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[54] **MAGNETIC LATCHING REED RELAY**

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[52] **U.S. Cl.** **335/153**, 335/152

[51] **Int. Cl.** **H01h 51/22**, H01h 51/27

[58] **Field of Search** 335/153, 152, 151, 335/154

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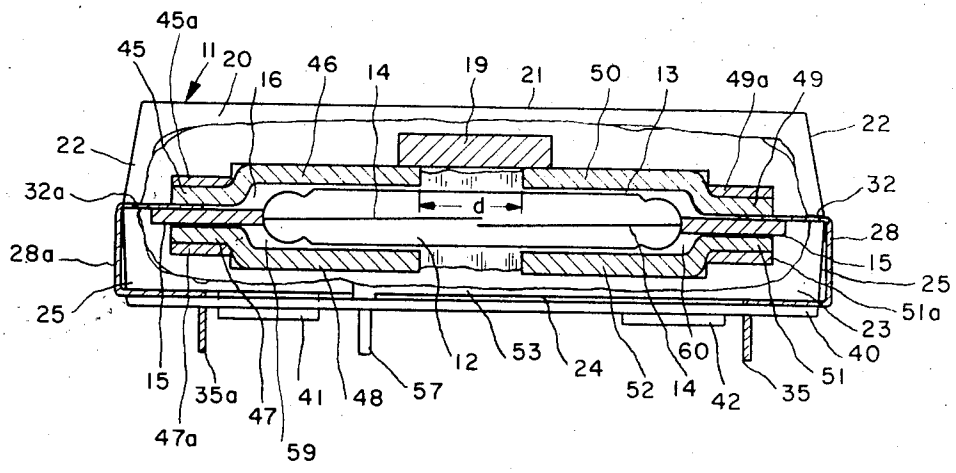
[57] **ABSTRACT**

A reed relay of the multi-pole type having a magnetic latching feature. The coil for producing a flux to operate the relay is wound about an iron core which has two pair of spaced apart extended pole pieces of a substantially L shape. The plurality of reed switch capsules are accommodated in a side-by-side arrangement between the spaced pairs of pole pieces so that the coil flux is more uniformly distributed to each reed switch through the iron magnetic circuit. A permanent magnet is placed over the pole pieces so as to provide a latching feature.

