No. 798,342.

PATENTED AUG. 29, 1905.

G. H. HILL.

SYSTEM OF MOTOR CONTROL.

APPLICATION FILED SEPT. 30, 1903.

2 SHEETS—SHEET 1.

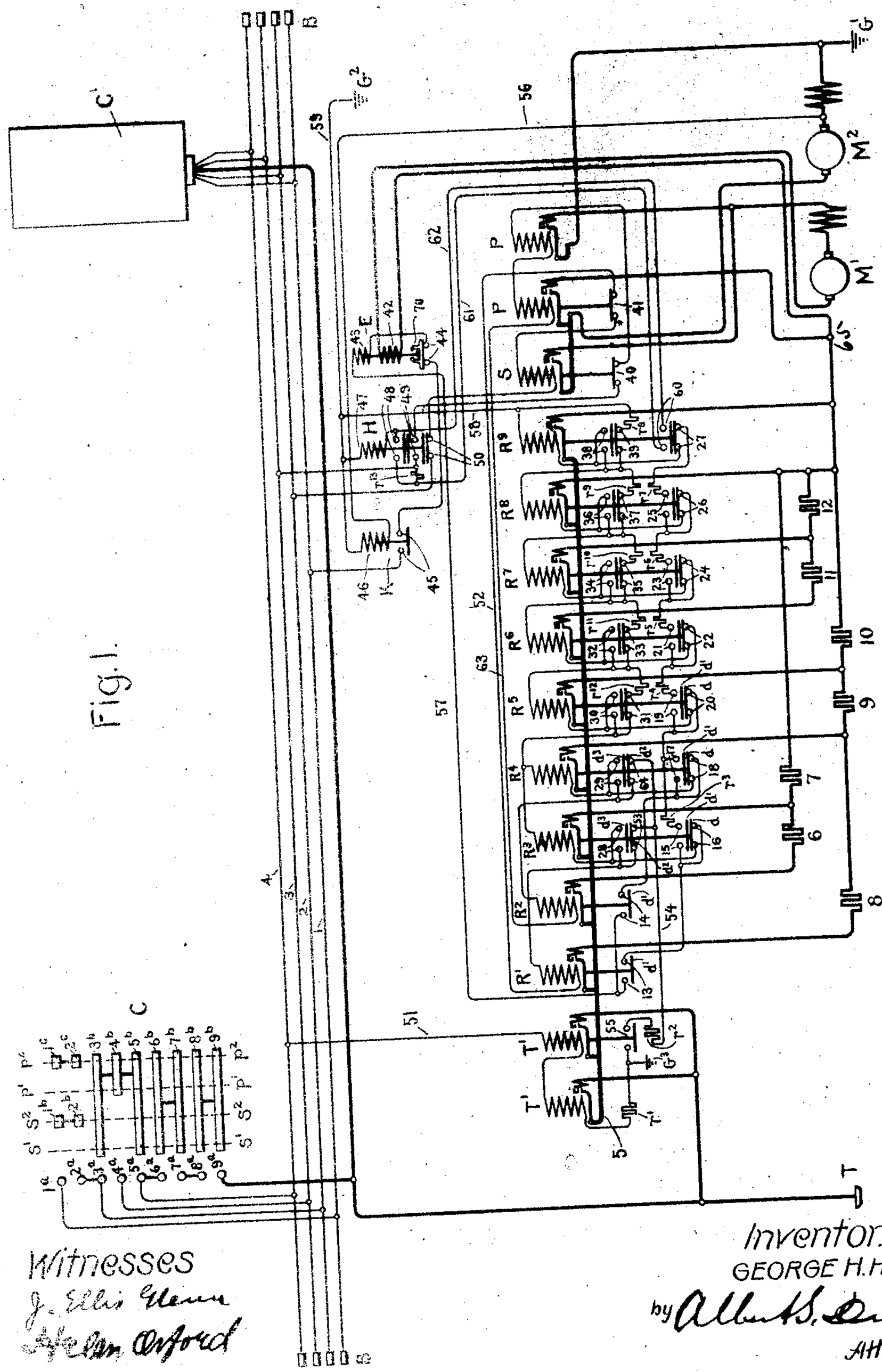

Fig. 1.

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2 SHEETS—SHEET 2.

Fig. 4.

