April 4, 1950 J. E. WILLING ET AL 2,502,811

POLARIZED RELAY

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FIG. 1.

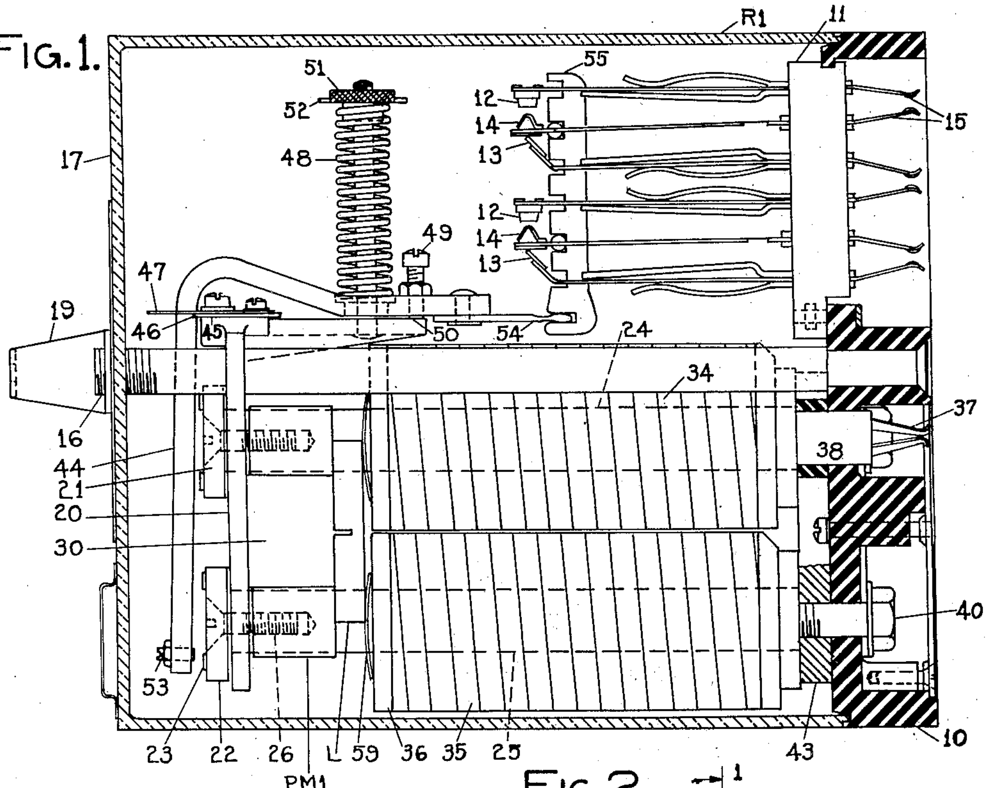


FIG. 2.

