J. H. HALL.

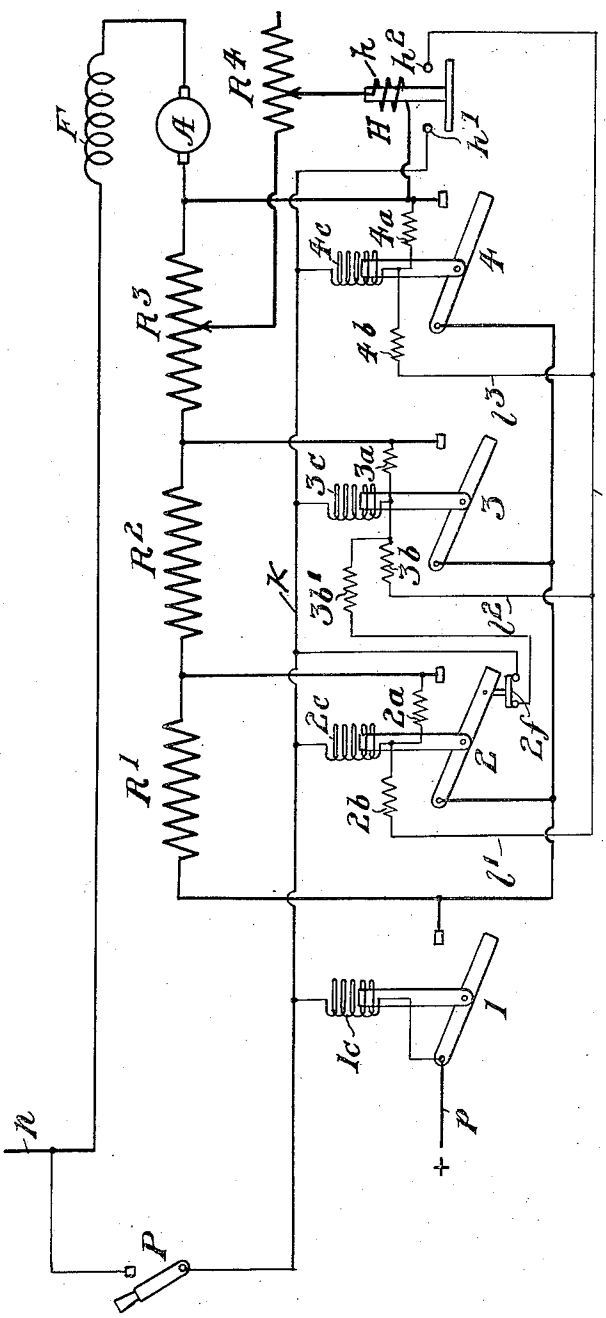
CIRCUIT CONTROLLING SYSTEM.

APPLICATION FILED DEC. 22, 1910.

1,053,495. Patented Feb. 18, 1913.

4 SHEETS—SHEET 1.

FIG. 1



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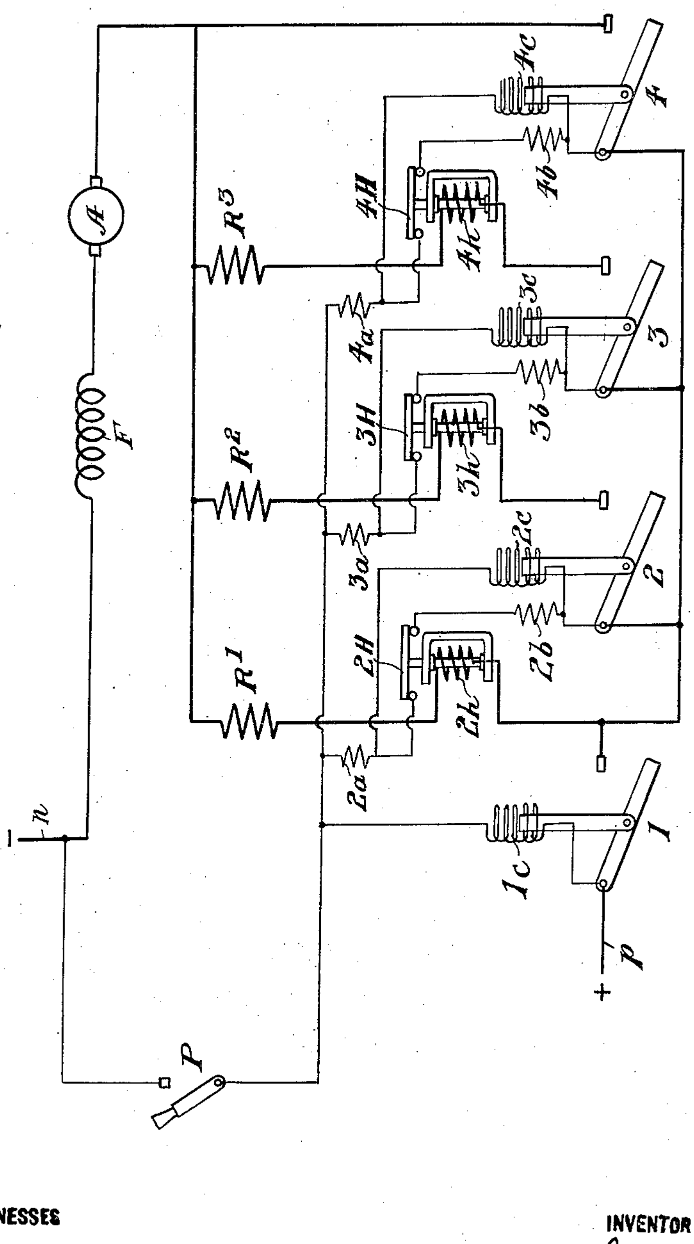
4 SHEETS—SHEET 2.