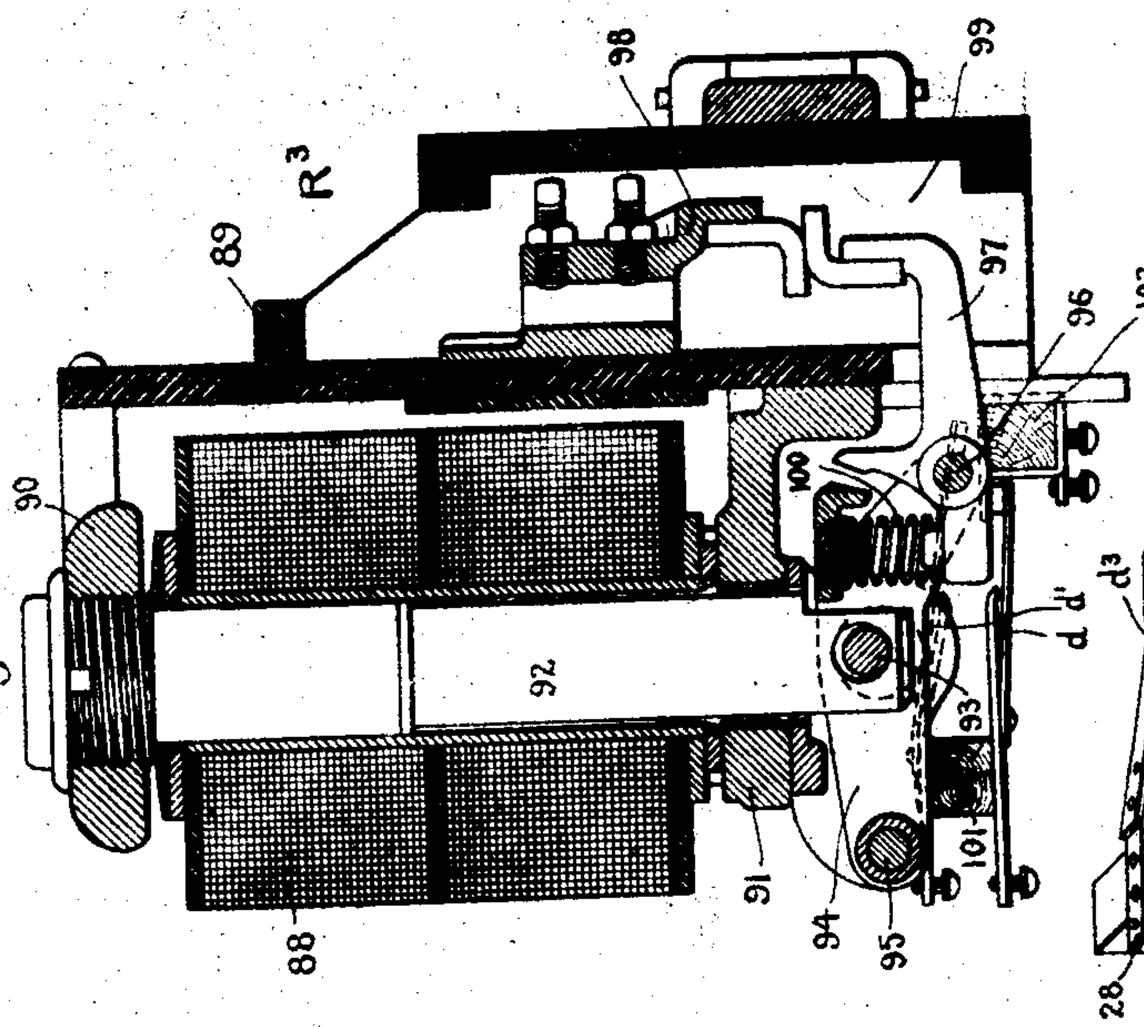


Fig. 5.

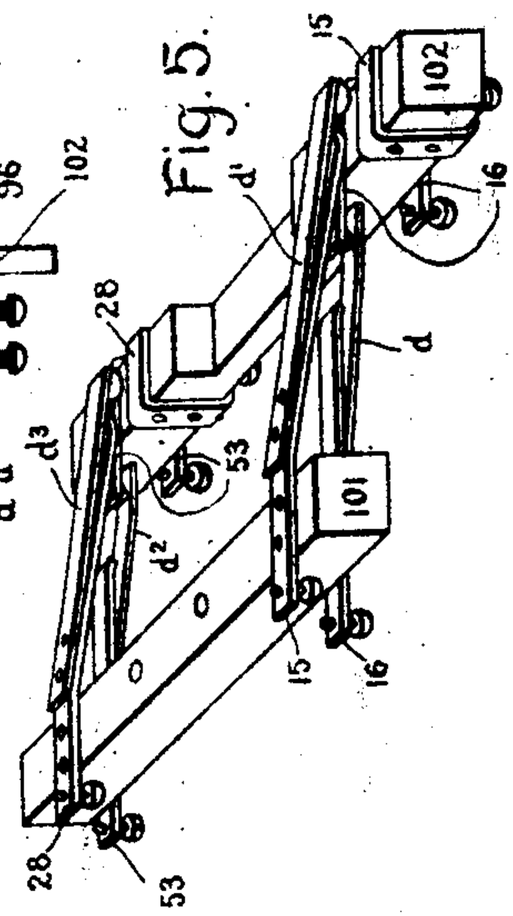


Fig. 2.

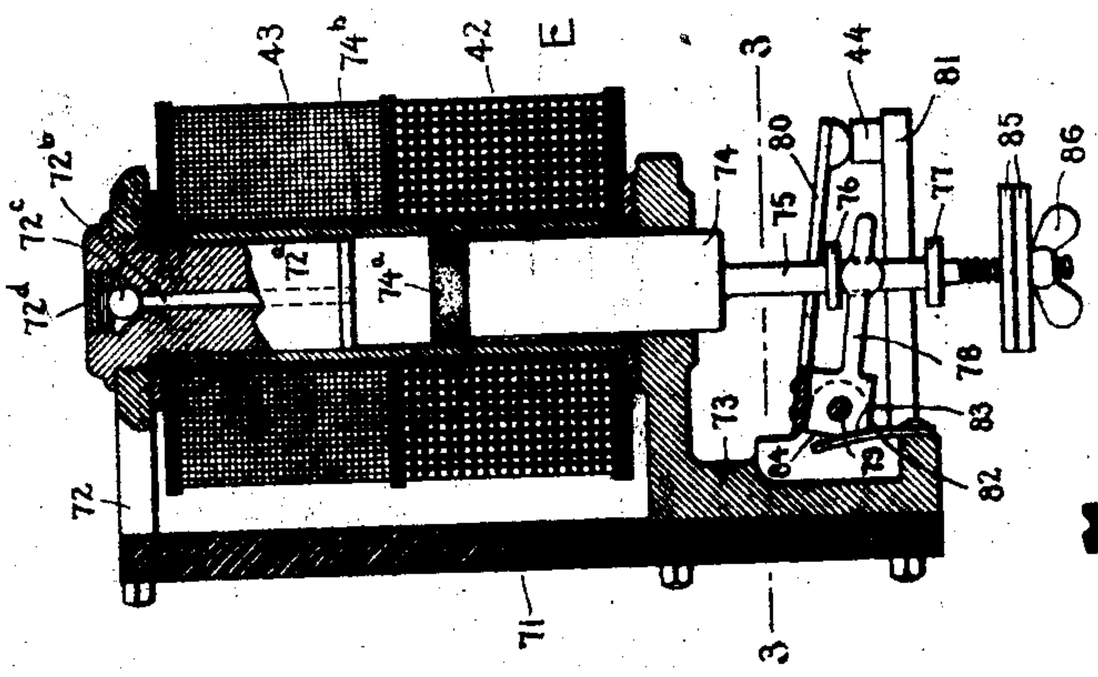
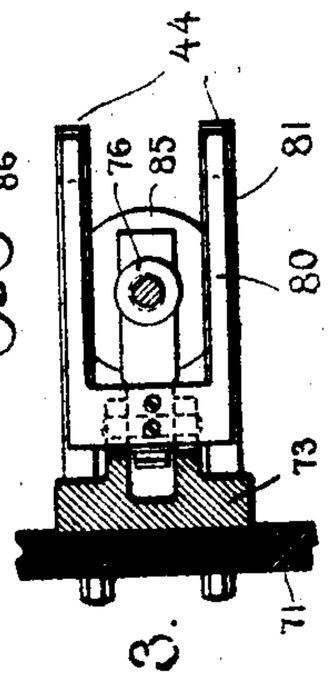


Fig. 3.



