No. 867,810. PATENTED OCT. 8, 1907.

A. C. EASTWOOD.

AUTOMATIC ACCELERATING CONTROLLER.

APPLICATION FILED JAN. 16, 1907.

2 SHEETS—SHEET 1.

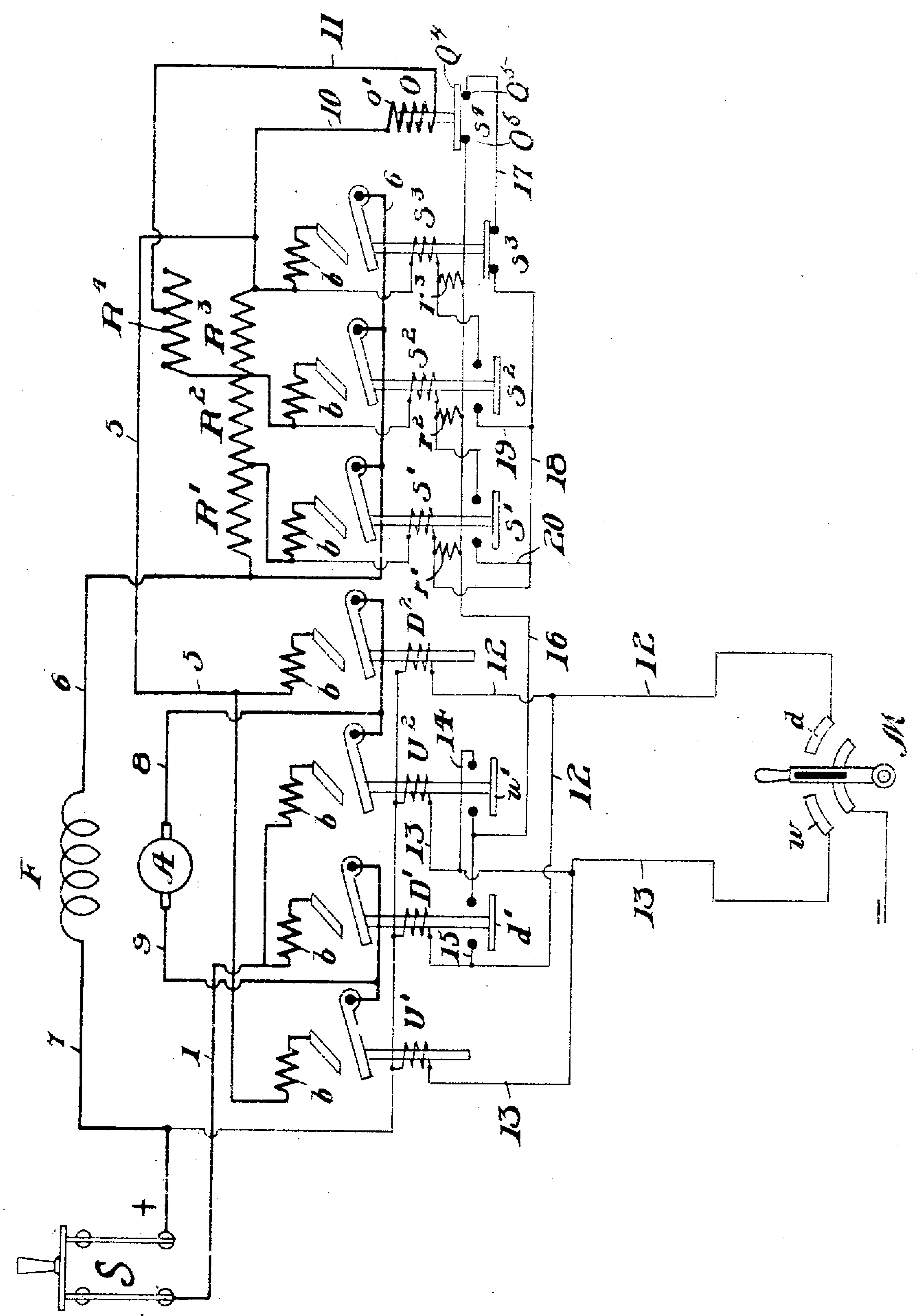

FIG. 1.

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2 SHEETS—SHEET 2.

Fig-2.