FIG. 2



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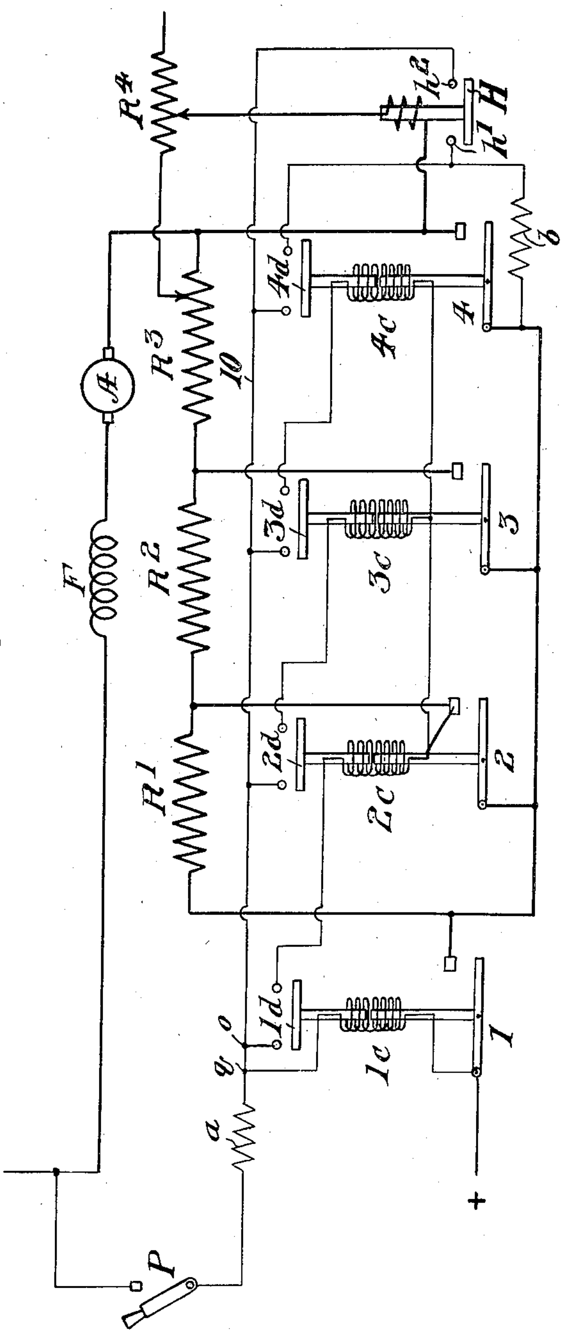
4 SHEETS—SHEET 3.

