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Kupec

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[54] **MAGNET SYSTEM FOR A RELAY HAVING A FREELY ROLLING ARMATURE**

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[51] **Int. Cl.** **H01h 51/22**

[58] **Field of Search** 335/78, 79, 80, 81, 82, 335/229, 230, 234, 153

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[57] **ABSTRACT**

A magnet system for a relay whose armature rolls freely on a polepiece, so that its free end can be placed as desired in contact with a first or a second mating polepiece, the application of a permanent magnetic force between at least the armature and the first mating polepiece, being designed to produce a stable switched position, and, in order to switch the armature, the flux developed by an energizing coil being superimposable on the permanent magnetic flux in the air gap between the first and second mating polepieces.

14 Claims, 3 Drawing Figures

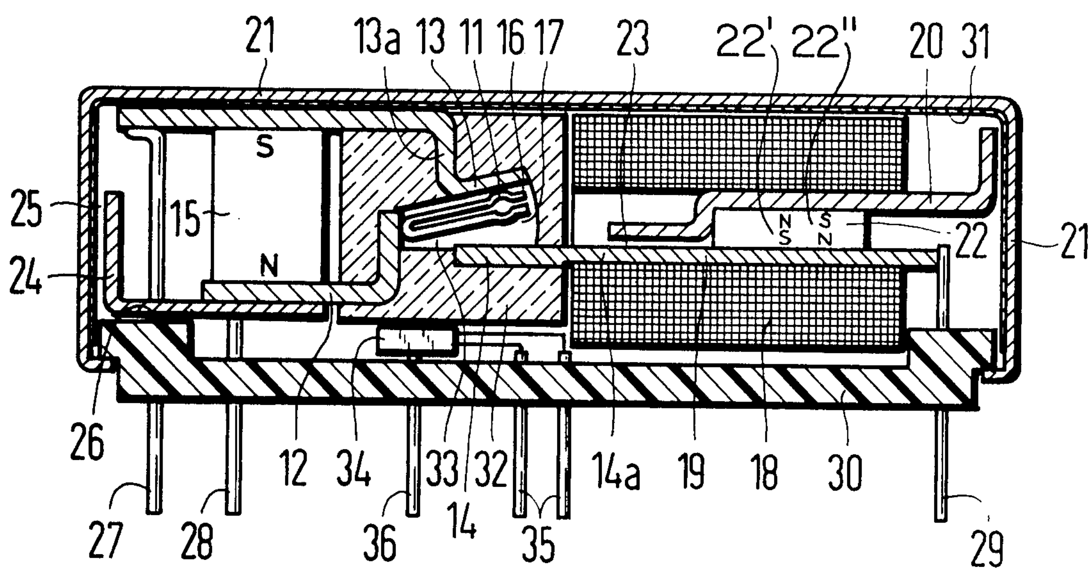


Fig.1

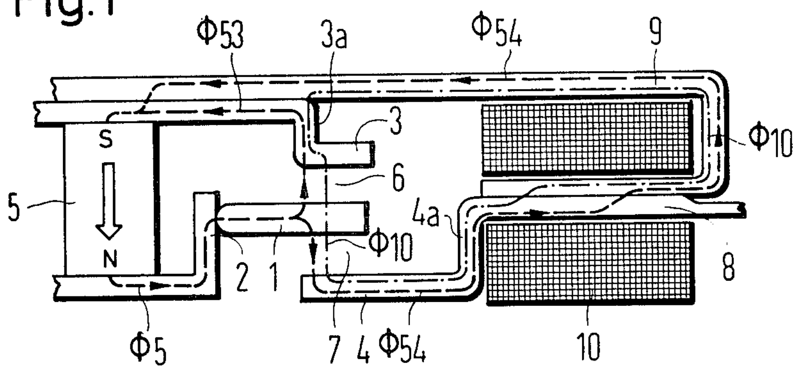


Fig.2

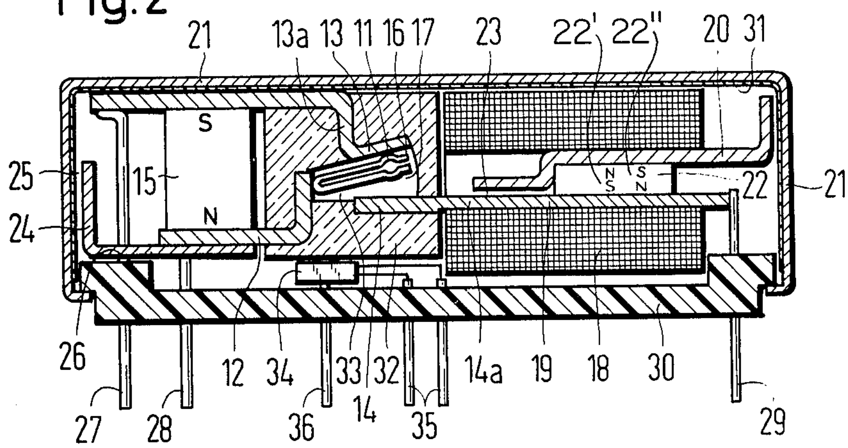
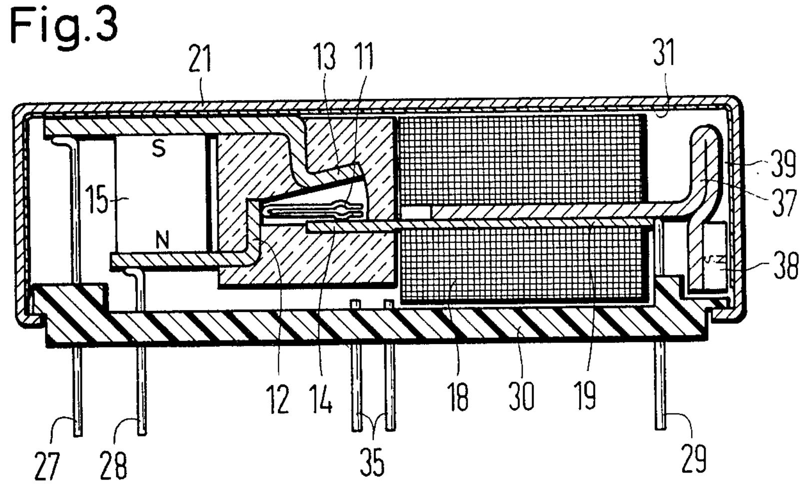


Fig.3



MAGNET SYSTEM FOR A RELAY HAVING A FREELY ROLLING ARMATURE

This invention relates to a magnet system for a relay whose armature rolls freely on a polepiece.

Relays of the kind with a free-moving armature contact are well known. For example, in DOS 1 922 **204**, a relay design is described in which a free-rolling armature can arbitrarily occupy either of two switched positions, in a symmetrical arrangement in each of the switched positions there being a permanent magnet in order to hold the armature contact. A similar design, in this case using a ball armature, is described in DOS 2 **143 715.** These known designs of armature contact relays of symmetrical construction thus, in each case, require two permanent magnets between which the switching interval or gap must be disposed. The energizing coil, in this kind of relay, is arranged either above the switching interval or gap as a permanent magnet, or embraces these parts. In either instance, the relay has a relatively high or wide construction and in the latter instance, the coil too must have a very large mean winding length.

Relays of the construction described are frequently provided on printed circuit boards where, for example, they operate in conjunction with integrated circuits. This means that there is a requirement for matching the dimensions for the relays used to these IC modules so that it is possible without any difficulty to install and appropriately connect a relay on a printed circuit board at the location of an IC module. Because these IC modules, however, have an elongated form of very low height and small width, a relay having the abovementioned kinds of magnet systems, cannot be used in this kind of application.

