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[54] **POLARIZED ELECTROMAGNETIC RELAY**

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[52] **U.S. Cl.**..................................**335/230,** 335/234
[51] **Int. Cl.**...**H01f 7/08**
[58] **Field of Search**..............335/229, 230, 276, 234

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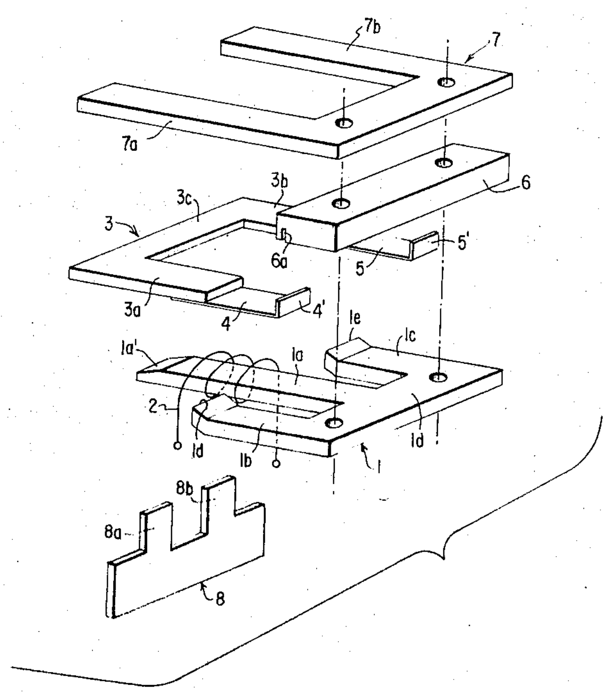
Attorney—George H. Spencer et al.

[57] **ABSTRACT**

A polarized electromagnetic relay of the conductor plate type in which a single permanent magnet is disposed between body portions of an E-shaped core yoke and a U-shaped yoke. A U-shaped armature is resiliently supported coaxially of its legs from the body portion of the E-shaped core yoke for swinging movement between the yokes. The center leg of the E-shaped core yoke is longer than the outer legs and in response to a reversal of direction of flux in the armature, the armature moves between first and second stable positions in which it bears against the legs of the U-shaped yoke and the free end of the center, and the free ends of the outer legs, respectively, of the E-shaped core yoke.