FIG. 3



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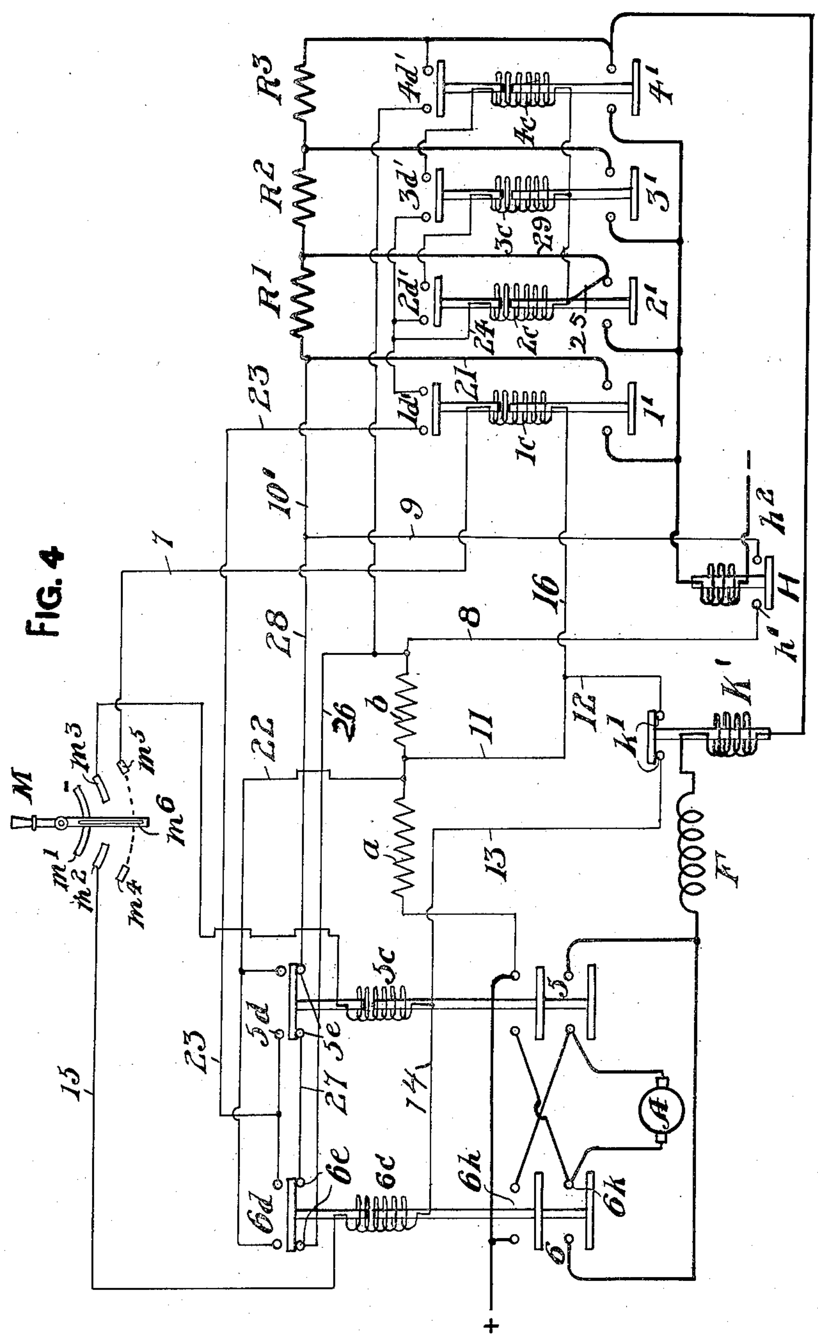
4 SHEETS—SHEET 4.

FIG. 4



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UNITED STATES PATENT OFFICE.

JAY H. HALL, OF CLEVELAND, OHIO, ASSIGNOR TO THE ELECTRIC CONTROLLER AND MANUFACTURING COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF OHIO.

CIRCUIT-CONTROLLING SYSTEM.

1,053,495. Specification of Letters Patent. Patented Feb. 18, 1913.

Application filed December 22, 1910. Serial No. 598,798.

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 Circuit-Controlling Systems, of which the following is a specification.

My invention relates to circuit controlling systems, particularly that kind in which magnetically operated switches are used to vary the current in the system. It is used particularly in connection with motor control systems in which magnetically-operated switches are used as resistance cutting-out switches during the acceleration of the motor.

The objects of my invention are to control the automatic progression of a series of resistance switches by shunting the operating windings of these switches when, during the acceleration of the motor, the motor current rises above a safe value, and, by means of these shunts in connection with a throttle, to prevent each switch from closing until the motor current is reduced to a safe value.

Another object of my invention is to cut down the current in the operating windings of the switches after they have operated, and so reduce the heating of these windings.