Also, the said relay, like other known relays having rolling armatures, can only be produced in bistable form, in which case two permanent magnets are always required for the two stable switched positions. Consequently, the range of application of relays of this kind is rather drastically restricted.

The object of the invention is to modify the magnet system of relays of the aforementioned known kind, which have free-rolling armatures, so that an extremely low and narrow relay design is made possible. In order to keep the field of application as wide as possible, this relay should be capable of manufacture without major design modification, in both monostable and bistable forms, should have a low switching power, and should furthermore have a long service life.

Considering a relay of the kind introductorily described, in accordance with the invention, this is achieved that the polepiece is attached simply to the pole of a permanent magnet arranged between it and the first mating polepiece, whilst the second mating polepiece, via the core of the energizing coil and via additional flux guide elements, forms a flux path, parallel to the first mating polepiece, for the flux produced by said permanent magnet.

The relay in accordance with the invention can be designed, without the need for any constructional modification, to produce monostable or bistable switching characteristics. The permanent magnet flux will pass, for example, from the north pole via the polepiece to the armature and will then divide, part of the flux going directly via the first mating polepiece to the south pole and the other part via the second mating polepiece and the core of the energizing coil, taking a longer path, to the south pole of the permanent magnet. Depending upon the ratio of the magnetic resistances of these two parallel flux paths, either a monostable or bistable switching characteristic will be acquired on the part of the relay.

If, in other words, the flux path via the energizing coil has a high magnetic resistance, then (if the coil is not energized) in all cases the major part of the permanent magnetic flux will pass via the armature to the first mating polepiece and in the inoperative state, will always bias the armature against said first mating polepiece. If, however, the magnetic conductivity of the second flux path via the second mating polepiece and the coil core, is of similar magnitude to that of the first mating polepiece, then after switching, the armature will remain in contact with the second mating polepiece, and will form in relation thereto a second stable switched position. Drive is provided in this case, simply by pulses of opposite direction.

Through the design of the magnet system, as proposed in accordance with the invention, it also becomes possible to connect the permanent magnet, the switching interval with the armature contact, and the energizing coil, in series with one another, so that the desired low and narrow profile is achieved. By way of connection between the energizing coil and the permanent magnet, all that is required is a flux guide component which can run directly over the coil. In a preferred embodiment of the invention, to this end a housing cover of ferromagnetic material is used. Because, also, the coil does not embrace the switching gap, it simply has a thin iron core inside it. The means length of the coil winding is thus very short, which, besides providing a short overall length of coil wire for a given excitation, yields a low energizing power and a correspondingly low level of heating.

The switching behavior of the relay can be improved by an additional permanent magnet which is arranged in series in the magnetic circuit extending via the coil core. In the case of the monostable relay, this additional permanent magnet is of opposite polarity to the first permanent magnet so that the asymmetry of the two flux paths of said first permanent magnet is reinforced.

In the case of a bistable relay, on the other hand, the additional permanent magnet is polarized in the same direction as the first permanent magnet so that the permanent magnet flux via the coil core is strengthened and between the two switched positions, a position of magnetic symmetry is approximately achieved. In particular, using a second permanent magnet, magnetic asymmetries can be compensated for. These magnetic asymmetries are inevitably produced by electrical insulations in the magnetic circuit. Because the mating polepieces constitute both magnetic and electrical conductors, insulations of this kind are absolutely essential.

Thus, the second permanent magnet, which is generally substantially smaller than the first, serves to more effectively define the flux conditions and switching characteristics of the relay. However, its function is not that which is encountered in the known constructions, namely the creation of a symmetrical magnet system in which, for each switched position, an independent permanent magnet is provided. Instead, the first permanent magnet essentially determines the holding force in the two stable switching positions (in the case of bistable relays) or in the single stable switched position (as in the case of the monostable relay). The second permanent magnet is provided essentially in order to adjust the response excitation or energizing level.

