H. W. LEONARD.

ELECTRIC CIRCUIT CONTROLLER.

APPLICATION FILED NOV. 7, 1907.

929,609. **Patented July 27, 1909.**

Fig. 1

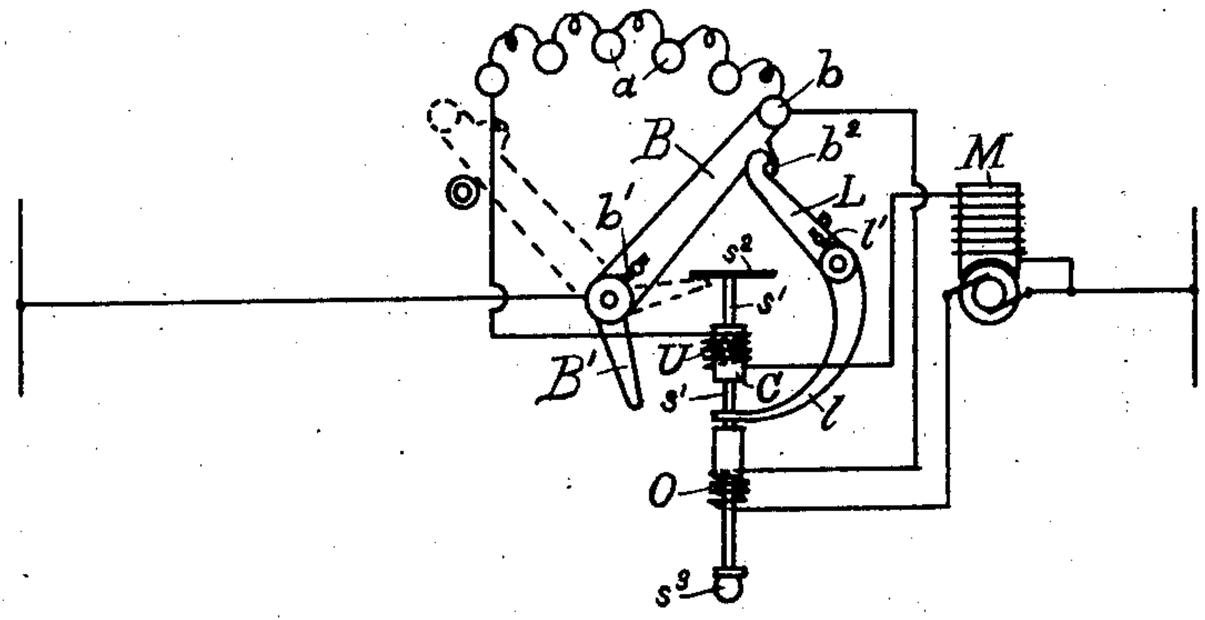
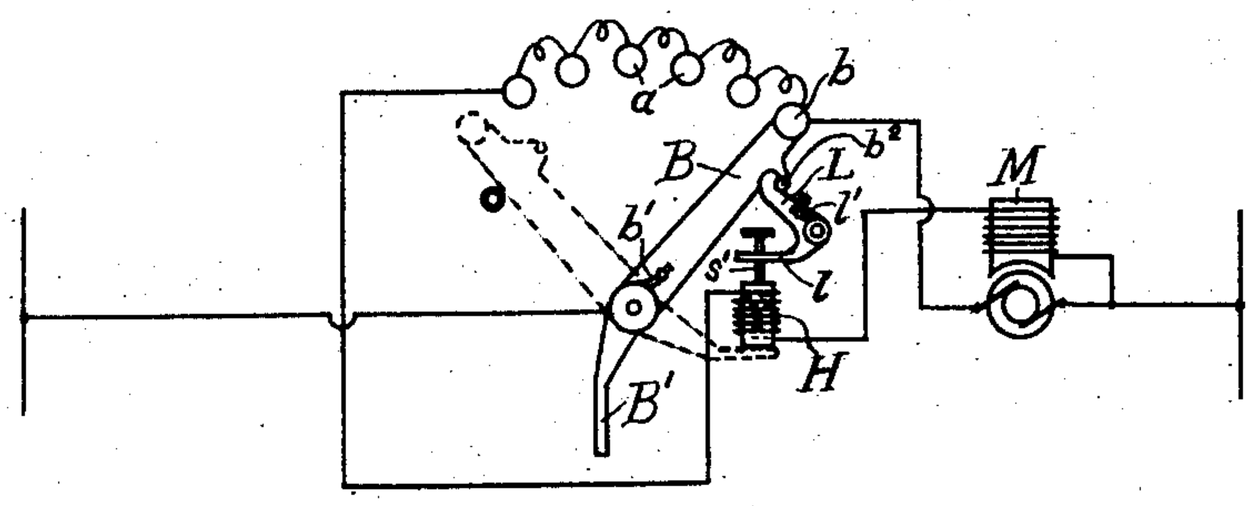