A further object is to secure by the use of one pair of resistances the automatic progression of the switches under the control of a throttle, as well as to prevent the main switch or reversing switches from reclosing after an overload or failure of current, or in the event that any of the resistance switches remain closed by accident while the master switch is in a running position.

Referring to the accompanying drawings, the four figures show diagrams of four out of the many species in which my invention may be embodied.

Referring first to Figure 1, the switch P is closed when it is desired to start the motor, having the armature A and the series field F. A circuit is established from the positive wire p through the actuating winding 1^c of the main switch 1 and the switch P to the negative wire n. The current in the winding 1^c closes the switch 1, thereby completing the motor circuit as follows: from the positive wire p through the switch 1, the resistance sections R', R^2, and R^3, the armature A, and the field F to the negative wire n, a part of the motor current passing through the adjustable resistance R^4 and the winding h of the throttle H, these being in parallel with an adjusted portion of the resistance R^3. If the motor current is above a predetermined value, the current in the winding h will close the contacts h', h^2 of the throttle H. The throttle closes practically simultaneously with the closure of the switch 1, a circuit then being established from the positive wire p through the switch 1, and the resistance R', from which one branch leads through the resistance 2^a and the actuating winding of the resistance switch 2 to the wire K, a second branch leads through the resistance R^2, the resistance 3^a and the actuating winding of the resistance switch 3 to the wire K, and a third branch leads through the resistances R^2 and R^3, the resistance 4^a, and the actuating winding of the resistance switch 4 to the wire K, whence the circuit from the three parallel branches extends through the switch P to the negative wire n. Each of the resistances 2^a, 3^a, and 4^a has one terminal connected to the fixed contact of the switch with which it is associated. The voltage across the resistance 2^a and the winding 2^c is that of the line minus the drop due to the motor current flowing through resistance R'. The voltage across resistance 3^a and winding 3^c is equal to the line voltage less the drop in voltage through the resistances R' and R^2; and the voltage across resistance 4^a and winding 4^c is that of the line minus the drop in voltage in the resistances R', R^2, and R^3. As long as the motor current is strong enough to cause the throttle H to close its contacts h' h^2, the wire K is connected to the wire L to which are connected three parallel wires as follows: the wire $1'$ leading through the resistance 2^b to a point between the winding 2^c and the resistance 2^a; the wire 1^2 leading through the resistance 3^b to a point between the winding 3^c and the resistance 3^a; and the wire 1^3 leading through the resistance 4^b to a point between the winding 4^c and the resistance 4^a. Thus, while the throttle H is closed there will exist from the points connecting the resistances 2^a, 3^a, and 4^a to the windings 2^c, 3^c, and 4^c, respectively, three pairs of parallel circuits, one member of each pair including one of the c windings and the other member, one of the b resistances. The amount of current flowing through any c winding is never great enough to close its switch when the throttle has closed its contacts, but will be large enough to hold the said switch closed after it has closed, so that there is no danger of a switch opening merely because the parallel circuit through the throttle H is closed. As soon as the current of the motor falls to the predetermined value at which the throttle will open its contacts, the throttle H will open and the parallel circuits through the b resistances will be opened, permitting the windings of the switches 2, 3, and 4 to receive larger current; whereupon the winding 2^c will receive sufficient current to close the switch 2, but the windings 3^c and 4^c will not receive enough current to actuate their switches because the voltage applied to them is not sufficient owing to the drop due to the resistances R^2 and R^3, which can not affect the current through the winding 2^c. The a and b resistances are so proportioned that, when the throttle opens, the switch 2 only will close, the voltage across the windings of the switches 3 and 4 being insufficient to close them. Upon the closure of the switch 2, the section R' of resistances is short-circuited and the motor current is increased, and, if this increased current is sufficient to again raise the throttle, the switches 3 and 4 will be prevented from closing as in the case of the switch 2 until the throttle again opens, which will occur when the motor current decreases to a predetermined value. At this point the current through the winding 3^c will be sufficient to close the switch 3 since the resistance R' has been short-circuited and the only drop in voltage caused by the motor current is that produced in the resistance R^2. The switch 4 is still prevented from closing since the drop of voltage across its winding is effected by the motor current in the resistances R^2 and R^3. The switch 3, therefore, closes, short-circuiting resistance R^2 which again increases the motor current, and if this increase is sufficient, the throttle H will again close its contacts and prevent the switch 4 from closing until the motor current is again reduced to the predetermined value. At this point the throttle will again open and allow switch 4 to close, as the only drop in voltage is caused by the resistance R^3. To stop the motor the switch P is opened, which deënergizes all the switch windings and causes them to open their switches. I have shown at 2^f an auxiliary contact on the switch 2, which, while the switch 2 is open, shunts the winding 3^c by means of the resistance $3^{b'}$, and prevents the winding 3^c from closing the switch 3 until after the switch 2 has closed. This device may be put upon each of the switches if so desired, but is not necessary for the successful operation of the system.

