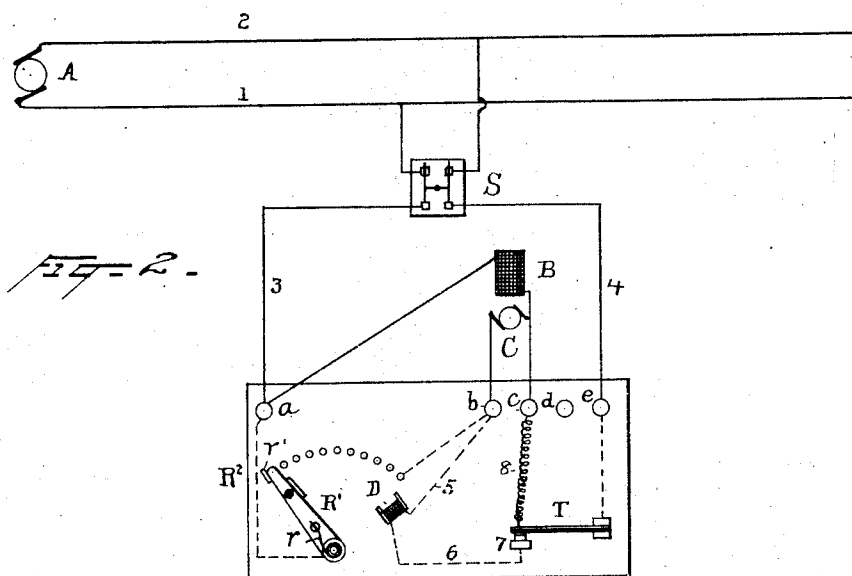
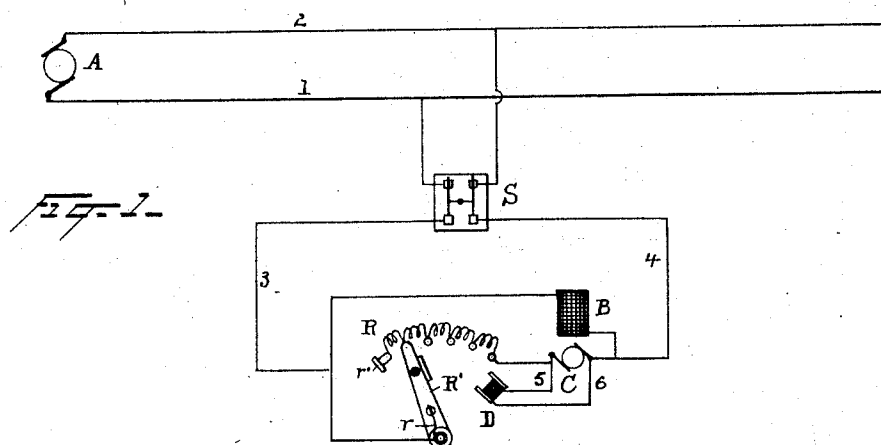


H. W. LEONARD.
RHEOSTAT AND CIRCUIT CONTROLLER.

No. 585,444.

Patented June 29, 1897.