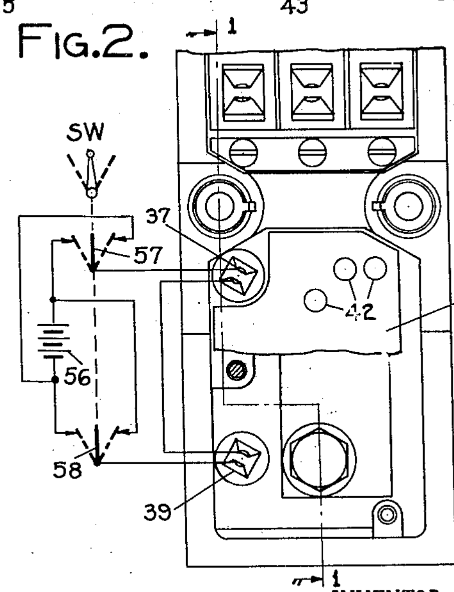
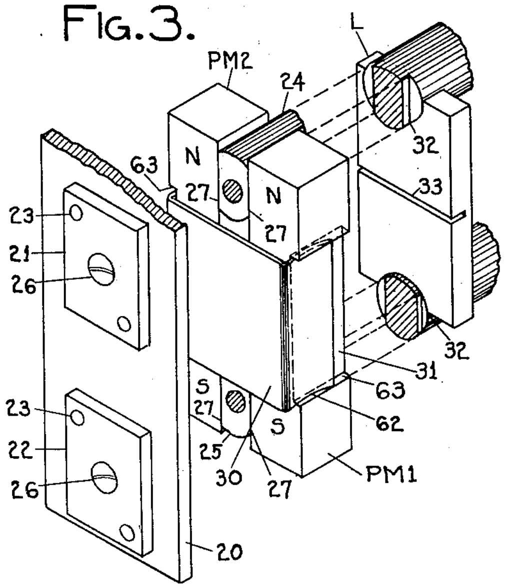
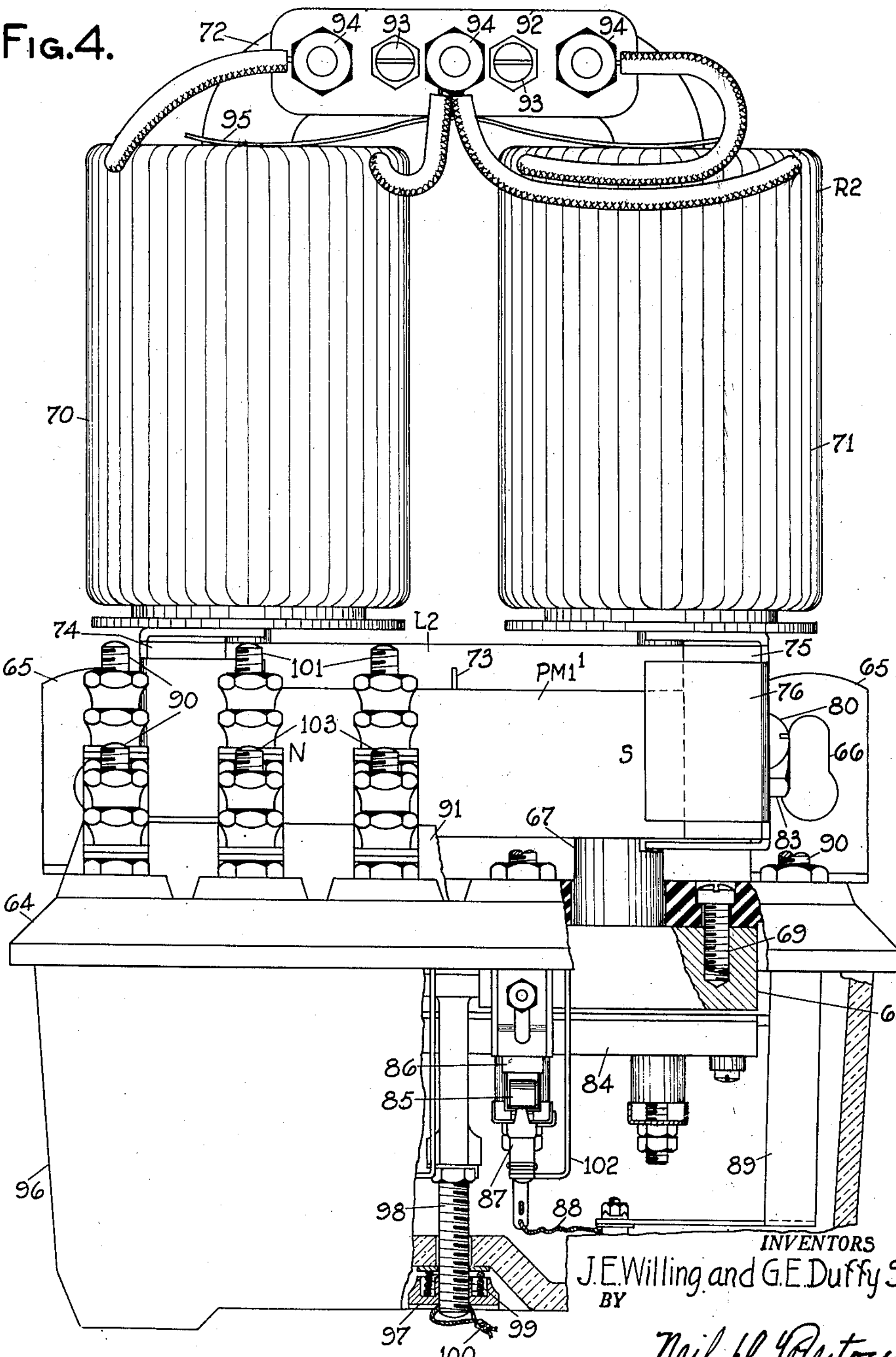


FIG. 3.



INVENTOR.
J. E. Willing & G. E. Duffy Sr.
BY
Neil W. Preston,
THEIR ATTORNEY

FIG. 4.



INVENTORS
J. E. Willing and G. E. Duffy Sr.
BY
Neil H. Preston,
Their ATTORNEY

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FIG. 5.

