July 1, 1947. O. I. PRICE 2,423,116

ELECTRIC RELAY

Filed June 30, 1944 2 Sheets-Sheet 1

FIG. 1

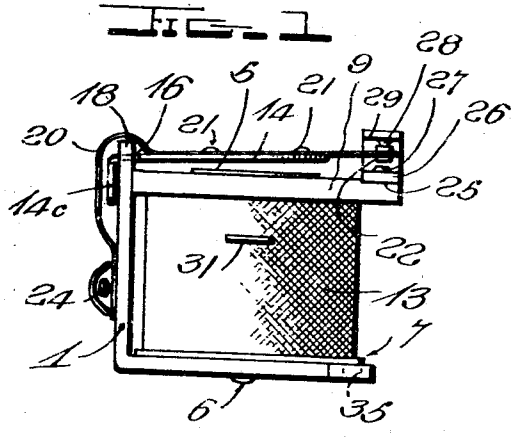


FIG. 2

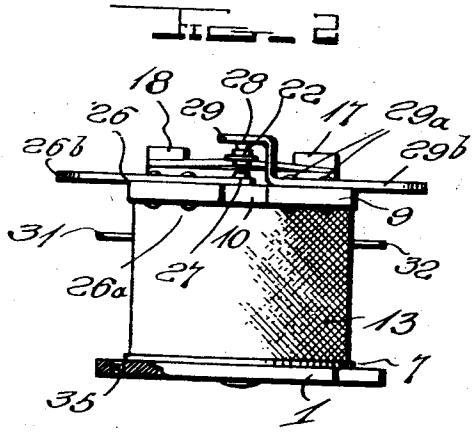


FIG. 3

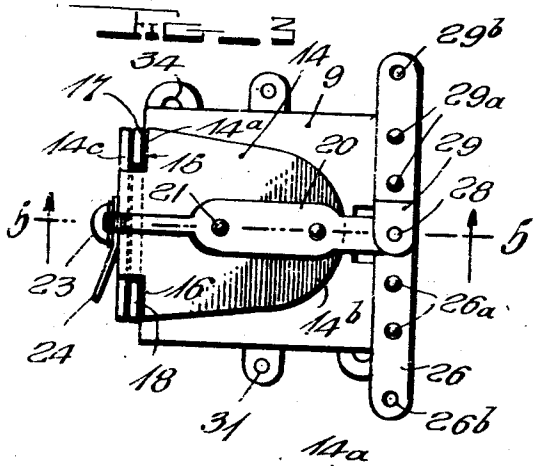


FIG. 4

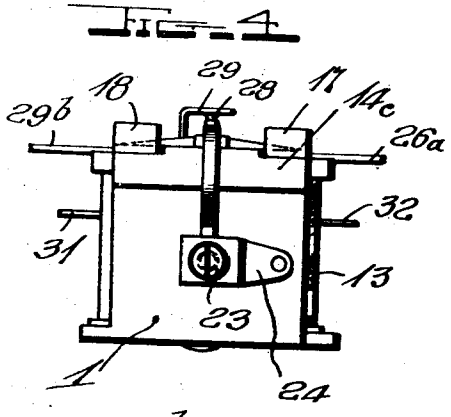
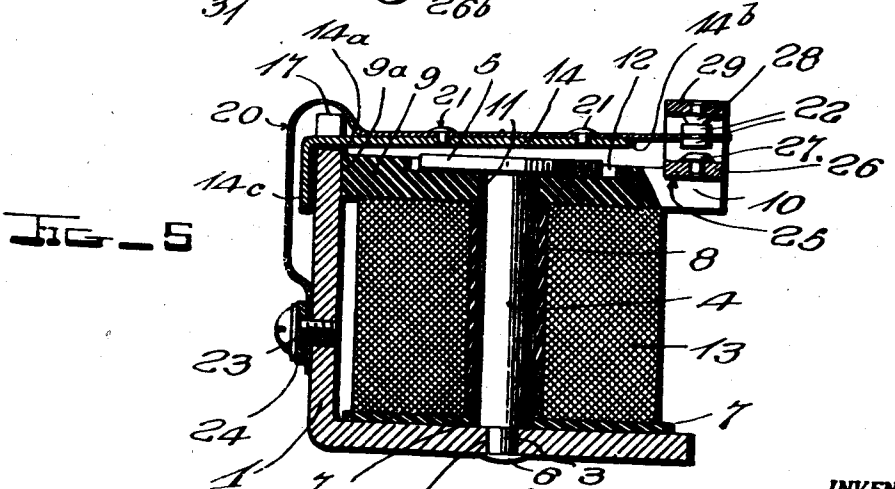


