H. W. LEONARD.

ELECTRIC CIRCUIT CONTROLLER.

APPLICATION FILED APR. 6, 1906.

941,425. **Patented Nov. 30, 1909.**

3 SHEETS—SHEET 1.

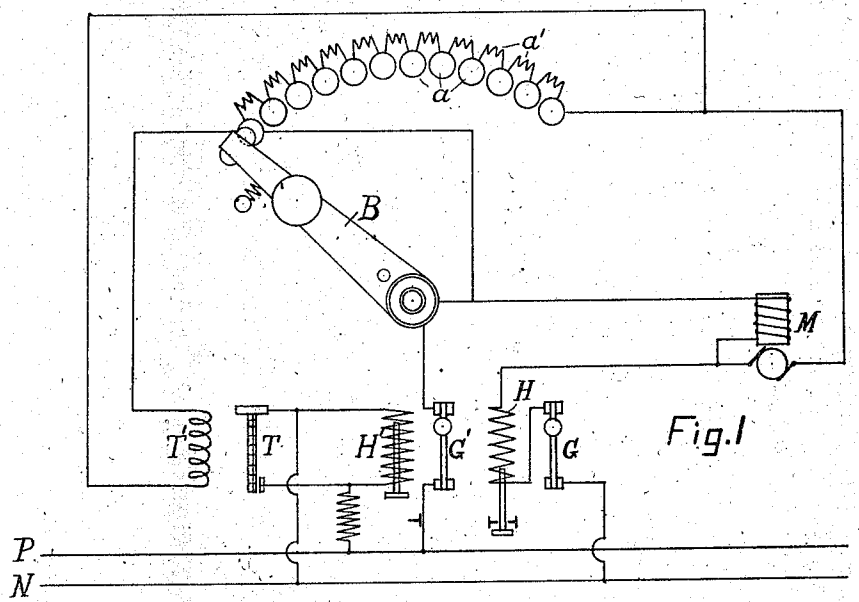

Fig. 1

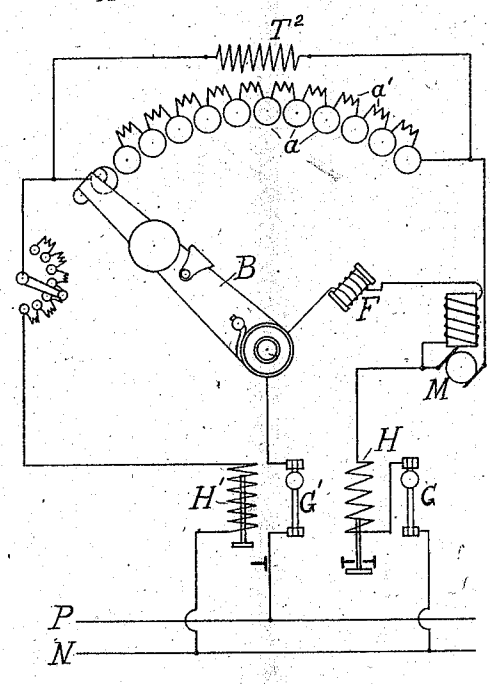

Fig. 2

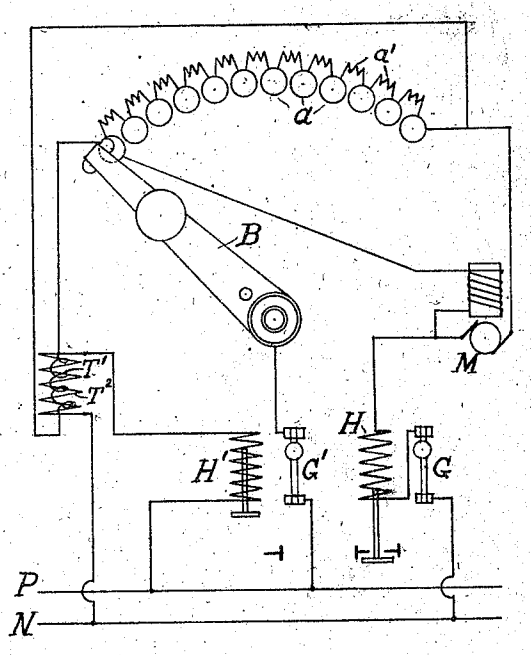