Fig. 2



WITNESSES

Geo. H. Kerr.

Geo. A. Hoffman

H. Ward Leonard INVENTOR

BY

Edwards, Sager & Wooster

his ATTORNEYS.

UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF BRONXVILLE, NEW YORK.

ELECTRIC-CIRCUIT CONTROLLER.

No. 929,609. Specification of Letters Patent. Patented July 27, 1909.

Original application filed June 1, 1903, Serial No. 159,528. Divided and this application filed November 7, 1907. Serial No. 401,056.

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.

My invention relates to devices such as are employed to cause the automatic release of the movable levers of switches, rheostats, &c., under abnormal conditions, and thus open, or affect the conditions in, an electric circuit.

The present application is a division of my copending application filed June 1, 1903, Serial Number 159,528, and which was renewed June 3, 1907, Serial Number 377,046.

The principal object of my invention is to produce an automatic release which will be simple, reliable, constant, compact, cheap to manufacture, economical in operation, and easily and cheaply kept in perfect operative condition in combination with circuit controlling devices as indicated herein.

In carrying my invention into effect I provide in my preferred form a mechanical locking device for holding a switch or rheostat lever in the desired operative position against spring or other tension, while the circuit to be controlled or a controlling circuit remains normal. This switch or rheostat lever is released to affect the circuit to be controlled when the condition of the circuit becomes abnormal and the release is effected by an electro-responsive device which responds automatically to abnormal changes in a circuit. This electro-responsive device preferably consists of a solenoid having a vertically moving core which is arranged to trip the latch. The core of the solenoid in the preferred arrangement, is normally held up against gravity by the magnetism, and upon the occurrence of "no-voltage" or underload the core will drop and trip the latch. In other forms the core may be held down by magnetism against spring pressure and upon the occurrence of abnormal conditions in the circuit the magnetism will fail to hold the core whereupon the core will be driven upward to trip the latch. These arrangements may be combined with automatic overload switches, employed in conjunction with a rheostat. In certain forms of the underload electro-responsive device, the core is moved to its normal operative position upward against gravity or in some direction against spring or equivalent pressure during the initial movement of the rheostat or switch lever. This movement of the core may be accomplished in several ways, either mechanically or electrically, and the object of this movement is to permit the latch to return to the locking position and in some instances to place the core in position to instantly trip the latch, even before the operator releases the switch, should the circuit become abnormal during the operation of the switch.

Other features of construction will be more fully described hereinafter.

One of the principal applications of this feature of my invention is to the "no-voltage" automatic release of a motor starting rheostat, and consequently I will illustrate and describe my invention as applied to such an apparatus.

