June 9, 1925.

1,541,618

H. W. BROWN

RELAY

Filed July 5, 1921

2 Sheets-Sheet 1

Fig. 1.

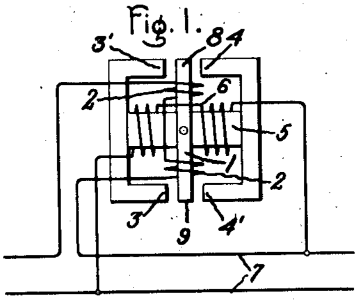


Fig. 2.

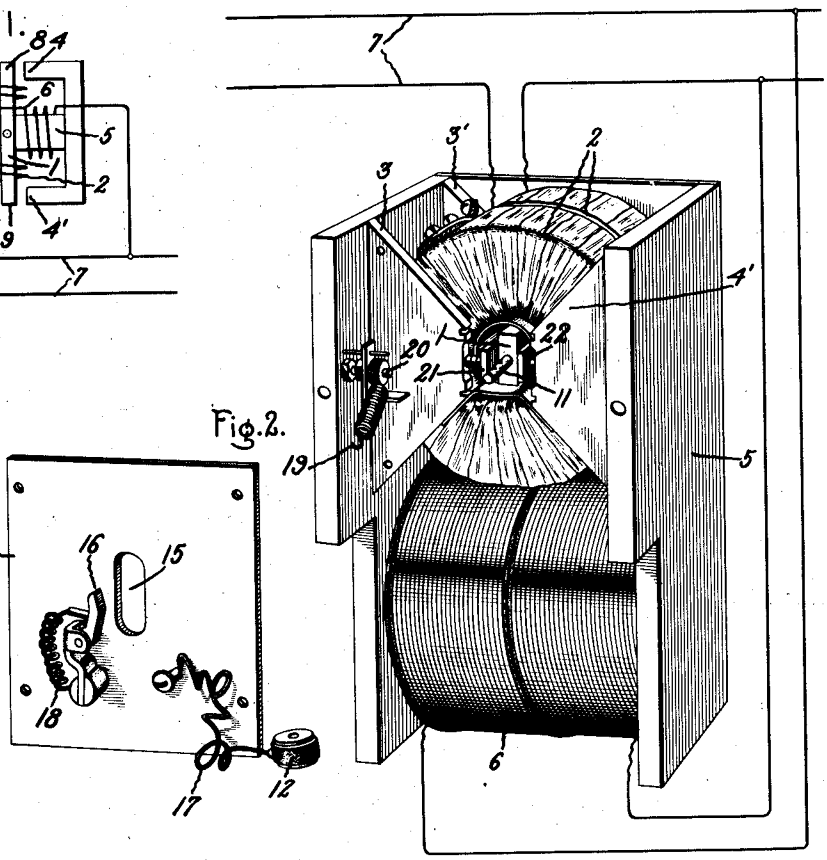


Fig. 4.

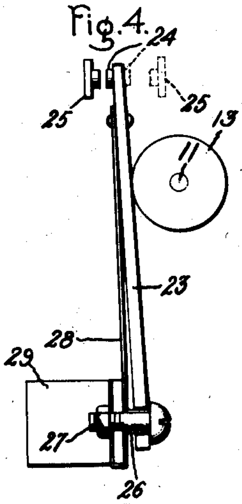


Fig. 3.

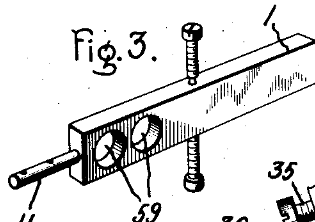
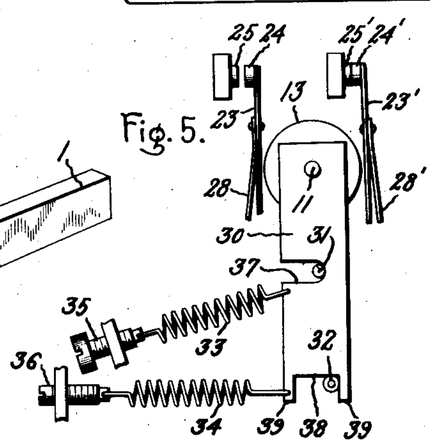


Fig. 5.