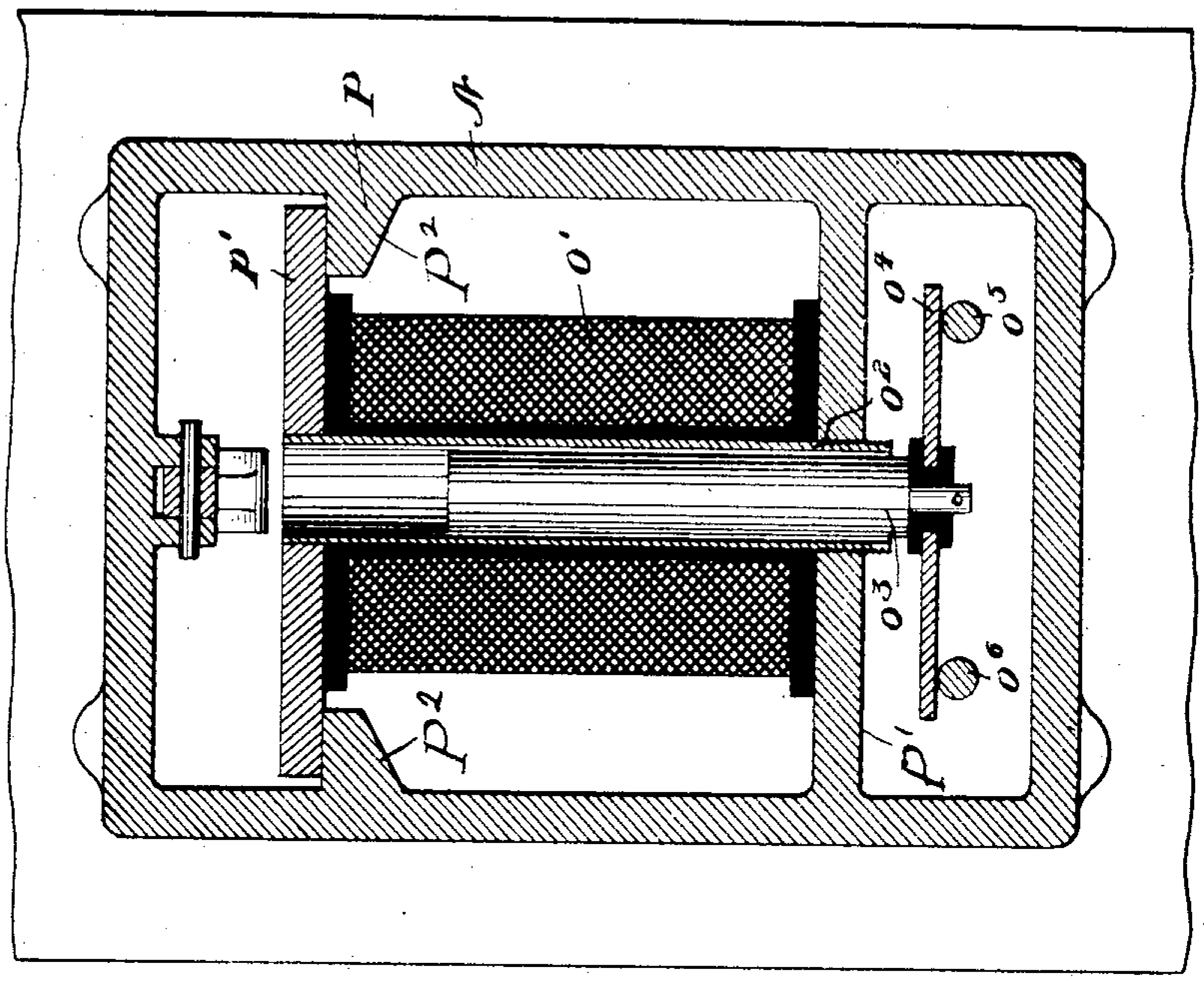