Witnesses
Thomas A. Clark.
W. Byer

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Harry Ward Leonard
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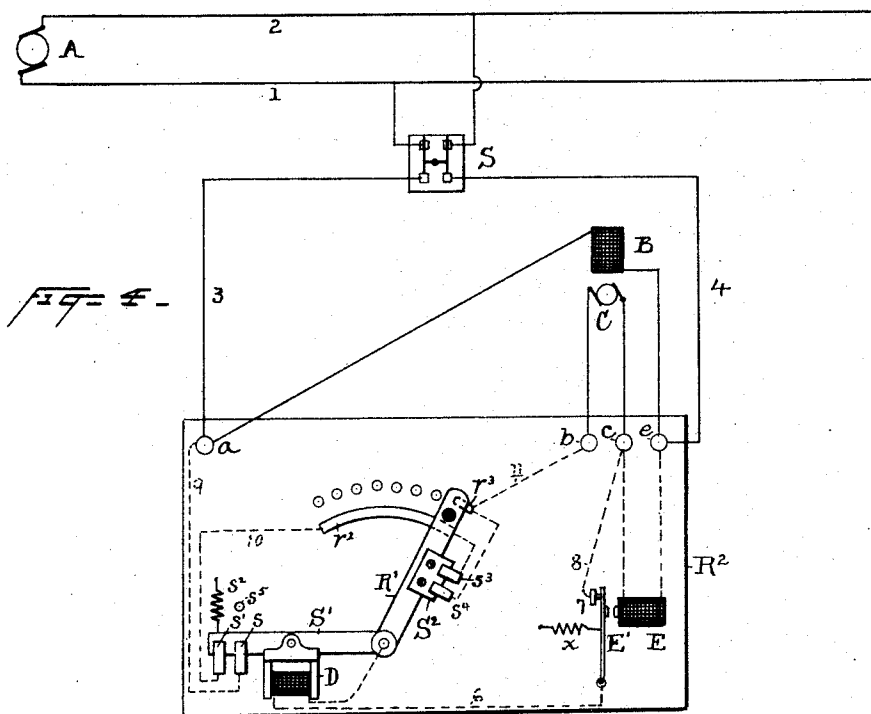
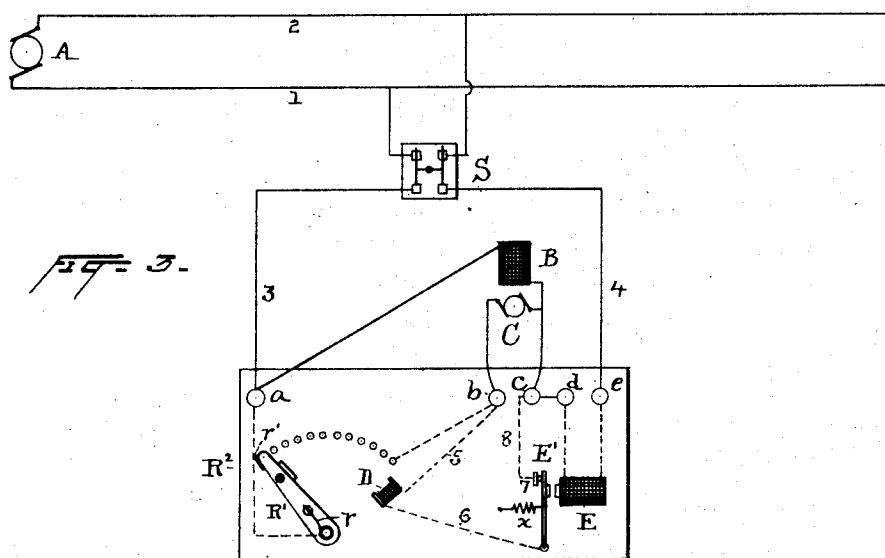
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UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF EAST ORANGE, NEW JERSEY.

RHEOSTAT AND CIRCUIT-CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 585,444, dated June 29, 1897.

Application filed November 24, 1896. Serial No. 613,242. (No model.)

To all whom it may concern:

Be it known that I, HARRY WARD LEONARD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Rheostats and Circuit-Controllers, of which the following is a specification.

My invention relates to rheostats, and particularly to motor-starting rheostats having means for automatically protecting the motor against excessive current under certain conditions. In such apparatus it has been customary to employ a controlling-electromagnet for locking the contact-lever of the rheostat in position when all of the resistance has been cut out of circuit, which magnet upon a decrease or failure of the current on the line would release the contact-lever and allow the same to return automatically to its starting position. Many devices of this general character have been heretofore proposed and put into use, and in most of these devices it has been usual to place the controlling-electromagnet in series with the field-winding of a shunt-wound motor; but there are many objections to this arrangement, both as regards manufacture and use.

It is well known that the amperes passing through the field-magnet of a shunt-wound motor vary greatly with motors of different size and make. Even with motors of the same make there is no definite relation between the field-current and the armature-current. It will be understood that the ampere-turns required for a certain field can be obtained with comparatively few turns and comparatively large amperes or with a comparatively large number of turns and small amperes. Hence it is frequently found in practice that a motor of comparatively small horse-power will require a larger field-current than that required for the field of a motor of the same voltage but of many times larger horse-power. Stating this in another way, motors of the same horse-power and voltage, but of different make, will require field-currents varying widely, even as much as six to one. Furthermore, motors are frequently wound with both a shunt and a series winding, in which case the shunt-winding will