Heretofore in motor starting rheostats equipped with an automatic underload release, such automatic device was in the form of a magnet the keeper of which is attached to the switch arm. This form of automatic release depends upon the magnetism of the magnet to hold the keeper and arm against the action of a spring, so that when the magnetism of this magnet fails the keeper is released and the spring moves the lever automatically to the desired position. There are several objectionable features to such an arrangement, which objectionable features I am able to avoid by my invention. First. The magnetic pull of such a magnet depends very largely upon the perfection of magnetic contact of the keeper. If the keeper be nicely fitted the residual magnetism is quite strong so that frequently the automatic release fails to act when it should do so upon the failure of current because the residual magnetism and the friction of the switch lever on the contacts are too great for the spring to overcome them. This residual magnetism is especially troublesome when the holding magnet is in the field circuit of a motor and the armature and field are kept in a closed circuit, for in such a case the gradual slowing down of the motor causes an extremely slow and gradual decrease of the current in the magnet to zero, which makes the

residual magnetism quite considerable in amount. To overcome this residual magnetism it becomes necessary to use a very high grade expensive quality of iron in the magnetic circuit of the magnet and also to make a slight magnetic gap where the keeper makes mechanical contact with the poles of the magnet. This is frequently done by copper plating or tinning this surface to a sufficient extent to create the desirable magnetic gap. But any slight variation in this magnetic gap makes a great difference in the magnetic pull and the amount of residual magnetism. Furthermore, such a construction makes it impracticable to use as strong a spring as is often desirable, on account of the size, cost, and energy required for a magnet sufficiently strong to positively hold the arm against the stronger spring. Furthermore, it is sometimes desired to have this magnet in series with the shunt field winding of the motor and here again another difficulty is met with as the current in the shunt field winding of the motor of a certain definite voltage and horsepower, is variable over an extremely wide range depending upon the particular make. In common practice this variation would have a range of from 1 to 4. Hence with the construction described, the magnetic pull would vary over a very wide range and the maker of such motor starters with automatic release cannot tell in advance what magnetic pull will be met with in practice and is obliged to make the magnet very much larger than really necessary in order to secure enough ampere turns to get the required pull even with the minimum amperes met with in practice and yet the magnet must be wound with a wire sufficiently large so as not to have it overheat with a current say 4 times as much as the minimum. All of these difficulties I avoid by means of my invention.

Instead of holding the spring actuated arm by means of magnetism produced by the shunt field current of the motor or other current, I hold the arm in my preferred form by means of the mechanical latch. By the employment of a mechanical latch, I am able to use as stiff a spring as desired, so that no difficulties arise due to the friction which the spring may have to overcome in moving the arm after the latch is released. The latch is released by means of a definite hammer blow due to the movement of a certain mass under the action of a constant force preferably gravity, although I may use a spring or other form of force producing device instead of gravity. I prefer however to use a freely falling weight falling a definite distance and therefore giving a predeterminable and constant blow to open the latch when it operates. This weight is preferably in the form of a magnetic plunger which is normally held up by a magnetic pull and which falls when the current falls below a certain amount and delivers a blow to open the latch. As I only have to sustain by means of the magnetism a weight, the weight of which is very slight as compared with the pull of the spring on the keeper in the former type, I can readily introduce a considerable air gap in my magnetic circuit and yet have a magnet which is smaller, cheaper, and in every way better and more reliable than the former type described above. For example, I find 70 turns of a certain size wire are amply sufficient for the magnet in the field circuit when 350 turns are necessary in the former type, and of course the first cost, space, and the energy required are proportional to these figures.

The latch may be so designed that its center of gravity is so disposed relatively to its pivot that the action of gravity tends to keep it in the locking position, as shown in Fig. 2 of my original application, or a light spring may be used tending constantly to keep it in that position, or the magnetic pull of the plunger may tend to keep the latch in that position, or the shape of the latch may be such as to have it tend to remain in the locking position.

I prefer to have the solenoid iron-clad and closed at the top by iron, so that when the plunger is at the top of its movement the iron of the plunger is almost in contact with the iron of the solenoid, being preferably separated by a thin film of non-magnetic material, so as to sufficiently reduce the residual magnetism effect.