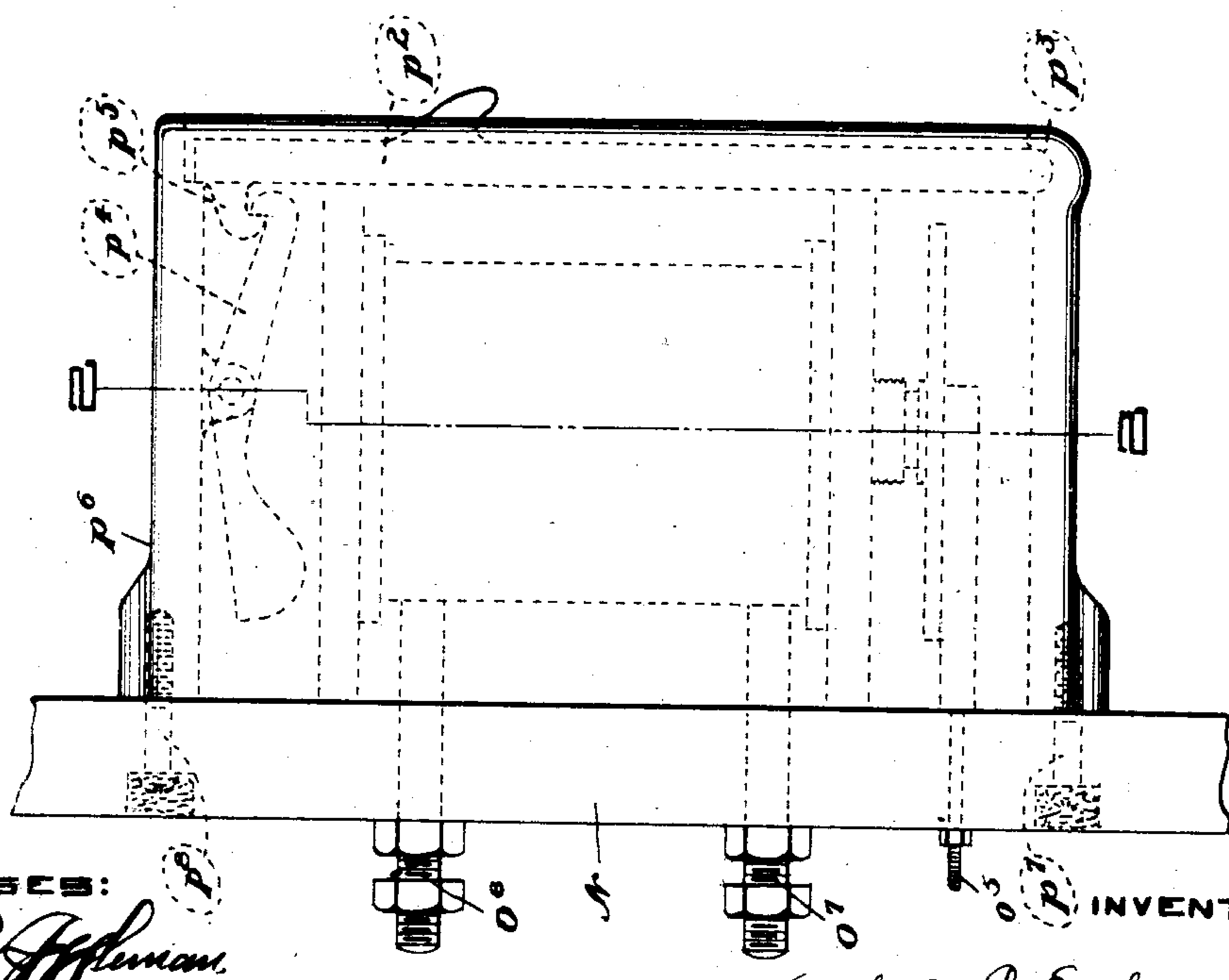


