No. 778,825. PATENTED DEC. 27, 1904.

G. H. HILL.

SYSTEM OF MOTOR CONTROL.

APPLICATION FILED JULY 25, 1904.

Fig. 1.

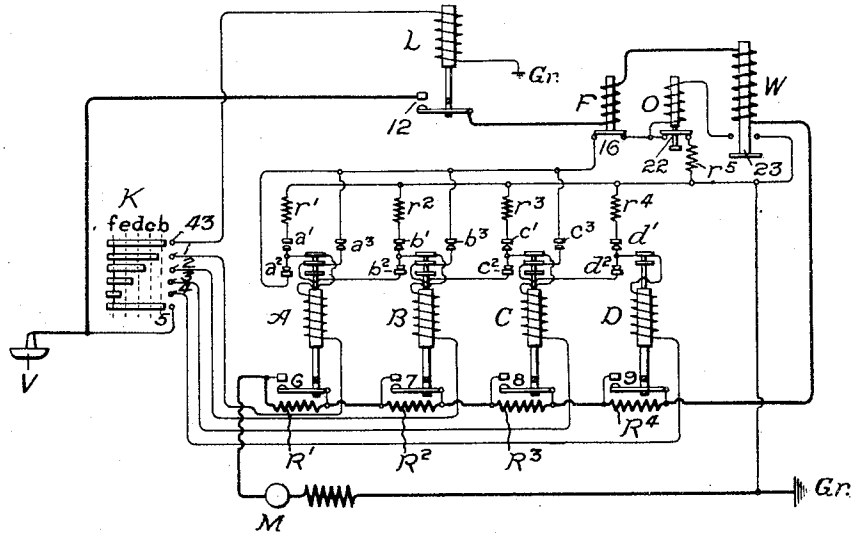
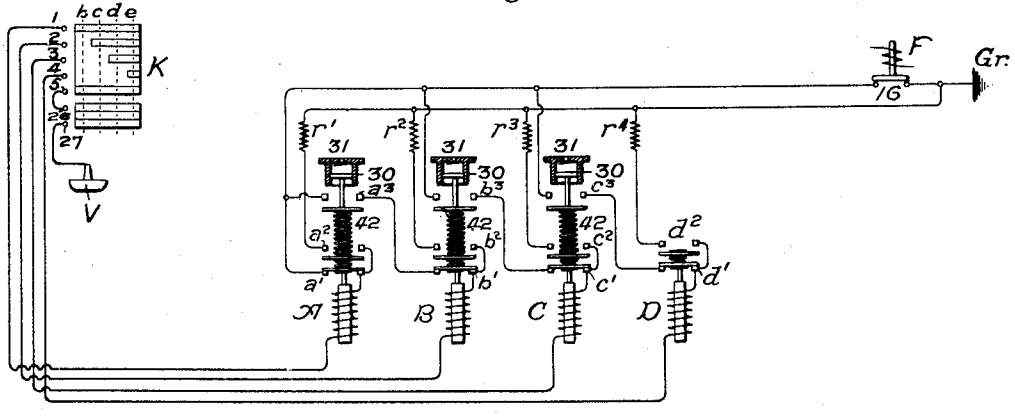


Fig. 2.



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No. 778,825. Patented December 27, 1904.

UNITED STATES PATENT OFFICE.

GEORGE H. HILL, OF SCHENECTADY, NEW YORK, ASSIGNOR TO SPRAGUE ELECTRIC COMPANY, A CORPORATION OF NEW JERSEY.

SYSTEM OF MOTOR CONTROL.

SPECIFICATION forming part of Letters Patent No. 778,825, dated December 27, 1904.

Original application filed June 27, 1902, Serial No. 113,454. Divided and this application filed July 25, 1904. Serial No. 218,024.

To all whom it may concern:

Be it known that I, GEORGE H. HILL, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Motor Control, of which the following is a specification.

The present invention relates to systems of electric control of the character set forth in my application, Serial No. 113,454, filed June 27, 1902, of which application the present application is a division.