Witnesses.
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UNITED STATES PATENT OFFICE.

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SYSTEM OF MOTOR CONTROL.

No. 798,342. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed September 30, 1903. Serial No. 175,176.

To all whom it may concern:

Be it known that I, GEORGE H. HILL, 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 Systems of Motor Control, of which the following is a specification.

My invention relates to systems of control for electric motors, and more particularly to systems employing controllers of the separately-actuated-contact type in which the contacts are operated successively to produce an automatic acceleration of the motors through series or parallel or through series and parallel, and relates more specifically to the construction and arrangement of the devices used for controlling the successive operation of said contacts—that is, the devices which control the rate of acceleration of the motors.

My invention constitutes an improvement on the system shown and described in my application, Serial No. 113,067, filed June 25, 1902. In said application I have disclosed a system in which the motor-controller contacts are automatically operated in succession and in which the progression may be stopped at any desired point. Two circuits are provided for the actuating-coils of the motor-controller contacts, one an actuating-circuit and the other a maintaining-circuit, and the master controller-contacts are so arranged that the actuating-circuit may be opened and the progressive operation of the motor-controller contacts stopped without opening the maintaining-circuit, which operates to hold the contacts closed after they have been operated. Provision is thus made for checking the cutting out of resistance at any point by the movement of the master-switch and the motorman can operate at any speed he desires independently of the automatic progression. Furthermore, the automatic progression is checked by an automatically-actuated switch or relay whenever the current in the motor-circuit is too high, the progression continuing when the current in said motor-circuit falls below a predetermined value. In the system shown in said application arrangement is also made for insuring the progression of the controller-contacts first in series and then in multiple relation of the motors through the successive resistance steps until the resistance is all cut out and the motors are connected in parallel, even though the motorman throws the handle of the master-switch directly to its full multiple position. In another application, Serial No. 113,454, filed June 27, 1902, I have shown means for retarding the automatic successive operation of the contacts by producing a retarded step-by-step movement known as "notching up." This is accomplished in the preferred arrangement by means of a checking magnet or relay, which opens the actuating-circuit whenever a motor-controller contact is operated and maintains said actuating-circuit open until the circuit through the actuating-coil of said checking-relay is opened by means of an independent overload or underload relay connected in the motor-circuit.

According to my present invention I combine the checking-relay with the overload-relay, which is operated whenever the current in the motor-circuit rises above a predetermined value. This combined checking and overload relay is adapted to open the actuating-circuit, and thereby prevent further progression of the contacts and maintaining said actuating-circuit open until the current in the motor-circuit has fallen to a predetermined value. By combining the checking-relay and the overload-relay in a single structure I produce a notching-up device which is simpler and much more sensitive than two independent relays and one which requires less change in motor-current strength to operate it effectively. In connection with said combined checking and overload relay I prefer to employ an underload-relay, which is adapted to open the said actuating-circuit whenever the current in the motor-circuit falls below a predetermined amount.

My invention further comprises improvements in the construction and arrangement of the checking and overload relay, which is preferably provided with means whereby it may be adjusted to respond to any predetermined strength of current in the motor-circuit and may be set to operate between very narrow limits and also with means for retarding the movements of the relay.

My invention further consists of improvements in the multiple controlling switch or relay and the controlling devices therefor, which will be hereinafter described, and specifically stated in the appended claims.

In the accompanying drawings, Figure 1 illustrates diagrammatically as much of the equipment of a single car in a train-control system as is necessary to illustrate my invention. Fig. 2 is a sectional elevation of the preferred form of my improved combined checking and overload relay. Fig. 3 is a sectional plan view of the relay, taken on line 3 3, Fig. 2. Fig. 4 is a sectional elevation of a motor-controller contact equipped with auxiliary switches, and Fig. 5 is a perspective view of the auxiliary switches and the mounting therefor.