Fig-3.



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AUTOMATIC ACCELERATING-CONTROLLER.

No. 867,810. Specification of Letters Patent. Patented Oct. 8, 1907.

Application filed January 15, 1907. Serial No. 352,407.

To all whom it may concern:

Be it known that I, ARTHUR C. EASTWOOD, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented or discovered new and useful Improvements in Automatic Accelerating-Controllers, of which the following is a specification.

My invention relates broadly to controllers of the automatic acceleration type for electric motors.

More specifically, my invention relates to controllers of the said type wherein the acceleration is made at a rate independent of the operator and wherein, under normal condition, it will be impossible to exceed a predetermined accelerating current.

The objects of my invention are to produce a controller wherein the accelerating current may be adjusted by such means as will not be readily tampered with by unskilled hands; wherein the time-element of the various magnetic switches which go into the makeup of the controller will be largely eliminated, thereby securing acceleration to full speed in the minimum time consistent with a given maximum accelerating current; wherein the rise in current which occurs at the instant of closure of a given resistance switch instantaneously lowers the voltage applied to the solenoid of the succeeding switch, thereby preventing the succeeding switch from closing so rapidly as to prevent the proper action of the current-controlled relay; wherein the current-controlled relay does not, upon the flow of an excess current, open the actuating circuit of the switch which is about to close, but merely acts to insert a resistance in series with the coil of the switch, which serves to deënergize it no further than is necessary to prevent the closure of the switch; wherein the resistance, which serves to prevent the closure of a switch upon the passage of an excess current, acts subsequent to the closure of the switch to reduce the flow of current through the actuating coil of the switch; wherein the winding of the current-controlled relay is so connected that it will be automatically short-circuited when the last resistance switch closes; and wherein the winding of the current-controlled relay is so connected that identical relays may be used in the controllers varying widely in capacity, thereby adding to the interchangeability of parts and effecting more economical production.

Referring to the accompanying drawings, Figure 1 is a diagram of connections, of one form of a controller constructed in accordance with my invention; Fig. 2, a vertical section of my preferred form of current-controlled relay and its inclosing casing; and Fig. 3, a side elevation of the same.

In Fig. 1, U^1, U^2, D^1, D^2, S^1, S^2, and S^3 are magnetically operated switches, the switches D^1, U^2, S^1 and S^2 being respectively provided with the auxiliary switch contacts d^1, u^1, s^1, and s^2 which are closed when the corresponding switches are closed. The switch S^3 is provided with an auxiliary switch s^3 which is closed when switch S^3 is open and opens when switch S^3 closes.

S is a main knife switch connecting the controller to a source of current supply.

A is the armature and F, the series field winding of the motor to be controlled.

M is the master switch which is moved by the operator to start, stop, and reverse the motor.

b is the winding of a blow-out magnet, with which each of the said magnetically operated switches is provided.

R^1, R^2, and R^3 are sections of a starting resistance controlled by the switches S^1, S^2, and S^3. R^4 is also a bank of starting resistance, any portion of which may be connected in parallel with the section R^3 through the winding o^1 of the current-controlled relay O. The resistance R^4 is provided with a number of taps which permit of an adjustable connection as will be later described. The switches S^1, S^2, and S^3 each have an auxiliary section of resistance designated respectively as r^1, r^2, and r^3 so connected that when the switch s^4, controlled by the current-controlled relay O is closed, these sections of resistance are short circuited and when the switch s^4 is opened by the passage of an excess current through the winding of the relay O, this resistance is placed in circuit. The resistances r^1 to r^3 are so proportioned that, when they are included in the circuit of their respective coils, sufficient current will not flow to cause the switch to close, but will permit sufficient current to flow to maintain the switch in the closed condition after it has once operated.

The operation of my controller is as follows: Assuming that the lever of the master switch M is moved to the right so that the brush makes contact with the segment *d*, current will then flow from the positive side of the switch S through the winding of switches D^1 and D^2, thence through the wire 12 to the contact *d* and the brush of the master controller M to the negative main. This causes the switches D^1 and D^2 to close. Switch D^1 in closing closes the auxiliary switch d^1. The closure of the switches D^1 and D^2 establishes the circuit through the motor as follows: From the positive side of the switch S, through the wire 7, the series field winding F, the wire 6 the resistance sections R^1 and R^2, at which latter section the current divides, part of it passing through the resistance R^3, and part through the resistance R^4 and the winding of the current-controller relay O to the wire 5, where the divided current reunites and flows thence through the contacts of the switch D^2, the wire 8, the armature A of the motor, the wire 9, and the switch D^1, to the negative side of the switch S, thus completing the circuit through the motor, which will cause rotation of the armature A. One end of the winding of each of the switches S^1, S^2, and S^3 is connected to a point on the starting resistance R. While this connection is shown as made at the point of resistance controlled by the switch in each case, this connection can be varied to suit conditions, as fully described in United States Patent No. 772,277, granted to me October 11th, 1904. By this arrangement the coil in each switch is energized by the line voltage minus the drop through a certain portion of the starting resistance, whereby the voltage applied to the coil of the switch is reduced proportionately with any increase in the current drawn by the motor. As soon, however, as a given switch is closed, the portion of starting resistance previously in circuit with its winding is short circuited through the closure of the switch. At the instant of starting the motor, the section of resistance R^1 is in circuit with the winding of switch S^1. Sections R^1 and R^2 are in circuit with the winding of switch S^2 and sections R^1 and R^2 connected in series and R^3 and R^4 connected in parallel are in circuit with the winding of switch S^3. As soon as switch S^1 closes, the resistance R^1 is short circuited, thus cutting out the resistance in circuit with switch S^1 and reducing the resistance in circuit with switches S^2 and S^3. Similarly when switch S^2 closes, the resistance is eliminated from the circuit of switch S^2 and resistance reduced in the circuit of switch S^3. When switch S^3 closes all of the resistance is short circuited.

