J. H. HALL.

ELECTRIC CONTROLLER.

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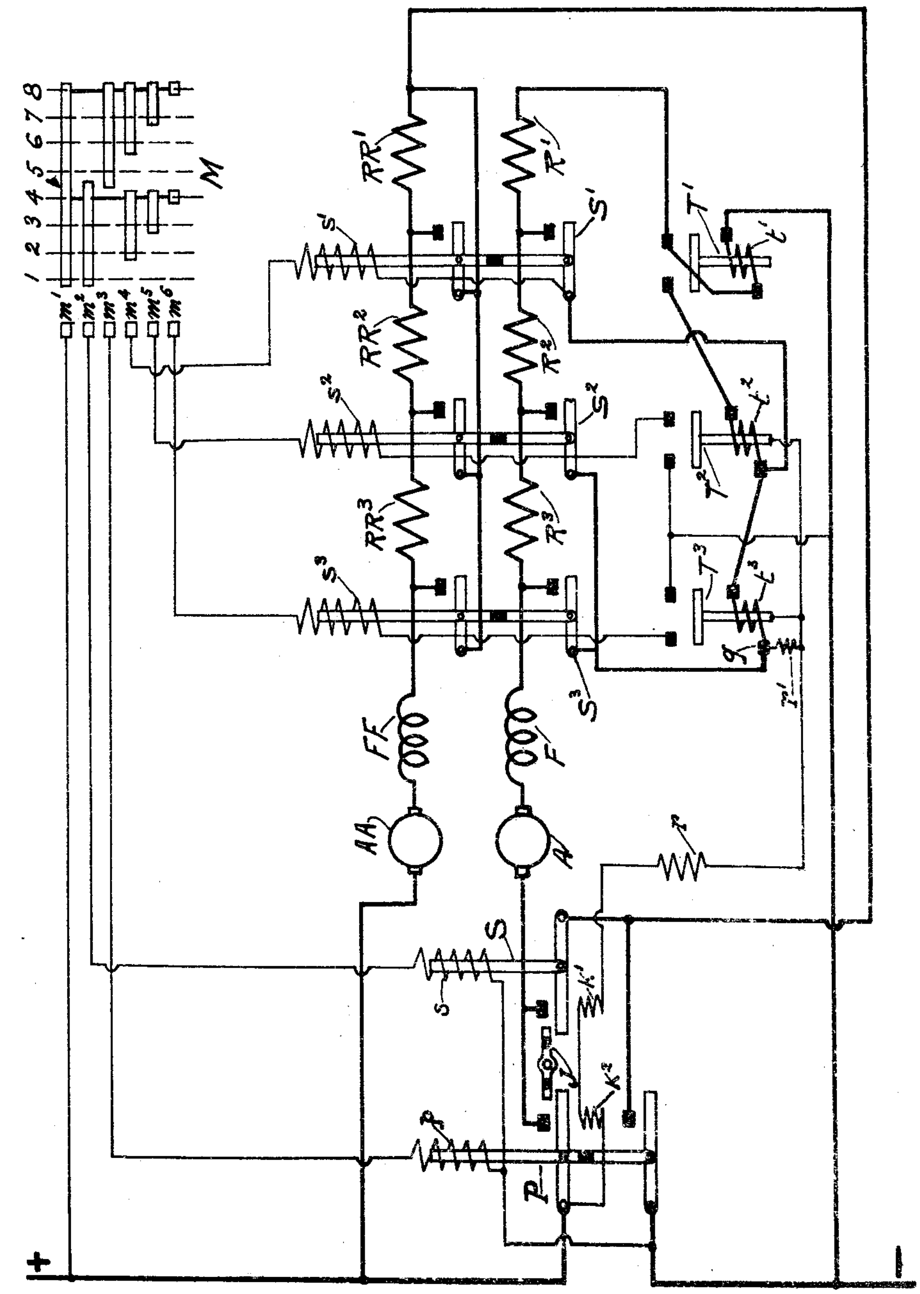

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ELECTRIC CONTROLLER.