Fig. 2 shows an arrangement by which each of the operating windings of the resistance cut-out switches 2, 3, and 4 have associated with them the two a and b resistances and in addition a relay or throttle, there being one for each of the said switches. The winding of each relay is in series with the motor current which flows from the preceding switch. The general type of switch used is that described in 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 construction of the switch is such that, when the current through the winding is above a predetermined limit, each switch will remain in its normal position; and when the current in this winding is reduced to a predetermined value, each switch will operate and open its contacts.

The connection to each of the b resistances is taken through the contacts of each switch which is energized by the preceding switch.

The operation is as follows: By the closure of the switch P, a circuit is closed through the operating winding of the switch 1 which causes this switch to close. The closure of the switch 1 establishes the motor circuit through the resistance R', the armature A, and the field F, which causes the motor to run at its slowest speed. In this circuit is connected the winding 2^h of the relay 2^H. Upon the closure of the switch 1 a circuit is simultaneously established through all of the a resistances in parallel, each circuit through such resistances being established through the actuating or c winding on each of the switches, but in parallel with the b resistance in each case. As long as the relay 2^H remains in its normal or closed position, the switch 2 cannot operate. If, upon the closure of the switch 1, the motor current is so large that it causes the relay 2^H to remain in its original position, the switch 2 will remain open until the motor current is reduced to a predetermined value, at which this relay will operate and open its contacts, whereupon the shunt resistance 2^b is removed from the winding 2^c and the switch 2 will operate. The switch 2 in closing connects the resistance R^2 in parallel with the resistance R', thereby increasing the motor current, and since this current which passes through the switch 2 passes also through the winding 3^h and the relay 3^H, this relay will be energized. If the current thus established is above the value at which the relay will operate, it will remain in its original position, causing the shunt resistance 3^b to remain connected in parallel with the winding 3^c, the parallel circuits being in series with the resistance

3^a, and the switch 3 will remain open. Upon the motor current being reduced in the winding 3^h to the point at which the relay will operate and open its contacts, the switch 3 will operate and connect the resistance R^3 in parallel with the resistances R' and R^2. This will cause the motor current to again increase its speed and the winding 4^h of the relay 4^H will be energized. As before, as long as the relay remains in its original position due to too large a motor current flowing through the winding 4^h, the switch 4 will remain open. When the motor current is again reduced to the point at which the relay 4^H will operate, its contacts are opened and the shunt resistance 4^b is disconnected and the switch 4 will be allowed to operate. Upon the closure of the switch 4, all of the starting resistance will be short-circuited and the motor will be connected directly across the line and will operate at its normal speed. When the switch 4 is closed, no current will flow through the windings 2^h, 3^h, and 4^h of the relays which will, therefore, assume their original positions and close their contacts, whereupon the b resistances are connected in shunt with their respective switch windings, thus reducing the current through the windings to a point which will still maintain the switches in their closed positions, and will materially diminish the amount of heating in the windings. To stop the motor the switch P is opened so as to cause all the switches 1, 2, 3, and 4 to open their contacts and disconnect the motor from the source of supply.

In Fig. 3 I show a system, securing the progressive operation of the switches by means of auxiliary contacts on each switch, which contacts are used in connection with a single pair of a and b resistances and the throttle H. It will be noticed that the lower terminals of all of the switch windings 2^c, 3^c, 4^c are connected together and to the stationary contact of the switch 2. This has the effect of reducing the voltage on the winding 2^c by the amount of drop in voltage in the resistance R' caused by the motor current therein at the time the switch 1 closes. This causes the switch 2 to be delayed sufficiently to allow the throttle H to close its contacts upon the establishing of the motor circuit in case the current exceeds a certain value.