14 Claims, 6 Drawing Figures



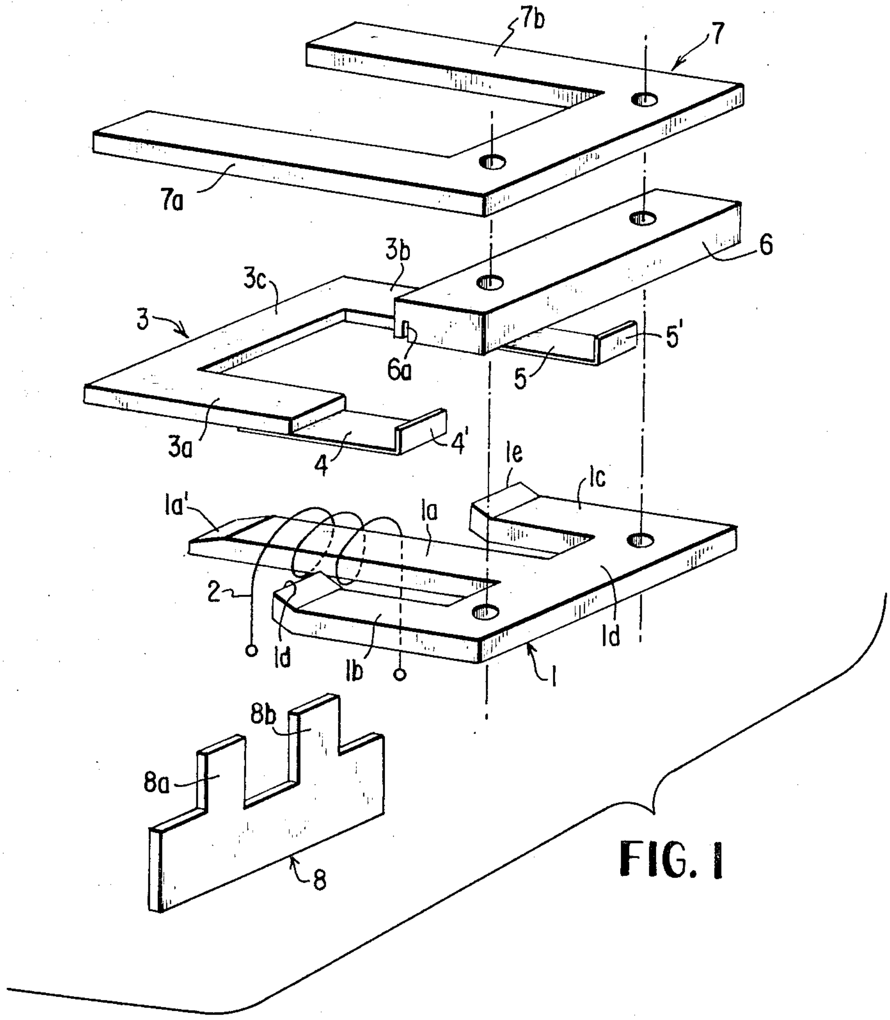


FIG. 1

FIG. 2

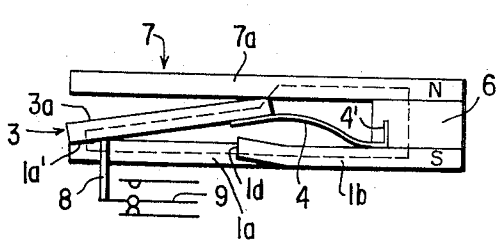
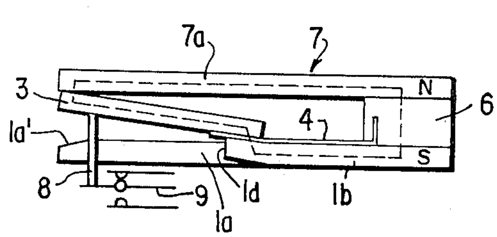