1,053,503. Specification of Letters Patent. **Patented Feb. 18, 1913.**

Application filed October 30, 1911, Serial No. 657,495. Renewed October 25, 1912. Serial No. 727,785.

To all whom it may concern:

Be it known that I, JAY H. HALL, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented new and useful Improvements in Electric Controllers, of which the following is a specification.

My invention relates to improvements in that type of electric controllers known as series-parallel controllers, in which a series of individually operated switches are employed to control the speed of the motors, and particularly that type in which the closure of certain switches is governed by relays controlled by the motor circuit.

The objects of my invention are (1) to provide a system of control by which the resistance may be cut out of a motor circuit to start the motor by means of magnetically operated switches, the closure of which is governed by relays controlled by the current flowing in the motor circuit, and also governed at will from a master switch: (2) to provide an interlock by means of which a circuit-closing switch in a motor control system cannot close if any of the resistance switches or relays governing them is closed: and (3) in a series parallel controller to prevent the change from series to parallel when any of the resistance controlling switches or relays is closed.

Referring to the accompanying sheet of drawing which shows diagrammatically the preferred form of my invention, A is the armature of one motor, and F the series field thereof. R′, R^2 and R^3 are sections of resistance for the said motor. The armature of the other motor is shown at AA, and the series field thereof at FF. The resistance sections RR^3, RR^2, and RR′ form a rheostat for the motor AA. These sections of resistance are governed in groups of two by the magnetically operated switches S′, S^2, and S^3, which are provided with the actuating windings s', s^2, and s^3, respectively. One end of the windings s' is connected to the finger m^4 of a master-controller M and the other end is connected to the lower bridging piece of the switch S′; one end of the winding s^2 is connected to the finger m^5 of the master-controller, while the other end is connected to a contact of a relay T^2, the other contact of which is directly connected to the negative; one end of the winding s^3 is connected to the finger m^6 of the master controller, and the other end is connected to a contact of a relay T^3, the other contact of which is directly connected to the negative.

The operation of the switches S′, S^2, S^3 is governed independently of the master controller by the relays T′, T^2, and T^3. The operating winding t, of the relay T′ is in the circuit of the motor A, in series with all the rheostat, and is in circuit all the time the motors are in operation. The operating windings t^2 and t^3 of the relays T^2 and T^3 are connected in series in a circuit connected on the one hand to the lower bridging pieces of the switches S^2 and S^3 and on the other to the left-hand contact of the relay T′. The lower terminal of the winding t^2 is also connected to the lower bridging piece of the switch S′. The contacts of the relays T^2 and T^3 which are not connected to either winding s^2 or s^3 are connected together and to the negative.

The relays T′, T^2, and T^3 are of the type of switches described in Harry R. Canfield's applications, Serial Number 583,000, filed September 21, 1910, and Serial Number 604,331, filed January 23, 1911, and in Eastwood's Patent, No. 1,040,292, granted October 8, 1912. In these applications and in this patent, particularly in Fig. 2, the switches have the peculiar characteristic of locking open when the current in their operating windings is above a predetermined value and of operating when the current diminishes to that value.

A series switch and a parallel switch are illustrated, respectively, at S and P. Their respective actuating windings s and p have one end connected to a common wire leading to the negative: the other end of the winding s is connected to the finger m^2, and the other end of the winding p is connected to the finger m^3 of the master-controller. The switches S and P are provided with a mechanical interlock J and with a locking circuit. This locking circuit is traced from the positive through the magnets K^2 and K′, a limiting resistance r, and thence is connected to the bridging pieces of relays T^2 and T^3, and also to the terminal q through a resistance r', that is, to the lower bridging pieces of the switches S', S^2, and S^3. The purpose of the resistance r' is to avoid a short circuit around the windings t^3, t^2, and t' through the bridging piece of either relay T^3 or T^2.

The master-controller M is of the drum type. The finger m' is connected to the positive. By moving the master-controller the motors are first connected in series and the speed regulated, and then in parallel with further regulation of speed.