10 Claims, 3 Drawing Figures



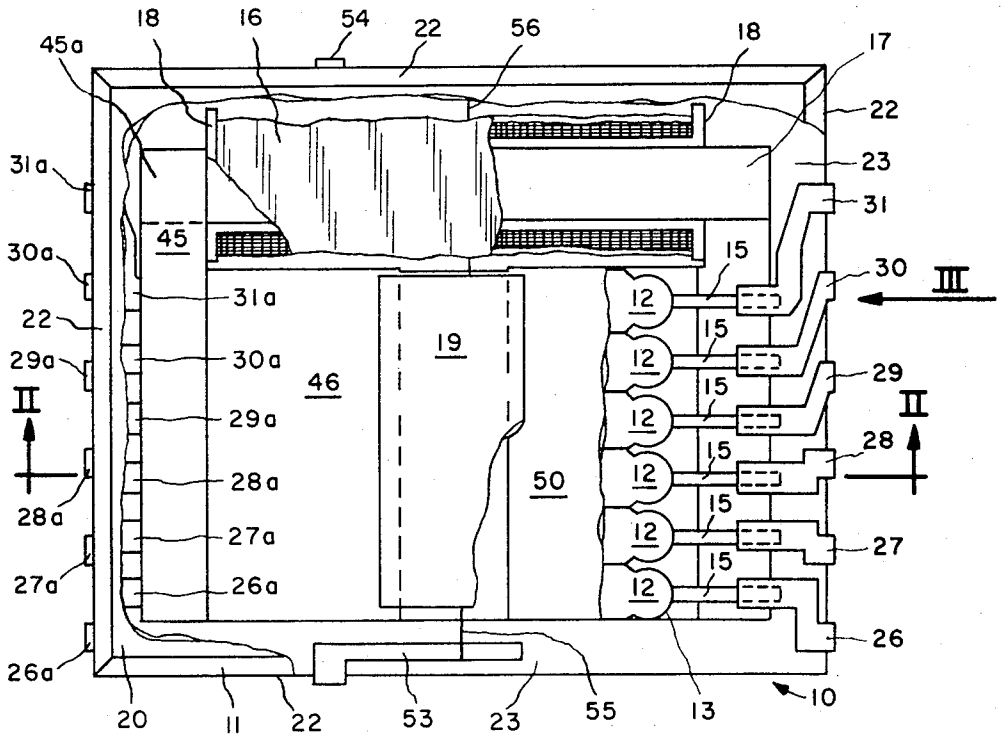

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Fig. 1

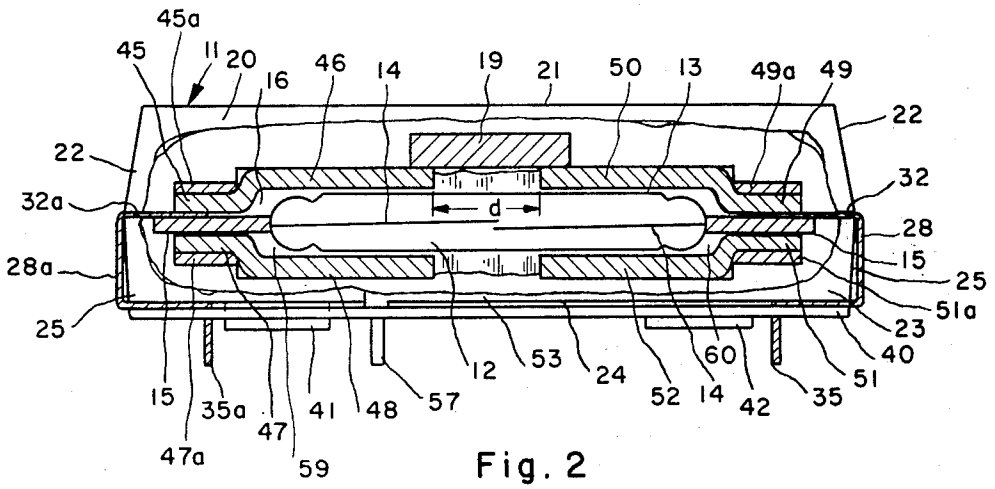
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Fig. 2

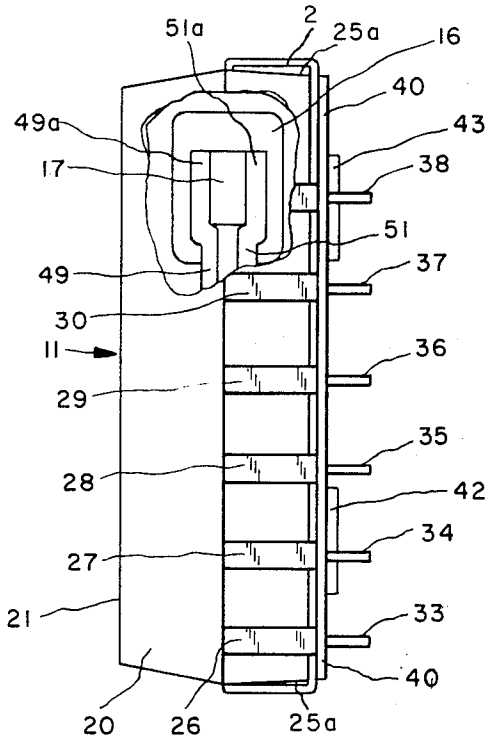
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Fig. 3

MAGNETIC LATCHING REED RELAY

BACKGROUND OF THE INVENTION

This invention relates generally to the field of reed relays and more particularly to a reed relay assembly having a plurality of reed switches (i.e., a multi-pole relay) and having a magnetic latching feature. The reed relay assembly of the present invention is of the type intended for use on printed circuit boards.