The second permanent magnet, which could also be referred to as the auxiliary permanent magnet, can be positioned at a variety of positions in the corresponding flux path passing through the energizing coil, depending upon what position is the most suitable from the design viewpoint. For example, the second permanent magnet could be positioned inside the coil between two halves of the coil core, or at the end of the coil, between the end thereof and the flux-transmitting housing cover. Because this second permanent magnet of course represents a resistance vis-a-vis the flux produced by the first permanent magnet, it is convenient furthermore to shunt it with a parallel air gap. This shunt air gap must be so dimensioned that it allows a sufficient amount of the flux developed by the first permanent magnet to pass, but must also not be so small that it short-circuits the second permanent magnet.

In a preferred embodiment of the invention, the mating polepieces are so designed in terms of cross sectional area that they are magnetically saturated when the relay is energized to produce switching.

This design is of importance because the relay, in accordance with the invention, has an armature which on striking a mating polepiece is damped neither by a bearing spring nor by any kind of contact spring. If, in a relay of this kind, the polepieces were not saturated, then the magnetic flux in the reducing air gap would continuously increase during the whole of the switching process so that at the end of the motion, the armature would be attracted under an extremely high force and wound bounce against the mating polepiece. Because of the saturation of the cross sectional iron areas, this effect is at least kept within limits. Conveniently, for these mating polepieces, a material having an approximately rectangular hysterisis loop will be used, as for example, permalloy or vacon. Because the armature contact is normally disposed in a hermetically sealed switching chamber, so that the mating contact elements extend through a glass component or some other insulator, relevant magnetic materials are chosen whose coefficient of thermal expansion substantially corresponds, for example, to that of the glass component.

In order to render the relay of the invention, as far as possible independent of temperature, in an advantageous further development, it is arranged that the first permanent magnet has a temperaturedependent shunt. This can be produced by means of a flux loop with a temperature-dependent saturation inductance which is arranged at one pole of the permanent magnet and, vis-a-vis the mating pole, constitutes an additional shunt air gap.

Other features of the invention will become more apparent when considering the description below in conjunction with the following drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates the magnetic circuit of a relay in accordance with the invention;

FIG. 2 is an embodiment of the relay in accordance with the invention using a second permanent magnet;

FIG. 3 is a further embodiment of the relay in accordance with the invention, showing another arrangement of the second permanent magnet.

DESCRIPTION OF PREFERRED EMBODIMENTS

The electromagnetic relay of FIG. 1 contains a ferromagnetic armature 1 which has no fixed bearing arrangement and pivots on a polepiece 2, executing switching movements between two mating polepieces 3 and 4 as it does so. The polepiece 2 and the mating polepieces 3 and 4 serve at the same time as electrical contact elements so that the armature 1 acts as a magnetic and an electrical bridging element. It is held at the polepiece 2 and in each case at one of the mating polepieces 3 and 4, simply by the flux of a permanent magnet 5 which is arranged between the polepiece 2 and the mating polepiece 3. The flux ϕ 5 in each case passes through the polepiece 2 to the armature 1 and then splits into a flux ϕ 53 and a flux ϕ54. Depending upon which of the mating polepieces the armature is in contact with, the associated magnetic flux component will be substantially larger than at the other mating polepiece. This means that if the armature 1 is in contact with the mating polepiece 3, the major part of the flux ϕ 5 will pass in the form of the flux ϕ 53 via the air gap 6 to the mating polepiece 3 and thence back to the associated magnetic pole S. The flux component ϕ 54 via the air gap 7 is then very small, passing via the mating polepiece 4 to the core 8 and via a flux guide element 9 to the magnetic pole S of the permanent magnet 5.