My original application disclosed several forms and arrangements of various embodiments of my invention but the present application relates more particularly to forms in which the plunger is raised mechanically as distinguished from electromagnetic means. After the plunger is raised, it is then held up by magnetism due to the shunt field current or a current due to an independent circuit across the line, and I may arrange another plunger so that it is mechanically attached to the first one and a coil in series with the armature which acting on the second plunger when excessive current passes through the armature, pulls the second plunger and consequently the first plunger to release the latch. Thus I get no voltage and overload automatic protection with a single arm, a single latch and a very compact form of magnet windings.

When the air gap is large the cross section of the iron is not important, and by making the cross section very small, economy in cost and size of both the lifting coil and the holding coil is effected. I therefore reduce the size of the plunger in practice to about one-quarter of an inch in diameter. This results in a further advantage in that the density of the lines of force is increased at the magnetic holding surface which gives a better result

for the same number of ampere turns. With this reduced plunger additional weight may be supplied thereto exterior to the coil or at the bottom of the plunger.

Some forms of my invention are illustrated in the accompanying drawings in which—

Figure 1 is a diagram showing one form employed in connection with a shunt wound electric motor; and Fig. 2 is a diagram of a modification.

The mechanism will preferably be mounted upon the usual base of insulating material, carrying the resistance steps and circuit connections on its underside and the contact buttons *a* of the resistance steps on its upper side or face.

B is the usual pivoted switch arm provided with an operating handle *b* and a spring *b'* tending to return the arm to the initial or starting position.

L designates a latch pivotally mounted on the base plate and provided with a tripping arm *l*. The latch and tripping arm should be so shaped and proportioned in weight that it will always assume the latching position when free, and such an arrangement will be suitable where the apparatus is designed to be placed vertically; but since the apparatus will not always be hung sufficiently accurately, or since it may be desired to place it in a horizontal position, I preferably provide the latch with a very light spring *l'* which tends to return the latch to the locking position. Latch L engages a pin b^2 on arm B to hold the arm in its final position. An iron-clad solenoid as shown and described in Fig. 6 of my original application, may be provided, and the core thereof arranged as described so that when the current through the solenoid fails or decreases abnormally the magnetism will be insufficient to hold the core in its raised position and hence the core will drop, and through the head on rod *s'* impart a blow to the tripping arm of the latch, thereby releasing the switch arm B and permitting the spring *b'* to return the switch arm to the initial or starting position. With my preferred form of invention I provide a mechanical device whereby when the contact arm is moving from the open circuit to the closed circuit position, the core will be held in a sufficiently elevated position to permit the magnetic pull to hold the same or lift it farther to its full elevated position. Arrangements for accomplishing the elevation of the core are illustrated in the accompanying figures in addition to other features.

Referring to Fig. 1, M represents a shunt wound electric motor connected across a circuit through a starting rheostat. The holding or no-voltage coil is indicated at U acting upon the core C and connected between the first contact of the rheostat and the motor field winding. In Fig. 1, two windings are employed to represent respectively the overload and underload, and the cores are raised to the operative position either by hand or by an arm on the rheostat switch, both arrangements being shown. In this construction, the underload coil U is placed above the overload coil O, and the two cores are carried by a rod *s'*. This rod at the upper end may be provided with a disk or arm s^3, placed in the path of the arm B' on switch B, so that when the switch is in the initial or starting position said arm B' will hold the cores in the elevated position so that the pull of coil U will hold the cores elevated as the switch is moved toward the final position. Instead of employing arm B' and disk s^2, the cores may be elevated by hand by means of a knob s^3 at the lower extension of rod *s'*. In such case the operator will raise the cores with one hand as he starts switch B forward with the other hand. The tripping arm *l* of the latch extends between the two cores in position to be struck by the upper core when both cores descend. Under normal conditions the pull of coil U will hold the cores elevated against gravity and against the pull of coil O, but upon the occurrence of no-voltage or an abnormal decrease of current, coil U will have insufficient pull to hold the cores against gravity whereupon they will fall and deliver a blow to and thereby trip the latch. Upon the occurrence of a predetermined overload, the pull of coil O will increase sufficiently to overcome the pull of coil U, and the cores will be drawn downward and trip the latch. It will thus be seen that by the provision of an extremely simple and compact device, *i. e.*, a single arm, a single latch and a very simple, cheap and compact solenoid, I secure both "no-voltage" and "overload" release in a most effective and reliable manner. It will be noted that the circuit connections extend from one side of the line through the arm B, which, when closed on the first resistance contact will cause the current to pass through the starting resistance thence through overload coil O and through the motor armature to the other side of the line; also, a shunt circuit extends from the initial contact through the holding or no-voltage coil U and the motor field winding to the other side of the line. It will be noted that the motor armature, overload coil, holding coil and motor field winding are in a permanently closed circuit. When from any cause the latch is tripped by the falling of the cores of the solenoids, the arm B' will engage the disk s^2 upon the return of the rheostat arm to the initial position and mechanically raise the cores and rod *s'* to the position shown in the drawing. Consequently, upon again starting the motor, the coil U will be energized and hold the cores in the raised position as above referred to. The running position is shown in full line in the figure with all of the starting resistance removed