Reed relays having a magnetic latching feature, sometimes referred to as bi-stable reed relays, are generally known in the art. Such reed relays usually comprise a reed switch which includes a pair of overlapping cantilever reed contacts sealed within a glass capsule. The reeds extend through the capsule terminating in external leads. The reed contact elements are separated at the overlapping point being spaced apart by an air gap and are brought into contact with each other by applying an electromagnetic force about the cantilever reed contacts. This electromagnetic force is usually produced by a coil or winding surrounding the glass capsule accommodating the cantilever reed contacts. The magnetic flux produced by the coil, when energized, is coupled to the reed switch through air and then through the cantilever reeds within the capsule producing a force across the air gap of the reed contacts thus causing attraction between them and ultimate closing of the gap. When it is desired that the contacts should remain in the closed position even after the coil or winding surrounding the capsule is de-energized, a permanent magnet may be placed in the vicinity of the capsule, thus producing an independent magnetic flux to maintain the reed contacts closed. The magnetic flux produced by the permanent magnet will not be, in and of itself, sufficient to cause closing of the contacts so that the contacts will close only when the coil is energized so that the flux produced by the coil aids that of the permanent magnet thus causing closure of the contacts. The magnetic flux of the permanent magnet will, however, be sufficient to maintain the contacts in their closed position (latched) without the aid of the coil flux.

In order to open the reed contacts a voltage must be applied to the coil so as to produce a flux having a polarity opposite to that of the permanent magnet and of sufficient magnitude so as to overcome the force thereof thereby unlatching the contacts. When this voltage of opposite polarity is removed from the coil the contacts will remain in their open position because the flux of the permanent magnet will not be strong enough to cause reclosing. The same effect can be achieved by placing two windings on the same coil form so as to produce fluxes of opposite polarity. Another alternative would be to use two separate coils, one coil would be used to latch the contacts and the other coil would be used to unlatch them.

A magnetic latching relay of the type described therefore requires only very little coil power for a short duration to latch the contacts because of the flux already produced by the permanent magnet. No coil power at all is required to maintain the contacts in their closed or open position after the coil has been pulsed with the correct voltage polarity to cause latching or unlatching.

When combining a magnetic latching feature such as described above, with a reed relay assembly having a plurality of reed switches, a variety of problems are encountered. When employing the usual method of producing flux, i.e., surrounding the capsules with a coil winding, to cause latching of reed contacts in a multi-pole relay, the coupling of the magnetic flux from the coil to each reed switch through the medium of air will not be uniform. In a multi-pole reed relay assembly where the plurality of capsules are arranged in a side-by-side alignment, with the coil surrounding the entire arrangement, those capsules at the ends of the line will receive a greater concentration of coil flux than those in the middle because there will be more coil windings surrounding these end capsules. This produces a problem referred to as the "ladder effect." The flux is initially coupled to the reed contacts through the air and between the cantilever reeds through an air gap. When the contacts are closed because of the magnetomotive force applied to the reed contacts, the reluctance through the contacts will drop and the flux will follow a path directly through the contacts. In the side-by-side arrangement of the multi-pole relay, the contacts receiving the greatest concentration flux will close first. Since the end switches have the greatest concentration of coil flux, these will close first. All the flux generated by the coil will then flow through the contacts of the closed switch because the closed iron members offer a lower reluctance path than the air of the remaining open switches. Only when the flux through the closed switch becomes saturated will there be a sufficient surplus of flux to close the next switch.

The "ladder effect" and the effect of the two outside reed switches operating first in a multi-pole relay with the coil around the reeds, does not present a great problem in conventional on-off type applications. When, however, the magnetic latching feature is added to this type of reed relay assembly, the lack of uniform distribution of coil flux becomes more critical. The additional flux produced by the permanent magnet creates the added problem of balancing the coil flux with the magnet flux.

It is accordingly one of the objects of the present invention to provide a reed relay assembly, of the multi-pole type, in which the coil flux is more uniformly distributed to each of the reed switches of the assembly.