To switch the armature 1, an energizing coil 10 is provided which is arranged on the core 8 and generally comprises two windings. This generates an energizing flux ϕ 10 which passes via the core 8, the flux guide element 9, the mating polepiece 3, the air gap 6, the armature 1, the air gap 7 and the mating polepiece 4. If the energizing flux ϕ 10 is so directed that, in the air gap 6, it reinforces the flux component ϕ 53, then it opposes the flux component ϕ 54 and the armature 1 is attracted to the mating polepiece 3. If the energizing flux ϕ 10 is oppositely polarized, then it reinforces the flux component ϕ 54 and weakens the flux component ϕ 53 so that the armature is attracted to the mating polepiece 4. To switch the armature, in the bistable embodiment of the relay in each case a short energizing pulse will suffice, because the armature is retained in the terminal position by the flux developed by the permanent magnet 5. The central position of the armature 1, as illustrated, occurs only briefly during the switching phase because the armature otherwise always occupies one of its two stable terminal positions.

In a monostable embodiment of the relay, the magnetic resistance in the flux path extending via the second mating polepiece 4 and the coil core 8, is so much greater than the magnetic resistance in the first mating polepiece 3, that the flux component ϕ 53 is always substantially stronger than the flux component ϕ 54. In this case, the armature can only be held against the mating polepiece 4 by a correspondingly strong energizing flux ϕ 10. After the excitation is removed, the armature returns to and always occupies the inoperative position against the mating polepiece 3.

In order that during switching, the armature does not strike the mating polepieces 3 and 4 with two high a final velocity, these mating polepieces have their cross sectional areas reduced at the locations 3*a* and 4*a* so that these components, for a given magnetic flux level made up of the permanent magnetic flux ϕ 5 and the energizing flux ϕ 10, are saturated. In this way, the flux is prevented from increasing and the armature impact force is restricted. Instead of thinning down the mating polepieces 3 and 4 at specific locations, they can of course be designed with an overall correspondingly smaller cross sectional area.

FIG. 2 illustrates a bistable electromagnetic relay whose magnetic circuit corresponds in principle to the illustration of FIG. 1. The armature 11, U-shaped so that it has better damping properties at impact, pivots on a polepiece 12 and establishes contact arbitrarily with a mating polepiece 13 or 14. To retain the armature in the particular stable position, a permanent magnet 15 is provided, the flux of which, in the illustrated switched position, passes the major part via the armature 11 and the mating polepiece 13. To effect switching, the energizing flux developed by a coil 18 is superimposed upon this permanent magnetic flux, in the air gaps 16 and 17. The energizing flux developed by the coil 18 and, depending upon the switched position, a greater or lesser part of the permanent magnetic flux produced by the permanent magnet 15 in accordance with the flux ϕ 54 in FIG. 1, passes via the mating polepiece 14, the core 19, the flux guide plate 20 and via ferromagnetic housing cover 21, to the mating polepiece 13. Because this magnetic circuit presents a higher magnetic resistance to the permanent magnetic flux, than the flux path from the polepiece 12 via the armature 11 directly to the mating pole-piece 13, between the core 19 and the flux guide plate 20 a second permanent magnet 22 is arranged in series with the first permanent magnet 15. However, in order not to produce an excessive increase in the magnetic resistance for the flux developed by the permanent magnet 15, the permanent magnet 22 has a shunt air gap connected in parallel across it between the core 19 and the flux guide plate 20. By appropriate dimensioning of this shunt air gap 23, the result can be achieved that the magnetic resistance in the overall circuit is reduced to the minimum without short-circuiting the second permanent magnet 22. As already described in relation to FIG. 1, here, again, the cross sectional areas of the mating polepieces 13 and 14 are reduced at the locations 13*a* and 14*a* in order to prevent the development of excessively high flux levels at the time of switching the armature.

The permanent magnet may be disposed in either of the two polarized positions 22′ or 22″.

To compensate for the temperature dependence of the permanent magnet 15, furthermore, at the polepiece 12 there is a shunt plate 24 which forms a shunt air gap 25 in relation to the ferromagnetic housing cover 21. This shunt plate 24, at least in the section 26, consists of a material having temperature-dependent saturation inductance, for example, thermoflux. In this fashion, at low temperatures, part of the permanent magnetic flux is short-circuited across the shunt air gap 25 whilst at higher temperatures, the saturation inductance of the section 26 drops so that the flux of the permanent magnet 15, weakened by the effect of temperature, passes virtually completely via the armature 11.