have a different number of amperes from that which it would require were there no series winding. It will be evident, therefore, that if in the manufacture of rheostats provided with automatic controlling-magnets only the horse-power and voltage of the motor be taken into consideration the action of the controlling-magnet would be dependent upon a field-current of indefinite amount. Thus if such a rheostat—say one designed for a five-horse-power two-hundred-and-twenty-volt motor—be employed with a motor of that capacity, but requiring 1.5 amperes in its shunt field-circuit, the action of the controlling-magnet in that case would be materially different from the action of the same magnet were it used with a similar motor requiring but .5 of an ampere. In the first case the ampere-turns would be three times that of the second case, and the watts developed in the magnet of the first case would be nine times as much as in the magnet of the second case. If the controlling-magnet of the rheostat be suitable for the motor requiring .5 of an ampere, the result would be that the magnet would become excessively hot if used with the motor requiring 1.5 amperes, and the comparatively high resistance of the magnet-winding in series with the comparatively low resistance-field of the motor requiring 1.5 amperes would weaken the field of that motor, and hence the speed of its armature would vary from its rated speed and the tendency to spark at the motor-brushes would be increased. If the magnet were designed for the motor requiring 1.5 amperes and used with the other motor, it would have insufficient ampere-turns, and hence would not reliably hold the rheostat-lever. Another objection to this style of rheostat is that it cannot be used with a series motor on a constant electromotive-force circuit, as such a motor would have no shunt field-winding.

It is of the greatest importance to the manufacturer of rheostats and to the manufacturer of motors (as a general rule two different and independent manufacturers) that any rheostat designed for a continuous-current motor of a given horse-power and voltage—for instance, five-horse power and two hundred and twenty volts—shall be suitable for

use with any five-horse-power motor on a two-hundred-and-twenty-volt circuit, whether it be a shunt, compound, or series wound motor and entirely regardless of its field-winding. When that is accomplished, rheostats can be manufactured in quantities and carried in stock without the necessity of making special parts to suit the varying conditions. One feature of my invention accomplishes this object. I provide an electro-responsive controlling device, such as a magnet, which in practice is connected directly across the terminals of the armature of a motor or other translating device to lock a circuit-controller, which may be either a switch or a rheostat contact-lever. The magnet is wound for a given voltage, and its action will always be dependent upon the electromotive force upon the terminals of the motor or other translating device. In practice there are three voltages commonly in use, the most common being two hundred and twenty volts, such as is met with upon the outside wires of the Edison three-wire system, the second being about five hundred volts, which is frequently used from railway-circuits and special circuits for power uses, and the third about one hundred and ten volts, which is the voltage of the ordinary two-wire continuous-current incandescent-lighting plants. Thus I am enabled to greatly reduce the number of kinds of magnets to be manufactured for use with rheostats of the character described, and three standard sizes only need be manufactured in quantities for stock purposes for the voltages above stated, thus greatly simplifying the process and cost of manufacture and also simplifying the handling and broadening the field of use of such rheostats. By placing the controlling-magnet across the armature-terminals of a motor the magnet is not subject to the injurious effects which would result from the discharge of the field-magnet coils upon the opening of the armature-circuit, as would be the case were the magnet connected across the line as a shunt to the field of the motor.

A further feature of my invention is the employment of a winding for the controlling-magnet made of a metal wire whose material has a very high specific resistance or resistivity. Heretofore in winding magnets for uses similar to this it has been customary to wind them with copper wire, so as to secure the greatest number of ampere-turns possible with a certain resistance; but to make a magnet wound with copper wire so as to go directly across five hundred volts would be very expensive and the magnet would be very large and cumbersome. It must be borne in mind that to be commercially practicable the magnet must be quite small. This means that it must have but a few watts to dissipate or it will get so hot as to destroy itself. Also it must be cheap. I have found that I can secure an extremely economical result by winding

the magnet, not with copper, as heretofore customary, but with a wire having the highest possible ohms per foot.

To secure the high ohms per foot, I use a material of the highest commercially-obtainable specific resistance and use a wire of the finest size consistent with cost and handling. In practice I use a wire whose specific resistance is more than fifty times that of copper and have it drawn down to a size of four mills—that is, .004 inch. This wire measures more than thirty ohms per foot. I take a magnet-core about one-fourth inch in diameter and about one and one-quarter inches long and wind upon it about four thousand turns of this wire to make a magnet suitable to use upon two-hundred-and-twenty-volt circuits. The resistance of this winding is about ten thousand ohms, the watts developed will be about five, and the ampere-turns about ninety. This magnet is very small and can be conveniently placed upon a rheostat of even the smallest size used in practice, and the cost of manufacture is quite low in view of the features above pointed out.