Inventor:
Harold W. Brown

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His Attorney.

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Filed July 5, 1921 2 Sheets-Sheet 2

Fig. 6.

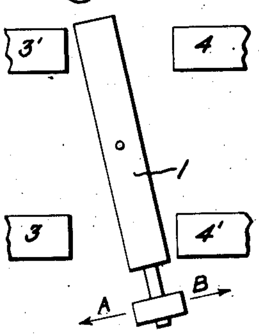


Fig. 7.

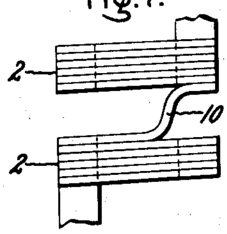


Fig. 8.

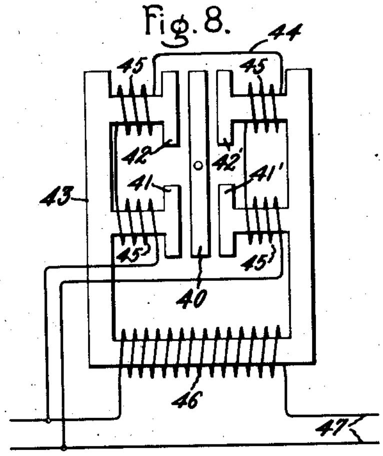
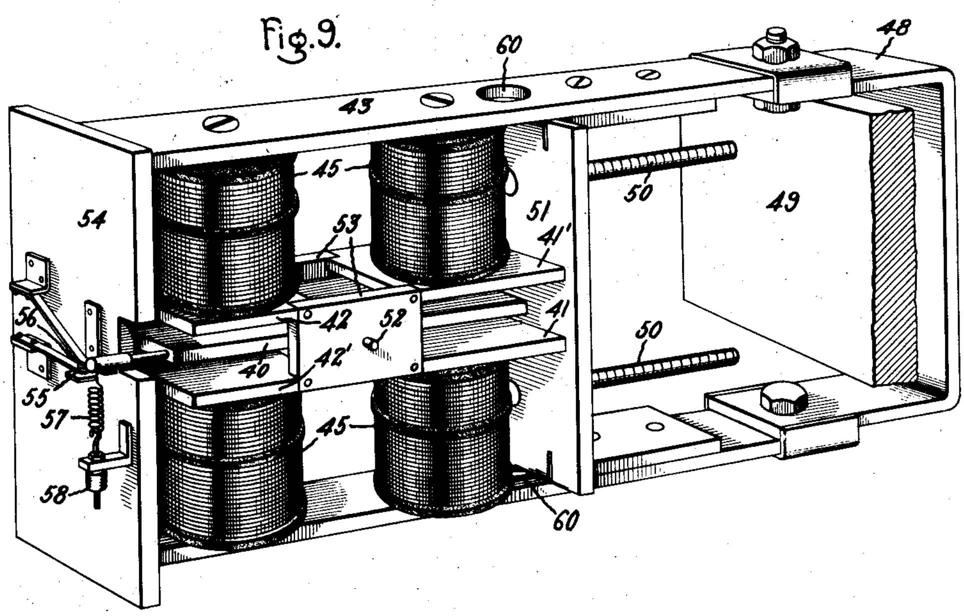


Fig. 9.



Inventor:
Harold W. Brown
by Albert G. Davis
His Attorney

Patented June 9, 1925. **1,541,618**

UNITED STATES PATENT OFFICE.

HAROLD W. BROWN, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RELAY.

Application filed July 5, 1921. Serial No. 482,630.