Fig. 3

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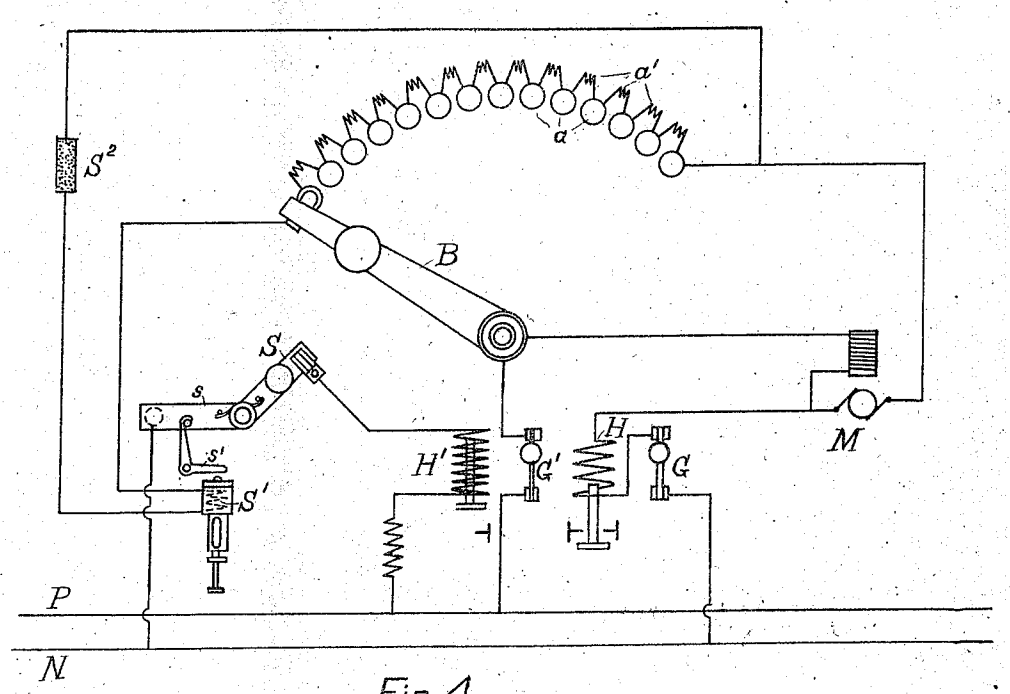

Fig. 4

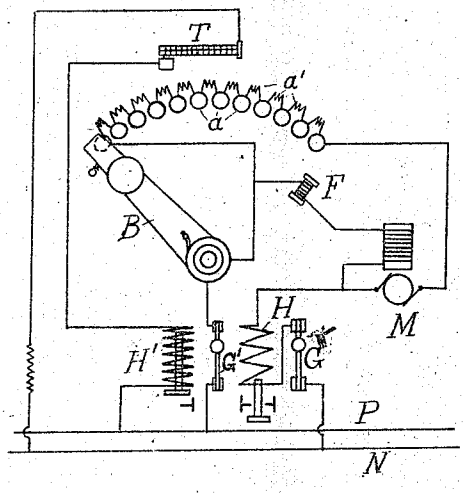

Fig. 5

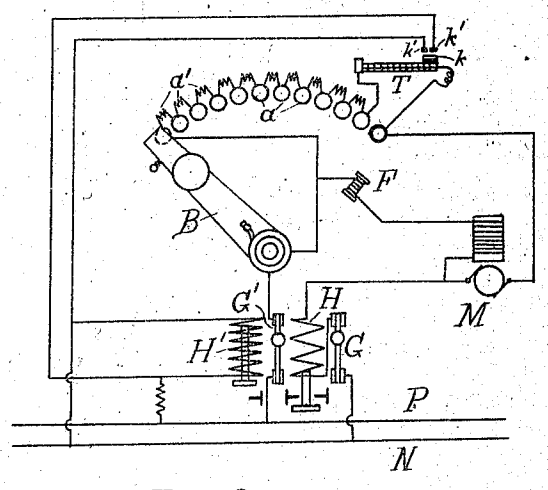

Fig. 6

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3 SHEETS—SHEET 3.