A further feature of my invention is the employment of separate means for opening the shunt-circuit in which the controlling-magnet is placed upon an abnormal increase of energy in the motor-circuit. This object may be accomplished by placing a switch in the shunt-circuit of the controlling-magnet, which is normally held closed and which may be opened under abnormal conditions either by a magnet or a thermostat or an equivalent device placed in series with the armature. When a magnet is employed for this purpose, it is wound with wire having the highest possible conductivity.

A further feature of my invention is the employment of a snap cut-out switch for controlling the armature-circuit. A locking or controlling magnet is provided for this switch, which releases the switch upon the development of abnormal conditions in the circuit and allows the switch to automatically open the armature-circuit. With such an arrangement the rheostat contact-lever is not preferably provided with a spring for restoring it to starting position, as heretofore, and I can therefore considerably increase the degree of frictional engagement between the contact lever and plates, thus producing better electrical connections and preventing the heating thereat. This arrangement results in an efficient apparatus for large motors requiring heavy currents. To further reduce heating at contact-points, the cut-out switch has two contact-plates bridged by the switch-blade, one of which plates is connected to the line and the other to a rheostat-plate. With this arrangement no current is carried through the pivots of the switch and rheostat contact-lever, thus avoiding heating at those points; and to prevent heating at the final contact of the rheostat I provide the rheostat contact-

lever with a switch-blade which bridges two sets of contact-plates to short-circuit the rheostat-contacts.

My invention is illustrated in the accompanying drawings, in which—

Figure 1 is a diagram illustrating a shunt-wound motor operated from a constant electromotive-force circuit and provided with a controlling-magnet connected across the terminals of the motor, the main circuit to the motor being controlled by a main-line switch. Fig. 2 illustrates a similar arrangement with the addition of a thermostatic circuit-controller in series with the motor-armature for opening the circuit of the controlling-magnet upon an abnormal increase in the current through the motor-armature. Fig. 3 is an arrangement similar to Fig. 2, but illustrating the use of a magnet in place of the thermostat, and Fig. 4 shows the arrangement of Fig. 2 embodied in a rheostat having a separate switch-lever for controlling the armature-circuit and a device for short-circuiting the rheostat-contacts when the resistance is entirely cut out of circuit.

Referring to Fig. 1 of the drawings, A indicates the generator supplying current to the line 1 2, and S is a double-pole main-line switch. From the main-line switch extend the conductors 3 4, across which the field-magnet B of the motor is connected in shunt relation to its armature C, which is connected in series with the resistance R of the rheostat. The controlling-magnet D for the contact-lever of the rheostat is connected in a shunt 5 6 across the armature-terminals of the motor. From this illustration it will be seen that any decrease in the electromotive force upon the armature-terminals of the motor below the normal electromotive force for which the motor is designed and for which the controlling-magnet is wound will immediately decrease the magnetism of the controlling-magnet, and any very great decrease below its normal magnetism will cause the magnetism to become insufficient to hold the contact-lever R' of the rheostat against the pull of its spring τ , whereupon the spring will return the contact-lever to the starting position. In practice I construct the first contact-plate of the rheostat with a lug τ' , against which the contact-lever will strike, because I prefer not to open the armature-circuit, the resistance inserted, however, being sufficient to protect the armature from excessive current. By this arrangement of connections I prevent any injurious effects which would result upon the opening of the armature-circuit, although I may, when desired, open the armature-circuit without detrimental results to the controlling-magnet, since it is protected by reason of its being connected so as to be free from the discharge of the field-coils, as before stated. Furthermore, all sparking at the rheostat due to opening the armature-circuit is avoided.