The operation of the system shown on Fig. 3 is as follows: Upon the closure of the switch P a circuit is established through the winding 1^c and the resistance a, which causes the switch 1 to close and establish the motor circuit through all the starting resistance. The motor current causes the throttle H to close its contacts providing it is above the predetermined value, and the operating winding 2^c of the switch 2 is only partially energized, because it is shunted by the resistance b through the contacts of the throttle H. The circuit at that time is as follows: from the positive through the switch 1, the resistance R', the stationary contact of the switch 2, the switch winding 2^c, the auxiliary contacts 1^d, where it is joined by the parallel circuit from the positive through the resistance b, the contacts h' and h^2 of the throttle H and the wire 10 to the point O where these two circuits unite and proceed to the point q where they unite with the circuit through the winding 1^c and then proceed through the resistance a to the negative. The reduced current through the switch winding 1^c is not sufficient to cause this switch to open, but the reduced current through the winding 2^c prevents the switch 2 from closing until the motor current falls to the predetermined value at which the throttle H will open its contacts. This disconnects the circuit through the resistance b and allows the winding 2^c to close its switch 2. The motor current is immediately increased by the short-circuiting of the resistance R', and the throttle H closes its contacts again, and in a similar manner prevents the closure of the switch 3 by connecting the resistance b in shunt with the three windings 1^c, 2^c, and 3^c. Reduced current through the switch windings 1^c and 2^c does not open these switches but prevents the switch 3 from closing until the motor current again decreases, allowing the throttle H to open its contacts. The switch 3 then closes, and short-circuiting the section R^2 of the starting resistance, again increases the motor current whereupon the throttle H again proceeds to check the operation of the switch 4 until the motor current has again fallen to a point where the throttle H will open its contacts and the shunt connection through the resistance b. Upon the closure of the switch 4, all the starting resistance is cut out and the motor operates at its normal speed. The throttle winding at the same time is short-circuited, causing the throttle to open its contacts which would leave the resistance b out of circuit, if I had not provided the auxiliary contacts 4^d on the switch 4 which, upon the closure of the switch 4, connect the shunt circuit through the resistance b to the wire 10 thereby shunting all the windings 1^c, 2^c, 3^c, and 4^c, and reducing the current in them not to a value which will cause the switches to open, but which will materially reduce the heating of their windings.

In Fig. 4 the function of the resistances a and b is three-fold. At one time they act to lock the reversing switches 5 and 6 open to prevent their closure in case any of the resistance switches 1, 2, 3, and 4 is closed, and thereby insure a restarting of the motor only when all of the starting resistance is in circuit therewith. As soon as one of the reversing switches has operated the function of the resistances a and b is, as described under Fig. 3, to regulate the closing of the resistance switches under the control of the throttle H. A third function they perform is to prevent the closing of the reversing switches so long as the master controller handle remains in the full running position on the occasion of a failure of voltage or in the event of an overload causing the overload relay K′ to open its contacts k'.