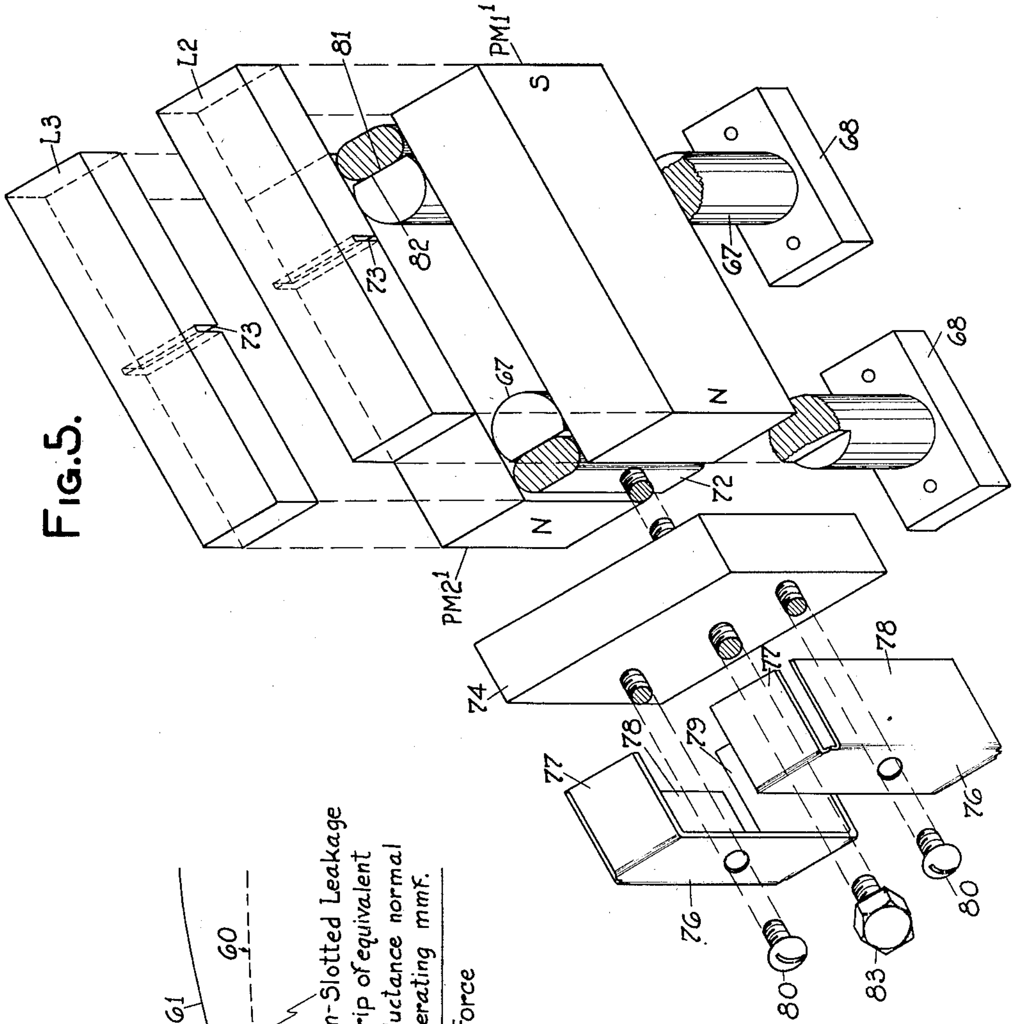
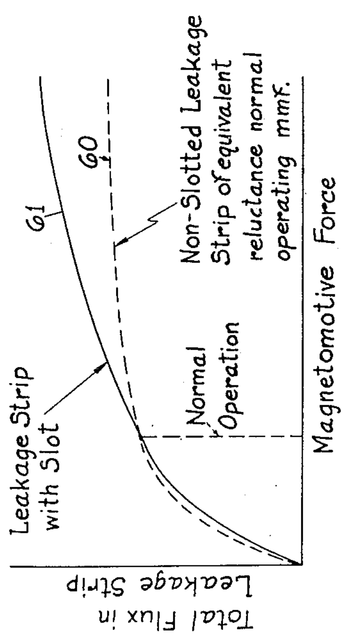


FIG. 6.



INVENTORS.
J.E.Willing and G.E.Duffy Sr.
BY
Neil W. Preston,
Their ATTORNEY

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UNITED STATES PATENT OFFICE

2,502,811

POLARIZED RELAY

Joseph E. Willing and George E. Duffy, Sr., Rochester, N. Y., assignors to General Railway Signal Company, Rochester, N. Y.

Application September 27, 1946, Serial No. 699,678

3 Claims. (Cl. 175—339)

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This invention relates to direct current relays, and it more particularly pertains to relays of the biased polar type which have armatures actuated only in response to a particular polarity of energization of the relay windings.

A relay of this character is disclosed in the prior application of G. E. Duffy, Sr., Ser. No. 542,203, filed June 26, 1944, which has resulted in Patent No. 2,414,583, dated January 21, 1947, and the present invention is to be considered as providing improvements in the relay of that disclosure, no claim being made herein to subject matter disclosed in that prior application.