In my prior application various forms are shown of a system for preventing a too rapid progression of the contacts in a system of electric control in which the control is accomplished by means of a series of individually-actuated contacts. Said system contemplates the use of a checking device acting with successive contact devices and adapted to check at least temporarily the operation of the succeeding contact device, thereby securing by means of the master-switch or master-controlling device or by means operated by the current in the controlled circuit a control of the extent and rate of progression of the contacts. The form of said system which is specifically made the subject of one or more of the claims in the foregoing application embodies a single actuating-circuit from the master-switch for all the contacts, together with a maintaining-circuit therefor, the manual control of the progression of the contacts being obtained by making and breaking the actuating-circuit for the contacts at the master-switch. With this arrangement the operator must move the switch-handle back and forth if he desires to control the contacts, and, furthermore, he has no means of knowing definitely the positions of the contacts.

In accordance with my present invention I provide a separate connection from each contact-actuating means to the master-switch and a position of the switch corresponding to each contact, whereby the master-switch may be moved to its extreme position to permit the progression of all the contacts to be affected automatically, or it may be moved to any of its intermediate positions, thereby stopping the progression of the contacts at any point, the position of the master-switch indicating the point to which automatic progression may take place.

Several forms of the type of control system, in which independent connection are employed from the master-switch to each contact-actuating device are disclosed in my previous application, and these are utilized in illustrating the subject-matter of the present application, although the present invention in its broader aspects is not limited to the details illustrated.

In the accompanying drawings, which represent diagrammatically certain forms of the present invention, Figure 1 illustrates the circuit connections between the source of electric supply (indicated by a trolley-shoe) through a motor and the governing devices to the ground. Fig. 2 is a detail showing a modified type of checking device for limiting the rate of automatic acceleration.

In Fig. 1 a single motor M is shown for the sake of clearness, although the present invention is of course applicable to equipments embodying a plurality of motors which are adapted to be connected together in various combinations. A, B, C, and D are electromagnets operating switches 6, 7, 8, and 9, each bridging one of the resistances R', R^2, R^3, and R^4 in the motor-circuit. Besides controlling the main contacts referred to above the magnets A B C D also control the contacts a' a^3, b' b^3, c' c^3, and d' and d^2, which govern the circuits of the controlling-magnets. Resistances r' r^4 are provided in the controlling-magnet circuits. L is a magnet for operating contact 12 in motor-circuit. F is a throttle-magnet whose coil is in the controlled motor-circuit and which controls a contact 16 in the actuating-circuit of the controlling-magnets. Its function is to interrupt the actuating-circuit automatically when the current in the motor-circuit exceeds a predetermined value. K is the master-switch, which when the present invention is applied as a car equipment may be arranged at one end of the car while a duplicate switch is placed at the other end. Also when the present invention is employed as part of a train-control system one or more

