

Aug. 15, 1944.

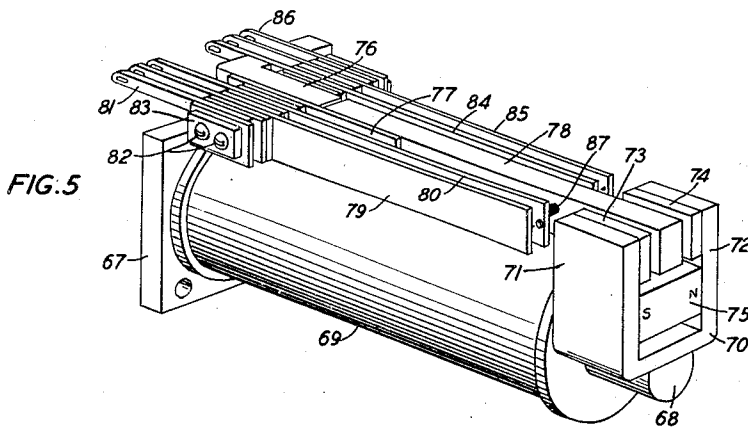
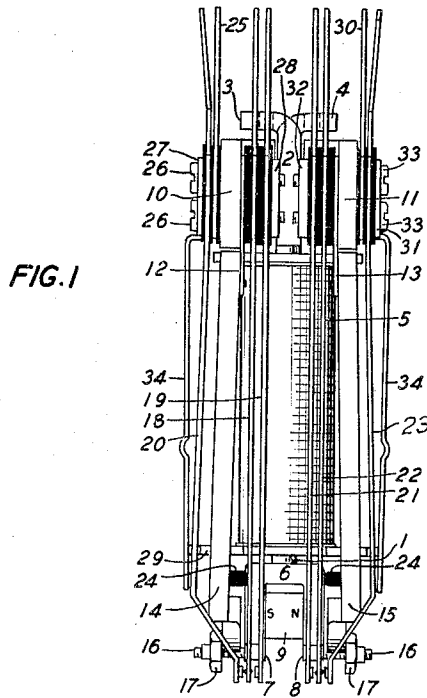
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2,355,909

POLARIZED RELAY

Filed July 11, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2

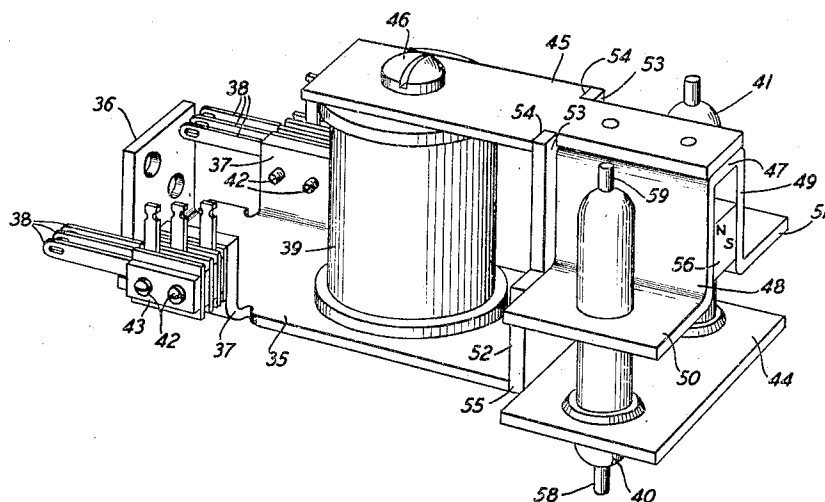


FIG. 3

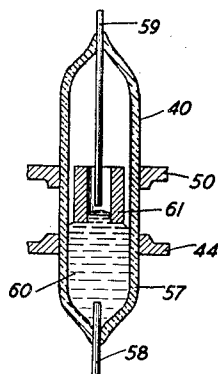
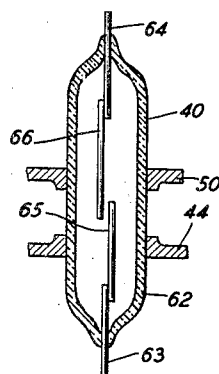


FIG. 4



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2,355,909

POLARIZED RELAY

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Application July 11, 1940, Serial No. 344,898

4 Claims. (Cl. 175—339)

This invention relates to an electromagnetic device and more particularly to a polarized relay.