I will now describe the operation of the controller as shown in Fig. 4. Assuming that the motor is at rest and the master controller handle is moved so that it connects the segments m' and m^2, a circuit is established from the positive through the resistance a, the wires 11 and 12, the contact k' of the overload device K′, the wires 13 and 14, the winding 6^c of the reversing switch 6, the wire 15, the segment m^2, the brush m^6, and the segment m', to the negative. This causes the reversing switch 6 to close. Upon movement of the master controller to the full running position so that the contact m^4 is also connected to the negative contact m', a circuit is also established through the operating winding 1^c of the switch 1′ from the positive through the resistance a, the wires 11 and 16, the operating winding 1^c of the switch 1′, the wire 7, the contacts m^5 and m^4, and the brush m^6 to the negative on the contact m'. The switch 1′ then closes its contacts and a motor circuit is established from the positive through the contacts 6^h, the motor armature A from right to left, the contacts 6^k, the field F, the winding of the overload relay K′, the starting resistance sections R^3, R^2, R′, the contacts of the switch 1′, and the winding of throttle H to the negative main. The motor should start and run at its slowest speed. When the switches 6 and 1′ operate, they close their auxiliary contacts 6^d and $1^{d'}$ respectively. As soon as the motor circuit is established, if it is above the limit at which the throttle H is set to operate, the throttle causes its contacts h' and h^2 to be closed. The switch 2′ is prevented from closing because its winding 2^c, which is partially energized by current in the circuit from the positive main through the resistance a, the wire 22, the contacts 6^d, the wire 23, the contacts $1^{d'}$, the wire 24, the winding 2^c, the wires 25 and 29, the resistance section R′, wire 21, switch 1 and the winding of the throttle H to the negative main, is shunted by the circuit from a point between the resistance a and the wire 22 through the resistance b, the wire 8, the contacts h' and h^2 of the throttle H, the wires 9, 10′, and 21, the main contacts of the switch 1′, and the winding of the throttle H to the negative main. This shunt circuit will prevent the switch 2′ from closing, but as soon as the current in the motor circuit drops below the predetermined limit and the throttle H opens its contacts, this shunt circuit is opened and the switch 2′ will close. The section R′ of the resistance is thereby short-circuited which causes the motor to increase its speed and at the same time causes the current in the motor circuit to increase. If this increase in the motor current is above the predetermined limit at which the throttle is set to operate, it will close its contacts and reconnect the resistance b to the negative main, and thus prevent the switch 3′ from closing until the current again decreases to the point at which the throttle opens its contacts. When the switch 3′ closes, it short-circuits the section R^2 of the starting resistance. In a like manner the switch 4′ will close under the control of the throttle, at which time all of the starting resistance will be short-circuited, and the motor will operate at its normal speed. Each of the switches 2′, 3′, and 4′ are relayed through the auxiliary contacts of the preceding switch, which causes them to operate in a predetermined sequence, but their operation is always under the control of the throttle, since the current through each winding, whenever the throttle contacts are closed, has a value too small to operate the switch, but after the switch has operated, this reduction of the current does not cause the switch to open again. When the switch 4′ closes, it also closes the auxiliary contacts $4^{d'}$, which reconnects the resistance b to the negative main through the contacts of the switch 4′, causing the current in all of the windings of the switches to be reduced and thus prevented from overheating. In the event of an overload which causes the overload relay K′ to open its contacts, the connection is opened to the lower terminal of the reversing switch windings causing the reversing switch in use to open and cut off the motor circuit. The switch 1′, however, does not open since it still receives current through the resistance a and the contact m^4 of the master controller, and the resistance b is connected to the negative main through the wire 26, the auxiliary contacts 6^e of the switch 6, the wire 27, the auxiliary contacts 5^e of the switch 5, and the wires 28, 10′ and 21 to the negative through the contacts of the switch 1′. The reversing switches therefore remain open as long as the master controller handle remains in full running position, and they cannot be closed until the handle is moved off of the contact m^4, thereby opening the switch 1′, and the shunt through the resistance b. Similarly, on the occasion of a failure of voltage when the master controller handle is in full running position all of the switches will become deënergized and open their contacts; but upon a return of voltage to the line, such as upon the closing of the circuit breakers in the power house, the windings 6^c and 1^c will become energized simultaneously. The winding 1^c can be made to take enough current to produce so large a current through the resistance a that the switch winding 6^c will not become sufficiently energized to close the switch; or the switch 1′ may be designed, since it is lighter, to close more quickly than the switch 6, and thereby reconnect the resistance b to the negative main through the path just described, that is, the wire 26, the contacts 6^e, the wire 27, the contacts 5^e, and the wires 28, 10′, and 21 to the negative main through the contacts of the switch 1′. It is readily seen that if, when the master controller handle is moved to the off position, any one of the resistance switches 1′, 2′, 3′, and 4′ should remain closed for any reason, such as the sticking of its contacts due to too great a current, the resistance b will be connected to the negative main through the path just described, and either reversing switch will be prevented from closing when the master controller handle is again moved to a running position.

I have described the operation of the controller shown in Fig. 4 when the reversing switch 6^c is closed by movement of the master controller handle so as to connect the segments m', m^2, m^4, and it will be readily understood that the operation would be the same when the handle is moved to the opposite side to connect the segments $m1$, m^3, m^5, except that the reversing switch 5 will be closed instead of the switch 6 and the motor will be connected with its armature reversed and will operate in the reversed direction.

I do not limit my invention to the few forms which I have shown, and it will be obvious to those skilled in the art that the spirit of my invention may be applied to many other forms of control systems.

In the claims I use the term main switch to indicate the reversing switches when a reversing motor is to be controlled and to indicate a main circuit closing switch when a non-reversing motor is to be controlled.

I claim—

1. In a current varying controller, a circuit, a series of magnetically controlled switches to control the circuit, means to cause the switches to close in a predetermined sequence, a winding for each of the switches, open shunting means around the windings of the switches, and means controlled by the current in the circuit when above a predetermined value to close the shunting means.