To all whom it may concern:

Be it known that I, HAROLD W. BROWN, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Relays, of which the following is a specification.

My invention relates to electroresponsive devices or relays for controlling electric systems or apparatus in response to predetermined conditions, and an object of my invention is to provide an improved highly sensitive relay certain in its operation and adapted to be readily arranged to operate in response to various circuit conditions such as predetermined current, undervoltage, reverse polarity, reverse power or combinations of these conditions.

My invention will be better understood from the following description taken in connection with the accompanying two sheets of drawings, and its scope will be pointed out in the appended claims.

Figure 1 illustrates diagrammatically one embodiment of my invention; Fig. 2 shows, in perspective, a practical form of the embodiment of my invention illustrated in Fig. 1; Fig. 3 shows, in perspective, the armature of the embodiment of my invention shown in Fig. 2; Fig. 4 is an elevation of one form of contact controlling device adapted for use with my invention; Fig. 5 is an elevation of a double-action contact controlling device; Fig. 6 illustrates diagrammatically the armature of the relay displaced from the neutral position; Fig. 7 shows diagrammatically a form of edgewise wound coil adapted for use with the embodiment of my invention shown in Fig. 2; Fig. 8 illustrates diagrammatically a modification of my invention; and Fig. 9 shows, in perspective, a practical form of the embodiment of my invention illustrated in Fig. 8.

The embodiment of my invention shown in Fig. 1 comprises an armature 1 pivotally mounted within a winding comprising coils 2 and between pairs of polar projections 3, 3′ and 4, 4′, having opposite polarities, of a magnetic structure 5 which may be either permanently magnetized or energized by a winding or coil 6 connected for example across a circuit 7. With the magnetic structure 5 permanently magnetized or energized by a current in the winding 6, the armature 1 will tend to turn on its pivot in one direction or the other depending upon the direction of current in the coils 2. Thus, for example, if polar projections 3, 3′ are of north polarity and polar projections 4, 4′ south and the direction of current in coils 2 is such that the end 8 of armature 1 has a north pole and the end 9 a south pole, then the joint action of the two magnetic fields tends to cause the armature 1 to turn on its pivot toward polar projections 3 and 4, and, if the direction of current in coils 2 were reversed, then the armature 1 would tend to turn on its pivot in the opposite direction towards polar projections 3′ and 4′. It is therefore obvious that, if the movable element or armature 1 were provided with suitable contact controlling devices, the embodiment of my invention shown diagrammatically in Fig. 1 would be adapted to respond to various predetermined conditions to operate the contact devices, which may be arranged to control suitable protective apparatus for the system in which the relay is connected.

Fig. 2 shows a practical form of the embodiment of my invetnion shown in Fig. 1, a part of the device being removed and shown at the left. In this form, of my invention, an armature 1 is arranged within and pivotally mounted intermediate the spaced coils of a winding 2 and between pairs of polar projections 3, 3′ and 4, 4′ of a magnetic structure 5. The polar projection 4 does not appear in the perspective shown in Fig. 2, but its position opposite polar projection 3′ will be obvious from Fig. 1. The magnetic structure 5 may be either permanently magnetized or the polarizing flux may be produced by a winding 6, which tends to prevent undue interference from stray magnetic fields and also to make the relay more sensitive in its operation. The winding 6 may also be used when it is desired to have the value of the polarizing flux vary with the circuit condition. With either arrangement, the polar projections 3, 3′ will be of like polarity as will also the polar projections 4, 4′ but the polarity of the latter pair will differ from that of the former. The armature 1 will, therefore, turn on its pivoted mounting in one direction or the other according to the direction of the current in coils 2, that is to say, according to the polarities produced in the ends of the armature 1 by the magnetic field of the coils 2. The coils 2 may be edgewise wound and formed from one piece of suitable conducting material and with an offset 10 between them as shown in Fig. 7, thus avoiding the necessity of separate means for connecting the two parts of the winding and providing ample room for the pivoted mounting of the armature 1 which is clearly shown in Fig. 3. The armature 1 is provided with a projecting portion or pin 11 for carrying a contact controlling member such as 12 of Fig. 2 or 13 of Figs. 4 and 5.