The operation of this controller is as follows: Assuming that the drum of the master controller is moved to bring the row of fingers to position 1, a circuit is established from the positive through the fingers m', m^2, and the winding s to the negative. The series switch S will then close its contacts, whereupon the motor circuit is established as follows: from the positive through the armature AA, the field FF, the resistances RR^3, RR^2, RR', the contacts of the switch S, the armature A, the field F, the resistances R^3, R^2, R', and the operating winding t' of the relay T, to the negative. The two motors are connected in series with all the resistances in circuit. If the operator waits long enough, the acceleration of the motors will cause the current in the motor circuit to decrease to that value at which the relay T' is adjusted to operate. Then the relay T', which had been locked open by the first rush of current, will close its contacts. When the operator turns the master-controller to bring the fingers to the position 2, a circuit is established from the positive through the fingers m' and m^4, the winding s' of the switch S', the winding t^2 of the relay T^2, the contacts of the relay T', and the winding t' thereof to the negative. The winding of the switch S' being energized will close its contacts, thereby short-circuiting the resistance sections R' and RR' simultaneously and connecting the operating winding t^2 of the relay T^2 in series with the winding t' in the motor circuit. Owing to the rush of current, the relay T^2 will lock open until the motors accelerate sufficiently to cause the current to decrease to that value at which the relay T^2 is adjusted to operate, whereupon the said relay will close its contacts. If now the operator brings the master-controller to the third position so that the brushes come on line 3, another operating circuit is established from the positive through the fingers m' and m^5, the winding s^2 of the switch S^2, and the contacts of the relay T^2 to the negative. The switch S^2 will close its contacts, thereby short-circuiting the resistance sections R^2, RR^2 simultaneously and connecting the operating winding t^3 of the relay T^3 in series with the windings t^2 and t'. The relay T^3 will lock open till the current in the motor circuit has decreased to that value at which said relay is adjusted to operate, whereupon it will close its contacts. Finally, bringing the master controller to the fourth position completes an operating circuit from the positive through the fingers m', m^6, the winding s^3, and the contacts of the relay T^3 to the negative. Consequently, the switch S^3 will close its contacts, thereby short-circuiting simultaneously the last two sections RR^3 and R^3 of the starting resistance and connecting the motors in series directly across the line. In these conditions the motor circuit is traced as follows: from the positive through the armature AA and the field FF of one motor, the upper contact of the switch S^3, the contact of the series switch S, the armature A and the field F of the other motor, the lower contact of the switch S^3, and the windings t^3, t^2, t' to the negative.

It will be seen that, however rapidly the operator moves the master controller from position 1 to position 4, the winding s' of the switch S' cannot be energized until the relay T' closes its contacts; that the winding s^2 of the switch S^2 cannot be energized until the relay T^2 closes its contacts, and that the winding s^3 cannot be energized until the relay T^3 closes its contacts. Moreover, as the relay T^2 can operate only after the relay T' has operated, and as the relay T^3 can operate only after the relay T^2 has operated, it follows that the switches S', S^2 and S^3 always close their contacts in a predetermined sequence independently of the rapidity with which the master controller is moved.

The locking circuit is established as soon as the relay T' closes its contacts, current flowing from the positive through the windings K^2, K', the resistance r, the resistance r' the terminal q, the windings t^3, t^2, the contacts of the relay T', and the winding t' to the negative. This current energizes the magnets K^2 and K'. Each magnet when energized is strong enough to prevent the operation of its respective switch, but is unable to force it open after it has operated. Therefore, the parallel switch which has been already locked in open position by the interlock J will be positively held in the said position by the magnet K^2. If the resistance r' were omitted, a direct path to ground for the motor circuit would be had through the terminal q, the bridging pieces of the relays T^3 and T^2 and the contacts thereof, thereby short-circuiting the operating windings of all the relays and starting a pumping action.