Another object of the invention is to provide a reed relay of the type described, having a magnetic latching feature, in which the flux produced by the coil is applied to the switches more uniformly so as to minimize the "ladder effect" and in which the flux produced by the coil is more balanced with that of the permanent magnet.

A further object of the present invention is to provide a reed relay assembly having a magnetic latching feature which requires low power operation and which can operate over a narrow range of operating values.

Yet another object of the present invention is to produce a reed relay assembly of the type described which will maintain its latched or unlatched position even when the coil is overdriven with more than five times its nominal coil voltage.

A still further object of the present invention is to provide a reed relay assembly of the magnetic latching type in which the magnetic flux is so close coupled that external magnetic shielding is not required and relay assemblies may be mounted as close to each other as 0.2 of an inch in any direction without interaction between relays and which is of a physical size so that

when mounted on a printed circuit board adjacent boards may be spaced as close as 0.5 of an inch.

SUMMARY OF THE INVENTION

One embodiment of the present invention is characterized, and the foregoing objects achieved, by providing a multi-pole magnetic latching reed relay assembly in which a plurality of reed switches are arranged alligned in side-by-side relation, and is characterized by the coil being wound about a ferromagnetic core having extended feeromagnetic pole pieces between which the reed capsules are placed. The coil flux produced by the winding, when energized, is thus distributed through the pole pieces more uniformly to each of the reed capsules than would be the case if distributed through the air. The "ladder effect" is thus minimized because the flux is more closely coupled to the reeds through the lower reluctance of the pole pieces instead of the air. In order to achieve maximum uniformity of flux produced by the permanent magnet, the magnet is placed directly over the pole pieces and located above a gap between the pole pieces, thus shunting the force of the magnet through the core. The magnet is of a sufficient size and strength so that, relative to what is consumed in the core, a balance of forces is obtained. In this manner a tight coupling between the magnet and the iron circuit is achieved.

As a result of the foregoing construction, a multi-pole relay with a magnetic latch feature having uniform distribution of flux is made possible.

Other objects, advantages, and features will become more apparent from the following detailed description of the invention in connection with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of the reed relay assembly with parts thereof partially broken away;

FIG. 2 is a front elevational view of the reed relay assembly shown in FIG. 1 with a portion thereof broken away and a portion thereof shown in section taken along the line II-II of FIG. 1; and

FIG. 3 is a side view of the reed relay assembly shown in FIG. 1 taken along the direction of arrow III and having a portion thereof broken away.

DESCRIPTION OF THE INVENTION

Referring now in detail to the drawings, a preferred form of the invention is shown in which the reed relay assembly is referred to generally as reference numeral **10.** The arrangement of elements is housed within casing **11** which is preferably formed of an epoxy plastic.

The casing **11** comprises a top cover **20** having a top **21** and four side walls **22.** In the embodiment shown, the side walls **22** have a sloped surface. The casing further comprises a bottom cover **23** having a bottom surface **24,** opposed parallel sloping end walls **25** and sloping side walls **25*a*** being parallel and opposite each other. The top cover **20** and bottom **23** are arranged to be fitted together so as to form the enclosed casing **11.** Casing **11** may also be made by completely encapsulating the relay in plastic.

A plurality of reed switches **12** are arranged in abutting side-by-side relation within the housing having their longitudinal axes parallel. In the embodiment shown six reed switches are used. However, it should be understood by those skilled in the art that any number of reed switches may be used depending upon the particular application of the relay assembly. Each of the reed switches employed in the assembly is of the type generally commercially available and comprises a glass envelope **13** having cantilevered reed contact elements **14** housed therein. The reed contacts are preferably made of nickel iron and extend through the glass envelope into external leads **15.**