In Fig. 2 the rheostat-contacts and contact-lever with its controlling-magnet are mount-

ed upon a rheostat-plate R², which is provided with a set of binding-posts a, b, c, d , and e . The circuit-wires 3 4 from the main-line switch are connected to the binding-posts a and e , respectively. The field of the motor is connected between the binding-posts a and c . The resistance of the rheostat is connected between the binding-posts a and b , and the armature is connected between the binding-posts b and c , the armature being connected in series with the resistance of the rheostat between the posts a and c . The controlling-magnet D is connected in a shunt-circuit across the terminals of the motor-armature at binding-posts b and c , the connection being from the post b by wire 5 through the magnet and wire 6 to contact 7, the thermostat T and wire 8 to the post c . The field and armature circuits are connected with the main-line wire 4 from the binding-post c , through the wire 8, thermostat T, to binding-post e . The operation of the controlling-magnet D is the same as with the arrangement indicated in Fig. 1, except that its shunt-circuit is designed to be opened by the thermostat T by reason of an increase in temperature, due either to the heating of the conductors upon an abnormal increase of energy in the armature-circuit or to the abnormal heating of the rheostat-plate, or both.

In motor-starting rheostats the resistance is not designed to be kept in circuit for any length of time, as in the case of speed-regulating rheostats, and hence it becomes desirable to provide some means which will prevent injury to the starting-rheostat should the contact-lever be held at intermediate positions, leaving resistance in circuit unnecessarily and an undesirable length of time. This objection is obviated by the use of the thermostatic controller T, which will automatically open the circuit when the rheostat becomes excessively heated from the cause stated.

The arrangement and connections of Fig. 3 are identical with those of Fig. 2, with the exception of the substitution of the magnet E for the thermostat T. This magnet controls a switch E' in the shunt-circuit 5 6 7 8, and which is normally held closed by the spring α . Magnet E is connected between binding-posts d and e , thus placing it between the motor-circuit and the main-line conductor 4. This magnet is wound with a wire of the highest possible conductivity—such, for instance, as copper—so as to obtain the cheapest and most compact and economical form of magnet for the purpose required, and this magnet is designed to operate so as to open the switch E' only upon an abnormal increase of current through the motor-armature.

In the ordinary form of rheostat the current passes through the contact-lever, and where an automatic device of the general character herein described is employed for restoring the rheostat to starting position the contact-lever must have a light frictional engagement with

the rheostat-contacts in order to avoid the sticking of the contact-lever through friction and insure its return when the automatic device operates. With heavy currents, such as required for large motors, the contact-lever must be in heavy frictional engagement with the rheostat-contacts, so as to prevent heating at the contacts, especially in the case of speed-regulators, where the contact-lever is kept at intermediate positions for long periods; but since the degree of friction necessary to give proper contact will necessitate a very strong spring to throw the contact-lever to starting position with any degree of certainty the apparatus becomes objectionable on account of the force required to move the contact-lever over the contacts. With large motors a serious objection against moving the contact-lever backward, so as to insert resistance, is that this causes detrimental sparking between the contact-lever and the rheostat-contacts. This sparking results in such an increased friction that the spring will frequently fail to move the lever to the starting position against the increased friction, and consequently the automatic controlling devices will fail to perform their function. To obviate these difficulties, I employ the arrangement of Fig. 4. In that arrangement I show a separate switch, preferably a knife-switch, for the motor-circuit and another knife-switch for short-circuiting the contact between the rheostat-lever and the contact-plates when the resistance is all cut out of circuit. In this way I avoid the necessity of conducting the current through the switch-pivot, and the frictional engagement between the rheostat contact-lever and the contact-plates may be of any desired degree, and by short-circuiting the contacts at the final position of the contact-lever by means of a knife-switch all undue heating is avoided.

Referring to Fig. 4, the rheostat contact-lever R' is designed in its movement to the left to close the knife-switch S', which bridges the contact-plates s s' and closes the circuit 9 10 from the binding-post a to the contact-plate r², with which the contact-lever R' makes contact in moving over the contact-plates. The closing of switch S' establishes a circuit as follows: from line 3 and binding-post a by wire 9 to plate s, switch-blade S' to plate s', wire 10 to contact-plate r², contact-arm R' to the rheostat contact-plates, and through the resistance and wire 11 to binding-post b. The armature C is connected between the binding-posts b and c, and the circuit from the binding-post c to binding-post e and line-wire 4 is through the magnet E. Thus it will be seen that no current passes through a switch-pivot in reaching the armature. In this arrangement the controlling-magnet D is connected between the pivot of switch S' and the binding-post c, so that the magnet D becomes energized as soon as the switch S' is closed, even though the armature-circuit should be open or contain a high resistance. When the

