circuit. This automatic progression of the resistance-contact takes place of course subject to the limiting and checking action of the time-interval throttle-relay O, which, being well known in the art, will not be described in detail. When switches $R^3$ and $R^6$ are closed, the actuating-circuit is transferred to the upper auxiliary contact *i*, associated with the switch $R^3$, and then passes through wire 35, interlock $p^2$, associated with the parallel switch P, through the actuating-coil of switch B, to ground. Accordingly switch B is closed and in closing establishes a shunt about the resistances and the resistance and series switches, so that the circuit between the two motors is through lead 37, switch B, and lead 38. Consequently switch S may be opened without affecting the motor-circuit, and this switch is caused to open by means of a valve *b*, which is operated upon the closing of the switch B to shut off communication between the actuating means of the switch S and pipe 28 and to connect said actuating means to atmosphere. The opening of the switch S interrupts the previous actuating and maintaining circuits which pass through the normally open contacts *s* and $s^2$, associated with the switch S; but a maintaining-circuit for the switch B is established through the lowermost auxiliary contacts $s^3$ of switch S, through auxiliary contacts *p'* of switch P, auxiliary contacts *b'* of switch B, thence through the actuating-coil of the switch B, to ground. Since the actuating and maintaining circuits for the resistance-switches have been broken, these switches are now all open, and by again opening switch B and closing parallel switches P P' the parallel connection of the motors with all resistance in circuit may be established. This is accomplished by reducing the pressure in train-pipe 2 to twenty-five pounds, so that piston of the accelerating-relay may again rise and prevent the resistance-switches from being automatically cut out again as soon as the parallel switches are closed and admitting air to train-pipe 1 at pressure of twenty-five pounds. The air in train-pipe 1 flows through branch pipe 5 into casing $18^a$ and by reason of the valve 25 being in its raised position, wherein it closes the port leading to pipe $19^a$ and opens the port leading to pipe 26, into pipe 26 and above the piston of relay 38. The piston is forced downwardly, bringing contact 39 into engagement with fixed contacts 40, and thereby establishing the actuating-circuit for the switch P P'. This actuating-circuit is as follows: from trolley to switch E, auxiliary contact *s'*, associated with switch S, contacts 39 and 40, through the actuating-coil of switch P and the actuating-coil of switch P', through wire 41, the lowermost auxiliary contacts $i^4$ of switches R to $R^4$, to ground. The closing of switch P interrupts the maintaining-circuit of switch B, and consequently this latter switch opens. Before the switch P closes, however, the valve *p* has been operated so as to place the actuating means of the switch S in communication with the atmosphere, preventing this switch from being again operated until the parallel switch is opened. Upon again raising the pressure in pipe 2 to forty pounds the relay 30 is actuated and an actuating-circuit for the resistance-contacts is established from auxiliary contacts $s^3$, through the upper auxiliary contact $p^3$ of the switch P, through wire 33, and thence following the circuit previously traced. The resistance-switches are again closed in automatic progression, as previously described, until finally the motors are connected across the line in parallel with each other and with none of the resistance in circuit.

The master-valves V V' may have any suitable construction, that shown in my previous application being, with slight modifications, adapted for operation as part of the present system. One of the valves is illustrated diagrammatically as consisting of a plug-valve *v*, for determining the order in which the train-pipes are to be energized, and a disk valve *v'*, provided with suitable reducing-valves for supplying the train-pipes with air at the proper pressures. In the position of the parts shown both train-pipes are connected to atmosphere through exhaust-ports 41 and 42, respectively. Upon turning the valve *v'* in a clockwise direction until port 43 registers with port 44, pipe 2 will receive air at twenty-five pounds pressure. Upon bringing port 45 into registration with port 44 pressure in pipe 2 will be increased to forty pounds. Upon bringing port 46 into registration with port 44 the pressure in pipe 2 will be decreased to twenty-five pounds. In the next position of the valve, port 47 registers with port 48, and train-pipe 1 receives

air at twenty-five pounds pressure. In the final position of the valve, port 49 registers with port 44 and pipe 2 is again supplied with air at forty pounds pressure. If the plug-valve *v* is turned so as to bring port 50 into registration with port 48 and port 51 into registration with port 44, the order in which the train-pipes are energized will be reversed. When the master-valves are in their off position, the entire pneumatic apparatus is exhausted and all the switches and contacts are open.