The reversing switches D^1 and D^2 having closed as previously described, the control circuit is as follows: From the positive main through the wire 7, the field F, the wire 6, the starting resistance R^1, the winding of the switch S^1, the wire 18, the auxiliary contacts s^3 of the switch S^3, the wire 17, the contacts O^4, O^5, and O^6 of the current-controlled relay O, the wire 16, the auxiliary switch d^1 controlled by the reversing switch D^1, the connection 15, the wire 12 to the master controller M, and thence through the contact d and the brush of the master controller to the negative main. This circuit is as traced on the assumption that only normal current is passing to the motor, and, therefore, that the current-controlled relay O has not acted to open the switch contacts O^4 to O^6. If this is the case, switch S^1 will close. In case an excess current is flowing to the motor, the switch contacts O^4 to O^6 will be opened by the current-controlled relay O. The path of the current through the winding of the switch S^1 will then be from the positive main, the wire 7, the field F, the wire 6, the section R^1 of the resistance, thence through the winding of the switch S^1, the resistance r^1, the wire 16, the auxiliary switch d^1, the connection 15, the wire 12, and thence through the contact d and the brush of the master controller M to the negative main. It will thus be seen that the resistance r^1 is in circuit with the winding of switch S^1 and, as previously stated, this resistance is so proportioned that sufficient current is not permitted to pass to cause the switch S^1 to close. When the current flowing to the motor has been reduced to the normal value, the switch S^4 controlled by the current-controlled relay O, will close, thus completing the path through the circuit of the winding of the switch S^1 as originally traced, this circuit by-passing or short circuiting the resistance r^1 and permitting the switch to close. The switch S^1 in closing, short circuits the section R^1 of the resistance and also closes the auxiliary switch s^1. In case an excess flow of current occurs upon the closure of the switch, current will flow from the positive side of switch S, through the wire 7, the field F, the wire 6, the main contacts of switch S^1, the resistance R^2, the winding of switch S^2, the resistance r^2, the wire 16, the auxiliary switch d^1, the connection 15, the wire 12, and the master controller to the negative main. As previously mentioned, the resistance r^2 is so proportioned that, under the condition just described, the switch S^2 will not close. At the same time, the voltage applied to the winding of switch S^2 is reduced through the drop in voltage caused by the passage of an excess current through the resistance R^2. As the current is reduced through the speeding up of the armature, the drop through the resistance R^2 is reduced and when the proper reduction in current is effected the switch O^4 closes. This short circuits the resistance r^2 and permits current to flow from the positive side of switch S, the wire 7, the field F, the wire 6, the main contacts of switch S^1, the section R^2 of the resistance through the winding of switch S^2, thence through the auxiliary switch s^1, the switch S^3, the switch O^4, the wire 16, the switch d^1, the wire 15, and the wire 12, and the master controller M to the negative main. Switch S^2 then closes.

Switch S^3 operates in a similar manner. When switch S^3 closes, it opens the auxiliary switch s^3 and opens the path through the auxiliary switch s^4 to the master controller. The resistance r^1 is then in series with the winding of the switch S^1, the resistance r^2 in series with the winding of the switch S^2, and the resistance r^3 in series with the winding of the switch S^3. This serves to cut down the amount of current taken by the windings of the switches and prevents the overheating of the windings. It will be seen also that switch S^3 in closing short circuits the winding of the current-controlled relay O. This winding is, therefore, in circuit only during the period of acceleration and may, therefore, be designed for intermittent service.

When the operating lever of the master controller M is moved in the reverse direction from the off-position, that is to say, with its contact brush in contact with the segment u, the reversing switches U^1 and U^2 will close in place of the reversing switches D^1 and D^2. This causes current to pass through the armature of the motor in a direction the reverse of that above described, which will cause the armature to revolve in the reverse direction, as will be readily understood. In this case the control circuit is completed through the auxiliary switch u^1 in place of the auxiliary switch d^1, the remaining circuits and the operation of the remaining switches being the same as above described.