contact-lever R' reaches its final position, the knife-switch S', carried thereby, bridges the contacts s³ s⁴, which are connected with the contact-plates r² and r³, respectively, and hence the circuit to the armature C is from wire 10 by way of plate r² to plate s³, knife-switch S' to plate s⁴, to contact r³, and wire 11 to post b. Thus it will be seen that when the rheostat-lever reaches its final position and the armature C is receiving its full current the circuit thereto will be through direct wire connections and knife-switches making heavy frictional contact, and thus all heating at contact-points is avoided. The actions of the controlling-magnets D and E are the same as with the arrangements already described and need no further description. When the current to magnet D fails, due to any cause, the spring s² will pull the knife-switch S' with a quick snap against the stop s⁵ and open the armature-circuit, which cannot be reestablished until the contact-lever R' is brought back to its starting position, which movement, as before explained, moves the switch S' to the position indicated. With this arrangement the lever R' does not require a spring, as heretofore, and hence the degree of friction between it and the contacts may be considerably increased, although a spring may be employed with starting-rheostats, if desired, to guard against leaving the contact-lever at intermediate positions.

While I have shown and described my arrangement of electroresponsive devices as applied to rheostats, it will be understood that such arrangement may be applied to automatic switches as well. Furthermore, it will be understood that rheostats or switches provided with my improved controlling devices may be employed in handling all forms of translating devices, both on continuous and alternating current systems.

What I claim is—

1. The combination, in an automatic circuit-controller, of an electroresponsive device connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device, a circuit-controller held by said device in a definite position under normal conditions and which device releases said controller when the electromotive force at the terminals of the translating device is abnormally low, means for effecting the release of said controller when the current through the translating device is abnormally large, and means for operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

2. The combination, in an automatic circuit-controller, of an electroresponsive device connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device, a circuit-controller held by said device in a definite position under normal conditions and

which device releases said controller when the electromotive force at the terminals of the translating device is abnormally low, a device in series with the translating device for effecting the release of said controller when the current through the translating device is abnormally large, and means for operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

3. The combination, in an automatic circuit-controller, of an electroresponsive device, a circuit-controller held by said device in a definite position under normal conditions and which device releases said controller under abnormal conditions, said device having a high-resistance winding composed of a material having high resistivity, an electroresponsive device for effecting the release of said controller when the current through a translating device becomes abnormally large, said latter device having a low-resistance winding, and means for operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

4. The combination, in an automatic circuit-controller, of an electroresponsive device, a circuit-controller which in opening the circuit first inserts a resistance and then opens the circuit, said controller being held by said device in a definite position under normal conditions and which device releases said controller under abnormal conditions, said device having a high-resistance winding composed of a material having high resistivity, an electroresponsive device for causing the release of the controller when the current through a translating device becomes abnormally large, said latter device having a low-resistance winding, and means for operating said controller when released to open the circuit to a translating device, substantially as set forth.

5. In a rheostat, the combination with a circuit-controller, of an electroresponsive device connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device and which holds said controller in a definite position under normal conditions and releases it when the electromotive force at the terminals of the translating device is abnormally low, means for effecting the release of said controller when the current through the translating device is abnormally large, and means for automatically operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

6. In a rheostat, the combination with a circuit-controller, of an electromagnet connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device and which

holds said controller in a definite position under normal conditions and releases it when the electromotive force at the terminals of the translating device is abnormally low, means for effecting the release of said controller when the current through the translating device is abnormally large, and means for automatically operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

7. In a rheostat, the combination with a circuit-controller, of an electromagnet connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device and which holds said controller in a definite position under normal conditions and releases it when the electromotive force at the terminals of the translating device is abnormally low, an electromagnet for effecting the release of said controller when the current through the translating device is abnormally large, and means for automatically operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

8. In a rheostat, the combination with a circuit-controller, of an electroresponsive device having a high-resistance winding composed of a material having high resistivity and connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device and which holds said controller in a definite position under normal conditions and releases it when the electromotive force at the terminals of the translating device is abnormally low, means for effecting the release of said controller when the current through the translating device is abnormally large, and means for automatically operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

9. In a rheostat, the combination with a circuit-controller, of an electroresponsive device having a high-resistance winding composed of a material having high resistivity and connected across the terminals of a translating device so as to be subjected to the same electromotive force as the translating device and which holds said controller in a definite position under normal conditions and releases it when the electromotive force at the terminals of the translating device is abnormally low, an electroresponsive device having a low-resistance winding and connected so as to effect the release of said controller when the current through the translating device is abnormally large, and means for automatically operating said controller when so released to prevent or reduce the flow of current through the translating device, substantially as set forth.