FIG. 3



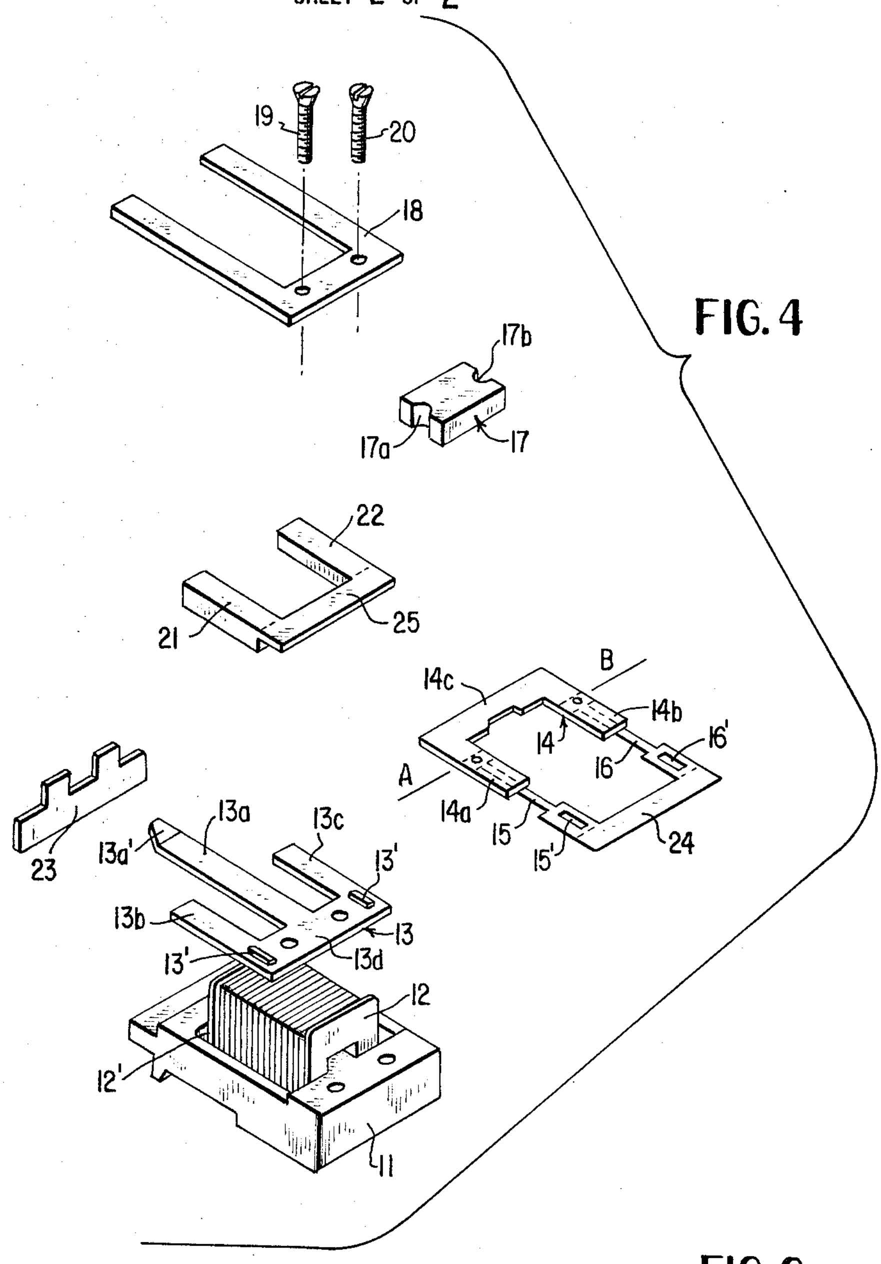


FIG. 4

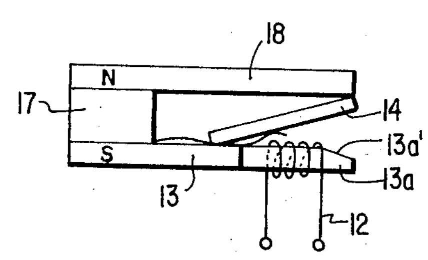


FIG. 5

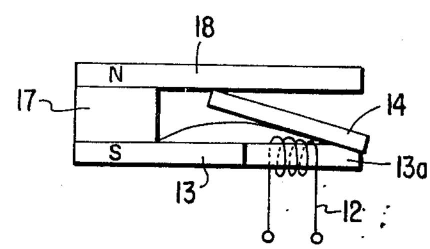


FIG. 6

POLARIZED ELECTROMAGNETIC RELAY

BACKGROUND OF THE INVENTION

The present invention relates to a polarized electromagnetic relay and particularly to a polarized conductor plate relay.

Polarized electromagnetic relays in which permanent magnets are incorporated in the magnetic circuits to produce two stable positions for the armature are known in the art. Thus, a polarized conductor plate relay which is part of the state of the art generally comprises an E-shaped core yoke, a U-shaped armature, a coil, a set of contact springs disposed below the magnetic circuit and two permanent magnets which are identified as the main magnet and the auxiliary magnet. The main magnet, which is block-shaped, is glued to the end of the center leg of the E-shaped core yoke and is magnetized in a direction perpendicular to the yoke plane. The auxiliary magnet is connected with the coil body above the armature in such a manner that it holds the armature in the flipped-up position. The two magnets are thus positioned to lie above and below the U-shaped armature. In this construction, the magnetic flux emanating from the coil is conducted over the main magnet. Consequently, the main magnet represents an increased magnetic resistance for this flux in the magnetic circuit. Another drawback of this type of construction is that at least the main magnet must be fastened by some sort of gluing process. Moreover, the size of the two magnets is rather limited so that no strong holding forces can be produced.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to arrange the magnetic circuit for polarized relays in such a manner that a single permanent magnet can be used.

It is another object of the invention to provide means whereby this magnet can be easily and inexpensively mounted on the relay so as to furnish strong holding forces for the armature.

A still further object of the invention is to accommodate the permanent magnet at a point in the magnetic circuit where there is a relatively large amount of space so that the outer dimensions of the relay as a whole do not have to be increased.

It is yet another object of the present invention to substantially reduce the excitation energy required to operate such a polarized relay and at the same time even more simplify the structural configuration of the relay.

One embodiment of the present invention involves the use of a block-shaped permanent magnet which is disposed between the transverse bar of the E-shaped core yoke and a U-shaped yoke. The outer legs of the E-shaped core yoke are shorter than the center leg and the edges at the ends of these outer legs serve as knife-edge bearing points for a U-shaped armature resiliently held between the E-shaped core yoke and the U-shaped yoke. In a first stable position, the U-shaped armature is held between the U-shaped yoke and the center leg of the E-shaped core yoke and in a second stable position, with a reversal of the direction of flux in the armature, between the U-shaped yoke and the outer legs of the E-shaped core yoke.