Referring again to Fig. 2, a plate 14, removed from the magnetic structure 5 and shown at the left for the sake of clearness, is provided with a slot 15 through which the armature pin 11 projects to receive the contact controlling member 12. The plate 14 carries a contact finger 16 against which the contact controlling member 12 is adapted to abut to complete a control circuit, not shown, through leads 17 and 18. When the plate 14 is secured in place against the polar projections 3 and 4′, the contact controlling member 12 is slipped on the pin 11 and suitable biasing means, such as a spring 19 secured to the pin 11 to aid in biasing the armature 1 to a predetermined position. Suitable adjusting means 20 is provided for varying the force of the spring 19. With this arrangement, the relay is of a circuit opening type operative in desponse to a change in the direction of the current in coils 2, such as would occur for example upon a reversal of power in an electric circuit 7, to control the operation of suitable circuit interrupting means, not shown, through a control circuit including the contact controlling member 12 and the cooperating contact finger 16. In order to obtain increased sensitiveness of operation, the armature 1 is held displaced from the central or neutral position, shown in Fig. 1, by a stop 21 of non-magnetic material. This displaced position is shown in Fig. 6 where the arrow A indicates the direction in which the armature 1 tends to move with current in the normal direction, and arrow B indicates the direction of movement of the armature 1 upon reversal of current in the coils 2.

Thus with the form of my relay shown in Fig. 2 and with current in normal direction in the coils 2, the armature 1, under the action of spring 19 and the joint action of coils 2 and 6, is held against the stop 21 with contact controlling member 12 against contact finger 16. Upon reversal of current in the coils 2, the polarities of the ends of the armature 1 are changed and under the joint action of coils 2 and 6, the spring 19 is overcome and armature 1 is caused to move thus drawing contact controlling member 12 away from contact finger 16. By mounting the contact finger 16 on the opposite side of the slot 15 in the plate 14, from that shown in Fig. 2, it is obvious that the relay would be circuit closing for the conditions described.

The form of my relay shown in Fig. 2 is also adapted to operate on either a reversal of current or current below a predetermined amount in the coils 2 as follows:— As long as the current in the coils 2 is in the normal direction and above a predetermined amount, the armature 1 will be held against a non-magnetic stop 22 by the joint action of the coils 2 and 6 opposing the action of the spring 19. If now the current drops below the predetermined value, the spring 19 will move the armature 1 in a direction to bring contact controlling member 12 against contact finger 16 or if the current in the coils 2 is reversed the joint action of the coils 2 and 6 assists the spring 19 in moving the armature 1 and therefore contact controlling member 12 in contact closing direction. By mounting the contact finger 16 on the opposite side of the slot 15 in the plate 14 from that shown, it is obvious that the relay would be circuit opening under the conditions described.

My invention is not, however, limited to an arrangement in which the coils 2 are arranged for operation in response to the current in the system. Where desired, both windings of the relay may be made voltage-responsive. With such an arrangement, the relay will operate upon under-voltage. Where the magnetic structure is permanently magnetized, or excited from a source of electromotive force of constant polarity, the relay will operate upon under-voltage or reverse polarity or both.

Fig. 4 illustrates another form of contact controlling mechanism adapted for use with my relay. This contact controlling mechanism comprises a rigid member 23 of suitable conducting material provided with one or more contacts 24 adapted to cooperate with one or more contacts 25. The rigid member 23 fits loosely over a bushing 26 held in place by suitable fastening means such as a bolt 27 that serves to fasten a resilient element or spring 28 to a fixed base or supporting bracket 29 adapted to be mounted on the relay structure. One end of the spring 28 is secured to the rigid member 23 and the other end is bent around a portion of the bracket 29 to prevent lateral displacement of the member 23 and the spring 28. The resilient element or spring 28 serves to bias the rigid member 23 in a predetermined direction against the contact controlling member 13 and also as a conductor to carry current from the base or bracket 29 to the rigid member 23 which is actuated by the roller or contact controlling member 13 carried on the projecting portion or pin 11 of the armature 1.