It is often desirable in signaling systems to selectively close two work circuits by the operation of a polarized relay in response to the energization of its winding by current of either positive or negative polarity. If a polarized relay of the type which has a single armature biased to a neutral position is used for this type of service, there is always the possibility that if the armature is not accurately biased in the neutral position, it may fail to operate on current of one polarity or may operate falsely due to vibration when the winding is not energized or is energized with a non-operating value of current.

It is therefore the object of the present invention to provide a relay structure of the polarized type which has three very definite positions of which two are circuit closing and the third a neutral or open circuit position.

It is a further object of the invention to provide a polarized relay structure which has a suitable margin of safety against false operation when a high percentage of the operate current is flowing and the relay is at the same time subjected to vibrations.

It is also a further object of the invention to provide a polarized relay structure which is economical to manufacture and which requires a minimum of maintenance.

In accordance with this invention, several modifications of which have been disclosed, these objects have been obtained by the use of the non-linear magnetic characteristic of a section of iron as a magnetic rectifier to admit or impede the flow of magnetic flux according to its polarity. As illustrative, the iron is in the form of a small U-shaped keeper or yoke short-circuiting a short permanent bar magnet. A high magnetic flux exists in the yoke which is considered to be essentially saturated. Flux from the core of an electromagnet is fed into the base of the keeper and is directed to either one of two working gaps near the ends of the legs of the keeper. In one leg of the keeper, flux due to the electromagnet opposes the saturating flux set up by the bar magnet, making the sum of the two fluxes less than the saturating value and consequently operating flux reaches the working gap near the end of that leg. In the other leg the electromagnetic flux is in a direction to aid the saturating flux thereby tending to create a flux greater than the sat-

urating flux but since this can produce only a negligible increase, operating flux can reach only one working gap depending on the direction of the operating current.

Two independent armatures may be used at the two working gaps or a single armature may be provided for cooperation with both gaps.

For a more comprehensive understanding of the invention, reference may be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a top plan view of a two armature relay embodying the invention;

Fig. 2 is a perspective view of a modified form of the invention as applied to a relay of the sealed switch or contact type;

Fig. 3 shows in cross-section, a mercury type switch element applicable to the relay disclosed in Fig. 2;

Fig. 4 shows in cross-section a magnetic type switch element applicable to the relay disclosed in Fig. 2; and

Fig. 5 is a perspective view of a further modified form of the invention having a single three-position armature.

Referring first to Fig. 1, the invention has been disclosed as applied to a well-known type of relay structure, having a core 1, the rear end of which terminates in a flattened portion 2 provided with two oppositely extending ears 3 and 4 by means of which the relay may be secured to a mounting rack. Surrounding the core is an operating coil 5. Welded or otherwise secured by its base to the forward end of the core 1, beyond the front spoolhead 29 of the coil 5, is a U-shaped iron yoke 6, the legs 7 and 8 of which extend forwardly with their outer or pole faces lying in planes parallel to the flattened portion 2 of the core 1. Secured between the ends of the legs of the yoke 6 is a short permanent bar magnet 9 having its north pole in engagement with the inner face of the leg 8 and having its south pole in engagement with the inner face of the leg 7. The yoke 6 serves as a keeper for the magnet 9 and is so proportioned that it is normally essentially saturated by the flux flowing therethrough from the magnet 9.

Disposed on the opposite faces of the flattened portion 2 of the core 1 are two U-shaped members 10 and 11 having their bases suitably secured thereto as by screws (not shown) and each having the ends of its outwardly extending arms bent oppositely and parallel to the faces of the portion 2 to serve as supports for spring pile-ups

and for the reed hinges 12 and 13 of the armatures 14 and 15. Each armature is substantially U-shaped, the ends of its rearwardly extending legs being hinged to the forward edges of the members 10 or 11 by the reed hinges and its forward cross-reach overlying an outer pole face of the yoke 6. For adjusting the length of the air gaps between the cross-reaches of the armatures and the pole faces of the yoke 6 and for limiting the extent of the movement of the armatures, back-stop studs 16 are secured to the ends of the legs of yoke 6 with back-stop nuts 17 threaded thereon against which the ends of the armatures are normally biased by the contact springs 18 and 21 which engage against the insulating studs 24 carried by the armatures.