Another embodiment of the present invention involves the use of resilient means which are fastened to the transverse bar of the E-shaped core yoke and to the underside of the armature at the level of its imaginary axis of rotation.

According to this further embodiment, armature and core yokes are planar in the area of their contact surfaces and the resilient means provide a positive air gap in the area of these contact surfaces.

In this embodiment, the resilient means are very long and narrow springs which engage the armature at the imaginary axis of rotation, the spring moment acting on the armature remains low so that less excitation energy for the relay is required. Since the contact surfaces between the outer legs of the E-shaped core yoke and the armature are kept planar, additional process steps involved with providing bearing surfaces are eliminated.

It has also been found that a substantially shorter permanent magnet is sufficient which can be clamped between the springs of the relay.

The present invention makes it possible to obtain two stable end positions of the armature with the use of a single permanent magnet in the relay. In addition, the permanent magnet and the additional U-shaped yoke are accommodated outside the coil body of the relay in such a manner that the total structural height of the relay is not increased. Thus, substantially the same parts can be used for both polarized and nonpolarized embodiments of the relay.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an expanded perspective view of one embodiment of the magnetic circuit of a polarized relay according to the invention.

FIG. 2 is a side elevational view showing the armature position of the relay of FIG. 1 in a first stable switching position.

FIG. 3 is a side elevational view showing the armature position of the relay in a second stable switching position.

FIG. 4 is an expanded view of another embodiment of the relay.

FIG. 5 is a side elevational view showing the magnetic circuits of the relay of FIG. 4 and the armature position is illustrated schematically when in a first stable switching position.

FIG. 6 is a side elevational view similar to FIG. 5 but shows the armature in a second stable switching position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a substantially E-shaped core yoke, generally indicated at 1, has a center leg 1*a*, outer legs 1*b* and 1*c*, and body portion 1*d*. An excitation coil body 2, shown schematically, is wound on the center leg 1*a* and is adapted to be connected to a source of electrical power, not shown, in a well-known manner.

The end of the center leg 1*a* is slanted at 1*a'*. The two outer legs 1*b* and 1*c* are shorter and slightly angled upwardly at their ends so that edges 1*d* and 1*e* serve as the knife-edge bearings for the armature, generally shown at 3, in a manner to be described later.

The armature 3 is U-shaped and the legs *3a* and *3b* of the armature are connected with springs 4 and 5 having flanges 4′ and 5′, respectively. A block-shaped permanent magnet 6 has a slit *6a* at its lower rear edge into which the flanges 4′ and 5′ of springs 4 and 5 can be inserted. Above the permanent magnet 6 a U-shaped yoke 7 is shown whose legs *7a* and *7b* are approximately the same length as the center leg *1a* of the E-shaped core yoke 1.

As seen in FIG. 1, core yoke 1, permanent magnet 6 and U-shaped yoke 7 each have openings therethrough which can be aligned in the manner indicated by the dash-dot lines so that these components of the relay can be secured together by suitable means such as fastening screws, not shown. When assembled, these components are positioned as seen in FIGS. 2 and 3 with permanent magnet 6 bearing on end leg 1d of core yoke 1 and with flanges 4′ and 5′ of springs 4 and 5 confined in slit 6a. U-shaped yoke 7 rests on permanent magnet 6 with legs *7a* and *7b* aligned with legs *3a* and *3b* as well as with legs *1b* and *1c*.

In addition to the above-described components, a contact actuation slide, generally shown at 8, has upstanding lugs *8a* and *8b* which are designed to be guidingly received on center leg *1a* of core yoke 1, as best seen in FIGS. 2 and 3. The lower edge *8c* of slide 8 is adapted to ride on the switching contact 9, schematically shown in FIGS. 2 and 3, forming part of a contact spring element, not shown, which can be connected to the relay by means of the above-mentioned fastening screws in a desired manner. Leg *3c* of armature 3 rests on the top edges of lugs *8a* and *8b* so that movement of the armature 3, in a manner to be described below, is translated into movement of contact actuation slide 8 and switching contact 9 in a contact set. In a known manner, slide 8 is movable within a molded-on guide, not shown, associated with coil body 2.