The next step is to connect the motors in parallel. To do this the master controller is moved so as to bring all its fingers on the line 5. Before the master controller reaches this position, the switches S', S^2, S^3 and S are deënergized and should drop to the open position. The switches S′, S^2, and S^3 in dropping reinsert all the resistance sections in circuit, and the switch S in dropping opens the motor circuit, whereupon the relays T′, T^2, and T^3 will be deënergized and will open their contacts, thereby opening the actuating circuits of the resistance controlling switches.

The winding p of the switch P is already energized, current flowing from the positive through the fingers m', m^3 and the winding p to the negative, but the switch P cannot close its contacts so long as any of the relays T′, T^2, T^3, or the switches S′, S^2, S^3 is closed, because current flows in the locking circuit. The circuit is easy to trace if any of the relays T′, T^2, or T^3 remains closed. If a resistance switch, say S^2, sticks to the closed position, or is slow in opening, the locking circuit is completed from the positive through the windings K^2 and K′, the resistance r, the resistance r', the point q, the lower contact of the switch S^2, the resistance R^2, R′, and the winding t' of the relay T′ to the negative. Therefore, the magnets K^2 and K′ are energized, and the switch P and also the switch S are locked in the open position. If the switch S′ stays closed the locking circuit is traced as before to the point q, thence through the winding t^s, the lower contact of the switch S′, the resistance R′, and the winding t' to the negative. The magnets K^2 and K′ are again energized and the switches P and S are locked in the open position.

Assuming that the switch S, the resistance switches, and the relays have opened their contacts, the locking circuit is deënergized, and the parallel switch P will close its contacts, connecting the motors in parallel, each in series with the resistances composing its rheostat. The motor circuit is as follows: One branch is from the positive through the armature AA, the field FF, the resistances RR^3, RR^2, RR′, and the lower contact of the switch P to the negative; the other branch is from the positive through the upper contact of the switch P, the armature A, the field F, the resistances R^3, R^2, R′, and the operating winding t' of the relay T′ to the negative. Again, when the current in the winding t' falls to the value at which relay T′ has been adjusted to operate, the said relay will close its contacts. To increase the speed of the motors the operator turns the master controller to the next position, so that the row of fingers comes on line 6, which establishes the circuit through the winding s', as explained previously, whereupon the switch S′ closes its contacts, short-circuits simultaneously the resistance R′ in the circuit of the motor A and the resistance RR′ in the circuit of the motor AA, and connects the operating winding t^2 of the relay T^2 in the circuit of the motor A. The sudden rush of current due to the short-circuiting of the resistance sections R′ and RR′ locks open the relay T^2 till the current in the circuit of the motor A diminishes to that value at which the relay t^2 has been adjusted to operate. At that moment the relay T^2 will close its contacts. If now the operator moves the master controller to the position 7, the circuit through the winding s^2 is established and the switch S^2 will close its contacts and short-circuit simultaneously the resistance section R^2 in the circuit of the motor A, and the resistance section RR^2 in the circuit of the motor AA. The operation of the switch S^2 also connects the winding t^3 of the relay T^3 in series with the windings t^2 and t' in the circuit of the motor A. The sudden increase of the current will cause the relay T^3 to lock open until the current falls to that value at which the said relay is adjusted to operate. Then the relay T^3 will close its contacts. If, finally, the operator brings the master controller to the last position 8, the circuit through the winding s^3 is completed and the switch S^3 will close its contacts and short-circuit the two last sections R^3 and RR^3 of the starting resistance. The operation of the switch S^3 also connects the two motors in parallel, directly across the line. The motor circuit is then as follows: One branch is traced from the positive through the armature AA, the field FF, the upper contact of the switch S^3, and the lower contact of the parallel switch P to the negative; the other branch is traced from the positive through the upper contact of the switch P, the armature A, the field F, the lower contact of the switch S^3, the winding t^3 of the relay T^3, the winding t^2 of the relay T^2, and the winding t' of the relay T′ to the negative.