Referring now to Fig. 1, the separately-actuated contacts of the motor-controller, which control the operation of the motors M′ and M², are indicated by T′, T², R′ to R⁹, inclusive, S, and P P. The contacts T′ T′ are known as the "line-contacts" and control the connection between the trolley or collector shoe T and the conductor 5. The frame on which the contacts are mounted is constructed of conducting material and may form the conductor 5, if so desired. The contacts R′ to R⁹, inclusive, control the connections between said conductor 5 and the motors and regulate the amount of resistance connected in the motor-circuit and will hereinafter be known as "resistance-controlling" contacts. The contacts R³ to R⁹, inclusive, will also be known as "resistance-varying" contacts. The resistance-sections which are adapted to be connected in the motor-circuit are represented by 6 to 12, inclusive, and are combined to vary the motor-circuit resistance in a manner to be hereinafter described. The contacts S and P P control, respectively, the series and parallel connections for the motors M′ and M². The actuating-coils of the controller-contacts are connected to the train-wires 1 to 4, inclusive, through the automatic actuating mechanism to be hereinafter described. The master-controllers C and C′, located at any desired points on the car or train, are also connected with the train-wires 1 to 4, inclusive, which are connected to corresponding train-wires in the other cars of the train by means of the couplers B. One of the master controlling-switches C is shown in development in a manner customarily used in illustrating such a structure and comprises contact-fingers 1^a to 9^a, inclusive, and the contact-segments 1^b, 2^b, 1^c, 2^c, and 3^b to 9^b, inclusive, carried by the movable member of said switch. The series positions of said master controlling-switch are represented by the dotted lines s' s' and s^2 s^2, and the parallel positions are represented by p' p' and p^2 p^2. The actuating-coils of the contacts of the motor-controller are adapted to be connected in an actuating-circuit, and then as the said contacts are successively operated the coils are shifted over into a maintaining-circuit, while the actuating-circuit is completed through the actuating-coil of the next contact in advance. This is accomplished by means of auxiliary switches operatively connected to the controller-contacts. The actuating-circuit operates in part through the auxiliary contacts 13 to 27, inclusive, which are controlled by the auxiliary switch members d and d', carried by the contacts R′ to R⁹, inclusive. After said actuating-coils have operated their respective contacts they are connected in the maintaining-circuit which operates in part through the auxiliary contacts 28 to 39, inclusive, controlled by the auxiliary switch members d^2 and d^3, carried by the contacts R³ to R⁹, inclusive. Certain of said auxiliary contacts are included in both of said circuits during certain parts of the automatic progression of the contacts. The auxiliary switch 40, operatively connected with the contact S, is located in the circuit which includes the actuating-coils of the parallel contact P P and prevents the closing of said parallel circuit while the contact S is operated. The auxiliary switch 41, operatively connected with one of the contacts P, is connected in the circuit which includes the actuating-coil of the series contact S and prevents the operation of said contact S whenever the parallel contacts are operated. The auxiliary contacts 53 and 64, controlled by the auxiliary switch members d^2 on the motor-controller contacts R³ and R⁴, respectively coöperate with the auxiliary switch 55, carried by one of the line-contacts T′ to prevent the completion of the motor-circuit in series and in parallel unless the line-switch is closed and the motors are properly protected by resistance—that is, unless the first resistance-varying contact is open. The resistance r' is used for the purpose of cutting down the current flowing through the actuating-coils of the line-contacts T′ T′. The resistances r^8 to r^{13}, inclusive, are adapted to be inserted in their respective control-circuits to compensate for the resistance of the actuating-coils, so as to maintain an approximately constant current strength in the controlling-circuits throughout the progressive operation of the controller-contacts. The resistance r^2 is larger than the remaining resistance-sections, since it compensates for a greater number of actuating-coils. The combined checking and overload relay is represented by E, the actuating-coil of said relay being connected in the actuating-circuit in series with the contacts 44 of said relay. The actuating-coil 43 is adapted to open the actuating-circuit, and consequently its own circuit, at the contacts 44 whenever the said coil is energized. The overload or maintaining coil 42 of said relay E is connected in the motor-circuit in series with the motors. The relay E is provided with a lost-motion device, (indicated diagrammatically at 70, Fig. 1, but shown more clearly in Fig. 2,) which allows the core to move a considerable distance into the coil 43 before the circuit through said coil is broken at the contacts 44.

The lost-motion device allows the actuating-circuit to be energized for an appreciable length of time before it is opened, and thus allows sufficient time for one of the controller-contacts to be operated. The actuating-coil 46 of the underload-relay K is connected in the motor-circuit in shunt to the field of the motor M^2 and is adapted to open the said actuating-circuit at the contacts 45 whenever the current in the motor-circuit falls below a predetermined value. The multiple controlling-relay which controls the operation of the series and multiple contacts of the motor-controller is represented by H, and its actuating-coil 47, the energization of which is controlled by the motor-controller contact R^9 through the auxiliary contacts 60, controls the contacts 48, 49, and 50, which are connected in the multiple and series control-circuits in a manner to be hereinafter described.

In Figs. 2 and 3 I have shown a sectional elevation and sectional plan, respectively, of the preferred form of my improved combined checking and overload relay. The actuating-coil 43 and the overload or retaining coil 42 are supported on the panel 71 by means of the brackets 72 and 73. The movable core 74 of said relay operates through an opening in the bracket 73 and has formed on its lower end an extension 75, which carries the two collars or shoulders 76 and 77. Said collars are adapted to engage the arm 78, through which the extension 75 passes, said arm being pivoted to the bracket 73 at 79. The arm 78 carries the U-shaped contact-fingers 80, which are adapted to engage the contacts 44, mounted on the insulating bars or supports 81. The spring 82 is adapted to engage the respective faces 83 and 84 so as to maintain the arm 78 and contact-fingers 80 in either their closed or open position when moved into said position by the engagement of the collars 76 and 77, respectively, with the outer end of the arm 78. The said spring also serves to produce a snap action of the contact-fingers 80 in opening and closing the switch. The lower end of the extension 75 is screw-threaded, and weights 85 are held in position on said extension by means of the thumb-nut 86. These weights are for the purpose of adjusting the relay so that it will respond to different current strengths in the motor-circuit and also to retard the upward movement of the relay plunger or core to a slight extent. Other means, such as adjustable springs, may, if desired, be used in place of the weights 85. Means are also provided for producing a slow downward movement of the core 74. Surrounding the upper end of the movable core 74 is a bushing of graphite or other self-lubricating material 74^a, which fits snugly the tube or cylinder 74^b. This may be made in the form of a disk of slightly-larger diameter than the core 74 and mounted on the upper end of said core. An opening 72^b is formed through the fixed core 72^a, and at the upper end of this opening is formed a valve-seat on which rests a ball-valve 72^c, with means, such as an adjustable cross-bar 72^d, for limiting the movement of said ball-valve from its seat. A dash-pot action is thus produced by the movement of the core 74^b, allowing said core to move upward freely, since the valve 72^c is forced from its seat during such upward movement, but retarding the downward movement of said core. This retarding action gives the desired time interval between the time the coil 43 is deënergized by the opening of its circuit at the contacts 44 and the time the coil 42 is sufficiently energized to hold the relay open. It also serves to prevent two motor-controller contacts from being operated in rapid succession in case the overload-coil 42 fails to operate.