A terminal, preferably made of nickel silver alloy, is attached by means such as spot welding, to each of the reed switch external leads **15.** Each reed switch capsule has two such external leads, one for each reed contact element. There are therefore two such terminals **26,26*a*; 27,27*a*; 28,28*a*; 29,29*a*; 30,30*a*; 31,31*a*** for each of the reed switch capsules. Each of the terminals **26** through **31** extend externally of the casing **11** through an opening therein such as opening **32,32*a*** as seen best in FIG. **2.** Each of the terminals is formed in a substantially U-shaped configuration so as to be wrapped about the end walls **25*a*** of the bottom cover **23** as shown most clearly in FIG. **2.** Each of the terminals terminate in a mounting pin extending in a direction normal to the bottom surface of the bottom cover away therefrom. The pins **33** through **38** are extended from terminals **26** through **31** respectively on one side of the assembly and pins **33*a*** through **38*a*** extend from terminals **26*a*** through **31*a*** respectively on the other side of the assembly.

The reed relay assembly of the present invention is intended for ultimate use on printed circuit boards and accordingly an insulator plate **40** is attached by means of an adhesive to the bottom surface **24** of the bottom cover **23** so that the assembly may be mounted on the circuit board without fear of shorting between pins because of conductor paths on the surface of the circuit board. The pins **33,33*a*** through **38,38*a*** are passed through openings in the insulator plate for mounting on the circuit board. Such mounting requires that the pins be spaced approximately 0.150 inches apart and since the typical reed relay capsule suitable for use in the present invention has an outside diameter of approximately 0.100 inches and the external leads **15** of adjacent capsules are spaced apart by an amount no greater than that, when the capsules are aligned in an abutting side-by-side arrangement, it is necessary that the terminals **26** through **31** and **26*a*** through **31*a*** be shaped appropriately so that when they are wrapped about the end wall of the bottom cover **23** the spacing between the terminating pins will be the appropriate amount. It can be seen therefore in FIG. **1** that terminal **26** and **26*a*** will have an L-shaped plan view extending in one direction while terminals **29** and **29*a*** for example will have a somewhat different L-shaped plan view extending in the other direction. It has been found that by providing the terminals with the plan view configuration as shown in FIG. **1,** the appropriate spacing between terminating pins can be easily achieved.

As previously noted, the most common and widely used method of energizing a reed switch is to arrange a coil around the capsule so that when the coil is energized the magnetomotive force produced thereby will cause the contacts to close. In a multipole reed relay assembly such as the one described above in connection with the present invention, using a coil surrounding all the capsules for energizing each of the reed switches produces the undesirable effects described above as the "ladder effect." This is due to the fact that

the capsules at both ends of the in line arrangement of abutting capsules will be surrounded by a greater amount of windings than will capsules in the middle of the line and hence will be most sensitive when the coil is energized. In the present invention this undesirable effect is minimized to the greatest extent by forming a magnetic circuit which will most uniformly distribute the flux to each of the reed switches in the assembly. This is accomplished by arranging the coil **16** around a core **17** of ferromagnetic material and off-setting the coil and core arrangement from the alignment of reed capsules **12.** The coil and core are arranged within the casing **11** having its longitudinal axis arranged parallel to the longitudinal axis of each of the reed capsules. The coil **16** is wound about a hollow coil form **18** of insulating material (preferably nylon) with the core **17** passing therethrough. In order to extend the magnetic circuit for coupling to the individual reed switches, two pair of ferromagnetic pole pieces **45, 46** and **47, 48** comprising one such pair, and **49, 50** and **51, 52** comprising the other pair are spot welded to opposite sides of the core **17.** Each of the pole pieces is L-shaped having one leg thereof (**45, 47, 49** and **51,** respectively) necked down from the other leg **46, 48, 50** and **52,** respectively). Each of the legs **45, 47, 49** and **51** have an additional flared out portion **45***a*, **47***a*, **49***a* and **51***a*, respectively, thereby forming a tab. The tab of each leg will overlap the core and is at this area spot welded to the core. Legs **46** and **48** of one pair of pole pieces extend in the same direction inwardly from the end walls of the casing and legs **50** and **52** of the other pair of pole pieces extend inwardly and toward the other set of pole pieces. A space **59** and **60** between legs **46** and **48** of one set of pole pieces and **50** and **52** of the other set of pole pieces is thereby provided for accommodating therebetween the reed capsules **12.** The leads **15** of each of the reed capsules will pass between the necked down legs **45, 47** and **49, 51** of each of the set of pole pieces where they are connected to the terminals. In this manner, a path of low reluctance through the ferromagnetic core and extended pole pieces is provided for coupling the flux of the coil to the reed switches. The legs **46, 48, 50** and **52** are extended so as to overlie each of the capsules thereby providing the most uniform distribution of coil flux. In operation, pole pieces **45, 46** and **47, 48** will have the same polarity and will be opposite to the polarity of pole pieces **49, 50** and **51, 52** so that the flux generated by the coil, when it is energized, will pass from one set of pole pieces through each of the reed switches to the other set of pole pieces hence completing the circuit. In this manner, coupling of the coil flux to the reed switches through air is minimized and the distribution of flux to each of the reed switches is made most uniform so as to minimize the "ladder effect."