FIG. 2 shows the magnetic circuit of a relay in the first stable position in which leg *3a* of the U-shaped armature 3 rests on slanted end *1a*′, the center leg 1a on the core yoke 1 and legs *3a* and *3b* bear upward on legs *7a* and *7b* of the U-shaped yoke 7. In the illustrated armature position, spring 4 and spring 5, not seen, are curved upwardly. The illustrated characters N and S show that the magnet 6 is magnetized in a direction perpendicular to the planes of the yokes. The path of the flux through the parts which can be formed from suitable material, such as iron, is shown with dashed lines.

FIG. 3 shows the second stable position of the armature 3. In this position, leg *3c* of armature 3 contacts the ends of the legs *7a* and *7b* of the U-shaped yoke 7. Simultaneously, legs *3a* and *3b*, with the underlying portions of springs 4 and 5, respectively, bear against knife-edge bearings *1d* and *1e* on legs *1b* and *1c* of the E-shaped core yoke 1. Spring 4 and spring 5, not seen, in this case lie flat on legs *1b* and *1c*, respectively. The path of the flux in the magnetic circuit is again shown with dashed lines.

A comparison of FIGS. 2 and 3 reveals that the direction of flux in the legs of the U-shaped armature 3 is reversed when the relay is switched by current pulses in the excitation coil 2. Thus the electromagnetic flux flowing in the one or the other direction is superimposed on the flux produced by permanent magnet 6 in such a manner that the armature changes its stable position. The individual phases of these movements are described below.

If, in FIG. 3, the left end of armature 3 is moved downwardly, the armature rolls from the edges *1d* and *1e* which act as knife-edge bearings. The right upper edges *3a* and *3b* of armature 3 thus come close to the arms *7a* and *7b* on yoke 7 to such an extent that these edges are pulled up to the yoke 7 by the forces of the permanent magnet. Thus, the position shown in FIG. 2 has been reached. The magnetic forces occurring here are strong enough to overcome the spring forces of the switching contact 9. During switching from the position shown in FIG. 2 to a first stable position, shown in FIG. 3, the armature 3 is additionally accelerated by the forces of the switching contact 9.

It can be seen that, as the armature 3 is held in the position shown in FIG. 2, spring 4 is deformed relatively strongly as is spring 5 which cannot be seen. For this reason, very slim springs of a non-ferromagnetic material are used so as to avoid the creation of an undesired magnetic shunt. If desired, the springs may, of course, also have downwardly bent flanges 4′ and 5′ to be fastened in slits, not shown, in legs *1b* and *1c*.

It would also be conceivable to clamp the springs 4 and 5 flat underneath the permanent magnet 6, but this would result in an additional air gap. The armature springs can also be entirely eliminated if the armature is guided, by the appropriate shape of the relay housing (not shown), so that the armature can perform the switching movements without slipping out of its intended position.

In a further modification of the structure according to the present invention as disclosed in FIGS. 1–3, the bending upward of the edges *1d* and *1e* on legs *1b* and *1c* could be omitted if the armature 3 is appropriately deformed at its bearing point with these legs as, for example, with a downward bulge. In this case, legs *1b* and *1c* can have the same length as leg *1a* without this interfering with the principle of the invention. However, it may be advisable to use the illustrated embodiment because of the saving in weight in the relay. It is important, however, in any case, that the legs *3a* and *3b* of the U-shaped armature 3 be extended beyond the bearing points so that the upper right edges of the armature can come sufficiently close to legs *7a* and *7b* on yoke 7.

The polarized relay constructed according to the principle of the present invention develops extraordinarily strong holding forces so that multiple contact sets with strong contact forces can be used.

The height of the magnet 6 and yoke 7 can be so dimensioned that yoke 7 will not extend above the upper limit of the body of the excitation coil 2 and consequently no additional installation space is required.

The illustrated polarized relay differs from a nonpolarized relay only in that is has a different core yoke 1, different armature springs 4 and 5 and an additional magnet 6 and an additional yoke 7. All other parts, as for example the coil body and the contact spring body, can be used without modification as provided in known constructions.

The springs 4, 5 which consist of nonferromagnetic material are fastened to the undersides of the legs *3a* and *3b* of armature 3 so as to intentionally provide air gaps between armature 3 and the bearing edges *1d* and *1e*.