10. In a rheostat, the combination of a rheo-

stat contact-lever for varying the resistance in circuit, a switch-lever for controlling the circuit to the rheostat, an electroresponsive device connected across the terminals of a translating device for holding said switch in its closed position under normal conditions and which releases the switch under abnormal conditions, and means for automatically opening said switch when so released to prevent the flow of current to the translating device, substantially as set forth.

11. In a rheostat, the combination of a rheostat contact-lever for varying the resistance in circuit, a knife-switch for controlling the circuit to a translating device, an electroresponsive device connected across the terminals of the translating device for holding said switch in its closed position under normal conditions and which releases the switch under abnormal conditions, and a spring for opening said switch when so released to prevent the flow of current to the translating device, substantially as set forth.

12. In a rheostat, the combination with the rheostat contact-lever and the resistance contact-plates, of a switch for controlling the circuit to a translating device, means for holding said switch closed under normal conditions and which releases said switch under abnormal conditions, means for opening said switch when so released, and means carried by the rheostat contact-lever for short-circuiting the rheostat-contacts when all the resistance is cut out of circuit, whereby the heating of the contact-lever and contact-plates is prevented, substantially as set forth.

13. In a rheostat, the combination with the rheostat contact-lever and the resistance contact-plates, of a switch for controlling the circuit to a translating device, means for holding said switch closed under normal conditions and which releases said switch when the electromotive force at the terminals of the translating device becomes abnormally low, separate means for causing the release of said switch when the current becomes abnormally large, means for opening said switch when so released, and means carried by the rheostat contact-lever for short-circuiting the rheostat-contacts when all the resistance is cut out of circuit, whereby the heating of the contact-lever and contact-plates is prevented, substantially as set forth.

14. The combination with a constant electromotive-force circuit, of a motor connected therewith through a line-switch, a rheostat having a contact-lever for varying the resistance in circuit, a second contact-lever, an electroresponsive device connected across the armature-terminals of the motor so as to be subjected to the same electromotive force as the armature and adapted under normal conditions to hold the last-named contact-lever in a definite position, and means for operating said lever when released by said device

under abnormal conditions, substantially as set forth.

15. The combination with a constant electromotive-force circuit, of a motor having a shunt-field winding, a rheostat connected therewith so as to form a closed circuit through the field and armature windings, and having a contact-lever for varying the resistance in circuit, a magnet connected across the armature-terminals of the motor and adapted under normal conditions to hold the contact-lever of the rheostat in a definite position, means for returning the contact-lever to its starting position when released by said magnet under abnormal conditions, and a device for opening the magnet-circuit when the current through the motor-armature becomes abnormally large, substantially as set forth.

16. The combination with a circuit-controller, of means for holding said controller in a definite position under normal conditions and which releases said controller when the electromotive force at the terminals of a translating device becomes abnormally low and independently of the current through the translating device, means for effecting the release of said controller when the current through the translating device becomes abnormally large and independently of the electromotive force at the terminals of the translating device, and means for operating the controller when so released to prevent or reduce the flow of current, substantially as set forth.

17. The combination in a circuit-controller, of an electroresponsive device connected across the circuit and arranged to hold the circuit-controller in its closed position, and means for opening the circuit of said device to effect the release of said circuit-controller, substantially as set forth.

18. An electromagnet in multiple arc with a translating device across a constant electromotive force and a second electromagnet in series with the said translating device, the said second magnet causing the demagnetization of the first magnet whenever the current through the translating device exceeds a predetermined maximum, substantially as set forth.

19. An electroresponsive device in multiple arc with a translating device across a constant electromotive force and a second electroresponsive device in series with the said translating device, the said second electroresponsive device causing the demagnetization of the first electroresponsive device whenever the current through the translating device exceeds a predetermined maximum, substantially as set forth.

This specification signed and witnessed this 23d day of November, 1896.

HARRY WARD LEONARD.

Witnesses:

EUGENE CONRAN,
W. PELZER.