In order to provide a means for energizing the coil, coil leads **55, 56** are connected to coil terminals **53, 54** which, in a manner similar to the reed lead terminals **26, 26***a* through **31, 31***a* is wrapped about the side walls **25***a* of bottom cover **23.** Terminals **53** and **54** are connected to coil pins **57** and **58,** respectively, which pass through insulator plate **40** for mounting on the printed circuit board for connection to a source of electrical energy so as to energize the coil. The coil **16** may be energized by a D.C. voltage and may have a nominal voltage of 5, 6 or 12 volts and coil resistance of 290,460 or 1,840 ohms, respectively. At 25°C, these coils will operate the switches with a 5.5 milisecond pulse of 3.6, 4.5 or 9.0 volts, respectively.

A permanent magnet **19** is arranged within the casing positioned above the reed capsules (with respect to top and bottom covers) and having its longitudinal axis extending in a direction perpendicular to the longitudinal axis of each of the reed capsules **12.** The magnet **19** has a width sufficient to cover the gap *d* between the extended pole piece legs **46, 48** and **50, 52** so that the magnet slightly overlaps the pole piece legs **46** and **50.** The magnet **19** is of a type commonly referred to as Alinco No. 5 and is commercially available. Magnet **19** has a length which extends to almost the full width of the pole pieces so as to provide a flux which will be most uniformly balanced by the flux produced by the coil and distributed through the iron pole pieces.

In setting the magnet it is first charged up to full strength and then brought into balance with the flux produced by the coil so that upon energizing the coil only the smallest amount of power will be necessary to cause latching of the reed elements **14** as a result of the flux produced by the coil in combination with the flux of the permanent magnet **19.** The magnet **19** is magnetized so as to have sufficient strength for maintaining the contacts in their latched position but will not produce sufficient flux to cause latching when they are opened.

In order to cause unlatching of the contacts **14,** a voltage having a polarity opposite to that impressed upon the coil for causing latching will be applied to the coil **16** thereby counteracting the flux of permanent magnet **19** and driving the reed element **14** to its unlatched position.

As previously noted, the unlatching pulse of voltage with opposite polarity may also be provided by a separate winding carried by the same coil form.

From the foregoing it can be seen that a reed relay assembly having a multi-pole construction and a magnetic latching feature has been provided which requires low power operation and which most uniformly distributes the flux amongst the various reed switch elements.

Because of the direct and uniform coupling of the flux to the reed switches, close spacing between them is possible, thus making it possible to space relays as close as 0.2 of an inch apart in any direction. The relay thickness may also be kept to a minimum.

In practice, it has been found that a reed relay assembly of the type described above can have an overall length of approximately 1.290 inches, an overall width of approximately 1.06 inches and an overall thickness of approximately 0.375 inches. The height of the relay above the surface of a circuit board when mounted thereon may however be effectively lengthened by providing spacers **41** and **42.** These spacers may be attached to the bottom surface **24** of bottom cover **23** and will extend through apertures in insulator plate **40.** The spacers may be 0.01 inches.