As previously mentioned, during the acceleration of the motor, the current flowing to the motor divides at the end of the section R^2 of the starting resistance, part of it passing directly through the section R^3 of the resistance to the wire 5 and part of it passing through the resistance R^4, the wire 11, the winding of the current-controlled relay O and the wire 10 to the wire 5. Current will divide through these two paths in inverse proportion to the resistances of the paths according to the well known law. For instance, if the resistance of the path through the resistance R^4 and winding of the current controlled relay O is precisely the same as the resistance of the section R^3, exactly one-half of the current will flow through the winding of the relay O. If more resistance be included in the section R^4, less than one-half of the current being taken by the motor will pass through the winding of the relay. If the resistance of the section R^4 be decreased, more than one-half of the current taken by the motor will pass through the winding of the relay. It is thus seen that by adjusting the resistance R^4, any desired proportion of the current taken by the motor may be made to flow through the winding of the current-controlled relay O. This, therefore, forms a ready means of adjusting the maximum current which may be drawn by the motor before the current-controlled relay will act to open the switch s^4 and thus interrupt the successive action of the switches S^1 to S^3. It will be further understood that this construction makes it possible to use a perfectly standard winding for the current-controlled relay O in the case of motors differing widely in power for the reason that any proportion of the motor current from zero to the full current taken by the motor may be made to pass through the winding of the relay by adjusting the resistance R^4 as above described. For instance, if a standard relay is wound for a capacity of 100 amperes, the entire current would be passed through the winding of the relay in case of a motor which required an accelerating current of 100 amperes. If a larger motor required an accelerating current of 200 amperes, one-half of the total current will be passed through the relay. Similarly, in case of a motor requiring 400 amperes, one-fourth of the current would be passed through the relay.

From the description previously given, it will be apparent that the initial rush of current caused by the closure of each of the switches S^1 and S^2 reduces the voltage applied to the succeeding switch by virtue of the drop in voltage caused by the passage of excess current through the portion of the resistance in circuit with the winding of the succeeding switch. This gives the current controlled relay O an opportunity to act before full voltage is applied to the winding of the succeeding switch. The current controlled relay O in acting does not open the circuit of the winding of the succeeding switch, but merely inserts the corresponding resistance of the *r*-series of resistances in circuit with the winding, or rather, opens the short-circuit around the resistance *r*, which permits current to flow through the winding of the succeeding switch, but limits the value of the current to such a point that the switch will not close. Therefore, the operating electro-magnet of the switch is not entirely deënergized and the switch will close much more quickly when the current-controlled relay returns to its normal position than would be the case if its circuit had been entirely open and its electro-magnet entirely deënergized by the action of the current-controlled relay. The reason for this is on account of the fact that the building up of the magnetic flux in any electro-magnet, particularly one in which the magnetic circuit is not laminated, requires an appreciable interval of time.

In Figs. 2 and 3, N is a base, such as slate, upon which the parts are mounted. O^1 is a magnetizing coil of the relay O which is provided with terminals O^7 and O^8 extending through the base N and provided with suitable attachments for connecting the winding in circuit. The coil O^1 is mounted upon and suitably insulated from a non-magnetic tube O^2. P is a casing, preferably of cast iron in which the apparatus is mounted. This casing is closed at its rear side by the base N and its front side is provided with a removable cover p^2 so constructed that, when the cover is in place, the apparatus is completely inclosed. The non-magnetic tube O^2 is tapped into a cross piece P^1 within the case and a yoke of magnetic material p^1 is slipped over the upper end of the tube and rests upon shoulders P^2 in the case. O^3 is the plunger of the electro-magnet, which, upon the flow of a predetermined current through the winding O^1, rises and lifts the contact disk O^4 from contact with the pins O^5 and O^6. The disk O^4 is suitably insulated from the plunger as indicated. The upward motion of the plunger is limited by the lower end of the brass tube O^2. It will be noted that the plunger O^3 when in its uppermost position by no means completes the magnetic circuit of the electro-magnet, there being still a considerable air gap between the upper end of the plunger and the yoke p^1. This is for the purpose of rendering the relay more sensitive in action, particularly in causing the plunger O^3 to drop when the current flowing through the magnetizing winding O^1 is decreased to the necessary extent.