Each of the four spring pile-ups, of which two are disclosed, comprises three contact springs and two of the spring pile-ups also include terminal lugs for the coil 5. For example, the left-hand pile-up comprises contact springs 18 and 19 mounted on the inner face of the arm of member 10 and contact spring 20 and terminal lug 25 mounted on the outer face of the arm of member 10. These springs and the terminal lug are secured to the member 10 by screws 26 which extend through holes in the clamping plate 27, the springs and terminal lug, the member 10 and into tapped holes in the inner clamping plate 28. The springs and the terminal lug are insulated from the clamping plates, from the member 10 and from each other by interposed strips of insulating material and from the screws 26 by the usual sleeves of insulating material which surround the screws. The contact springs 19 and 20 are provided with the usual tangs which engage in notches in the front spoolhead 29 for determining the gaps between their contacts and the contacts of spring 18. The pile-up including contact springs 21, 22 and 23 and terminal lug 30 are similarly insulatedly supported on the end of member 11 by the clamping plates 31 and 32 and the screws 33. The back contact springs 20 and 23 may, if not required, be omitted.

Can cover guides 34 are secured at their rear ends to the members 10 and 11 by the same screws which secure the members to the flattened portion 2 of the core with their forward ends engaged against the edges of the front spoolhead 29.

Considering the operation of this relay, the permanent magnet 9 and the yoke 6 are so proportioned that a flux density is normally produced in the yoke, sufficiently large to operate the iron of the yoke in the vicinity of or above the knee of the saturation curve. In this high flux density condition the yoke will still have a low reluctance compared with that of the air-gaps between the pole faces of the yoke and the cross-reaches of the armatures 14 and 15 and thus the yoke 6 sufficiently shields the armatures magnetically so that there is a negligible initial attractive force applied to the armatures due to leakage or stray flux from the permanent magnet 9. Neglecting leakage, the permanent magnet flux may be visualized as leaving the north pole and proceeding around the short-circuiting yoke 6 and entering the magnet at its south pole.

When the coil 5 is energized, a coil flux will be created which will flow through the core 1, dividing at its junction with the yoke 6 and will tend to flow through the legs 7 and 8 of the yoke, thence across the air-gaps and through the

armatures 14 and 15 and uniting again at the rear end of the core. The direction of the flow of flux in this divided flux path will, of course, depend upon the direction of the energizing current flowing through the coil 5. If the direction of flux due to current in the coil is visualized as leaving the core and entering the yoke, the coil flux opposes the permanent magnet flux in the direction of the armature 15 and the flux density in the leg 8 of the yoke is therefore decreased and flux readily flows across the air-gap from the leg 8 to the armature 15, whereby the armature 15 is attracted to close the contacts of springs 21 and 22 and to open the contacts between springs 22 and 23. At the same time in the leg 7 of the yoke, the coil flux aids the permanent magnet flux but since this leg is already almost or entirely saturated due to the permanent magnet flux, the increase in flux in this leg will be slight or nil and armature 14 will be unaffected. Thus armature 15 will tend to operate while armature 14 remains unoperated.

As the total amount of flux due to the coil 5 approaches that due to the permanent magnet 9, the entire flux will flow through the leg 7 of the yoke, through the permanent magnet 9, across the air-gap between the leg 8 and armature 15 through the armature back to the core 1. This is under the assumption that there is no leakage flux and that the leg 7 of the yoke on the side of the unoperated armature 14 can carry no more than the initial permanent magnet flux. A current of opposite polarity in the coil 5 will reverse the direction of the coil flux and cause the attraction of armature 14 while armature 15 is unaffected.