Although a relay of this character has many applications in railway signalling practice, it is often used in polarized circuits in which its windings are subject to energization of the reverse polarity from that to which it is responsive. It is desirable to provide a structure in the biased polar relay that will prevent relay operation on reverse current, even if the reverse current is provided by an extraneous source of energy at a voltage many times greater than the normal operating voltage of the relay. Protection against the operation of the relay by reverse current is provided as disclosed in the abovementioned application by use of a leakage strip forming a shunt across the magnetic circuit including the relay armature in combination with a permanent magnet for substantially saturating the shunt under normal operating conditions.

An object of the present invention is to increase the extent of protection against the relay operating on reverse current over that provided with a leakage strip as in the above prior application, without increasing the operating current of the relay, by the use of a leakage strip bridging the poles of an electro-magnet having a reduced cross section at a point between the poles. A leakage strip of this character provides better shunting characteristic at higher voltages of reverse current without requiring an increase in normal operating current.

Another object of the present invention is to provide a convenient and economical means for securing the permanent magnets across the cores of an electromagnet. This feature of the invention, illustrated more particularly in Fig. 3 of this disclosure, has been disclosed and claimed in our divisional application, Ser. No. 123,618, filed October 26, 1949.

Other objects, purposes, and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference is made to the accompanying drawings in which corresponding reference characters identify corresponding or similar parts of different views, and in which:

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Fig. 1 is an elevational view of a plug board mounting relay constructed according to the present invention with certain parts shown in cross section as taken along the section line 1—1 of Fig. 2;

Fig. 2 is a right-hand end view of the relay as shown in Fig. 1;

Fig. 3 is a view in perspective showing certain of the relay elements in an expanded relationship;

Fig. 4 is an elevational view of a relay of the shelf or bracket mounting type having certain parts shown in cross section;

Fig. 5 is a perspective view of certain parts of the relay of Fig. 4 shown in expanded relationship; and

Fig. 6 shows graphically a comparison between the total flux at various values of magnetomotive force of a leakage strip having a reduced cross section and a solid leakage strip of comparable reluctance at normal operating values.

It is to be understood that the application of the present invention to relays of the character disclosed in Fig. 1 and Fig. 4 is merely typical of the manner in which the present invention may be applied to other types of relays, such, for example, as to the structures of relays having different arrangements of contacts and different types of core and armature structures.

With reference to Fig. 1, the relay R1 is of the quickly detachable plug board mounting type of the general character disclosed, for example, in the patent to J. F. Merkel, Patent No. 2,258,123, dated October 7, 1941, to which reference can be made for a more complete disclosure, particularly as to the manner of adjustment of the restoration spring for the relay armature, and as to other features of the relay common to that disclosure and the relay as shown in Fig. 1.

The relay as shown in Fig. 1 comprises a base member 10, preferably molded of insulating material, in which is suitably secured a contact block 11 also of insulating material having suitably secured therein front contact fingers 12, back contact fingers 13 and movable contact fingers 14, such contacts being electrically connected to the contact tips 15 which extend to the right of the contact block 11 for engagement with plug contacts of a suitable plug board (not shown).

The relay R1 is adapted by the tubular members 16 for mounting over rods of a plug board (not shown), such tubular members being suitably secured in the base member 10 and extending through openings in the cover 17, such cover being preferably of transparent material, and being secured over the relay to protect its contacts and operating mechanism from dust and mechanical damage. The brackets 19 are threaded on to the left-hand ends of the tubular members 16 to secure the cover 17 tightly in place.

A bracket 20 of non-magnetic material has pole faces 21 and 22 of magnetic material, such, for example, as silicon steel, suitably secured thereto as by the non-magnetic rivets 23 which protrude slightly to serve as minimum residual pin spacers to provide a minimum air gap of approximately ten thousandths of an inch between the armature 44 and the pole faces 21 and 22 when the armature is picked up.

The pole faces 21 and 22 are suitably secured to the respective cores 24 and 25 as by the screws 26.

The cores 24 and 25 have flat finished sides formed thereon at their left-hand ends at the points 27 for making contact with the permanent magnets PM1 and PM2 which are securely held against the finished surfaces 27 on the opposite sides of the cores 24 and 25 by the spring 30 of phosphor-bronze or other suitable spring material, such material being preferably non-magnetic. The U-shaped spring 30 having somewhat curved sides 62 not only holds the magnets PM1 and PM2 tightly against the cores 24 and 25, but it also holds the magnets in alignment because of its width being substantially equal to the spacing between the cores 24 and 25, and because of the sides of the spring engaging a recessed portion 31 of the magnet PM1 having shoulder 63, and a similar portion of magnet PM2 (not shown) to hold the magnets PM1 and PM2 in vertical alignment.