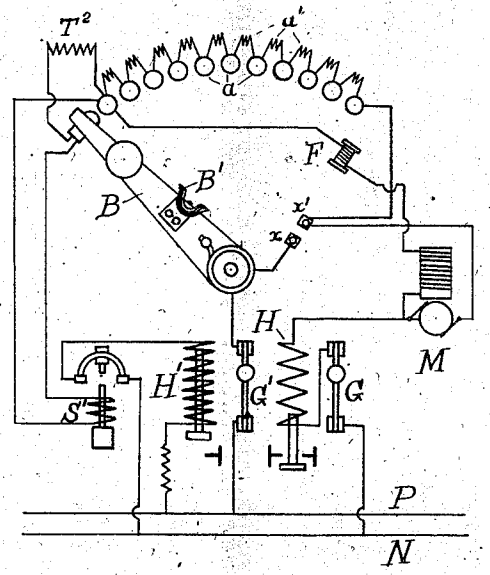

Fig. 7

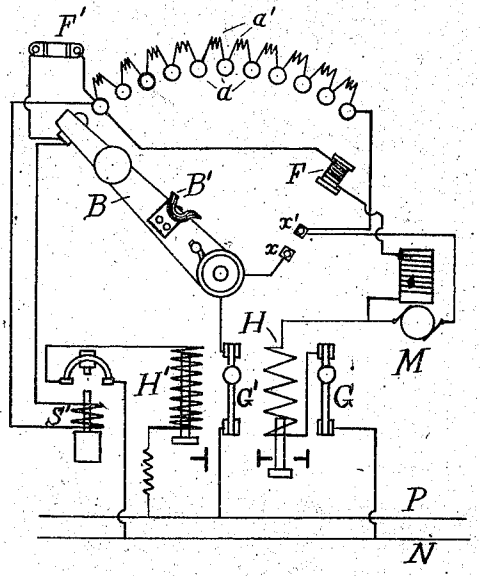

Fig. 8

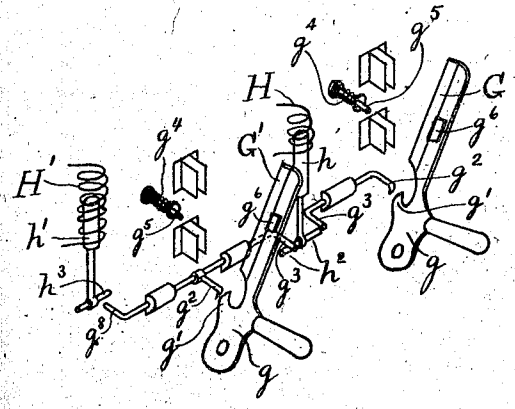

Fig. 9

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UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF BRONXVILLE, NEW YORK.

ELECTRIC-CIRCUIT CONTROLLER.

941,425. Specification of Letters Patent. Patented Nov. 30, 1909.

Original application filed November 30, 1901, Serial No. 84,188. Divided and this application filed April 6, 1906. Serial No. 310,199.

To all whom it may concern.

Be it known that I, HARRY WARD LEONARD, a citizen of the United States, residing at Bronxville, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Electric-Circuit Controllers, of which the following is a full, clear, and exact specification.

This application is a division of my pending application filed November 30, 1901, Serial No. 84,188, renewed December 20, 1904, Serial No. 237,653, granted April 10, 1907, Patent No. 817,719, and relates generally to controlling switches and has a particular application to motor starting rheostats, or rheostats employed with electric motors or other electrical translating devices, in which the resistance is employed not for regulating the energy supplied to the motor or other translating device, but mainly for gradually raising the energy at the terminals of the translating device to the full electromotive force.

My invention is also of importance where regulating resistances are used and to prevent their improper operation.

I have found in practice that starting rheostats are frequently damaged by holding or permitting the contact lever to remain on the initial or starting contact or contacts near the same with all the resistance of the rheostat or a considerable portion thereof in circuit. I have also found that operators frequently close the circuit at the initial or starting contact of the rheostat and then return the lever to the idle position, thus drawing an arc at the initial contact. This also damages the rheostat. I have also found that sometimes operators close the main circuit when the resistance controlling device which might be used as a regulator is in an intermediate position. This, of course, allows an excessive and damaging flow of current.