Referring now to Figs. 4 and 5; in which I have illustrated one form of motor-controller contact equipped with auxiliary switches, the actuating-coil is indicated by 88 and is held rigidly in place on the frame 89 by means of the brackets 90 and 91. For the sake of uniformity in the designation of corresponding parts of the motor-controller contact and auxiliary switches I will consider that the contact shown in Figs. 4 and 5 is the same as that indicated by R^3 in the diagram in Fig. 1. The core 92 of the said motor-controller contact is pivotally attached at 93 to the lever-arm 94, pivoted at 95 on the bracket 91. The outer end of the pivoted arm 94 has pivotally attached thereto at 96 a contact-arm 97, which is adapted to engage with the fixed contact 98, contained within the blow-out chute 99. The contact-arm 97 is maintained in such a position relative to the pivoted arm 94 that it will yield against the action of the spring 100 when said contact-arm engages the fixed contact 98. Carried by the pivoted arm 94 is an insulating-block 101, which has mounted thereon spring contact-fingers d, d', d^2, and d^3, the fixed ends of which are respectively connected with the contact-terminals 16, 15, 53, and 28, respectively, on said block 101 and the free ends of which are adapted to engage the contacts 16, 15, 53, and 28, respectively, mounted on the insulating-block 102, carried by the bracket 91. The said spring-pressed fingers d d' d^2 d^3 are so arranged that when the actuating-coil 88 of the contact is energized so as to raise the core 92 the contact-fingers d and d^2 engage the contacts 16 and 53 on block 102, respectively, before the contact-fingers d' and d^3 leave the contacts 15 and 28 on block 102, respectively, the last-mentioned contact fingers being in engagement with their respective contacts 15 and 28 when the coil 88 is deenergized, but moved out of engagement with said contacts when the said coil is energized.

The operation of my improved system of motor control is as follows: When the master controlling-switch C is moved into its first operative position, (indicated by s' s',) a control-

circuit is completed from the trolley or collector shoe T through the contact-finger 9^a, contact-segments 9^b and 8^b, contact-fingers 8^a and 7^a, contact-segments 7^b and 6^b, contact-fingers 6^a and 5^a, train-wire 4, conductor 51, actuating-coils of the contacts T' T', resistance r', to ground at G^3. A second control-circuit is completed from the contact-finger 5^a through the contact-segments 5^b, 4^b, and 3^b, contact-finger 3^a, train-wire 2, contacts 50, actuating-coil of the contact S, auxiliary switch 41, conductor 52, actuating-coil of the contact R', contacts 53, controlled by the motor-controller contact R^3, conductor 54, resistance r^2, contacts 55, controlled by one of the contacts T', to ground at G^3. It will thus be seen that the line-contacts T' T' are closed, and immediately afterward the contact R' and the series contact S are closed to complete a circuit through the motors, as follows: from the trolley or collector shoe T through the contacts T' T' in parallel, conductor or frame 5, contact R', resistance-sections 8, 9, and 10, maintaining-coil 42 of the relay E, motor M', contact S, motor M^2, to ground at G'. A circuit is also completed in shunt to the field of the motor M^2 through the conductor 56, the actuating-coil 46 of the underload-relay K to ground at G^2, thereby closing said underload-relay. The circuits remain as just described until the master controlling-switch C is moved into its second series position (indicated by s^2 s^2.) In said second position an additional control-circuit—viz., the actuating-circuit for the resistance-varying contacts of the motor-controller—is completed from the contact-finger 3^a through contact-finger 2^a, contact-segments 2^b and 1^b, contact-finger 1^a, train-wire 1, contacts 45 of the underload-relay K, contacts 44 of the relay E, actuating-coil 43 of said relay, conductor 57, contacts 13, controlled by the contact R', contacts 16, controlled by the contact R^3, through the actuating-coil of said contact R^3, thence through the contacts 31, resistance r^{12}, contacts 33, resistance r^{11}, contacts 35, resistance r^{10}, contacts 37, resistance r^9, contacts 39, resistance r^8, conductors 58 and 59 to ground at G^2, thereby operating the contact R^3 of the motor-controller. The closing of the contact R^3 causes said actuating-circuit to be broken at the contacts 16, thus cutting the coil of contact R^3 out of the actuating-circuit. The actuating-coil of the contact R^5 is at the same time connected in the actuating-circuit as follows: through the contacts 15, resistance r^3, contacts 20, actuating-coil of the contact R^5, contacts 33, resistance r^{11}, &c., to ground at G^2, as before described. Simultaneously with the energization of the actuating-coil of the contact R^3 the actuating-coil 43 of the relay E is energized, but, due to the lost-motion device 70, the actuating-circuit in which both said coils are connected is not broken until the coil of contact R^3 has had time to operate contact R^3 and the auxiliary switches attached thereto; but the relay E operates sufficiently rapid to open the actuating-circuit to prevent the contact R^5 from operating. The operation of the contact R^3 also opens at the contacts 53 the maintaining-circuit which was before traced from the conductor 52 through the actuating-coil of the contact R', through the contacts 53, operated by the contact R^3, to ground at G^3 and immediately thereafter cuts its own actuating-coil into the maintaining-circuit, which is completed as follows: from conductor 52, through the actuating-coil of the contact R', the contacts 28, the actuating-coil of the contact R^3, thence through the contacts 31, resistance r^{12}, &c., to ground at G^2, as before traced, or provided the contact R^5 has been operated by the completion of the actuating-circuit at the contacts 44 of relay E then through the contacts 30, actuating-coil of the contact R^5, contacts 33, resistance r^{11} to ground at G^2, as before described. The auxiliary switches are so arranged, as shown in Figs. 4 and 5, that the contact-fingers d' and d^3 engage the contacts 15 and 28, respectively, before the contact-fingers d and d^2 leave the contacts 16 and 53, respectively. The relay E is maintained in such a position as to hold the actuating-circuit open and prevent the automatic progression of the controller-contacts so long as there is an excess of current flowing through the maintaining-coil 42 of said relay, which may be set to respond to different current values by adjusting the number of weights 85 that are added to the core extension 75, Fig. 2. The relay is also retarded in its downward movement by the dash-pot mechanism above described. After the contact R^5 is operated by the closing of the relay E the relay is again opened and is maintained in its open position until the current again falls to the desired amount in the motor-circuit. At this time the said relay closes again and allows the next successive contact R^6 of the motor-controller to operate, the relay opening immediately thereafter, thus again breaking the actuating-circuit and checking temporarily further progression of said contacts. Therefore the contacts, including the contacts R^7, R^8, and R^9, are operated successively and automatically in a step-by-step manner. This process is called "notching up," and the rate of acceleration of the motors may be varied by varying the number of weights 85 and adjusting the dash-pot valve, thereby varying the rapidity with which the relay E will operate to produce the successive notching-up steps. Simultaneously with the operation of the last contact of the motor-controller—namely, the contact R^9—the contacts 60 are bridged across by the auxiliary switch member d'', carried by said contact R^9, in such a manner as to allow the actuating-coil 47 of the multiple controlling-relay H to be actuated when the master controlling-switch is moved