The leakage strip L is shown as being substantially rectangular in shape and of a substantial thickness, the thickness being dependent upon the relative size of the core structure with which it cooperates. The leakage strip L has semi-circular recesses 32 formed therein of a radius to conform to the radius of the cylindrical portion of the cores 24 and 25, such recesses being spaced from each other by a distance comparable to the spacing of the cores 24 and 25 so that the leakage strip L will fit tightly, when positioned as shown in Fig. 3, between the cores 24 and 25. By this arrangement a magnetic circuit of relatively low reluctance can be established through the cores 24 and 25 in series with the leakage strip L. It is to be understood that other means may be employed for securing the leakage strip across the cores in accordance with the requirements of practice, such, for example, as using two leakage strips and clamping them on opposite sides of the cores as the permanent magnets are clamped.

In an intermediate position in the leakage strip L, there is a reduction in the cross section of such leakage strip for purposes to be hereinafter pointed out when considering the mode of operation of the relay. One form of reduced cross section is illustrated in Fig. 3 in which a slot 33 is formed in the leakage strip transverse to the lines of flux. Although the slot 33 is effective in various degrees in accordance with its depth, it has been found in practice that a depth substantially two-thirds of the thickness of the leakage strip L is satisfactory for providing the desired mode of operation. Although different width slots may be employed, it has been found to be desirable that the slot be maintained at as narrow a width as possible in order to provide the most desired mode of operation of the relay. A slot one thirty-second of an inch in width has been found to be satisfactory. The leakage strip L is fitted between the cores 24 and 25 at a point adjacent the permanent magnets PM1 and PM2,

with the slot 33 adjacent the permanent magnets as a means for standardizing the construction and arrangement of parts of the relay, although it is to be understood that the characteristics of the relay would be modified only slightly if the leakage strip L were spaced a short distance from the permanent magnets, or if the leakage strip L were assembled in the relay with the slot 33 spaced away from, rather than being adjacent to, the permanent magnets PM1 and PM2.

The relay windings 34 and 35 are provided on suitable spools with spacers 36 of insulating material formed on the ends thereof, such spools being fitted over the respective cores 24 and 25 at the right of the leakage strip L.

The contact tips 37 make connections to the respective ends of the relay winding 34 by extending through a sleeve 38 formed of insulating material to the wire connections at the respective ends of the winding 34. Similarly, tips 39 (see Fig. 2) are provided for coupling the wiring connections for the winding 35 to a suitable plug board (not shown).

The cores 24 and 25 are suitably assembled to the base member 10 and to the yoke 43 bridging the ends of the cores 24 and 25 as by bolts 40 threaded into the ends of the respective cores 24 and 25. The heads of such bolts are recessed into the base 10 and a registration plate 41 (see Fig. 2) is secured over the heads of the bolts 40, such registration plate having holes 42 formed therein at positions characteristic of this type of relay to match with the positions of suitable registration pins (not shown) in a suitable plug board (not shown). The spring washers 59 take up what end play there may be in the parts thus assembled. It is preferable that the yoke 43 be permanently secured across the ends of the cores 24 and 25 as by welding to insure against the omission of that part if for any reason the relay is later disassembled.

The armature 44, of suitable magnetic material such, for example, as silicon steel, is of an L-shaped structure and is positioned by the bearing plate 45 which fits loosely into the slot 46 formed in the armature 44. The armature plate 47 retains the bearing plate 45 within the slot 46. The armature 44 is biased to a restored or dropped away position by the biasing spring 48 to an extent limited by the adjustment screw 49 acting upon the non-magnetic bracket 20 at the point 50. The adjustment of the spring 48 is accomplished by the thumb nut 51 which is locked in its adjusted position by the pin 52. The residual screw 53 of non-magnetic material is adjustable to limit the degree of attraction of the armature 44 to the pole faces 21 and 22. In accordance with the actuation of the armature 44 to its attracted or restored positions, the lever 54 operates the pusher 55 vertically to selectively close front and back contacts in accordance with the picking up and the restoration respectively of the armature 44.

Although various types of material may be used for the magnetic circuits of the relay R1, it has been found that silicon steel provides satisfactory operation when employed as the material for the cores 24 and 25, the leakage strip L, the armature 44 and the yoke 43. It is desirable because of the conditions of reverse current energization of the relay R1 that the permanent magnets be of a material requiring a high coercive force for demagnetization such, for example, as an aluminum-nickel-cobalt-iron alloy. Because of the hardness of such material the means heretofore described for securing the magnets PM1 and PM2 to the cores 24 and 25, without the use of bolts, is highly desirable.