The main object of my invention is to devise a starting rheostat or controller, or to provide the present type of starting rheostats with a controlling device, which will prevent this improper handling of such rheostats. I have devised many ways for carrying out this object, both mechanically and electrically.

The full torque current is the current which the motor takes when developing its full rated horse power. In starting any motor it becomes necessary to produce a torque larger than that due to the full torque current, because the motor and the load have to be accelerated and during the period of acceleration, a larger current will be required than that necessary after the motor has been accelerated to full speed. In the manufacture of motor starting rheostats, it is common practice to have such a resistance in the rheostat that the current which will flow when the motor is at rest, and the first contact is made at the rheostat, will be fifty per cent. larger than the current taken by the motor when producing its normal full torque. In other words, this starting accelerating current is fifty per cent. larger than the full torque current, that is, it is one hundred and fifty per cent. of the full torque current.

In order to prevent the burning at the initial contact of the rheostat, due to the closing of the circuit upon insufficient surface, or due to the backward movement of the contact lever after making the first contact, which results in the formation of an arc due to the full electromotive force and one hundred and fifty per cent. of the full torque current (when the motor has no counter electromotive force), the rheostat should be provided with an auxiliary switch, by which the circuit is closed upon an ample surface and which switch will open the circuit with a snap-action when the contact lever is returned to the initial position. This auxiliary switch should be beyond direct hand control in opening and may be mechanically or electrically controlled by the rheostat contact lever or controlling switch.

In my original application I have disclosed two forms of my invention, in which the auxiliary switch is mechanically controlled. The present application relates to forms in which the control of the auxiliary switch is by electrical means, and more particularly to constructions in which a predetermined interval of time is caused to elapse before the automatic action of the auxiliary switch or switches takes place. An advantage of this construction is that excessive currents which may exist only for a short interval and which may not be harmful, are allowed to pass without causing the operation of the automatic devices, but when continued for a longer period or periods, the

controlling devices will be actuated and the harmful effects which might occur by a continuance of the conditions are avoided.

My invention includes various other improvements and advantages which will be understood from the following description and accompanying drawings.

Figure 1 is a diagrammatic view showing one form of my invention; Figs. 2 to 8 inclusive, are similar views of modified forms of my invention; and Fig. 9 is a perspective view indicating the construction of certain parts.

Referring to Fig. 1, there is mounted on a suitable base (not shown) a series of contacts a, to which the sections of the resistance a' are connected. This resistance is will be understood, is arranged in any suitable manner beneath the base or within a casing, and the sections of resistance will be insulated from each other and in some instances provided with means for absorbing the local energy developed therein. B is a switch in the form of a rheostat contact lever pivoted on the base.

The auxiliary switch of Fig. 1 is an automatic circuit breaker of the type shown in the patent to Leonard and Ball, No. 705,102, granted July 22, 1902.

G, G′ are independently movable switches coöperating with stationary contacts between which is connected an overload coil H, said switches and coil being connected in series between conductors P and N. Switch G′ in this form serves as the auxiliary switch and its automatic opening is controlled by fine wire coil H′ which is connected between conductors P and N through a suitable resistance. When the plunger of coil H, which is normally down, is raised by an abnormal current flowing in coil H, the latches holding switches G, and G′ will both be tripped as is customary in double pole circuit breakers and as in the Leonard and Ball patent above referred to. The core of coil H′ is normally up under running conditions, being upheld against gravity by the current flowing in its coil. If the solenoid H′ be de-magnetized in any way, or if an abnormally low or no-voltage condition exists, coil H′ will be too weak to hold its core and in falling will trip the latch of switch G′ and cause the same to be automatically opened.

The construction of a suitable automatic switch or switches is indicated in Fig. 9. Here each switch G, G′ is shown as carried by the pivoted part g, each part having a handle for manual closing. Each part g has a projection g' adapted to be engaged by a latch g^2 for holding the switch in a closed position. The latches g^2 of both switches are controlled by the coil H, and its core h. When the core is raised, due to the large current passing in coil H, both latches will be tripped by reason of the cross piece h^2 engaging the extensions g^3, g^3 connected to the latches. The switches will then be opened, as by the force of spring g^4 and the rods g^5, since the latter are drawn outwardly by the tension of the springs, and which rods engage the surfaces g^6 on the switches. The coil H′ is shown as having a core h', and the falling of this core will cause the opening of switch G′. This is accomplished by the cross piece h^3 of core h' engaging extension g^8 connected to latch g^2 and so cause the latch to be moved to release switch G′ which will then be quickly opened by the force of spring g^4.