In Fig. 3 I have illustrated a satisfactory form of switch adapted for use as the bridging switch. The construction illustrated, inso far as the switch mechanism is concerned, is substantially the same as that disclosed in Patent No. 815,826, granted on March 20, 1906, on an application filed by George H. Hill. Briefly stated, the switch consists of a fixed contact 55 and a movable contact member 56 for coöperating with the fixed contact. 57 is an electromagnet whose plunger 58 is connected to the movable contact member and serves to close the switch when the electromagnet is energized. The movable member of the auxiliary switch *b'* is carried upon a rod 59, which is pivotally connected to one end of a lever 60. The lever 60 is pivoted to a fixed support at 61 and is connected to the plunger 58, at the end opposite to that carrying the auxiliary contact, by means of a hooked member 62, which engages a pin 63 on the lever. When the plunger rises, the lever 60 is oscillated and the auxiliary switch *b'* is closed. When the electromagnet is deenergized, the plunger drops, allowing the main switch to open, and the auxiliary switch *b'* also opens. The valve *b* consists of a casing 64, within which is arranged the valve proper, 65, carried upon the upper end of the rod 59. A port 66 in the valve 65 is adapted to connect the pipe 29 to the pipe 29' when the valve is raised; but when the valve is in its lower position communication between these pipes is shut off. The parts are so arranged that when the switch-operating electromagnet is energized and the main and auxiliary switches are closed the pipe 29 is closed at the valve; but when the electromagnet is deënergized and the switches are opened the valve is brought to the position wherein free communication is established between the pipes 29 and 29'.

In Fig. 4 I have illustrated one of the pneumatically-operated switches, which may consist of fixed and movable contacts 67 and 68, respectively, together with a piston 69, movable within the cylinder 70 and operatively connected to the movable contact member 68 through the piston-rod 71. A spring 72 may be inserted between the piston and the cylinder in order to open the switch quickly when pressure is removed. The piston is operated against the tension of the spring to close the switch by compressed fluid, which enters the cylinder at a point beneath the piston through the pipe 28.

Although I have described one form of the present invention in great detail, I do not desire to limit the present invention to the details illustrated and described, since in its broader aspects the present invention may be embodied in various forms, and in the appended claims I intend covering all such forms in addition to the particular form illustrated.

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

1. In a system of control, a motor-controller comprising a plurality of separately-actuated contacts, some of which are arranged to be actuated in automatic progression, a reversing-switch, operating means for said reversing-switch, a switch in the actuating-circuit of the contacts which are arranged to be actuated in automatic progression, and means for controlling said latter switch by said reversing-switch-operating means.

2. In a system of control, a motor-controller comprising electromagnetically-actuated contacts and pneumatically-actuated contacts, and means associated with one of said electromagnetically-actuated contacts for exhausting the pneumatic actuating means of one of said pneumatically-actuated contacts.

3. In a system of motor control, an electromagnetically-actuated contact, a pneumatically-actuated contact, and a valve associated with the first contact for controlling the latter contact.

4. In a system of motor control, a controller of the separately-actuated-contact type, pneumatic control apparatus therefor including two pipes, and a master-valve for admitting to said pipes fluid differing in degree of compression, the arrangement being such that the order in which said pipes are energized determines the direction of rotation of the motor, and the master-valve being constructed so as to supply to the second pipe to be energized fluid having the lowest degree of compression.

5. In a system of control, a series of individual contacts, means for actuating said contacts in automatic progression, a relay for controlling said actuating means, a reversing-switch, and means associated with said reversing-switch for controlling said relay.

6. In a system of motor control, a speed-controller, a reversing-switch, actuating means for said speed-controller, a relay for controlling said actuating means, and means associated with the reversing-switch for controlling the relay.

7. In a system of motor control, a speed-controller, electromagnetic actuating means therefor, a pneumatically-actuated reversing-switch, a pneumatically-actuated con-

trolling-switch for said electromagnetic actuating means, and a valve associated with said reversing-switch for admitting compressed fluid to the actuating means for said controlling-switch.

8. In a system of control, a controller including a series of electromagnetically-actuated contacts and a series of pneumatically-actuated contacts, a pneumatically-actuated reversing-switch, controlling-relays for said electromagnetically-actuated contacts, and valve mechanism controlled by the reverser-switch mechanism for admitting compressed fluid to the actuating means for said pneumatically-actuated contacts and to said relays.

9. In a system of motor control, a series contact, parallel contacts, and resistance-contacts, pneumatic actuating means for said series contact, electromagnetic actuating means for said parallel and resistance contacts, pneumatic relays for controlling said electromagnetic actuating means, and means for supplying compressed fluid to said controller.

10. In a system of motor control, a pneumatically-actuated series contact, parallel contacts, a bridging contact arranged to close a shunt about said series contact, and valve mechanism controlled by the movement of said bridging contact and one of said parallel contacts for exhausting the actuating means for said series contact.

11. In a system of motor control, a series of separately-actuated contacts, pneumatic actuating means therefor, a series of electromagnetically-actuated contacts arranged to close in automatic progression, and a valve operated by the closing movement of the last of said electromagnetically-actuated contacts for exhausting the actuating means for one of said pneumatically-actuated contacts.

12. In a system of control, a motor-controller comprising a series of electromagnetically-actuated contacts and a series of pneumatically-actuated contacts, a pneumatically-actuated reversing-switch, and means associated with said reversing-switch for controlling the actuating means for said contacts.