It is possible to arrange my relay to control two circuit controlling devices selectively operated in response to different circuit conditions and independently to adjust or calibrate the responsiveness of the relay for the respective conditions. To secure this result, I provide a double-action device illustrated in Fig. 5. This device comprises two sets of cooperating contacts 24—25 and 24′—25′, the contacts 24 and 24′ being mounted on the rigid members 23 and 23′ respectively, each of which has a mounting similar to that shown in Fig. 4. The members 23 and 23′ are biased towards the contact controlling member 13 by their respective springs 28 and 28′. In order to obtain the double-action feature, that is to say to control the contacts so that the action of each set of contacts can be independently calibrated, I provide a control member such as a lever 30 pivotally mounted on the armature pin 11 and biased for movement in response to the actuation of the armature 1 about either one of a pair of fixed pivots or fulcrums 31 and 32 by suitable biasing means such as springs 33 and 34 provided with adjusting means 35 and 36 respectively. The fulcrum 31 is arranged within a cut out or recessed portion 37 of the lever 30 and the fulcrum 32 within a cut out or recessed portion 38, the projecting portions 39 of which limit the movement of the lever 30 about the fulcrum 31.

The displaced position in the direction of motion on a reversal of current in coils 2 of the armature 1, as illustrated in Fig. 6, may be obtained by varying the position of either or both of the fulcrums 31 and 32.

The middle position of the parts shown in Fig. 5 corresponds to a current flow below a predetermined amount in the winding of the armature 1, the contacts 24 and 25 being open and the contacts 24′ and 25′ closed. Assuming now current flow in the normal direction and above the predetermined amount, the armature is deflected to the left carrying with it the contact controlling member 13 to close the contacts 24 and 25 and turning the lever 30 about the fulcrum 31 against the action of biasing means or spring 34. The effect of spring 33 to oppose this motion is negligible since its pull is substantially in line with fulcrum 31, its effect being merely to assist in holding the lever 30 against this fulcrum. Upon a reversal of current in the winding of the armature 1, the contact controlling member 13 would be moved to the right through the middle position thus allowing contact 24 to move away from contact 25 under the action of spring 28 and moving contact 24′ to circuit opening position, and the lever 30 would be turned against the action of biasing means or springs 33, about the fulcrum 32 against which the lever 30 is held by the spring 34. By this arrangement, it is, therefore, possible to calibrate independently the responsiveness of two sets of contacts operative in response to different predetermined conditions. When the lever 30 pivots about the fulcrum 31 any slight friction produced at the fulcrum 32 is negligible in effect since there is ample power in the relay at this time. To produce sensitive operation in the reverse direction, however, when the lever pivots about fulcrum 32 it is desirable to have as little friction as possible. The spring 33 is therefore somewhat inclined to exert a component force to hold the lever down against the fulcrum 32. Fulcrum 31 is therefore entirely disengaged from the lever 30. When my relay is used on direct current circuits and is provided with the double-action feature described, it is preferable to have the coils 2 connected across a shunt in series with the circuit to be protected. Then, when the circuit is interrupted, there will be no tendency for the armature 1 to move beyond the middle position and thus actuate the contact 24′ as the inductive effect of the coils 2 in the circuit including the shunt will produce a slowly collapsing field thereby prolonging the action of the current coils and preventing any tendency the armature might have to overtravel. With the double-action feature shown, both sets of contacts are circuit opening, one set on current below a predetermined amount and the other set upon a reversal of current in the armature winding. Obviously, the contacts 24—25 and 24′—25′ may be arranged on either side of their respective rigid members 23, 23′ as illustrated in Fig. 4. Consequently, the relay may be arranged to have both sets of contacts either circuit opening or circuit closing or either one of the sets of contacts can be circuit opening and the other set circuit closing.