Referring again to Fig. 1, a thermostatic switch T is connected across the terminals of coil H′ so that when contact is made at the platinum points, coil H′ will be short circuited and its core or plunger will drop, tripping the latch which holds switch G′ closed and permitting its spring to throw it open. To actuate thermo switch T, I provide a small electric heater T′, which may be a pottery tube having a resistance wound thereon, as shown in my patent No. 691,949, granted January 28, 1902. This heater is connected around all or part of the resistance of the rheostat, and it will be seen that since the heater, when lever B remains on the initial rheostat contact, will be in the armature circuit of the motor M across the line P N, its temperature will rise rapidly, causing thermo switch T to short circuit coil H′ and open the circuit between the rheostat lever B and conductor P.

In operating the controller of Fig. 1, the operator first closes switches G and G′ and will see that the core or plunger of fine wire coil H′ is raised into the coil. The closure of switches G and G′ gives a full field to motor M and closes the armature circuit through the entire resistance of the rheostat. The drop on the resistance a' causes heater T′ to heat up, and if lever B is allowed to remain in the initial position, the heat of T′ will in a predeterminable time cause the thermostatic switch T to close the shunt around coil H′ thus demagnetizing that coil, whereupon its core drops and trips the latch which holds switch G′ closed. The movement of switch G′ through its actuating spring opens the circuit to the motor and rheostat. An overload current will cause the coil H to raise its core and trip the latches holding both switches. If an abnormally low or no voltage condition exists, coil H′ will be too weak to hold its core and switch G′ will be opened.

Various arrangements might be devised for heating the switch T when current flows through the resistance, and the switch T might cause the coil H′ to be deënergized in other ways. In Fig. 5, I have shown switch T in proximity to a part of the resistance a', which resistance will serve to heat the

switch, if the arm B is held in position on the resistance contacts an objectionable length of time. In this figure, the switch T is shown in series with coil H′ and is adapted to open the circuit of this coil when heated instead of shunting the same as in the case of Fig. 1. Also in Fig. 5, the arm B is shown as spring pressed and a no-voltage magnet F is shown in series with the field winding of the motor for holding the arm B in its restrained position. The form of Fig. 5 is therefore adapted for use as a starting rheostat, whereas the form of Fig. 1 may be used as a regulating rheostat.

Another modification is shown in Fig. 6, in which the thermostatic controlling switch T is connected in series with resistance a', and if this resistance, or any part thereof, is kept in circuit an improper length of time, it will cause the thermostatic switch T to be heated to such a degree that it will move and force the insulated conductor k to engage the contacts k' and short circuit coil H′. The coil H′ is thus de-magnetized, and the dropping of its core will cause the main circuit to be opened at switch G′. When the resistance controlling arm is in final position, the thermostatic switch is cut out of circuit.

Instead of the thermal strip T for controlling the action of coil H′, a resistance T^2 of iron, nickel, or other material having a high temperature coefficient might be connected in series with coil H′ across the line as shown in Fig. 2. In the arrangement of this figure, the circuit through coil H′ is closed by the closing of switch G′, and when the rheostat lever B is moved to engage the initial resistance contacts, the motor will start and begin to accelerate. After being held there a proper length of time, the lever will be moved along the starting resistance contacts thereby disconnecting the initial resistance contacts from the first contact which originally actuated coil H′ and this coil is then placed in series with the resistance T^2. If the rheostat arm B is left for an improper length of time on the starting resistance contacts, the magnetism of coil H′, due to the gradual increase in resistance of T^2 on account of being heated by resistance a' in close proximity to it, would gradually become less as the time interval increased and in a predeterminable time the core or plunger of that coil would drop and trip the latch, that holds switch G′ closed, whereupon that switch would open. Another modification of this idea is shown in Fig. 3, in which a resistance T′ which may be mounted on a pottery tube, as in Fig. 1, is placed inside of a second pottery tube carrying a resistance T^2 of iron, nickel or other material having a high temperature coefficient. In this arrangement coil H′ and resistance T^2 are connected in series across the line, and heater T′ is connected in shunt around the resistance a' of the rheostat as in Fig. 1, and for the same purpose. Instead of separating the resistances T′ and T^2, they might be arranged upon the same support and suitably insulated. To determine the time interval at which the condition of coils T′ and T^2 would cause the coil H′ to release its plunger, an adjustable resistance might be provided for heater T′, or when the windings of T′ and T^2 are on separate supports, the distance between them, or the relative positions of one within the other, might be varied to vary the heating effect of T′ upon T^2. Various other ways of regulating the action of T′ and T^2 and H′ in the arrangement of Figs. 1, 2 and 3 might be devised without departing from the main feature of my invention.