The operation of the switches S′, S^2, and S^3 is controlled, when the motors are connected in parallel, by the current in the circuit of the motor A, since the switch S′ cannot operate before the relay T′ has closed its contacts, the switch S^2 cannot operate before the relay T^2 has closed its contacts, and the switch S^3 cannot operate before the relay T^3 has closed its contacts. The relays T′, T^2, and T^3 do not close so long as the current in the circuit of the motor A is above a certain predetermined limit. Consequently, no matter how rapidly the operator moves the master-controller from position 5 to position 8, the resistance controlling switches will always operate in a predetermined sequence.

When the relay T′ closes its contacts, the locking circuit is energized and the magnet K′ locks the series switch S in the open position, the said switch being already maintained in that position by the interlock J.

To stop the motors, the master controller is returned to the off position which causes all the switches to be deënergized and to open their contacts and the motor circuit to be opened at the switches S and P.

If any of the resistance switches stays closed, current will flow through the locking circuit as explained in the series running of the motors; and if one of the relays fails to open, the locking circuit will be closed through the bridging piece of the said relay. In both cases the two switches S and P will be locked in the open position by the magnets K′ and K^2, respectively, and further operation of the controller is prevented until the trouble has been remedied.

It will be noticed that the operating windings of the relays T′, T^2, and T^3 are always connected in one motor circuit only, which insures that they operate at the same value of current whether the two motors are connected in series or in parallel.

It will be readily understood by those skilled in the art that the number of resistance controlling switches may be greater or less than three. In case it is desired to add another switch another relay such as T^2 is provided for governing the operating circuit of the said switch. If only two switches are needed, the switch S^2 and the relay T^2 are suppressed and the upper terminal of the winding t^3 is connected to the left-hand contact of the relay T′.

It will be also understood that reversing switches may be provided, magnetically operated or otherwise.

In the case of magnetically operated reversing switches, the locking circuit may be provided with extra magnets, such as K′ and K^2, the function of which will be to insure a proper electrical interlock for the reversing switches.

My invention may also be applied to the control of a single motor, as can be readily understood by considering the operation of the motor with armature A in connection with the switch S and the first four positions of the master controller, omitting the other motor and the switch P. In that case only the lower contacts of the switches S′, S^2, S^3 and the resistances controlled thereby need be considered in addition to the relays. The locking circuit will remain unchanged. The switches S, S′, S^2, and S^3 can now be considered as a series of switches for controlling the circuit of the motor A, the switch S being a main switch.

I claim—

1. In a series parallel controller, two resistances, means for connecting them in series and in parallel, switches for controlling the resistances, actuating circuits therefor, individual relays for controlling the closure of the respective circuits, and operating windings therefor energized by the current through one of the resistances.

2. In a series parallel controller, two resistances, means for connecting them in series and in parallel, switches for controlling the resistances, actuating circuits for the switches, contacts in the circuits, relays for closing the contacts, and operating windings therefor energized by the current through one of the resistances.

3. In a system of electric control, two motors, a resistance for each motor, switches for controlling the resistances, an actuating circuit for each switch, a relay for closing each of the circuits, an operating winding for each relay energized by current in one motor circuit, and means for connecting the motors in series and in parallel.

4. In a series parallel controller, two resistances, means for connecting them in series and in parallel, switches for controlling the resistances, actuating circuits therefor, and relays adapted to control the closure of the circuits and including actuating windings in the circuit of one resistance, the relays adapted to lock their contacts open when the current in their windings is above a certain value and to close their contacts when the current is reduced.

5. In a motor control system, two motors, a resistance for each motor, means for connecting the motors in series and in parallel, switches for controlling the resistances, an actuating circuit for each switch, contacts for controlling the closure of the said circuits, an operating winding energized by current in one motor circuit for closing the said contacts and connecting the operating winding of the next succeeding contacts in the said motor circuit.

6. In a motor control system, two motors, a series of resistances for each motor, means for connecting the motors in series and in parallel, switches for controlling simultaneously the two series of resistances, an actuating circuit for each switch, a relay controlling the closure of the said circuit, and including an operating winding for closing the relay energized by current in one motor circuit, the relay adapted to lock its contacts open when the current in its winding is above a certain value and to close the contacts when the current is reduced, and contacts for connecting the operating winding of the next succeeding relay in the said motor circuit.