It is to be understood that the mode of operation of the relay R1 corresponds substantially to the mode of operation as set forth in the abovementioned patent to G. E. Duffy, Sr., No. 2,414,583, dated January 21, 1947, to which reference is to be made for a description more in detail as to the principles and theory of operation of the relay, thus the description of the mode of operation herein included will be limited to that which is desirable for an understanding of the improvements provided by the present invention, and it is to be understood that any theory of operation set forth herein is included to facilitate an understanding of reasons for the structure rather than to limit in any manner the scope of the present invention or the application of other theories of operation.

A schematic wiring connection is illustrated in Fig. 2 for providing energization of the relay R1 with one polarity or the other, or for the deenergization of the relay by the actuation of the switch SW, suitable connections being made to the contact tips 37 and 39 to connect the windings 34 and 35 with proper polarity to act in series in the establishment of magnetic circuits in the U-shaped core structure.

With the switch SW in its normal center position as shown, the windings 34 and 35 are deenergized, and the permanent magnets PM1 and PM2, which are poled the same in their assembly in the relay provide a magnetomotive force for three magnetic circuits. One of these magnetic circuits can be traced as extending from the north pole of the permanent magnets PM1 and PM2 including the left-hand end of core 24, armature 44, and the left-hand end of core 25, to the south pole of the permanent magnets PM1 and PM2. A second magnetic circuit can be traced as extending from the north pole of the permanent magnets PM1 and PM2 through the right-hand portion of the core 24, yoke 43, and right-hand portion of core 25, to the south pole of the permanent magnets PM1 and PM2. A third circuit for the permanent magnets PM1 and PM2 can be traced as extending from the north pole of such permanent magnets through the leakage strip L to the south pole of the permanent magnets PM1 and PM2. The direction of the flux in the respective magnetic circuits which have been described can be assumed to be in correspondence with the sequence in which the respective elements of each magnetic circuit have been mentioned in the description of the magnetic circuits.

To consider the magnetic circuits of the electromagnet and the effect of such magnet on the attraction of the armature 44, it will be assumed that the switch SW is operated to a right-hand position to apply proper polarity of energization to the windings 34 and 35 for effecting the picking up of the armature 44. A circuit is closed under such conditions extending from the positive terminal of battery 56, including contact 57 of switch SW in its right-hand position, winding 34 of relay R1, winding 35 of relay R1, and contact 58 of the switch SW in its right-hand position, to the negative terminal of battery 56. In response to such energization a magnetomotive force of the electromagnet establishes flux in a direction in the right-hand portions of the cores 24 and 25 in opposition to the permanent magnetic flux which has been established through these parts. The direction of magnetic flux of the electromagnet in the magnetic circuit established through the armature 44, however, is the same as the direction of flux of the permanent magnets PM1 and PM2, and therefore the density of flux in the armature 44 is increased to a point to cause such armature to be picked up against the action of the biasing spring 48, the flux through the armature having increased as a result of the shifting of permanent magnet flux from the magnetic circuit including the yoke 43 as well as because of the added flux of the electromagnet.

The energization of the electromagnet with the polarity as described also establishes flux in the leakage strip L in a direction corresponding to the direction of the flux through such leakage strip as supplied by the permanent magnets PM1 and PM2. Inasmuch as the permanent magnets PM1 and PM2 are magnetized sufficiently to normally substantially saturate the non-notched portion of the leakage strip L, the leakage strip L offers a high reluctance to the flux of the electromagnet at normal operating values of magnetomotive force, and thus little of the power of the electromagnet is lost by the shunt of the leakage strip L, in multiple with the armature 44. The magnetomotive force applied to the leakage strip L at normal operating values is insufficient to cause a substantial amount of flux to bridge the air gap of the slotted portion of the leakage strip.

Assuming the switch SW to be restored to its center position, the opening of the circuit for the relay R1 at contacts 57 and 58 is effective to cause the restoration of the armature 44 to its normal position because the magnetization of the permanent magnets PM1 and PM2 is insufficient to hold the armature in its attracted position without the aid of the electromagnet. The deenergization of the windings 34 and 35 of the relay R1 eliminates the electromagnetic flux established in opposition to the flux of the permanent magnet in the right-hand portions of the cores 24 and 25, and thus allows the strengthening of the permanent magnet flux in those portions of the magnetic structure of the relay and the weakening of the flux in the magnetic circuit including the armature 44. The restoration of the armature 44 further decreases the flux density in the magnetic circuit including such armature because of the increased air gap in that circuit, and more flux is thus diverted to the magnetic circuit including the right-hand portions of the cores 24 and 25 and the yoke 43.