Fig. 8 illustrates diagrammatically a modification of my invention comprising a movable element or armature 40, pivotally mounted between pairs of polar projections 41—41′ and 42—42′ of a magnetic structure 43. The polar projections are arranged to be energized by a winding 44 comprising coils 45 connected in circuit to produce a polarizing flux in the polar projections such that the polar projections 41 and 41′ are of like polarity, as are also the polar projections 42 and 42′ but the polarity of the former pair differs from that of the latter. The magnetic structure 43 is also provided with a winding 46 which, with current in one direction, will strengthen one pair of diagonally opposite polar projections and weaken the other pair of diagonally opposite polar projections and vice versa for current in the opposite direction. Consequently the armature 40 will be actuated in one direction or the other toward the strengthened polar projections in accordance with the direction of the current in the winding 46. Therefore, if the armature 40 were provided with suitable contact controlling devices, the embodiment of my invention shown in Fig. 8 would be adapted to respond to various predetermined conditions in an electric circuit 47, for example, to protect the same as well as apparatus installed thereon.

Fig. 9 shows a practical form of the embodiment of my invention illustrated in Fig. 8, as adapted for mounting on a switchboard with the legs of the magnetic structure 43 projecting therethrough and provided with an extension member 48 arranged to surround a current carrying member such as a bus bar 49, the magnetic field of which will establish a flux in the magnetic structure 43. The flux thus established may be in either direction depending upon the direction of the current in the member 49. Obviously the structure may be similar to that shown in Fig. 8, the current carrying member 49 being replaced by a winding 46 arranged to produce flux in either direction in the magnetic structure 43. In order to fasten the relay to the switchboard, fastening means or bolts 50 secured to a non-magnetic member 51, which is attached to the magnetic structure 43, are provided which extend through the switchboard to receive nuts on the rear side thereof. For clearness, the switchboard is not shown. The polar projections 41, 41′, 42 and 42′ of the magnetic structure 43 are arranged to be energized by a winding comprising coils 45 preferably connected in series with each other and in circuit to provide a polarizing flux in the polar projections such that polar projections 41, 41′ are of like polarity as are also polar projections 42, 42′ but the polarity of the former differs from that of the latter. The armature 40 is pivotally mounted between the polar projections on a pivot 52 journaled in bearings or non-magnetic pieces 53 secured to the polar projections as shown. The armature 40 is displaced from the middle or neutral position, as illustrated in Fig. 6, by a suitable stop to obtain a high degree of sensitiveness in operation when the current in the conductor 49 reverses in flow from the normal direction. Secured to the magnetic structure 43 is an insulating member 54 on which are mounted cooperating contacts 55 and 56 arranged to be controlled by the movement of the armature 40 which is biased in the example shown by a spring 57 provided with adjusting means 58.

With the arrangement shown, the contacts 55 and 56 are held closed with current in the normal direction in the conductor member 49, but on a reversal of current in this member the joint action of the magnetic fields produced in the magnetic structure 43 by the coils 45 and the conductor member 49, as heretofore explained, will actuate the armature against the action of the spring 57 to cause the opening of the contacts. Obviously the relay may be made circuit closing on reversal of current in conductor 49 by reversing the arrangement of the contacts. Similarly it is clear that the relay is adapted to operate on current below a predetermined amount in the conductor 49 as well as a reversal of current therein by merely placing the spring 57 on the opposite side of the armature 40 from that shown. In this case the armature 40 would be biased towards the polar projections 41 and 42 by the spring 57 and a predetermined current flow in the conductor 49 would hold the armature in a position to close contacts 55 and 56 against the action of spring 57. With current in the conductor 49 below the predetermined amount the spring 57 would move the armature 40 to open contacts 55 and 56 or with a reversal of current in the conductor 49, the joint action of the magnetic fields produced by coils 45 and conductor 49 would assist the spring to move the armature in contact controlling direction. Obviously the relay contacts 55 and 56 may be arranged to be either circuit opening or circuit closing under these conditions. It is also evident that the double action contact controlling arrangement shown in Fig. 5 may be used with the modification of my relay shown in Figs. 8 and 9.