In Fig. 4, the coil H′ is controlled by an automatic switch. The coil is connected across the circuit in series with the automatic switch and a resistance. The automatic switch is preferably a double arm switch S and s pivoted on a common pivot and provided with a spring tending to throw them toward each other. Switch S makes contact with a spring clip connected with coil H′, and which clip holds it in position, while arm s makes contact with a button connected to conductor N. This arm is held by a latch s' which is tripped by the action of the core or plunger of coil S′. Arm s is not provided with an operating handle and is arranged to be moved onto its contact by arm S.

The switch and coil are arranged as a time switch by placing coil S′ in shunt on the entire, or part of, rheostat resistance a', in series with a carbon resistance S^2 or other material of negative temperature coefficient.

In order to start the motor, the operator will first close switch arms s and S, and then switch G is closed. When switch G′ is next closed, the circuit connections will be as indicated. If the operator should cut out the starting resistance too slowly, or if he should leave much of the resistance in circuit a considerable period of time, the carbon S^2 would be heated, and the gradually increasing current which will flow in this shunt circuit would finally be sufficient to actuate the plunger of coil S′ and so release its switch which will open the circuit of coil H′. The deënergization of this coil would cause its plunger to fall and effect the automatic opening of switch G′. If the operator manipulates the arm B properly, this action will not take place. The automatic switches G and G′ will protect the circuit against no-voltage and overload conditions as has previously been referred to.

In Fig. 7, the coil S′ is connected across the first resistance contacts of the rheostat and a blind initial rheostat contact. A resistance T^2 of iron or nickel, or other ma-

terial of high temperature coefficient, is connected between the same contacts in parallel with the coil S′. The coil S′ is then connected as a shunt to an initial resistance step of variable resistance. If in starting, the operator permits the arm B to remain on the initial contact beyond a predetermined interval of time, the current which will pass through coil S′ will become such that it will be sufficient to raise its core and open the switch in the circuit of coil H′ and so interrupt the main circuit. If, however, the operator moves arm B from the initial contact within a proper time, the resistance T^2 will not become heated to such an extent that the coil S′ will raise its core and such automatic opening of the circuit will not take place. It will be understood that in this construction, the closing of switches G, G′ will cause the motor to start.

Instead of using a resistance T^2 as referred to with reference to Fig. 7, a time fuse might be employed, which when fused would cause the current to flow through coil S′. This modification is shown in Fig. 8, in which the time fuse is indicated at F′ between the first two contacts and is fused after carrying the starting current a predetermined length of time.

It will be noted that I have indicated a motor M in the drawings having a shunt field winding, and that the supply circuit to both the armature and shunt winding is opened by means of the automatic switch in the main circuit. Also that when the circuit is opened, the armature and field are closed on themselves, giving a closed circuit for the field discharge.

It is evident that my invention may be embodied in various forms of construction, and that I am not limited in the scope thereof except as indicated in the following claims.

Having thus described my invention, I declare that what I claim as new and desire to secure by Letters Patent, is,—

1. The combination with a motor starting rheostat, of a circuit breaker, means for automatically inserting resistance of said rheostat independently of the movement of said circuit breaker, and means for causing the automatic opening of said circuit breaker if the starting resistance is left in circuit a predetermined length of time.

2. The combination with a motor armature resistance, of means for opening the circuit outside the resistance, and a device for automatically controlling said means, said device being responsive to current flow through said resistance for a predetermined time interval independently of any change in the ohmic resistance of said motor armature resistance.