The cover p^2 of the casing fits in a slot p^3 at its lower end and is provided near its upper end with a hook p^5, which engages with the end of a pivoted latch p^4, which is made of magnetic material and is inclosed within the case, so that there is no ready means of gaining access to it mechanically. To release the latch so that the door p^2 may be removed the pole of a magnet will be placed above the latch p^4 at the point p^6, which will cause the rear end of the latch to rise, thereby releasing its hooked end from the hook p^5. This construction is adopted to prevent others than those properly equipped for caring for the apparatus from gaining access to the relay coil and interfering therewith.

The screws p^7 and p^8 which secure the casing to the base fit in counterbored holes in the base N and are preferably sealed in place so that they cannot be readily tampered with.

I claim—

1. In an electric controller, sections of resistance, magnetically operated switches for controlling said resistance, and a relay for controlling the action of said switches, said relay having its winding in a circuit connected in a shunt to a portion of said resistance.

2. In an electric controller, sections of resistance, magnetically operated switches for controlling said resistance, the last of said resistance sections to be cut out being made up of two banks of resistance in parallel, and a governing relay having its winding in series with one of said parallel banks of resistance.

3. In an electric controller, sections of resistance, magnetically operated switches for controlling said resistance, the last of said resistance sections to be cut out being made up of two banks of resistance in parallel, a governing relay having its winding in series with one of said parallel banks of resistance, and means for adjusting the amount of resistance in one of said parallel banks.

4. In an electric controller, sections of resistance for limiting the flow of current to a motor, magnetically operated switches for controlling said resistance, each of said switches having one end of its winding connected to a point on said resistance, an auxiliary resistance connected to the remaining end of each of said windings and

to one side of the supply circuit, an auxiliary switch operatively connected with each of said first named switches and controlled by the next preceding switch, a short-circuit including the auxiliary switch of said last named switch, the short-circuit passing around each auxiliary resistance, and a current-controlled relay having its contacts in the path short-circuiting said resistance.

5. In an electric controller, a motor circuit, the combination of sections of resistance in the motor circuit, magnetically operated switches for controlling said resistance, each of said switches having one end of its winding connected to one of the supply mains through a portion of said resistance, and an auxiliary resistance for each winding having one end connected to the remaining end of said winding and the other end thereof to the other supply main.

6. In an electric controller, the combination of sections of resistance in a motor circuit and magnetically operated switches for controlling said resistance, each of said switches having one end of its winding connected to one of the supply mains through a portion of said resistance, an auxiliary resistance for each winding having one end connected to the other supply main and the other end to the remaining end of the said winding, and means for short-circuiting said auxiliary resistance.

7. In an electric controller, the combination of sections of resistance in a motor circuit, magnetically operated switches for controlling said resistance, each of said switches having one end of its winding connected to one of the supply mains through a portion of said resistance, an auxiliary resistance for each winding having one end connected to the other supply main and the other end to the remaining end of said winding, and a current-controlled relay having contacts which short-circuit said auxiliary resistance when less than a predetermined current is flowing through the winding of said relay.

8. In an electric controller, the combination of sections of resistance in a motor circuit, magnetically operated switches for controlling said resistance, each of said switches having one end of its winding connected to one of the supply mains through a portion of said resistance, an auxiliary resistance for each winding having one end connected to the other supply main and the other end to the remaining end of said winding, and means for short-circuiting said auxiliary resistance, said means comprising an auxiliary switch closed by the closure of a preceding resistance-controlling switch and a current-controlled relay.

9. In an electric controller, a motor circuit, a series of separately-actuated magnetically-operated resistance switches, a separate auxiliary resistance for each switch and in series with the winding of its respective switch, and means for short-circuiting said resistance when the current falls below a predetermined strength.

10. In an electric controller, a motor circuit, a series of separately-actuated, magnetically-operated resistance switches, an auxiliary resistance in series with the winding of each switch, a short-circuit around the auxiliary resistance of each closed resistance switch, and means for opening the short-circuit when the current in said circuit rises above a predetermined strength.

11. In an electric controller, a resistance, a series of separately actuated magnetically operated resistance switches, and a relay for controlling the said switches, the winding of said relay being in shunt to a portion of the resistance controlled by the last resistance switch whereby said winding is short circuited when said last resistance switch closes.

12. In an electric controller, the combinations of sections of resistance, magnetically operated switches for controlling said resistance, a current controlled relay having a single winding and governing the closure of said switches, and means for varying the proportion of current which will flow through the winding of said relay.

Signed at Cleveland, Ohio, this 10th day of January, A. D. 1907.

ARTHUR C. EASTWOOD.

Witnesses:
J. E. WELLMAN,
M. N. REED.