The electrical connections for the polepieces 12, 13 and 14 serving as contact elements, comprise soldering pins 27, 28 and 29 which are welded to the corresponding polepieces and anchored in an insulating base 30. To electrically insulate these components from one another, an insulating foil 31 is provided which is secured onto the inside surface of the flux-conducting housing cover 21. At their contacting ends, the polepieces 12, 13 and 14 are fused insitu into a glass envelope 32 which forms a hermetically sealed switching chamber 33 for the armature 11. In this switching chamber 33, the contacting components can be dampened with a switching liquid, for example, mercury.

Furthermore, a double diode 34 is attached to the insulating base 30, which diode, in order to suppress voltage surges during disconnection of the relay energizing, is wired to the four coil terminals 35 (only two of which are shown) and a ground terminal 36.

FIG. 3 illustrates a bistable electromagnetic relay which is only slightly modified in relation to FIG. 2. To the extent that the components are identical in construction to those of FIG. 2, they are given the same reference numerals as used in FIG. 2, and are not being described in further detail herein. The distinction resides in the fact that in the case of the relay shown in FIG. 3, the second permanent magnet is no longer arranged inside the coil; consequently, the mean length of the coil winding can be reduced. A flux plate 37 is here arranged outside the coil and bent in such a fashion that between it and the housing, 21, a second permanent magnet 38 can be arranged, at the same time a shunt air gap 39 being produced. The second permanent magnet 38 of course could be located at other positions in the flux path extending from the mating polepiece 14 via the coil core 19, flux plate 37 to the mating polepiece 13. Functionally, the relay of FIG. 3 is indistinguishable from that of FIG. 2. Again, additional elements such as the shunt plate 24 or the double diode 34 could be arranged in the housing as in the case of FIG. 2.

As described, the relays illustrated in FIGS. 2 and 3 in each case possess bistable switching characteristics. However, without any need for design modifications, they can be converted to monostable relays. To this end, all that is necessary is to arrange for the auxiliary magnets 22 and 38 to be oppositely poled. The flux of the permanent magnet 15 is then asymmetrically distributed between the two mating polepieces 13 and 14 in such a fashion that the armature 11, when the energizing is switched off, always occupies a rest position against the mating polepiece 13.

What is claimed is:

1. A magnet system for a relay having an armature having a substantially flat cross-section, one end of which rolls freely on a polepiece, so that it's free end can be positioned as desired in contact with a first or second mating polepiece, the combination comprising:

a permanent magnet disposed between said polepiece and said first mating polepiece for applying a permanent magnetic force between at least said armature and said first mating polepiece to produce a stable switched condition, said polepiece being attached to one of the poles of said permanent magnet, said polepiece and said first mating polepiece being disposed at opposite ends of said permanent magnet and extending transversely thereto;

an energizing coil for developing a flux which may be superimposed on the permanent magnetic flux in an air gap between said first and second polepieces, said energizing coil having a core running therethrough;

said permanent magnet being laterally displaced from said energizing coil, said second mating polepiece being laterally displaced from said permanent magnet and extending through said energizing coil;

a flux guide element in close proximity to said energizing coil;

said second mating polepiece, said core of said energizing coil, said flux guide element forming a flux path parallel to said first mating polepiece for the flux produced by said permanent magnet.

2. The magnet system of claim **1**, including

a housing cover of ferromagnetic material through which the flux passing via the core of the energizing coil is guided.

3. A magnet system for a relay having an armature which rolls freely on a polepiece, so that its free end can be positioned as desired in contact with a first or second mating polepiece, the combination comprising:

a permanent magnet disposed between said polepiece and said first mating polepiece for applying a permanent magnetic force between at least said armature and said first mating polepiece to produce a stable switched condition, said polepiece being attached to one of the poles of said permanent magnet;

an energizing coil for developing a flux which may be superimposed on the permanent magnetic flux in an air gap between said first and second polepieces, said energizing coil having a core running therethrough;

a flux guide element in close proximity to said energizing coil;

said second mating polepiece, said core of said energizing coil, said flux guide element forming a flux path parallel to said first mating polepiece for the flux produced by said permanent magnet; and

a second permanent magnet arranged in series in the flux circuit extending through the energizing winding.