from the circuit, and the off-position is indicated in dotted lines.

In Fig. 2 I have shown another construction in which the core or plunger is raised to operative position mechanically. Here the switch arm B is provided with an angular extension B′, the pivotal point being so arranged relatively to the plunger that when the switch returns to its extreme inoperative position at the left, the extension B′ will raise the plunger to the position in which it is illustrated. When switch B is moved forward and the circuit closed, the plunger will still be within the no-voltage or holding coil H, and it will now be held by magnetism as switch B is moved toward the final position. The holding coil H is here connected in series with the field winding of motor M as in the other arrangements and the release is effected in the same way.

While I have shown and described certain forms of my invention, it will be understood that the invention is capable of embodiments in other forms of construction, and I do not wish to be limited in the scope thereof except as indicated by 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 of a circuit controller having a movable element for varying a resistance, said element being adapted to be restrained in a certain position, an electroresponsive device having an independently movable magnetic mass functionally related to the said element to effect the opening of the circuit by the movement of said element, and mechanical means operative only when said controller is in a position other than its normal operative position for moving said mass against a constantly acting force.

2. The combination with a switch, of a mechanical device for holding it in a definite position, an electromagnetic device having a movable part held by said electromagnetic device against the action of a force tending to move it whereby when the magnetism of said electromagnetic device falls below a certain strength, the said movable part will move under the action of said force and deliver a blow and cause the release of said mechanical holding device, and auxiliary mechanical means for moving said movable part to its normal operating position.

3. The combination of a spring actuated switch, mechanical restraining means therefor, a magnetic mass which falls under the action of gravity to release said restraining means upon abnormal conditions of the circuit, mechanical means for automatically raising said mass to its operative position and for retaining said mass in its operative position whereby the electric energy required for holding said mass in its operative position is materially less than the electric energy employed to raise said mass.

4. The combination of a circuit controller, mechanical restraining means for holding said controller in a certain position, a normally restrained mass which when released moves under the action of a force and delivers a hammer blow to release the mechanical restraining means, and auxiliary mechanical means acting only when said circuit controller is in a position other than its normally restrained position whereby the said mass is moved to its normal position.

5. The combination of an electric motor, a circuit-controller, protective means automatically responding to cause the opening of the circuit upon the occurrence of one abnormal condition and to cause the opening of the circuit upon the occurrence of a different abnormal condition, and auxiliary mechanical means controlled by said circuit controller for setting part of said protective means when said controller is placed in a certain position other than its normal operating position.

6. The combination of an electric motor, a circuit controller, protective means automatically responding to affect said controller upon the occurrence of one abnormal condition and to affect said controller upon the occurrence of a different abnormal condition, and auxiliary mechanical means controlled by said circuit controller for setting part of said protective means when said controller is placed in a position other than its normal operating position.