into its next operative position—namely, the multiple position. However, the relay H cannot be operated until the master-controller is moved into its multiple position. When the master controlling-switch C is moved into its first multiple position, (indicated by P' P',) the control-circuit through the actuating-coils of the line-contacts T' T' is maintained as before. Instead of breaking the maintaining-circuit, which passes through the actuating-coils of the controller-contacts, including the actuating-coils of the contact R' and the series contact S at the master controlling-switch, it is broken at the contacts 50 of the multiple controlling-relay H, thereby reducing arcing at the master controlling-switch. The multiple controlling-relay H is operated by the energization of a circuit which is completed as follows: from the contact-finger 5^a through contact-segments 5^b and 4^b, contact-finger 4^a, train-wire 3, resistance r^{13}, conductor 61, contacts 60, conductor 62, actuating-coil 47 of said relay H, conductor 59 to ground at G^2. The said relay H breaks the series control-circuit at 50 and completes the parallel control-circuit at the contacts 49. The latter circuit may be traced as follows: from the train-wire 3, through the contacts 49, auxiliary switch 40, controlled by the series contacts, actuating-coils of the parallel contacts P P, conductor 63, actuating-coil of the contact R^2, contacts 64, controlled by the actuating-coil of the contact R^4, through conductor 54, resistance r^2, contacts 55 to ground at G^3. The parallel contacts P P and the contact R^2 are thereby operated and the motors are connected in parallel, the circuits through said motors being as follows: from the trolley or collector shoe T through the contacts T' T' in parallel to conductor 5, thence through contact R^2, resistance-sections 6 and 7, maintaining-coil 42 of the relay E, motor M', one of the parallel contacts P to ground at G', also from the connection 65 through the other contact P and motor M^2 to ground at G'. The multiple controlling-relay H is maintained by the coil 47 in the position into which it is moved when the master-switch C is moved into its parallel position. The circuit through said coil is maintained through the contacts 48 after being broken at the contacts 60 by the opening of controller-contact R^9. The current for said maintaining-circuit flows from the train-wire 3, through the resistance r^{13}, contacts 48, actuating-coil 47, conductor 59, to ground at G^2. When the master controlling-switch C is moved into its final parallel position, (indicated by p^2 p^2,) the circuits as just described will be maintained and in addition an actuating control-circuit will be completed from the contact-finger 3^a, through contact-finger 2^a, contact-segments 2^c and 1^c, contact-finger 1^a, train-wire 1, contacts 45 of the underload-relay K, contacts 44 of the relay E, actuating-coil 43 of said relay, conductor 57, contacts 14, controlled by contact R^2, contacts 18, controlled by contact R^1, through the actuating-coil of said contact R^4, through contacts 31, resistance r^{12}, contacts 33, resistance r^{11}, contacts 35, resistance r^{10}, contacts 37, resistance r^9, contacts 39, resistance r^8, conductors 58 and 59, to ground at G^2. The contact R^1 is therefore operated, thereby opening at the contacts 64 the maintaining-circuit through said contacts and the contacts 55 and at the same time completing the maintaining-circuit through the contacts 29, contacts 31, resistance r^{12}, &c., to ground at G^2, as before described, so as to include the actuating-coil of the controller-contact R^4 in the maintaining-circuit. The actuating-circuit is opened at the contacts 18, but is simultaneously closed at the contacts 17, so as to cut the actuating-coil of R^4 out of and insert the actuating-coil of R^5 in the actuating-circuit. The successive operation of the contacts R^5, R^6, R^7, R^8, and R^9 is as has been heretofore described, the actuating-circuit being subject to the operation of the relay E as during acceleration in series. The above complete cycle of operations, first in series, then in parallel, will always take place even though the master-switch is moved directly from its off position into its full-multiple position. If the motorman should throw the handle of the controlling-switch into full-multiple position p^2 p^2 without pausing at the series position s^2 s^2, the multiple controlling-relay H would be operated automatically when the last contact of the motor-controller—namely, the short-circuiting contact R^9—is operated. The cycle of operations automatically performed in such case is first to close the line-contacts, then to put the motors in series relation, successively operate the resistance-varying contacts of the controller to reduce the resistance in the motor-circuit, then to energize the multiple governing-relay H so as to interrupt the maintaining-circuit, thereby allowing all the contacts except the line-contacts to assume their initial position and open-circuit the motors, also to actuate the parallel contacts, and thus place the motors in multiple relation in circuit with the resistance, then to operate the parallel resistance-varying contacts successively to cut out the resistance from the motor-circuit, and finally connect the motors in parallel with all the resistance cut out. The entire cycle is subject to the automatic control of the combined checking and overload relay E which interrupts the actuating-circuit immediately after said circuit is completed and maintains said actuating-circuit interrupted until the current in the motor-circuit falls below a certain predetermined limit.