To consider the operation of the relay on reverse current, it will be assumed that the switch SW is actuated to its left-hand position to close the contacts 57 and 58 and pole change the circuit for the windings 34 and 35 of the relay R1 as compared to the polarity of energization of such windings by the circuit which has been described. This polarity of energization of the electromagnet establishes electromagnetic flux in both the leakage strip L and the armature 44 in opposition to the permanent magnet flux in those magnetic circuits. For the armature to be picked up on reverse current it is necessary therefore that the flux in the armature be reversed in direction from that which is established by the permanent magnets PM1 and PM2, and that it be of a sufficient density, in the reverse direction, to attract the armature 44 against the action of the biasing spring 48.

It will be noted that the condition with respect to the leakage strip is somewhat different from that which has been described when considering the picking up of the relay by its normal polarity in that the flux must be neutralized in the leakage strip L and must be reverse in direction to an extent near saturation before sufficient flux for picking up the armature 44 will be diverted to the magnetic circuit including such armature and the substantial air gap between that armature and the pole faces 21 and 22. It is therefore established that in order to operate the relay R1 on reverse current, the degree of energization of the relay must be many times its normal degree of energization, and therefore the value of magnetomotive force applied across the leakage strip L would necessarily be many times that which is normally applied across such leakage strip.

With reference to Fig. 6, curves 60 and 61 are shown illustrating the manner in which the total flux of different types of leakage strips varies with different values of magnetomotive force. The curve 60 illustrates the manner in which the total flux varies with a varying magnetomotive force for a non-slotted leakage strip of comparable reluctance to that of the slotted leakage strip L at the normal operating value of magnetomotive force. The curve 61 of the slotted leakage strip L is a composite curve of the combination of the curve for the non-slotted portion of the leakage strip L with the curve of the slotted portion. The curve of the non-slotted portion would necessarily have a shape similar to the curve 60, and the curve for the slotted portion would be dependent upon the reluctance of the air gap in combination with the reluctance of the adjacent magnetic material for various degrees of magnetomotive force applied. Inasmuch as the magnetization curve of an air gap is substantially a straight line, and the width of the air gap is small, the leakage strip is effective to have its flux built up as the magnetomotive force is increased above the normal operating value, and thus rob flux away from the magnetic circuit through the armature 44, as compared to the condition illustrated by the curve 60 whereby the density of flux in a non-slotted leakage strip can be increased only slightly by an increase of several times the normal value of magnetomotive force.

It is to be understood that the curves shown in Fig. 6 are shown principally for illustrating the relative characters of slotted and non-slotted leakage strips rather than illustrating specifically the actual magnetization curve for leakage strips to be employed in practice, and that the leakage strips employed in practice may have different characteristics from those which have been illustrated in accordance with the size and shape of leakage strips employed, the depth of the slot 33 and the width of the slot 33.

A modified form of the present invention is found in the relay R2 illustrated in Fig. 4 which has a mode of operation corresponding to that which has been specifically described for the relay R1, and which has a core structure similar to that shown in the above-mentioned patent to G. E. Duffy, Sr.

The relay R2 comprises a plate 64 formed of insulating material having suitably secured thereto angular mounting brackets 65 provided with slots 66 for hanging the relay R2 on mounting screws (not shown), or the like. The pole shoes 67 with enlarged rectangular pole pieces 68 extend through the plate 64, and the pole pieces 68 are suitably secured to the underside of the plate 64 by screws threaded into such pole pieces, such, for example, as by the screw 69 (see Fig. 4).

After the windings 70 and 71 are inserted over the U-shaped core structure 72, the magnets PM1[1] and PM2[1] are disposed across the legs and on opposite sides of the core 72, such magnets being poled alike when disposed in this position.

The leakage strips L2 and L3 are disposed on the top of the respective permanent magnets PM1[1] and PM2[1], with their slots 73 adjacent the respective magnets. It is to be understood, however, that such leakage strips could be disposed in other positions, or with the slots 73 facing away from the permanent magnets without materially affecting the operation of the relay. The end plates 74 and 75 are disposed at the respective left-hand and right-hand ends of the permanent magnets PM1[1] and PM2[1] and the leakage strips L2 and L3 for providing a magnetic circuit of low reluctance extending from the core 72 through the respective leakage strips L2 and L3, and from the core 72 through the respective permanent magnets PM1[1] and PM2[1]. The leakage strips L2 and L3 are maintained in alignment with the end plates 74 and 75 by the brackets 76, such brackets having ears 77 at the top, 78 at the sides and 79 at the bottom, all formed inwardly at the sides of the permanent magnets PM1[1] and PM2[1] and the leakage strips L2 and L3. The brackets 76 are suitably secured to the end plates 74 and 75 as by the screws 80.