While the invention has been described and illustrated with respect to a certain preferred embodiment which gives satisfactory results it would be understood by those skilled in the art, after understanding the purpose of the invention, that various other changes and modifications may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A magnetic latching reed relay comprising a casing, a plurality of normally opened reed switches ar-

ranged in side-by-side abutting relationship housed within said casing, a coil for causing said switches to close when the coil is energized wound about a ferromagnetic core so as to provide a low reluctance path for the flux of the coil and arranged within said casing adjacent said reed switches, two sets of spaced apart pole pieces each set attached at one end thereof to opposite ends of said core and extending in a direction parallel to the axes of said switches so as to overlap all of said switches for extending said low reluctance path, said pole pieces extending from said core to a position adjacent all of said reed switches for coupling said flux to all of the switches through said low reluctance path, means connected to said coil for supplying electrical energy thereto so as to cause energization thereof, means connected to said reed switches and extending externally of said casing for connection to external circuitry, and a single magnet housed within said casing for producing magnetic flux sufficient to maintain all of said reed switches in the closed position after said switches have been closed by energizing said coil.

2. The magnetic latching reed relay according to claim 1 wherein each set of said pole pieces comprises first and second substantially L shaped ferromagnetic members, one of said sets of pole pieces being connected to one magnetic pole of said core and the other set of pole pieces being connected to the other magnetic pole of said core, one leg of each pole piece being connected at the end thereof to said core, the other leg of each pole piece extending in a direction parallel to the longitudinal axes of said reed switches, said other leg of each pole piece of said first pair of pole pieces extending in a direction opposite to that of the other leg of each pole piece of said second pair of pole pieces, said plurality of reed switches being carried within the space between the other legs of each pair of pole pieces, so that the magnetic circuit passes from the first set of pole pieces through said switches to the second set of pole pieces.

3. The magnetic latching reed relay according to claim 2 wherein said other leg of each pole piece is extended to cover each of said reed switches thereby coupling said flux produced by said coil uniformly to each of said switches.

4. The magnetic latching reed relay according to claim 1 wherein said coil is wound about a hollow nylon coil form, said core being carried within said form.

5. The magnetic latching reed relay according to claim 1 wherein each of said reed switches comprises a glass capsule, a pair of cantilevered reed contacts carried within said capsule and spaced apart by an air gap, and a lead connected to each reed contact and extending externally of said capsule.

6. The magnetic latching reed relay according to claim 1 wherein said magnet means is a permanent magnet of the Alinco No. 5 type.

7. The magnetic latching reed relay according to claim 1 further comprising an insulating plate attached to the bottom of said casing.

8. The magnetic relay according to claim 7 wherein said means extending externally of said casing terminate in mounting pins extending normal to said insulating plate and away therefrom so as to facilitate mounting of said relay on a printed circuit board.

9. The magnetic latching reed relay according to claim 1 wherein said casing is an epoxy plastic.

10. A magnetic latching multi-pole reed relay comprising an epoxy casing, a coil for producing electromagmagnetic lines of flux when energized, housed within said casing, being wound on a hollow-nylon form, a core for providing a low reluctance path for said flux arranged within the hollow of said form, a plurality of reed switch elements each comprising a glass capsule, a pair of spaced apart reed contacts within said capsule, and a lead attached to each of said reed contacts and extending externally of said capsule, means connected to each of said leads and extending externally of said casing for connection to external circuitry, two pair of spaced apart ferromagnetic pole pieces, each pair attached to opposite poles of said core extending in a direction parallel to the axes of said reed switches and adjacent said plurality of switches for extending said low reluctance path to said switches so as to uniformly distribute the flux generated by said coil when energized to each of said reed switches thereby causing more uniform operation thereof, means connected to said coil and extending externally of said casing for supplying electrical energy thereto so as to cause operation of said reed switches, and a permanent magnet housed within said casing for maintaining said reed switches closed after said coil has been deenergized.

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