Referring again to the modification of my invention shown in Figs. 1 and 2, the magnetic circuit energized by the coils 2 is arranged to become locally saturated by reducing the cross-section of the magnetic path thereof as illustrated in Fig. 3, where the armature 1 is provided with openings or holes 59 which limit or restrict the flux path. Similarly in the modification of my invention shown in Figs. 8 and 9, the magnetic circuit energized by the conductor 49 is arranged to become locally saturated by reducing the cross-section of the magnetic path thereof as illustrated in Fig. 9, where the magnetic structure 43 is provided with openings or holes 60, located as shown, so that only the magnetic circuit of the conductor 49 is locally saturated. This feature of localized saturation produces effects that are particularly desirable in electroresponsive devices or relays operative in response to current either below a predetermined amount or in a predetermined direction in one of the windings. One of these effects is to keep the total flux so small on normal current that other parts of the magnetic circuit do not become saturated and the residual magnetism is localized. The retentivity of the magnetic circuit is thus reduced and therefore the sensitivity of the relay is increased since the coercive force required to bring the flux to zero is less than would be required in the case of a longer saturated magnetic path. Another effect is to keep the total flux produced by current above a predetermined amount, that is to say normal or excessive current in the coils 2 of Fig. 2, in the winding 46 of Fig. 8, or in the conductor 49 of Fig. 9, so small that the relay cannot operate by the action of either magnetic element independent of the other. Without this localized saturation, particularly if the armature is out of the theoretically neutral position or displaced as is especially desirable in order to obtain increased sensitivity of operation, the flux in the four polar projections could be greatly unbalanced. Consequently, the magnetic force might reverse the flux through the polar projections near which the armature is held and operate the relay independently of the polarizing flux in the polar projections and thus produce an erroneous operation of the relay, that is to say the relay would operate under conditions other than those for which it is intended to respond.

It will be obvious to those skilled in the art, that the several embodiments of my invention, utilizing windings for producing both the polarizing and operating fluxes, are capable of use in many relations upon alternating current circuits as well as upon direct current circuits.

Although I have shown and described my invention in considerable detail, I do not wish to be limited to the specific details thereof, as shown and described, but may use such modifications, substitutions, or equivalents thereof, as are embraced within the scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. A protective relay of the class described, comprising a plurality of polar projections, an armature pivotally mounted between said polar projections, and a winding adapted to control the flux of said armature to cause movement of the same in one direction or the other, the flux path for said winding being locally restricted in area to become saturated upon a predetermined current in said winding whereby the retentivity of the magnetic circuit is reduced and abnormal currents in said winding are prevented from reversing the polarities of said polar projections.

2. A protective relay of the class described, comprising a plurality of polar projections, an armature pivotally mounted between said polar projections, a polarizing winding for said polar projections, a second winding adapted to control the flux of said armature to cause movement of the same in one direction or the other, the flux path for said second winding being locally restricted in area to become saturated upon predetermined current through said second winding, whereby the retentivity of the magnetic circuit is reduced and abnormal currents in said second winding are prevented from reversing the magnetism in the polar projections magnetized by said polarizing winding.

3. A relay comprising an armature, a magnetic structure adapted to provide a path for a polarizing magnetic flux, a current winding adapted to produce a flux in said structure coacting with the polarizing flux to control the operation of the armature characterized by the fact that a portion of the flux path for the current winding is reduced in area to permit local saturation with a predetermined current in said winding.