It will be noted that the working flux is due to the current passed through the operating coil and the performance is similar to two neutral relays having oppositely poled rectifiers in series with their coils. The function of the permanent magnet 9 is that of a magnetic rectifier, directing working flux to either one of the armature air-gaps depending upon the polarity of the operating current. The sensitivity is thus comparable to that of a neutral relay, the pull on an armature being proportional to the square of the flux in the working gap due to the current in the coil.

In the unoperated condition because of the permanent magnet flux in the yoke, there is a magnetomotive force drop across it. This tends to send flux through the path including both armatures and their air-gaps and to produce some initial force on the armatures. Since the reluctance of the air-gaps is high compared to that of the yoke, even when it is operated at a high density, this flux and hence the initial steady pull on the armatures will be small. This will be true so long as the armatures remain unoperated and the air-gaps are large. When an armature is operated, however, the reluctance of the corresponding air-gap is reduced and, being in parallel with one of the legs of the yoke, it will draw appreciable flux. Thus, the permanent magnet flux through this armature can be made to lock it in the operated position against the back force of the contact springs operated thereby after it has been brought to this position by the operating coil. This locking feature can be easily avoided by the use of armature stop discs of non-magnetic material to prevent too great a reduction of the air-gap reluctance when an armature operates.

Fig. 2 illustrates a further application of the

magnetic rectifier principle to a relay of the sealed contact type. This relay comprises a supporting member or heel piece 35 having a rear upturned ear 36 by which the relay may be supported on a relay mounting rack and two ears 37 upturned from the rear edges of the member 35 for supporting pile-ups of terminal lugs. Each pile-up comprises three T-shaped lugs 38 which serve as terminals to which the terminals of the operating coil 39 and the terminals of the switch elements 40 and 41 may be connected. The terminal lugs of these pile-ups are secured to the outer faces of the ears 37 by screws 42 which extend through holes in the clamping plate 43, in the lugs 38 and into threaded holes in the ears 37, the lugs being insulated from the ears 37, from the plates 43 and from each other by interposed strips of insulating material and further insulated from the screws 42 by the usual sleeves of insulating material which surround the screws.

The forward end of the supporting member 35 is widened out to form a lower pole-piece 44. Supported on the member 35 intermediate its ends is a vertically extending core on which the coil 39 is positioned and on the upper end of which the member 45 is secured. The member 45 and core may be secured to the member 35 by the screw 46. Secured by its base to the outwardly extending end of member 45 by screws is an iron yoke 47, the downwardly extending legs 48 and 49 of which are bent outwardly at right angles to form two upper pole-pieces 50 and 51 which lie in a plane parallel to the plane of the lower pole-piece 44. For maintaining the pole-pieces 50 and 51 properly spaced from the pole-piece 44 and to lend rigidity to the pole-pieces, a brace 52 of non-magnetic material is interposed between the member 35 and 45. The upper end of the brace is provided with lugs 53 engaged between the shoulders 54 of the member 55 and the rear edge of the yoke 47 and the lower end of the brace is provided with lugs 55 which engage in notches in the edges of the member 35 for holding the brace in its assembled position. Suitably secured between the legs 48 and 49 of the yoke 47 is a permanent bar magnet 56. The yoke 47 serves as a keeper for magnet 56 and is so proportioned that it is normally practically saturated by the flux flowing therethrough from the magnet 56.

The pole-pieces 44, 50 and 51 are provided with aligned embossed holes in which are positioned two sealed switch elements 40 and 41. These elements may be of any desired magnetically operable type, two such types suitable for use in the relay structure of Fig. 2 being disclosed in Figs. 3 and 4.

The switch element disclosed in Fig. 3 may be of the type disclosed in the application of H. C. Harrison and C. E. Pollard, Serial No. 302,526, filed November 2, 1939, now Patent No. 2,247,493, issued July 1, 1941. This element comprises a tubular glass vessel 57 into the upper and lower ends of which are sealed the terminals 58 and 59. The lower portion of the vessel is filled with a pool of mercury 60 into which the inner end of the lower terminal 58 extends and upon which an annular iron armature 61 floats. The inner end of the upper terminal 59 extends downwardly inside of the armature 61 to a point just above the surface of the mercury pool. Preferably the vessel 57 is evacuated before it is sealed and is refilled with a gas such as hydrogen. If switch elements of this type are used in the

relay assembly of Fig. 2, they are so positioned in the aligned holes in the pole-pieces thereof that the lower ends of their armatures 61 are positioned above the lower pole-piece 44 as disclosed in Fig. 3.