13. In combination, a circuit-breaker, a closing device therefor, means for tripping said circuit-breaker and rendering said closing device inoperative upon overload, and means for restoring the operative relation between the closing device and the circuit-breaker when the closing device is in an inoperative position.

14. In a system of control, a controlled circuit, a circuit-breaker in said circuit, a closing device for said circuit-breaker, a controller for determining the circuit connections, means associated with said controller for controlling said closing device, means for tripping said circuit-breaker and rendering said closing device inoperative upon overload, and means for restoring the operative relation between the closing device and the circuit-breaker only when the closing device is in a retracted position.

15. In a system of control, a controlled circuit, a circuit-breaker therein, a closing device for said circuit-breaker, a controller in said circuit, means for tripping said circuit-breaker and rendering said closing device inoperative upon overload, and means for restoring the operative relation between the closing device and the circuit-breaker only when the controller is in the "off" position.

16. In combination, a switch, a closing device therefor, means for tripping said switch independently of said closing device, and means for operatively connecting said closing device to said switch.

17. In combination, a switch, a closing device therefor normally inoperative to close the same, means for operatively connecting said closing device to said switch, and means for tripping said switch independently of said closing device.

18. In combination, a switch, a closing device therefor normally inoperative to close the same, and means for connecting said closing device and said switch in operative relation only when the closing device is in a retracted position.

19. In combination, a switch, a closing device therefor normally inoperative to close the same, normally deënergized means for connecting said switch and said closing device in operative relation to each other when the closing device is in a retracted position, and a manually-controlled member for connecting said means to a source of energy, said member being arranged to normally assume an inoperative position.

20. In a system of control, controller apparatus, a pneumatic controlling system therefor, a switch, a closing device for said switch arranged to be energized by the pneumatic system, the closing device being normally inoperative to close said switch, and means operative to connect said switch and closing device in operative relation only when said closing device is deënergized.

21. In a system of control, control apparatus, a master controlling device, a switch, a closing device for said switch normally inoperative to close the same, means controlled by said master controlling device for energizing said closing device when the master controlling device is in its operative position, and means operative to connect said switch and closing device in operative relation to each other only when said closing device is deënergized.

22. In a system of control, motor-control apparatus, a master controlling device, a circuit-breaker, a closing device for said circuit-breaker, means for connecting said

circuit-breaker in operative relation to said closing device only when the closing device is in a retracted position, means for energizing said closing device when the master control device is in an operative position, and means for breaking the operative connection between the circuit-breaker and the closing device upon overload.

23. In a system of train control, a motor-circuit upon each of a plurality of cars, a circuit-breaker in each of said circuits, circuit-breaker-closing means controlled from a single point, local controlling means, and means for tripping each circuit-breaker upon overload and rendering the closing means inoperative to again close the breaker until the local controlling means has been operated.

24. In a system of train control, a motor-circuit upon each of a plurality of cars, a circuit-breaker in each circuit, controlling means for said circuits including a master-controller, closing devices for said circuit-breakers controlled by said master-controller, means for tripping said circuit-breakers on local overloads and rendering said closing devices inoperative, and locally-operated controlling devices for rendering said closing devices operative to close said circuit-breakers.

25. In a system of train control, a motor-circuit upon each of a plurality of cars, circuit-breakers in said circuits, closing devices for said circuit-breakers, locally-operable controlling devices for rendering said closing devices operative to close said circuit-breakers, and means for controlling all of said closing devices from a single point upon the train.

26. In a system of train control, a motor-circuit upon each of a plurality of cars, circuit-breakers in said circuits, closing devices normally inoperative to close said circuit-breakers, controlling devices for placing said closing devices and said circuit-breakers in operative relation to each other, and means for tripping said controlling devices upon overload.

27. In a system of train control, a motor-circuit upon each of a plurality of cars, a circuit-breaker in each of said circuits, normally inoperative closing devices for said circuit-breakers, locally-controlled devices for rendering said closing devices operative to open and close the circuit-breakers, means for controlling said closing devices from a single point upon the train, and means for tripping said locally-controlled devices.

28. In a system of train control, a motor-circuit upon each of a plurality of cars, a circuit-breaker in each circuit, closing devices normally inoperative to close said circuit-breakers, locally-controlled devices operative to place said closing devices and said circuit-breakers in operative relation to each other when the closing devices are in a retracted position, means for tripping said locally-controlled devices upon overload, and means for controlling said closing devices from a single point.

29. In a system of train control, a motor-circuit upon each of a plurality of cars, a circuit-breaker in each of said circuits, a train system for controlling said circuits, closing devices for said circuit-breakers energized by said train system, means for tripping said circuit-breakers and rendering said closing devices inoperative upon overload, and local means for restoring the operative relation between the closing devices and the circuit-breakers only when the closing devices are deënergized.

In witness whereof I have hereunto set my hand this 14th day of April, 1905.

FRANK E. CASE.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.