By constructing the checking and overload relay as before described I am enabled to produce a very efficient and sensitive device which is positive in its action and may be adjusted to retard the acceleration of the mo-

tors to any desired degree. It will be seen that the said relay combines the function of two independent relays and is much more sensitive than two independent relays, because it is merely necessary for the current in the motor-circuit to increase in strength sufficient to maintain the relay in its open position and does not require said current to increase to such a strength as would be necessary to operate the relay from its closed position. The relay is opened by the energization of the actuating-coil 43, which itself is in the actuating-circuit and operates to open its own circuit.

The controller-contacts R^8 and R^9, which both act to short-circuit the motor-circuit resistance, are operated in succession instead of simultaneously for the purpose of allowing the motors to reach a speed corresponding to the final series position during the automatic acceleration through series and parallel before the relay H operates to connect the motors in parallel.

The underload-relay K acts to open the actuating-circuit whenever the current in the motor-circuit falls below a predetermined amount or there is an entire loss of voltage. Its main function is to prevent the rapid progression of the controller-contacts on a car of the train other than the car upon which the master-controller is being operated in case the motor-circuit on that car should become broken or interrupted by the jumping of the controller-shoe or the loss of current due to the shoe striking some insulating material on the power-conductor. Suppose the car illustrated in Fig. 1 is the second car of a train and the master-controllers on that car are in their "off" position and the master-controller on the first car is in such a position as to energize the train-wire 1, then if the motor-circuit on the second car becomes interrupted and no underload-relay, such as K, is provided the current from the first car will pass to the second car through train-wire 1 and energize the actuating-circuit of the second car, and the relay E will open and close as rapidly as the dash-pot will permit it, since the coil 42 is inoperative. The controller-contacts will therefore operate in relatively rapid succession, so that when the motor-circuit on the second car is again completed the said car will tend to move much more rapidly than the first or other cars on the train. This condition is very undesirable and dangerous and is entirely avoided by the use of relay K.

I aim to cover in the claims hereto appended all modifications and alterations which do not involve a departure from the spirit and scope of my invention.

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

1. In a motor-control system, the combination of a plurality of actuating-coils controlling the contacts in the motor-circuit, actuating and maintaining circuits for the actuating-coils, a master-switch for connecting and disconnecting said circuits and a source of supply of current, means adapted to include the actuating-coils in one of said circuits and to shift each coil when it has operated its contact to the other circuit, and an automatic switch actuated by the current in the actuating-circuit and maintained in its actuated position by means of the current in the motor-circuit, said automatic switch being adapted to interrupt the actuating-circuit.

2. In a motor-control system, the combination of a number of actuating-coils controlling the contacts in the motor-circuit, actuating and maintaining circuits for these contacts, and an automatic switch for interrupting the actuating-circuit actuated by the current flowing through said actuating-circuit and maintained in its actuated position by the current in the motor-circuit.

3. In a motor-control system, the combination of a plurality of actuating-coils controlling the contacts in the motor-circuit, actuating and maintaining circuits for the actuating-coils, means adapted to include the actuating-coils in one of said circuits and to shift each actuating-coil when it has operated its contact to the other circuit, and an automatic switch for interrupting the actuating-circuit actuated by the current in said actuating-circuit and maintained in its actuated position by the current in the motor-circuit.

4. In a motor-control system, the combination of a plurality of actuating-coils controlling contacts in the motor-circuit, actuating and maintaining circuits for these actuating-coils, means adapted to include the actuating-coils in one of said circuits and to shift each coil when it has operated its contact to the other circuit, and a combined checking and overload automatically-actuated relay operated by the current flowing through the actuating-circuit to open said actuating-circuit, and maintained in its operated position by the current flowing through the motor-circuit until the strength of the current in the motor-circuit falls below a predetermined amount.

5. In a motor-control system, a motor-controller of the separately-actuated contact type, an actuating-circuit and a maintaining-circuit for the contacts of said controller, a relay actuated by the current in the actuating-circuit and adapted to open said actuating-circuit and to be maintained in its open position by current in the motor-circuit, and an underload relay adapted to open said actuating-circuit when the current in the motor-circuit falls below a predetermined amount.

6. In a motor-control system, the combination of a plurality of actuating-coils controlling the contacts in the motor-circuit, a master-switch, a plurality of circuits from the master-switch to the actuating-coils, part of

said circuits being arranged to successively actuate said contacts, the other part of said circuits being arranged to maintain said contacts after being actuated, and an automatic switch actuated by the current in said actuating-circuit to open said actuating-circuit, and means operatively connected to said automatic switch and operated by the current in the motor-circuit for maintaining said automatic switch open until the current in the motor-circuit falls below a predetermined amount.

7. In a motor-control system, the combination with a plurality of successively-operating contacts, of actuating-coils for said contacts, a multiple controlling-relay, an actuating-coil for said relay, means actuated with one of said contacts arranged to control the circuit through the actuating-coil of said multiple controlling-relay, and a master controlling-switch adapted to complete the circuit through the actuating-coil of said multiple controlling-relay after the contact controlling said relay has been operated.

8. In a motor-control system, the combination with a plurality of successively-operating contacts, of actuating-coils for said contacts, a multiple controlling-relay, an actuating-coil for said relay, a master controlling-switch having contacts in its multiple position or positions for controlling said relay-actuating coil, and means actuated with one of said successively-operating contacts adapted to coact with the contacts of said master controlling-switch to prevent the operation of said multiple controlling-relay until the master controlling-switch is moved into one of its multiple positions.

9. In an automatically-accelerating motor-control system employing a motor-controller of the separately-actuated contact type, an actuating-circuit, and an electromagnetic switch for opening said actuating-circuit to check the automatic progression of the contacts of the motor-controller, the contacts of said electromagnetic switch being connected in said actuating-circuit in series with its own actuating-coil, whereby when the electromagnetic switch is operated the circuit through its actuating-coil is broken.

10. In an automatically-accelerating motor-control system employing a motor-controller of the separately-actuated contact type, an actuating-circuit, an electromagnetic switch for opening said actuating-circuit to check the automatic progression of the contacts of the motor-controller, the contacts of said switch being connected in said actuating-circuit in series with its own actuating-coil whereby when said switch is operated the circuit through its actuating-coil is broken, and an overload-coil connected in the motor-circuit adapted to maintain said switch in its open position after its actuating-coil has been deënergized provided the current in the motor-circuit is at or above a predetermined maximum and to allow the said switch to close when the current in the motor-circuit falls below the predetermined maximum.