This relay, if provided with switch elements of the type just described, functions in much the same manner as described in connection with the operation of the relay of Fig. 1 in that normally permanent magnet flux flows through the yoke 47 and operating flux due to energizing the coil will tend to flow from the pole-piece 50 to the pole-piece 44 across the air-gaps between the armature 61 and the pole-pieces to operate the armature 61 downwardly against the surface tension of the mercury and to thereby displace the mercury upwardly into engagement with the upper terminal 59 to interconnect the terminals 58 and 59 through the mercury if current flows in one direction through the coil 39 or to cause coil flux to flow from the pole-piece 44 to the pole-piece 51 to similarly operate the armature of the switch element 41 to interconnect its terminals if current flows in the reverse direction through the coil.

The switch elements 40 and 41 may be of the type disclosed in the application, Serial No. 193,629 of W. E. Ellwood, filed March 29, 1938, now Patent No. 2,289,830, issued July 14, 1942. This switch element, disclosed in Fig. 4, comprises a glass vessel 62 into the upper and lower ends of which are sealed terminals 64 and 63 to the inner ends of which are welded reeds 66 and 65 of magnetic material. The overlapping ends of these reeds are normally out of engagement and may be provided with contact surfaces of any suitable metal having good electrical conductivity. The vessel is evacuated before it is sealed and is refilled with a gas such as helium. If switch elements of this type are used in the relay assembly of Fig. 2, they are so positioned in the aligned holes in the pole-pieces thereof that the gaps between the ends of the reeds 65 and 66 are centrally located with respect to the upper and lower pole-pieces as disclosed in Fig. 4.

With the relay shown in Fig. 2 equipped with switch elements of this type, when the coil 39 is energized by current of one polarity, flux will flow from the pole-piece 50 to the pole-piece 44 across the air-gap between the reed 66 and pole-piece 50 across the air-gap between reeds 65 and 66 and across the air-gap between the reed 65 and the pole-piece 44 and the reeds will be attracted toward each other into contact engagement if current flows in one direction through the coil 39 or to cause flux to flow from pole-piece 51 to the pole-piece 44 to similarly operate the reeds of the switch element 41 into engagement if current flows in the reverse direction through the coil.

Fig. 5 discloses the magnetic rectifier principle applied to a relay structure having a single armature. In accordance with this modification, a heel-piece 57 is provided by means of which the relay may be secured to a mounting rack. A core 68 extends forwardly at right angles from the heel-piece having a coil 69 thereon and having an iron yoke 70 secured by its base to the forward end of the core 68 beyond the front spoolhead of the coil 69. The legs 71 and 72 of the yoke extend upwardly to a point above the coil 69 and are provided on their inside surfaces with pole blocks 73 and 74 welded or otherwise secured thereto. Secured between the legs 71 and 72 of the yoke is a permanent bar mag-

net 75. The yoke serves as a keeper for the permanent magnet and is so proportioned that it is normally essentially saturated by the flux flowing therethrough from the magnet.

The heel-piece 67 is provided with a tongue 76 extending forwardly over the top of the coil 69 which serves as a support for two spring pile-ups and for the reed hinge 77 of the armature 78. One spring pile-up, comprising the contact springs 79 and 80 and the coil terminal lug 81, is secured on one face of the tongue 76 by screws 82 and clamping plate 83, the springs and terminal lug being insulated from each other, from the tongue 76 and from the clamping plate 83 by interposed strips of insulating material and insulated from the screws 82 by the usual sleeves of insulating material which surround the screws. The other spring pile-up comprising the contact springs 84 and 85 and the coil terminal lug 86 are similarly secured on the other face of the tongue 76. The pairs of contact springs 79 and 80, and 84 and 85 normally have their contacts out of engagement. The armature 78 is hinged at its rear end by reed spring 77 to the tongue 76 of the heel-piece 67 and has its forward or free end positioned between the pole blocks 73 and 74. The end of the armature is held in a neutral or mid-position between the faces of the pole blocks by the inside springs 89 and 94 which are biased against the ends of the stud 87 of insulating material extending through the armature.