2. In a circuit controller, a circuit, a resistance therein, a magnetically-controlled switch arranged when closed to connect a circuit in parallel with the resistance, a winding for operating the switch, a shunt around the winding of the switch, and means controlled by the current in the first circuit when above a predetermined value to close the shunt.

3. In a circuit controller, a circuit, a series of resistances therein, a series of magnetically-controlled switches adapted to close in a predetermined sequence and govern the amount of resistance in the circuit, a winding for each of the switches, shunting means around the windings of the switches, a pair of contacts in the shunting means, and means controlled by the current in the circuit when above a predetermined value to insure a flow of current through the said contacts.

4. In a circuit controller, a circuit, a magnetically controlled switch, a resistance in series with the winding thereof, a shunting means around the winding of the switch, and a switch controlled by the current in the circuit when above a predetermined value to close the shunting means.

5. In a circuit controller, a circuit, a magnetically controlled switch, a resistance in series with the winding thereof, a shunting means around the winding of the switch, and means controlled by an excessive current in the circuit above a predetermined value for closing the shunting means.

6. In a circuit controller, a circuit, a series of switches for the circuit adapted to close in a predetermined sequence, an operating winding for each of the switches, means retarding the sequential closure of the switches, consisting of switching mechanism connecting a shunt around each energized winding when the current in the circuit is above a predetermined value.

7. In a circuit controller, a circuit, a series of switches for the circuit adapted to close in a predetermined sequence, each having an operating winding, resistance for the winding, and means shunting the windings which are energized when the current in the circuit is above a predetermined value.

8. In a circuit controller, a circuit, a resistance in the circuit, a series of magnetically-operated switches, means for causing the switches to automatically remove the resistance step by step from the circuit, and a shunt around the windings of the switches, said shunt including contacts closed by the final switch.

9. In a circuit controller, a circuit, a series of resistances therein, a series of magnetically-controlled switches adapted to close in a predetermined sequence and control the amount of resistance in the circuit, shunting means for the switches, said shunting means including a pair of contacts, and means controlled by the current in the circuit when above a predetermined value to close the said pair of contacts.

10. In a circuit control system, a circuit, a magnetically operated main switch and re-

sistance-controlling switches for the circuit, a resistance adapted to be connected in series with the operating windings of said switch, a second resistance, means for connecting the second resistance in shunt with the main switch winding when said main switch is open and any of the resistance switches is closed, and means for connecting the said second resistance in shunt with the resistance switch windings when the current in the said circuit is above a predetermined value, and when the said main switch is closed.

11. In a circuit control system, a circuit, a magnetically operated main switch and resistance controlling switches for the circuit, a pair of resistances, means for associating said resistances with the winding of the main switch to prevent its closure, if any of the resistance controlling switches is closed, and means for associating said resistances with the windings of the resistance controlling switches to cause each to close only when the current in the said circuit is below a predetermined value.

12. In a control system, a circuit, a magnetically-operated main switch and resistance-controlling switches for the circuit, a master switch therefor, a pair of resistances, means for associating said resistances with the windings of the resistance-controlling switches to prevent their closure when the current in the said circuit is above a predetermined value, and means for associating the resistances with the winding of the main switch to prevent its closure when any of the resistance-controlling switches is closed.

13. In a circuit control system, a magnetically-operated main switch, rheostatic resistance, magnetically-operated switches to control the said resistance, a master switch therefor, a pair of resistances, means for associating the pair of resistances with the windings of the resistance-controlling switches to prevent their closure when the current in the said circuit is above a predetermined value, means for associating the pair of resistances with the winding of the main switch to prevent its closure when any of the resistance-controlling switches is closed, an overload device which causes the main switch to open when the current through the said circuit becomes too large, and for shunting the winding of the main switch when the master switch is in a running position.

14. In a circuit control system, a magnetically-operated main switch, rheostatic resistance, magnetically-operated switches to control the said resistance, a master switch therefor, a pair of resistances, means for associating the pair of resistances with the windings of the resistance-controlling switches to prevent their closure when the current in the circuit is above a predetermined value, means for associating the pair of resistances with the winding of the main switch to prevent its closure when any of the resistance-controlling switches is closed, an overload device for causing the main switch to open when the current in the said circuit becomes too large, and means for causing one of the resistance controlling switches to remain closed when the master switch is in a running position.

Signed at Cleveland, Ohio, this 17th day of December, A. D. 1910.

JAY H. HALL.

Witnesses:
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H. M. DIEMER.