11. In an automatically-accelerating motor-control system employing a motor-controller of the separately-actuated contact type, an actuating-circuit, an electromagnetic switch for opening said actuating-circuit to check the automatic progression of the contacts of the motor-controller, the actuating-coil of said switch being connected in said actuating-circuit in series with the contacts of the switch whereby when said switch is operated the circuit through its actuating-coil is broken, an overload-coil connected in the motor-circuit and adapted to maintain said switch in its open position after its actuating-coil has been deënergized provided the current in the motor-circuit is at or above a predetermined maximum, and an underload-relay adapted to open said actuating-circuit when the current in the motor-circuit drops below a predetermined maximum.

12. In a system of electric control, the combination with a motor-circuit and means for varying the resistance in said motor-circuit, of a relay comprising a coil, a core, contacts connected by a lost-motion device with said core, and contact-terminals with which said contacts engage, said contact-terminals being in circuit with the actuating-coil of said relay, the whole being constructed and arranged so that when the coil is energized the core moves a predetermined distance before breaking the circuit through said coil.

13. In a system of electric control, the combination with a motor and means for varying the resistance in said motor-circuit, of a relay comprising a coil, a core, contacts connected by a lost-motion device with said core, and contact-terminals with which said contacts engage, said contact-terminals being in circuit with the actuating-coil of said relay, means for causing said contacts to open and close with a snap action, the whole being constructed and arranged so that when the coil is energized the core moves a predetermined distance before breaking the circuit through said coil.

14. In a system of electric control, the combination with a motor-circuit and means for varying the resistance in said motor-circuit, of a relay comprising a coil, a core, contacts connected by a lost-motion device with said core, contact-terminals with which said contacts engage, said contact-terminals being in circuit with the actuating-coil of said relay, the whole being constructed and arranged so that when the coil is energized the core moves a predetermined distance before breaking the circuit through said coil, and means independent of the actuating-coil for maintaining said contacts in their open position after said actuating-coil has been deënergized.

15. In a system of electric control, the combination with a motor-circuit and means for varying the resistance in said motor-circuit, of a relay comprising a coil, a core, contacts connected by a lost-motion device with said core, contact-terminals with which said contacts engage, said contact-terminals being in circuit with the actuating-coil of said relay, the whole being constructed and arranged so that when the coil is energized the core moves a predetermined distance before breaking the circuit through said coil, and a magnet-coil connected in the motor-circuit adapted to maintain said contacts in their open position after said actuating-coil has been deënergized whenever an excess of current flows through said motor-circuit.

16. A relay comprising an actuating-coil, movable contacts operated by said actuating-coil, contacts in circuit with the said actuating-coil engaged by said movable contacts, and means for allowing a free opening movement but retarding the closing movement of said movable contacts.

17. A relay comprising an actuating-coil, movable contacts operated by said actuating-coil, contacts in circuit with the said actuating-coil engaged by said movable contacts, and a dash-pot for allowing a free opening movement but retarding the closing movement of said movable contacts.

18. A relay comprising an actuating-coil, movable contacts operated by said actuating-coil, contacts in circuit with the said actuating-coil engaged by said movable contacts, a dash-pot for allowing a free opening movement but retarding the closing movement of said movable contacts, and an independent coil for holding said contacts open.

19. A relay comprising an actuating-coil, a core, movable contacts connected with said core and operated by said actuating-coil, contacts in circuit with the said actuating-coil engaged by said movable contacts, and means for allowing a free opening movement but retarding the closing movement of said core, said means comprising a dash-pot the cylinder of which is surrounded by the actuating-coil and the plunger of which is operatively related to the core, and an adjustable valve in said cylinder.

20. A relay comprising an actuating-coil, a core, movable contacts connected with said core and operated by said actuating-coil, contacts in circuit with the said actuating-coil with which said movable contacts engage, and means for allowing a free opening movement but retarding the closing movement of said core, said means comprising a dash-pot which is formed of the cylinder on which the coil is mounted and a plunger attached to said core, said plunger being provided with a graphite bushing.

21. A relay comprising an actuating-coil, a cylinder on which said coil is mounted, movable contacts operated by said actuating-coil, contacts with which said movable contacts engage, a core forming the plunger of a dash-pot and operating within said cylinder, and an adjustable valve in said dash-pot cylinder which allows a free opening movement but acts to retard the closing movement of said contacts.

22. A relay comprising an actuating-coil, a cylinder on which said coil is mounted, movable contacts operated by said actuating-coil, contacts with which said movable contacts engage, a core forming the plunger of a dash-pot and operating within said cylinder, an adjustable valve in said dash-pot cylinder which allows a free opening movement but acts to retard the closing movement of said contacts, and means whereby said movable contacts when nearly closed close with a snap action.

23. A relay comprising an actuating-coil, a cylinder on which said coil is mounted, movable contacts operated by said actuating-coil, contacts in circuit with said actuating-coil with which said movable contacts engage, a core forming the plunger of a dash-pot and operating within said cylinder, an adjustable valve in said dash-pot cylinder which allows a free opening movement but acts to retard the closing movement of said contacts, and a maintaining-coil independent of said actuating-coil adapted to hold said contacts in their open position when an excess of current flows through said maintaining-coil.

24. A relay comprising an actuating-coil, movable contacts operated by said actuating-coil, contacts in circuit with the actuating-coil engaged by said movable contacts, a maintaining-coil adapted to hold said contacts in the open position provided the current in said maintaining-coil is above a predetermined value, and means for adjusting said movable contacts to respond to some other predetermined strength of current in the maintaining-coil.

In witness whereof I have hereunto set my hand this 29th day of September, 1903.

GEORGE H. HILL.

Witnesses:

ALEX. F. MACDONALD,

HELEN ORFORD.