4. The magnet system of claim **3**, wherein

said second permanent magnet is of opposite polarity to said first permanent magnet.

5. The magnet system of claim **3**, wherein

said second permanent magnet is polarized in the same direction as the first.

6. The magnet system of claim **3**, wherein

said second permanent magnet is disposed in the interior of the coil between two flux guide elements.

7. The magnet system of claim **3**, wherein

said second permanent magnet is polarized in the same direction as the first and is disposed in the interior of the coil between two flux guide elements.

8. The magnet system of claim **3**, including

a flux guide plate and a housing cover and wherein said second permanent magnet is arranged outside the coil and between said flux guide plate and said housing cover.

9. The magnet system of claim **3**, including

means defining a secondary air gap disposed in parallel with said second permanent magnet.

10. A magnet system for a relay having an armature which rolls freely on a polepiece, so that its free end can be positioned as desired in contact with a first or second mating polepiece, the combination comprising:

a permanent magnet disposed between said polepiece and said first mating polepiece for applying a permanent magnetic force between at least said armature and said first mating polepiece to produce a stable switched condition, said polepiece being attached to one of the poles of said permanent magnet;

an energizing coil for developing a flux which may be superimposed on the permanent magnetic flux in an air gap between said first and second polepieces, said energizing coil having a core running therethrough;

a flux guide element in close proximity to said energizing coil;

said said second polepiece, said core of said energizing coil, said flux guide element forming a flux path parallel to said first mating polepiece for the flux produced by said permanent magnet;

said mating polepieces being constructed with a cross-sectional area in at least one portion thereof so that they become magnetically saturated when the relay is energized.

11. The magnet system of claim **10**, wherein

the mating polepieces consist of a material having an approximately rectangular hysterisis loop.

12. A magnet system for a relay having an armature which rolls freely on a polepiece, so that its free end can be positioned as desired in contact with a first or second mating polepiece, the combination comprising:

a permanent magnet disposed between said polepiece and said first mating polepiece for applying a permanent magnetic force between at least said armature and said first mating polepiece to produce a stable switched condition, said polepiece being attached to one of the poles of said permanent magnet;

an energizing coil for developing a flux which may be superimposed on the permanent magnetic flux in an air gap between said first and second polepieces, said energizing coil having a core running therethrough;

a flux guide element in close proximity to said energizing coil;

said second mating polepiece, said core of said energizing coil, said flux guide element forming a flux path parallel to said first mating polepiece for the flux produced by said permanent magnet;

said polepiece and mating polepieces being fused insitu in a glass body forming a hermetically sealed switching chamber.

13. A magnet system for a relay having an armature which rolls freely on a polepiece, so that its free end can be positioned as desired in contact with a first or second mating polepiece, the combination comprising:

a permanent magnet disposed between said polepiece and said first mating polepiece for applying a permanent magnetic force between at least said armature and said first mating polepiece to produce a stable switched condition, said polepiece being attached to one of the poles of said permanent magnet;

an energizing coil for developing a flux which may be superimposed on the permanent magnetic flux in an air gap between said first and second polepieces, said energizing coil having a core running therethrough;

a flux guide element in close proximity to said energizing coil;

said second mating polepiece, said core of said energizing coil, said flux guide element forming a flux path parallel to said first mating polepiece for the flux produced by said permanent magnet; and

a shunt plate whose saturation inductance is temperature dependent associated with said permanent magnet, said shunt plate being effective to partially short-circuit the permanent magnet via a shunt air gap.

14. The magnet system of claim **2,** including

a double diode disposed within said housing.

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