In a further modification, the permanent magnet 6 could have a structural height less than the distance between the U-shaped yoke 7 and the E-shaped core yoke 1. This could be accomplished by an intermediate layer of iron sheets. The result would be a change in the distribution of flux due to the change of the air gap at the location of the permanent magnet.

Another embodiment of the invention is shown in FIG. 4 where a contact supporting body 11 receives a coil body 12. The E-shaped core yoke, generally indicated at 13, is placed with its center leg 13*a* through the opening in coil body 12. The outer legs 13*b*, 13*c* of the core yoke 13 are shorter than leg 13*a* and are provided with planar contact surfaces for the U-shaped armature, generally indicated at 14.

Legs 14*a* and 14*b* of armature 14 are connected with armature holding springs 15, 16, which are relatively long and narrow. The holding springs are widened at their right-hand end, as seen in FIG. 4, and are provided with recesses 15′ and 16′ which are adapted to the corresponding fastening protrusions 13′ on the transverse portion 13*d* of the E-shaped core yoke 13. Springs 15 and 16 are fastened by welding or riveting to the underside of armature 14 at the level of the imaginary armature axis of rotation A-B of the armature in the relay. With this type of fastening, the springs are deformed only relatively slightly so that the spring return effect remains low.

A block-shaped permanent magnet 17, whose height is about one and a half to twice that of the thickness of the armature 14, is clamped between the transverse portion 13*d* of the E-shaped core yoke 13 and the U-shaped yoke 18 by means of screws 19, 20, which extend into contact support body 11. The magnet is provided at its sides with semicylindrical recesses 17*a* and 17*b* which effect an automatic alignment of the magnet between screws 19, 20. The magnet is magnetized in the direction of its shortest dimension.

For the defined fastening of the U-shaped yoke 18 with respect to yoke 13, two plastic blocks 21 and 22 are provided which have the same thickness as magnet 17. These plastic blocks are provided with recesses, not shown, at their underside into which the fastening protrusions 13′ of the E-shaped core yoke 13 engage. In their left-hand portion, as viewed in FIG. 4, the plastic blocks 21 and 22 are provided with tunnel-shaped recesses, not shown, which permit free but guided movement of springs 15 and 16 within these blocks during the switching process to be explained below.

A plastic actuation slide 23 is displaceably mounted in a recess, not shown, of the left-hand flange 12′ of coil body 12. In a manner similar to that illustrated in conjunction with the first embodiment of the invention, the slide is associated with contact springs, not shown.

To facilitate mounting, springs 15, 16 can be connected together by an auxiliary bar 24, which is appropriately scored for subsequent breaking off. An auxiliary bar 25 connects plastic blocks 21 and 22 before their installation and is also scored. The auxiliary bars 24 and 25 are either manually broken off when the relay is completely assembled or they are cut off by a machine.

As seen in FIG. 4, the center leg 13*a* of the E-shaped core yoke 13 has a reduced cross section at its left-hand end and is slanted at its upper side as indicated at 13*a*′. This reduction in cross section effects, in conjunction with the corresponding reduction in cross section of leg 14*c* at the armature 14, a so-called isthmus effect which substantially improves the switching behavior of the relay. The slanted upper surface has the effect that the leg 14*c* of armature 14 is in full contact with the center leg 13*a* of the core yoke 13 at 13*a*′ in the one switching position as will be explained later.

FIG. 5 is a schematic illustration, in a side view, of the magnetic circuit of the relay with the plastic blocks 21 and 22 not shown so as to provide a clearer view of the armature movement. The permanent magnet 17 is disposed above the E-shaped core yoke 13, the magnet being magnetized according to the pole indications N and S. Above the magnet lies the U-shaped yoke 18. The coil 12 which is disposed on the center leg 13*a* of the core yoke, is only indicated. The U-shaped armature 14 takes up a first stable position which corresponds to the rest position of the relay. In this rest position the contact springs are not deflected and the rest contacts are therefore closed in a manner similar to that shown in FIG. 3.