7. In a series parallel controller, two resistances, switches for connecting them in series and in parallel, switches for controlling simultaneously the two resistances, actuating circuits therefor, relays for controlling the closure of said circuits, and a locking circuit energized when any of the resistance controlling switches or any of the circuit-controlling relays is closed, for preventing the operation of the series parallel connecting switches.

8. In a motor control system, two motors,

switches for connecting them in series and in parallel, resistances for each motor, switches for controlling the resistances, actuating circuits therefor, contacts for controlling the closure of said circuits, and a locking circuit energized when any of the resistance switches or any of the circuit controlling contacts is closed, and controlling magnets in the locking circuit for preventing the operation of the series parallel connecting switches.

9. In an electric controller, the combination of a series of switches, each having main contacts and an actuating winding, a master switch for controlling the windings, relays associated with certain switches having contacts in the circuit of the winding of the switch next to close, windings for the relays arranged to be successively connected in the controlled circuit by the closure of the main contacts of the said switches, and a locking circuit for preventing the closure of the first switch of the series if the contacts of any of the relays or any of the said switches are closed.

10. In an electric controller, a circuit, a series of resistances, a series of switches for controlling the resistances, relays associated with certain switches for controlling the windings of the said switches, windings for the relays connected in said circuit and arranged to be energized by the successive closure of said switches, and a locking circuit for preventing the closure of the first switch of the series, if any of the said switches or relays is in its operated position.

11. In an electric controller, a main switch, a series of switches each having main contacts and an actuating winding, relays associated with certain of said switches having contacts in the circuit of the winding of the switch next to close, windings for the relays arranged to be connected in the controlled circuit by the closure of the main contacts of the said switches, and a locking circuit for preventing the closure of the main switch energized by the closure of the said contacts of any of the said switches in the series.

12. In an electric controller, a main switch, a series of switches each having main contacts and an actuating winding, relays associated with certain of said switches having contacts in the circuit of the winding of the switch next to close, windings for the relays arranged to be connected in the controlled circuit by the closure of the main contacts of the said switches, the said windings locking the relays open when the current therein is above a predetermined value and operating them when the current is reduced, and a locking circuit for preventing the closure of the main switch energized by the closure of the said contacts of any of the relays.

13. In an electric controller, a motor, a circuit therefor, a main switch for closing the said circuit, a plurality of resistances for said circuit, a plurality of switches for the resistances adapted to close in a predetermined order, a relay for each resistance switch for controlling the winding thereof, and a locking circuit for the main switch energized by the closure of any resistance switch or any relay.

14. In a motor control system, a motor, a switch for connecting the motor to a source of supply, resistances for the motor, switches for controlling said resistances, actuating circuits therefor, relays for controlling the closure of said circuits, and a locking circuit energized when any of the resistance switches or any of the circuit-controlling relays is closed, said locking circuit embracing the windings of magnets for preventing the operation of the circuit-closing switch.

15. In an electric control system, a circuit to be controlled, a series of resistance-controlling switches, a relay provided for each switch and having an actuating winding, the contacts of each switch in closing energizing the winding of the relay which controls the closure of the next resistance-controlling switch to operate, and connections whereby one of the relays in closing connects to the controlled circuit a contact of at least one of the resistance-controlling switches.

16. In an electric control system, a circuit to be controlled, a series of resistance-controlling switches, operating windings therefor, relays having windings connected in the controlled circuit by the switch which precedes in operation, and connections whereby the first relay in closing connects to the controlled circuit a contact of each of the resistance-controlling switches.

17. In an electric control system, a circuit to be controlled, a series of resistance-controlling switches, operating windings therefor, relays having windings connected in the controlled circuit by the switch which precedes in operation, connections whereby the first relay in closing connects to the controlled circuit a contact of each of the resistance-controlling switches, and a control circuit connected to the said contacts.

Signed at Cleveland, Ohio, this 26th day of October, A. D. 1911.

JAY H. HALL.

Witnesses:
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