4. A protective relay of the class described comprising a movable armature, a member pivotally related to said armature, fulcrums about which said member is respectively movable in accordance with the direction of movement of said armature, and means tending to hold said member against one of said fulcrums and opposing movement of said member about the other fulcrum with a predetermined force.

5. In a relay comprising an armature adapted to occupy an intermediate position and to take a position on either side of said intermediate position, the combination with said armature of a control member pivotally related to said armature, a pair of fulcrums about one or the other of which said member is arranged to move in accordance with the direction of movement of the armature from the intermediate position and against both of which said member is arranged to bear when the armature is in the intermediate position, and a spring device adjacent each fulcrum arranged to exert a force substantially in line therewith tending to hold said member against the fulcrum whereby opposite movements of the armature are substantially independently opposed by the respective spring devices.

6. A protective relay of the class described, comprising a plurality of polar projections, an armature pivotally mounted between said polar projections, a winding adapted to control the flux of said armature to cause movement of the same in one direction or the other, a control member pivotally related to said armature, fulcrums about which said member is respectively movable in accordance with the direction of movement of the armature, and independently adjustable means tending to hold said member against said fulcrums and opposing movement about the respective fulcrums.

7. A protective relay of the class de-

scribed, comprising a plurality of polar projections, an armature pivotally mounted between said polar projections, a polarizing winding for said polar projections, a second winding adapted to control the flux of said armature to cause movement of the same in one direction or the other, a lever pivotally related to said armature, fulcrums about which said lever is respectively movable in accordance with the direction of movement of the armature, means tending to hold said lever against said fulcrums and opposing movement of said lever about the respective fulcrums, and contacts on each side of said armature biased thereto and controlled by the movement thereof.

8. A protective relay of the class described comprising a plurality of polar projections, an armature pivotally mounted between said polar projections, a winding adapted to control the flux of said armature to cause movement of the same in one direction or the other according to the direction of the current in the winding, the flux path for said winding being locally restricted in area to become saturated upon a predetermined current in said winding, whereby the retentivity of the magnetic circuit is reduced and abnormal currents in said winding are prevented from reversing the polarities of said polar projections, and means adapted to prevent said armature from assuming a neutral position between said polar projections whereby the sensitiveness of the armature movement is increased upon a reversal of current in said winding.

9. An electro-responsive device of the class described comprising a magnetic structure provided with a plurality of oppositely disposed polar projections, a winding adapted to produce a polarizing flux in said magnetic structure and thereby to magnetize said polar projections, an armature pivotally mounted between said polar projections, a second winding adapted to produce a flux in said magnetic structure and thereby to control the flux of said armature to actuate the same in one direction or the other in accordance with the direction of the current in said second winding, characterized by the fact that the flux path of said second winding is locally restricted in area to become saturated upon predetermined current through said second winding whereby the retentivity of the magnetic circuit is reduced and abnormal currents in said second winding are prevented from reversing the magnetism in the polar projections magnetized by said first winding.

10. A protective relay of the class described, comprising a magnetic structure having oppositely disposed polar projections, a winding on said structure adapted to produce a polarizing flux therein and thereby to magnetize said polar projections, a winding surrounding said armature adapted to produce a flux therein to cause movement of the same in one direction or the other in accordance with the direction of current in said winding, contacts controlled by said armature, and openings in said armature locally restricting the flux path of said second winding to cause the flux path thereof to become saturated on predetermined current therein whereby the retentivity of the magnetic circuit is reduced and abnormal currents in said second winding are prevented from reversing the polarities of said polar projections.

11. A protective relay of the class described comprising a movable armature, a control member pivotally related to said armature, fulcrums about which said member is respectively movable in accordance with the direction of movement of said armature, and means tending to hold said member against one of said fulcrums and opposing movement of said member about the other fulcrum.

In witness whereof, I have hereunto set my hand this 1st day of July 1921.

HAROLD W. BROWN.