master-switches are placed on each car and all are connected together by train-lines, as disclosed in my application heretofore referred to. The description and illustration in the present application are confined to a single master-switch and a single set of circuits simply for the sake of clearness, since the multiplication of master-switches or equipments does not affect the operation of any one system. O is the checking-magnet, arranged in the actuating-circuit of the magnets A, B, C, and D and controls said circuit by means of the contact 22. W is an underload-magnet which serves as a governor for the checking-magnet O. It operates contact 23, which is in circuit with the coil of the checking-magnet, and its coil is illustrated as in series with the motor, although it may be arranged in any suitable manner, whereby when the current through the motor reaches a predetermined value the contact 23 is closed. The contacts 1, 2, 3, and 4 of the master-switch K are connected, respectively, to corresponding terminals of the controlling-magnets A, B, C, and D. The contact 5 is connected with the line-contact V, and the contact 43 is connected with one terminal of magnet L. Upon moving the master-switch to its first position *b* a circuit is established from line-contact V to contact 5, through the movable-contacts of the master-switch to contact 43, through the coil of magnet L, and to the ground. Magnet L thereby becomes energized and closes the motor-circuit at contact 12. Current is thereupon supplied to motor M through all of the resistances R′ to R⁴. Upon moving the controller to its second position *c* current flows from contact *l*, through the coil of magnet A, through contact a^2, contacts 16 and 22, resistance r^5 to the ground, thereby energizing magnet A, closing contact 6, and cutting resistance R′ out of the motor-circuit. Upon the energization of magnet A the actuating-circuit for the magnet is broken by the opening of contact a^2 and the maintaining-circuit of this magnet is established by the closing of contact a', the maintaining-circuit passing out from contact a' through the compensating resistance r' to the ground. The The contact a^3, arranged in the actuating-circuit of the succeeding magnet B, is also closed upon the energization of magnet A. If the current supplied to the motor upon the cutting out of resistance R′ does not exceed a predetermined value, then upon moving the master-switch to its third position *d* an actuating-circuit is established for magnet B from contact 2, through the coil of magnet B, out of contacts b^2 and a^3 through contacts 16 and 22, resistance r^5 to the ground. An additional resistance-section R² is thereby cut out of the motor-circuit. The actuating-circuit of magnet B is broken at contact b^2 and an actuating-circuit therefor established at b', and at the same time the contact b^3 in the actuating-circuit of the following magnet C is closed. In the same manner the resistances R³ and R⁴ may be progressively cut out upon moving the master-switch successively to its positions *e* and *f*. It is evident that the erganization of magnets B, C, and D is dependent upon the previous energization of magnets A, B, and C, respectively, and upon the closing of contacts thereby, so that a defect at one point will prevent the operation of succeeding devices, thereby, through the consequent diminution of the motor speed or failure of acceleration thereof, apprising the operator of the defect. It is evident that if the master-switch is moved from the zero or off position to its extreme running position the magnets A, B, C, and D will be progressively energized, since one terminal of each magnet is then connected directly to line-contact V by means of its independent connection with the master-switch and the actuating-circuits of magnets B, C, and D being established progressively through the contacts operated by preceding magnets. The rate at which acceleration may take place is limited by magnets F, O, and W. Throttle-magnet F opens the actuating-circuit of the magnets whenever motor-current becomes too great and prevents the further cutting out of resistance until the current diminishes. When the motor-current reaches a predetermined value, less than that which will cause the throttle F to act and somewhat less than the current at which it is desired to accelerate, the magnet W will be energized so as to close contact 23. This contact therefore remains closed during practically the entire acceleration of the motors, and it will be seen that as soon as the controller is moved to its second position for the purpose of establishing the actuating-circuit for magnet A current will pass through both the magnet A and the magnet O. Magnet O has its contact arranged loosely upon the stem of the plunger, so that the latter is capable of a limited loose motion or it is otherwise arranged, so that the plunger must move a certain distance before opening the contact. During the time that this contact is being opened the magnet A is closing its contacts 6, a', and a^3 and is opening contact a^2. When the contact a^2 is broken, the actuating-circuit of the magnet A is interrupted and current passes from the magnet A through contact a' and thence through the retaining-circuit, and at the same time the actuating-circuit of magnet B is established through contact a^3. The time required for the checking-magnet O to open this contact 22 is just sufficient to allow the magnet A to operate, so that just as contact a' closes and shifts the actuating-circuit to magnet B the actuating-circuit is broken by the checking-magnet at contact 22, and the magnet B is thus checked and cannot be energized, for the reason that magnet O is of high resistance and the current which maintains it is insuffi-

cient to actuate magnet B. The checking-magnet O remains energized and holds the contact 22 open as long as the actuating-circuit is otherwise kept intact. If the operation of the magnet A, the closing of its contact 6, and the subsequent short-circuiting of the resistance R′ in the motor-circuit has produced an increase in the current through the motors sufficient to cause the throttle-magnet F to be energized, it opens the contact 16 in the actuating-circuit. This will occur just after the checking-magnet O has opened its contact 22 and will cause the magnet O to be deënergized and to close its contact 22. The magnet B is not energized, because its current is interrupted at 16; but when current in the motor-circuit falls to its normal value the magnet F will be weakened, thereby closing its contact 16 and completing the circuit to the magnet B. Magnet B is now energized, closing its contacts 7, b', and b^3 and opening contact b^2, and the checking-magnet O operates as before. The same sequence of operations is repeated for the magnets C and D. If all the magnets have operated and the motor is running with no resistance in circuit and the main current-supply to the car be interrupted for a short time and then be reëstablished before the motor has materially decreased its speed, the interruption of the current thus occasioned deënergizes all the magnets and opens the motor-contacts. When the main contact is again established, the magnet L will be energized and the motor-circuit established through the resistances R′ R^2 R^3 R^4, but as the motor speed has not slackened the current in the motor-circuit will be lower than was flowing before the main contact had been broken and will not be sufficient to energize the magnet F or to energize and close the contact of the magnet W. The checking-magnet O is therefore put out of action by interruption of its circuit. Current will flow from l of the master-switch through magnet A, contact a^2, contacts 16 22, resistance r^5 to ground. As soon as the magnet A has been actuated current flows from the contact 2 of the master-switch through magnet B to contacts b^2 a^3 16 22, resistance r^5 to ground. As soon as B is actuated current flows from the master-switch contact 3 through magnet C, &c., to ground, and similarly from contact 4 and magnet D to ground. The magnets are thus energized successively without any checking action and quickly assumes the position they held before the break in the main contact.