3. The combination with a motor controlling resistance, a switch for protecting the main circuit, an electro-responsive winding for affecting said switch upon the occurrence of no voltage, an electro-responsive winding for affecting said switch upon the occurrence of over-load current independently of said first-named winding, and a time limit device for affecting said switch if said resistance is left in circuit a predetermined length of time.

4. The combination of a motor controlling resistance, a switch for opening the main circuit outside said resistance, a no-voltage electromagnetic winding energized independently of any current through the motor windings for controlling the opening of said switch, an overload electromagnetic winding for controlling the opening of said switch, and means dependent upon the length of time said resistance is in circuit for deënergizing said no-voltage winding.

5. The combination of a rheostat having a plurality of steps of resistance and a movable element by the movement of which any desired number of steps are cut in and out of circuit, a no-voltage magnet for holding said element in its restrained position, a quick-acting switch for opening the main circuit, and means dependent upon the length of time said resistance is in circuit for automatically effecting the opening of said switch.

6. The combination of a rheostat having a movable element, a no-voltage magnet for holding said element in its restrained position, a quick-acting switch for opening the main circuit, means dependent upon the length of time said resistance is in circuit for automatically effecting the opening of said switch, and means dependent upon the flow of overload current for effecting the opening of said switch, said latter means being effective independently of said no-voltage magnet.

7. The combination of an electric circuit, a rheostatic device adapted for carrying current a limited time only, means for temporarily connecting said device in a circuit and for cutting same out of said circuit, a non-rheostatic circuit protective device temporarily in series with said first named device, and means responsive to the length of time current flows through said first named device for controlling said protective device, said latter means comprising a device responsive only when said first named device is connected in circuit.

8. The combination of a translating device, an electromagnetic circuit breaker, the actuating coil of said circuit breaker carrying the entire current through said device, and means for automatically causing the opening of said circuit breaker when a current has flowed through the said device for a certain length of time.

9. The combination of a translating de-

vice, and a circuit breaker, the said circuit breaker comprising means for causing the same to be responsive immediately to predetermined maximum current, and means for causing the circuit breaker to also respond to a lesser current after a predetermined length of time.

10. The combination of a translating device, a switch, means for automatically controlling the movement of said switch under certain current conditions comprising an electromagnetic coil in series with said switch, and a second electromagnetic coil for controlling the automatic movement of said switch under different conditions, and means for causing said second coil to be dependent upon time for its action.

11. The combination of a translating device, and a circuit breaker, said circuit breaker comprising means responsive to overload current, to no-voltage, and to a current less than the overload current after said lesser current has continued a predetermined length of time.

12. The combination of a translating device, and an automatic circuit breaker, said circuit breaker comprising two independently closable independently openable switches in series with each other, means for opening both switches automatically upon predetermined overload current, and means for opening at least one of said switches when a certain current flows for a certain length of time.

13. The combination of an electric motor, and means for protecting the motor armature circuit comprising an automatic overload circuit breaker of the double arm type, and also comprising means dependent upon a time interval for causing the automatic action of at least one of said arms of the circuit breaker.

14. The combination of a translating device, a controlling resistance, a protective device in series with said resistance, means comprising a responsive winding connected in parallel with said translating device for controlling the protective movement of said protective device, and means for causing action of said latter means to be dependent upon a time interval.

15. The combination of an electric motor, a controlling armature resistance, and electro-responsive means for reducing the current flow, said means comprising a thermostatic contact device responsive to the passage of a predeterminable current for a certain interval of time through said resistance.

16. The combination of an electric motor, a motor armature resistance, and electromagnetic responsive means responsive independently of any change of said armature resistance due to passage of the current for protecting the resistance against the passage of the normal current therethrough longer than a certain time interval.

17. The combination of an electric motor, a starting resistance, circuit opening means for protecting the motor armature against overload current, and additional means for controlling the first-named circuit opening means for protecting the starting resistance against the passage of the normal current longer than a certain time interval.

18. The combination of a translating device, a controlling resistance, a protective device for said resistance, and non-rheostatic means for controlling the movement of said protective device responsive to current flow for a certain time interval.

19. The combination of a translating device, a controlling resistance, and a time limit electro-responsive protective device responsive to current flow through said resistance and responsive independently of any change in said resistance due to the passage of current through said resistance.