7. The combination of a circuit controller, electroresponsive means responsive to minimum conditions and to maximum conditions, and auxiliary mechanical means for moving a movable element of said first named means to its normal position against a constantly acting force.

8. The combination of an electric motor, a resistance having a movable element for varying the amount of resistance in circuit and adapted to be restrained in the resistance all out position, a magnetic mass functionally related to said device, electromagnetic means for retaining said device against the action of a force, and mechanical means for moving said mass to its operative position by movement of said element.

9. The combination of an electric motor, a resistance having a movable element for varying the amount of resistance in circuit and adapted to be restrained in the resistance all out position, a magnetic mass functionally related to said element, electromagnetic means for retaining said mass in a position against the action of a force, and mechanical means for moving said mass to its operative position, said means being operative while said device is being moved to its initial position.

10. The combination of an electric motor, a resistance having a movable device for varying the amount of resistance in circuit and adapted to be restrained in the resistance all out position, a magnetic mass functionally related to said device, electromagnetic means for retaining said mass in a position against the action of a force, mechanical means operative only when said device is in a position other than its resistance all out position for moving said mass against the action of said force, and functionally related overload protective means.

11. The combination with a switch lever, of a mechanical device for holding it in a definite position, an electromagnetic device having a movable part held by said electromagnetic device against the action of a force tending to move it whereby when the current which energizes said electromagnetic device falls below a certain strength the said movable part will move under the action of said force and deliver a blow and cause the release of said mechanical holding device, and auxiliary mechanical means acting only while the switch lever is in a position other than its normal operating position for moving said movable part to its held position.

12. The combination with an electric motor, of a circuit controlling switch, means for moving said switch, mechanical restraining means for holding said switch, an automatic device having a movable part normally restrained by magnetism and which automatically operates when the electromotive force of the circuit falls below a certain amount to release said mechanical restraining means and permitting the movement of said switch by its actuating means, and auxiliary mechanical means controlled by said switch for placing the said movable part in its normally restrained position.

13. The combination of a circuit controlling switch, means tending to move said switch automatically, mechanical restraining means for holding the switch in a certain position, an electromagnetic device having a magnetic mass normally held up against the action of gravity and which under abnormal conditions of the circuit falls and delivers a blow to cause the release of said restraining means, and means controlled by the automatic movement of said switch for raising said magnetic mass to its elevated position.

14. The combination of a circuit controlling device, mechanical means controlled by said device for moving a magnetic mass against a continually acting force, an electromagnetic device which normally holds said magnetic device against the action of said force, and means whereby upon the abnormal diminution of the magnetism said magnetic mass delivers a blow resulting in the movement of said circuit controlling device.

15. The combination of a circuit controlling switch having means tending to move the switch in one direction, a mechanical restraining device for holding said switch in a certain position, an electromagnetic device having a movable part for releasing said mechanical restraining device under abnormal conditions of the circuit, and auxiliary mechanical means controlled by said switch for placing the movable part of said electromagnetic device in operative position.

16. The combination of a circuit controlling switch, mechanical restraining means for holding said switch in a fixed position, an electromagnetic device responsive to abnormal conditions in the circuit for releasing said mechanical restraining means, and auxiliary mechanical means controlled by said switch for placing the movable part of said electromagnetic device in operative position.

17. The combination with a circuit controlling switch, mechanical restraining means for holding said switch in a fixed position, an electromagnetic device responsive to abnormal conditions of the circuit for releasing said mechanical restraining means, the movable part of said electromagnetic device being subjected to a continually acting force in one direction, and auxiliary mechanical means for moving said movable part against said continually acting force to place the same in operative position.

18. The combination of a circuit controlling switch, mechanical restraining means for holding said switch in a fixed position, an electromagnetic device responsive to abnormal conditions in the circuit for releasind said mechanical restraining means, the movable part of said electromagnetic device being operated by gravity, and auxiliary mechanical means controlled by said switch for moving said movable part against the force of gravity to place the same in operative position.