It can be seen from FIG. 5 that the permanent magnetic flux from the north pole of the magnet 17 continues over the U-shaped yoke 18, armature 14 and the shorter outer legs 13*b* and 13*c* of the E-shaped core yoke 13. If now coil 12 is so excited that a strong north pole is produced at the end of the core yoke leg 13*a*, the transverse portion 14c of the U-shaped armature 14 is attracted by this north pole and the armature flips into the second stable position which is shown in FIG. 6. At this switching process, the direction of flux in the legs 14*a* and 14*b* of the armature 14 is reversed. The contact springs are switched to the operating position in a manner as illustrated in FIG. 2. When the switching pulse has died out, the permanent magnetic flux passes from the north pole of the magnet 17 over the legs of the U-shaped yoke 18, armature 14 and the center leg 13a of the E-shaped core yoke 13 to the south pole of the magnet.

If now the coil is excited in the opposite direction, the coil field is superimposed on that of the permanent magnet is such a way that the armature 14 is pushed away from the second stable position and returns to its first stable position.

The number of ampere windings of the coil 12 for the excitation in the one or the other direction must be large enough that the permanent magnetic flux, produced by magnet 17, is temporarily cancelled out each time. With this prerequisite, the armature 14 can be attracted or pushed away, respectively, via the available operating air gaps so that it changes from the one stable position to the other.

It will be understood that the above description of the prevent invention is susceptible to various modifications, changes and adaptations and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a polarized electromagnetic relay of the conductor plate type having an E-shaped core yoke with a transverse bar connecting a center leg and a pair of outer legs, a U-shaped armature with a transverse leg connecting a pair of legs and movably mounted on the core yoke for selective contact with the ends of the

core yoke, the improvement which comprises, in combination:

a. a block-shaped permanent magnet disposed on the transverse bar of the E-shaped core yoke;

b. a U-shaped yoke with a transverse leg interconnecting a pair of legs, said transverse leg of the yoke being disposed on top of said permanent magnet and with the pair of legs in alignment with the pair of outer legs of the E-shaped core yoke;

c. means extending between the armature and the E-shaped core yoke to mount the armature for movement between the legs of the E-shaped core yoke and said U-shaped yoke; and

d. the center leg of the E-shaped core yoke having a free end that extends beyond the free ends of the pair of outer legs, the free ends of the pair of outer legs providing a bearing point for the associated legs of the U-shaped armature, whereby the armature is held in a first stable position between the U-shaped yoke and the free end of the center leg of the E-shaped core yoke and then in a second stable position between the U-shaped yoke and free ends of the pair of outer legs of the E-shaped core yoke when there is a reversal of flux in the armature.

2. A relay as defined in claim **1** wherein the free ends of the pair of outer legs of the E-shaped core yoke are angled upwardly.

3. A relay as defined in claim **1** wherein said means are relatively narrow holding springs.

4. A relay as defined in claim **3** wherein the holding springs are of nonferromagnetic material and are fastened to the underside of the free ends of the armature legs to provide an air gap between the free end of said pair of legs on the armature and the free ends of the associated outer legs on said E-shaped core yoke when the armature is in the second stable position.

5. A relay as defined in claim **1** wherein the U-shaped armature is supported only at the pair of legs.

6. A relay as defined in claim **1** wherein said permanent magnet has a lesser structural height than the distance between said U-shaped yoke and the E-shaped core yoke.

7. A relay as defined in claim **1** wherein said means are elongate holding springs which are fastened to the transverse bar of the E-shaped core yoke and to the underside of the pair of legs of the armature at the imaginary axis of rotation of the armature with respect to the core yoke.

8. A relay as defined in claim **7** wherein the height of the permanent magnet is approximately one and one half to twice that of the thickness of the U-shaped armature.

9. A relay as defined in claim **7** wherein the armature and the core yoke are planar in the area of their contact surfaces and said springs form a positive air gap at these contact surfaces.

10. A relay as defined in claim **7** wherein said block-shaped permanent magnet is disposed between two fastening screws.

11. A relay as defined in claim **7** wherein plastic blocks of the same height of said permanent magnet are disposed between the outer legs of the E-shaped core yoke and the pair of legs of the U-shaped yoke.

12. A relay as defined in claim **11** wherein the E-shaped core yoke is provided with protrusions at the point where the springs are fastened and wherein the springs and said plastic blocks are provided with corresponding recesses.

13. A relay as defined in claim **11** wherein the springs and said plastic blocks are provided, in pairs, with disposable transverse bars which are scored for breaking off from said springs and said blocks.

14. A relay as defined in claim **11** wherein said plastic blocks are provided with recesses at their undersides which encompass said springs and permit unimpeded deformation of said springs during switching from one stable position to another.

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