20. The combination of an automatic switch having a winding for controlling the action thereof, a device comprising a movable resistance varying element in series with said switch, a contact making non-rheostatic device for controlling the current in said winding, said latter device being responsive to an abnormal production of heat in a portion of the circuit containing said first device.

21. The combination of a translating device, an automatic switch having a coil thereof in series with said switch, and time limit protective means, said means comprising a part connected in series with said coil.

22. The combination with a translating device, of an automatic circuit controlling movable element having two coils, one of said coils being responsive to overload current in the circuit, and the other of said coils being responsive to the heating effect produced in a section of the circuit in series with said element.

23. The combination of an electric motor, an armature resistance, an automatic switch in series therewith, electro-responsive means controlling the automatic opening of said switch dependent upon the current through the armature, and electro-thermal responsive means controlling the automatic opening of said switch dependent upon an abnormal production of heat in a portion of the armature circuit.

24. The combination with a motor armature rheostat, of a switch outside said rheostat, and means comprising an electrically heated thermostatic device for effecting the opening of said switch after an excessive current has flowed a predetermined length of time.

25. The combination of an electro-mag-

netic circuit breaker, a resistance device in series with the switch of said circuit breaker, said circuit breaker comprising an electrically heated thermostatic device controlled by the current in said resistance device and independently of a change in the resistance of said resistance device.

26. The combination of an electromagnetic circuit protective switch, comprising no-voltage and overload responsive means, the latter acting independently of the former, a resistance device in series with and protected by said switch, and means dependent upon lapse of time of current flow through said resistance device for controlling said switch.

27. The combination of an electric motor, an automatic circuit breaker the coil and switch of which carry the entire current passing through the motor armature, and time controlled means for causing the automatic opening of said circuit breaker.

28. The combination of a circuit breaker, means for causing said circuit breaker to be automatically responsive to no-voltage and to overload current, the overload response being independent of the no-voltage response, and time controlled means for causing the automatic opening of the circuit breaker.

29. The combination of a rheostat, and time-controlled means for automatically protecting the rheostat against burn out, said means being dependent upon flow of current through the resistance of said rheostat and independent of any change in the resistance due to the current.

30. The combination of a resistance, a protective device in series with said resistance, and a time limit thermo-electric non-rheostatic device for controlling said protective device.

31. The combination of an electric motor, an armature starting resistance, and controlling means therefor comprising means for protecting the motor armature from no-voltage, for protecting the armature starting resistance from the passage of current through it for too long a period of time, and independently acting mechanically functionally related means for protecting the motor armature from excessive current.

32. The combination of an electric motor, an automatic switch in series therewith, an armature resistance in series therewith, and means dependent upon the time current effect of the current through the resistance and independent of any change in said resistance due to the passage of the current for controlling the automatic action of said switch.

33. The combination of an electric motor, an automatic circuit breaker having a coil and switch which carry the entire motor armature current, and means effective only after a certain time interval for causing the opening of said switch.

34. The combination of a circuit containing a resistance, an electromagnetic protective device in said circuit having a controlling winding, and an electro-thermostatic contact device responsive to the heat condition of a portion of said circuit, a contact of said device controlling said winding.

35. The combination of an electric motor, a rheostatic controlling device for the motor armature, and a time limit controlled non-rheostatic protective device, said latter device being responsive to an abnormal condition of a portion of the armature circuit as regards the heat produced therein.

36. The combination of an electric motor, a resistance, an automatic circuit controlling element, said resistance and controlling element and armature of the motor being all in series with each other, and means dependent upon current flow through said resistance for an undue length of time and independent of a change in said resistance due to the passage of the current for automatically controlling said element.

37. The combination of a circuit breaker, and means for causing said circuit breaker to automatically respond to novoltage, to excessive instantaneous current, and to a certain less current acting for some length of time.

38. The combination of a translating device, and controlling apparatus comprising a movable protective circuit controlling element, means for automatically causing the protective movement of said element instantaneously upon predetermined excessive current, and a time limit protective device responsive to abnormal passage of current through said translating device for also causing the protective movement of said element.

In testimony whereof, I affix my signature in the presence of two witnesses.

H. WARD LEONARD.

Witnesses:
L. K. SAGER,
GEO. A. HOFFMAN.