19. The combination of a motor having a field winding energized independently of its armature current, a movable circuit controlling element in series with one element of the motor, means for restraining said element against a constantly acting force, a mass adapted to be moved to deliver a blow to effect the release of said restraining means, electroresponsive means for retaining said mass in its operative position, and mechanical means for moving said mass to said operative position.

20. The combination of a supply circuit, two movable magnetic masses mechanically connected together, two electro-responsive windings acting upon said masses respectively, one of said windings being responsive to excessive current and the other of said windings being responsive to a different abnormal condition, each of said windings producing a magnetic field substantially in-

dependent of that produced by the other, and protective means controlled by the movement of said masses.

21. The combination of an electric motor, and protective means comprising a no-voltage protective winding and an over-load protective winding, each of said windings having its own respective magnetic mass under the influence of its magnetic field whereby the magnetic pull of each is substantially independent of that of the other and the masses being mechanically connected together.

22. The combination of an electric motor, and protective means comprising a movable part adapted to be moved freely under the action of gravity and deliver a hammer-like blow to cause the operation of the protective means and also adapted to be moved magnetically, two controlling electro-responsive windings acting upon said part, one of said windings being in series with the motor armature and the other of said windings being energized independently of the motor armature current.

23. The combination of an electric motor, and protective means comprising two electro-magnetic windings, one of said windings being in series with the motor armature and the other in parallel with the motor armature, a movable device controlled by said windings and adapted to deliver a hammer-like blow to cause the protective movement of the protective means upon the occurrence of an abnormal condition, and auxiliary means for moving said device.

24. The combination of a circuit controller having a movable element; two windings, one responsive to minimum energy conditions and the other responsive to maximum energy conditions in a circuit, each of said windings developing a magnetic field substantially independent of that produced by the other, a magnetic element controlled by said windings and normally magnetically restrained by magnetism against a constantly acting force and adapted when released to move under the action of said force to effect the automatic movement of said element.

25. The combination of a circuit controller having a movable element, two windings, one responsive to minimum energy conditions and the other responsive to maximum energy conditions in a circuit, a magnetic mass controlled by said windings and normally magnetically restrained by magnetism against a constantly acting force and adapted when released to move under the action of said force to effect the automatic movement of said element, and auxiliary means for moving said mass to its normally restrained position.

26. The combination of a circuit controller, means for causing said controller to be automatically responsive to abnormal conditions of the circuit comprising two electro-responsive windings, a magnetic element acted upon by said windings and normally restrained by magnetism against a constantly acting force, and auxiliary means for automatically moving said element against the action of said force to its restrained position.

27. The combination of a spring actuated switch, mechanical restraining means therefor, a movable magnetic element adapted to be moved from a certain position to deliver a blow to effect the release of said means, two electroresponsive windings for automatically controlling the movement of said element, and auxiliary means for automatically moving said element to said certain position.

28. The combination of an automatic switch, means for causing said switch to be automatically moved to a protective position comprising a magnetic element, two controlling windings for said element, one adapted to normally hold said element in its restrained position and the other winding adapted to counteract the effect of the first winding under certain conditions and thereby effect the movement of said element, and means depending upon the movement of said switch for moving said mass to its normally restrained position.

29. The combination with a switch, of a mechanical device for holding it in a definite position, an electro-magnetic device having a movable part held by said electro-magnetic device against the action of a force tending to move it whereby when the magnetism of said electro-magnetic device falls below a certain strength, the said movable part will move under the action of said force and cause the release of said mechanical holding device, and auxiliary mechanical means for moving said movable part to its normal operating position.

30. The combination of an automatic switch, means for causing said switch to be automatically moved to a protective position comprising a magnetic element, two controlling windings for said element, one adapted to normally hold said element in its restrained position and the other winding adapted to render ineffective the effect of the first winding under certain conditions and thereby effect the movement of said element, and means depending upon the movement of said switch for moving said mass to its normally restrained position.

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

HARRY WARD LEONARD.

Witnesses:

B. E. SMYTHE,

C. J. CORNELL.