The operation of this relay is much the same as that of the double armature relay of Fig. 1. The locking characteristic previously described is of special importance, however. Some of the permanent magnet flux will pass across the ends of the legs 71 and 72 of the yoke through the pole blocks 73 and 74 and through the end of the armature and will cause locking forces to act on the armature. With the armature biased in the mid-position, these locking forces are balanced, the armature is in unstable equilibrium, and the relay has a sensitivity to low coil or operating currents comparable to that of the usual type of polarized relay. On high operating currents, however, the operating flux in the gaps is large compared to the permanent magnet flux in the gaps and the relay assumes the square loss characteristic of a neutral relay.

From the foregoing discussion it will be apparent that a relay structure, which may take the forms illustrated and described or similar forms, has been devised which permits simple, compact and inexpensive mechanical construction since only a small bar magnet and a small yoke or keeper is required to direct operating flux to either one of two working gaps; that a relay structure is provided which produces a pull on the armature which is essentially proportional to the square of the operating current, thus permitting easy adjustment when close operate and non-operate requirements must be met and whereby a small change in current produces a large change in pull compared with the usual polarized relay having a pull directly proportional to the operating current; that a relay structure is provided which is not subject to false operation even on excess current and that the provision of a permanent magnet with a keeper produces an ideal magnetic condition in which the permanent magnet has no tendency to demagnetize and thus destroy the efficiency of the relay.

While permanent magnets have been disclosed bridged across the legs of the yokes 6, 47 and 70 of the relays disclosed in Figs. 1, 2 and 5, it is to be observed that such magnets could be replaced by electromagnets so designed as to supply saturating flux to the yokes.

What is claimed is:

1. In a magnetic structure, a heel-piece, a core secured thereto, a U-shaped member made wholly of magnetic material secured by its base directly to one end of said core, a permanent bar magnet interconnecting the legs of said member and wholly within the boundaries of said member, two armatures hinged to said heel-piece with their free ends in cooperative relationship with the two legs of said member respectively, back stops for adjusting the normal air-gaps between said armatures and the pole faces of said legs, springs supported by said heel-piece and associated respectively with said armatures, serving to normally maintain said armatures against their back stops and a coil on said core energizable to cause the selective operation of said armatures dependent upon the polarity of current applied to said coil.

2. In a magnetic structure, a core, an electromagnetic member connected to said core, a pair of armatures, each of which forms an operating magnetic circuit with said core and electromagnetic member, a coil on said core energizable by current in either direction for producing an operating flux in said core, and a permanent magnet forming a closed magnetic circuit with said electromagnetic member and serving to maintain said member in a state of substantial saturation for the purpose of directing the operating flux in said core to one or the other of said armatures to cause the selective operation thereof in accordance with the direction of current flow in said coil.

3. In a magnetic structure, a core, an electromagnetic member connected to said core, a pair of armatures, each of which forms an operating magnetic circuit with said core and electromagnetic member, a coil on said core energizable by current in either direction for producing an operating flux in said core, and a permanent bar magnet forming a closed magnetic circuit with said electromagnetic member and serving to maintain said member in a state of substantial saturation for the purpose of directing operating flux in said core to one or the other of said armatures to cause the selective operation thereof in accordance with the direction of current flow in said coil.

4. In a magnetic structure, a core, an electromagnetic member connected to said core, an armature forming an operating magnetic circuit with said core and electromagnetic member, a coil on said core energizable by current in either direction for producing an operating flux in said core and a permanent magnet forming a closed magnetic circuit with said electromagnetic member and serving to maintain said member in a state of substantial saturation for the purpose of directing the operating flux in said core to said armature to cause the operation thereof in accordance with the direction of current flow in said coil.

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