Fig. 2 is a modification of the control system and also shows means whereby a group of magnets, each operated by a separate circuit from the master-switch, are made successive in their action, and in which the rate of progression of the magnets may be controlled automatically and the master-switch be moved directly to its extreme position or may be controlled manually by progressive movement of the master-switch from contact to contact. Suppose the contacts of master-switch K be moved to their extreme position, current flows from line-contact V, through contacts 27 26 5, out 1, coil A, contacts a' 16 to ground. This operates the magnet A, which opens contact a' and closes a^2, thereby causing current to pass from the coil A through contact a^2, resistance r' to ground. The spring 42 is compressed and slowly moves the piston into the dash-pot 30 and closes the contact a^3. Current then flows from the contact 2 of the master-switch, coil B, contacts b' a^3 and 16 to ground. Magnet B is thus operated and cuts resistance r^2 into circuit with its coil, and the spring 42 proceeds to close the contacts b^3, &c. During the time between the operation of the respective magnets there is ample time for throttle F to act. It is evident that the master-switch contacts can be moved slowly or stopped at any point, and thereby control the rate of operation of the successive magnets at any rate slower than would take place by reason of the dash-pot's operation.

It is evident that in both forms in which my invention is herein disclosed the progression of the contacts is entirely under the control of the operator, who may determine the rate of progression, provided a slower rate than that of automatic progression of the whole series is desired, by the rate of forward movement of the master-switch, and the extent of progression by simply moving the master-switch to the desired point and leaving it there.

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

1. In a system of electric control, a series of circuit-governing electromagnets, a master-switch provided with an independent connection to each electromagnet, the energization of certain of the electromagnets being dependent upon the energization of another of the electromagnets.

2. In a system of electric control, a plurality of contact devices, a plurality of electromagnets for operating said contact devices, a master-switch having an independent connection to each of said electromagnets and each of certain of said electromagnets including in its circuit one of said contact devices controlled by another of said electromagnets.

3. In a system of electric control, a group of successively-acting magnets, means for effecting their automatic progression, a master-switch, circuits governed by the master-switch and adapted to arrest the progression of the magnets and maintain those already actuated, said circuit including an independent connection between the master-switch and each of said magnets.

4. In a system of electric control, a motor-circuit, a master-switch, a resistance in said motor-circuit, a plurality of magnets controlling separate portions of said resistance and arranged *seriatim*, the coil of each magnet ex-

cept the first having one terminal at a contact controlled by the preceding magnet and having its other terminal joined to the master-switch by an independent connection.

5. In a system of electric control, a group of successively-operating magnets, a controlling-circuit and master-switch, said controlling-circuit including an independent connection between each magnet and the master-switch, means for effecting automatic progression of the magnets, and means acting with successive magnets adapted to check the operation of the succeeding magnet.

6. In a system of electric control, a group of successively-operating magnets, a master-switch, an actuating and maintaining circuit for the magnets, and means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit the two circuits for each magnet having in common an independent connection with the master-switch.

7. In a system of electric control, a group of successively-operating magnets, an actuating and a maintaining circuit for the magnets, means whereby the magnets are successively included in the actuating-circuit and shifted to the maintaining-circuit, means acting with successive magnets to check the operation of a succeeding magnet, and a master-switch, the actuating and the maintaining circuit for the magnets having in common an independent connection between each magnet and the master-switch.

8. In a system of electric control, a group of successively-operating contact devices, means for effecting automatic progression of said contact devices, a master-switch, and an independent connection between said master-switch and each of said contact-operating devices.

9. In a system of electric control, a motor-circuit, a resistance in the motor-circuit, a plurality of magnets controlling separate portions of the resistance and arranged *seriatim*, a normally open circuit through the coil of each magnet, connection between the successive magnets whereby the operation of any one of the magnets completes the circuit through the coil of the magnet next in succession, a master-switch, and an independent connection between the master-switch and each magnet-coil.

In witness whereof I have hereunto set my hand this 22d day of July, 1904.

GEORGE H. HILL.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.