The core structure 72 has its legs secured to the pole shoes 67 at a point between the permanent magnets PM1[1] and PM2[1], such legs having flatly finished inside surfaces 81 to provide a joint of low reluctance with the flatly finished surfaces 82 of the pole shoes 67. The bolts 83 on opposite sides of the core structure extend through the end plates 74 and 75 at the respective left-hand and right-hand ends of such structure, through the legs of the core 72, and such bolts are threaded into the pole shoes 67.

Disposed beneath the pole pieces 68 is an armature 84 pivoted by suitable adjustable trunnion bearings (not shown) at the back of the relay, such bearings being secured to the plate 64. Movable contact fingers 85 are secured to the underside of the armature 84 in a suitable manner so as to be insulated from each other, and such contacts are preferably of an articulated structure such as is shown, for example, in the patent to J. F. Merkel, Patent No. 1,748,918, dated February 25, 1930. The movable contacts 85 act to close respective stationary front contacts 86 or stationary back contacts 87 in accordance with the selective energization and deenergization of the windings 70 and 71 of the relay R2 with the normal polarity of energization for that relay. The stationary back contacts are secured by suitable brackets 102 to a terminal post 101, and the stationary front contacts are suitably secured to respective terminal posts 103 in a similar manner. The movable contacts 85 are connected by flexible lead wires 88 to suitable brackets 89 attached to terminal posts 90. The rib 91 of insulating material is formed in the plate 64 to elevate the terminal posts 101 above the terminal posts 90 to make them more readily accessible for the attachment of wires.

The terminal block 92 of insulated material is suitably secured to the core 72 at the top of the core as by the screws 93, for providing terminal posts 94 for facilitating circuit connections to the windings 70 and 71 of the relay. The spring

95 having forked ends is inserted over the top of the windings 70 and 71 for securing such windings against longitudinal movement on the legs of the core 72.

A cover 96, preferably of transparent material, is fitted over the relay contacts 85, 86 and 87 and the armature 84 to protect such parts against dust and mechanical damage. The cover 96 is suitably secured against the under side of the plate 64 as by the thumb nut 97 threaded onto the stud 98, which in turn is suitably secured to the plate 64. The spring 99 insures a tight fit for the cover 96 without mechanical damage thereto, and a seal 100 when applied to the stud 98 with the cover 96 in place prevents unauthorized tampering with the operating mechanism of the relay.

It is to be understood that the use of two slotted leakage strips in relay R2 instead of a single larger leakage strip as shown for relay R1 is a matter of choice in accordance with the requirement of practice.

Although various materials may be suitably employed for the magnetic structure of the relay R2, it has been found that silicon steel is particularly suitable for the leakage strips L2 and L3, the end plates 74 and 75, the core 72, the shoes 67, and the brackets 76. It is desirable to use a magnetic material for the permanent magnets PM1[1] and PM2[1] requiring a high coercive force for demagnetization, such, for example, as the material known by the trade name of Alnico Black Streak steel.

Having thus described two specific embodiments of the present invention, it is desired to be understood that these forms are purely illustrative of the manner in which the present invention may be applied, and that the disclosure of these forms should in no way limit the number of forms which the invention may assume, and it is to be further understood that various adaptations, authorizations and modifications may be applied to the specific form shown to meet the requirements of practice without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What we claim is:

1. An electromagnetic relay responsive to direct current energization of one polarity but not to higher energizations of the opposite polarity comprising, a magnetic core structure of a general U-shape having legs terminating in enlarged pole pieces, a biased movable armature spanning said pole pieces, a permanent magnet connected across said legs tending to send flux through magnetic paths in multiple through a part of said core structure and said armature respectively, windings on said part of said core structure, and a magnetic leakage strip extending between the legs of said core structure adjacent said permanent magnet and constituting a magnetic shunt path for flux through said armature, said leakage strip having for a small part of its length a reduced cross section substantially saturated by flux from said permanent magnet alone, the saturation of the reduced cross section of said leakage strip causing it to have little shunting effect upon the flux path through said armature when said windings are energized with an operating polarity and tend to send flux through said leakage strip in the same direction as the permanent magnet flux, said leakage strip acting to shunt flux from said armature and prevent its operation by currents of the non-operating polarity larger than the currents of operating polarity up to a current level where said reduced portion of the leakage strip again becomes substantially saturated by flux in the other direction, said leakage strip also affording a relatively short leakage path through air around its reduced cross section to shunt flux from said armature and prevent its operation by still larger currents of the non-operating polarity.

2. A relay according to claim 1 in which the reduced cross section of the leakage strip is formed by a narrow transverse slot of a width comparable with the operating air gaps of the armature.

3. A relay structure according to claim 2 in which the narrow slot extends across approximately two-thirds of the adjacent cross section of said leakage strip.

JOSEPH E. WILLING.
GEORGE E. DUFFY, SR.

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