FIG. 5



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ELECTRIC RELAY

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FIG. 6

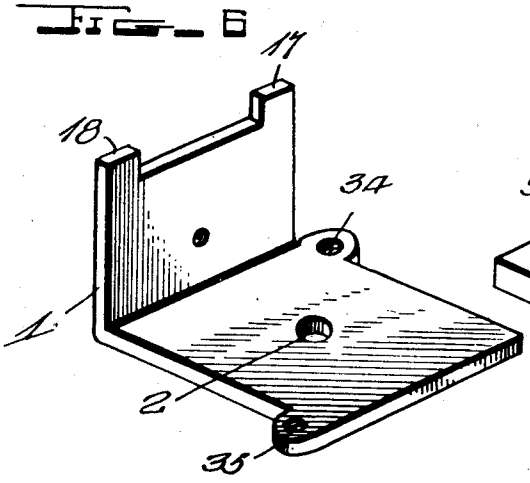


FIG. 7

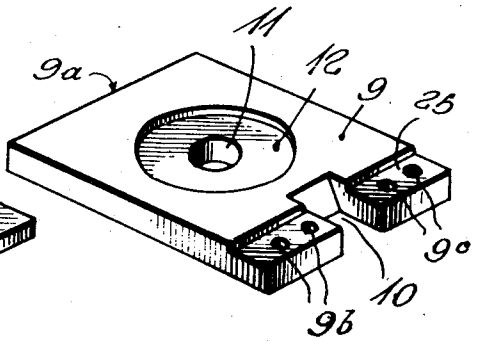


FIG. 8

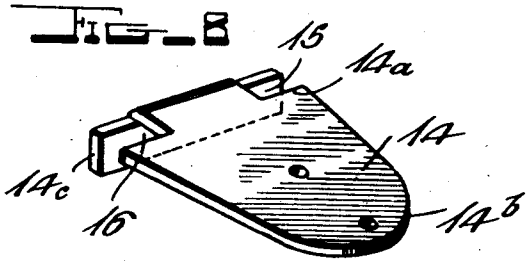


FIG. 9

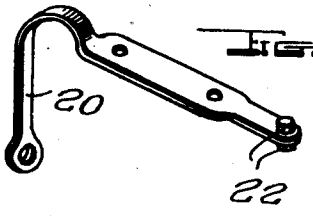


FIG. 14

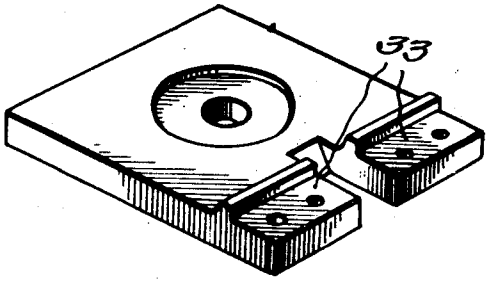


FIG. 10

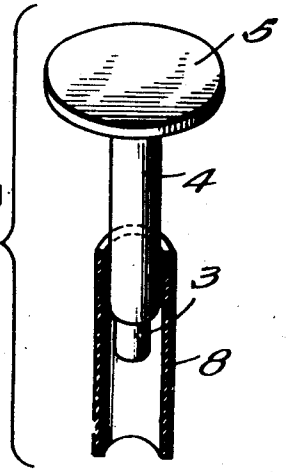
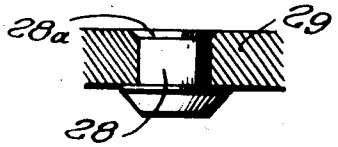


FIG. 12

FIG. 13



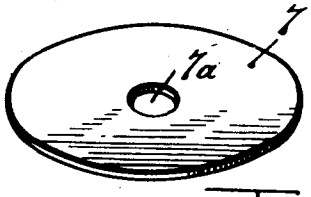


FIG. 11

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ELECTRIC RELAY

Osborne I. Price, Frederick, Md., assignor to Magnetic Devices, Inc., Frederick, Md., a corporation of Maryland

Application June 30, 1944, Serial No. 542,923

6 Claims. (Cl. 200—87)

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My invention relates broadly to electric relays and more particularly to an improved construction of light weight, small dimension relay requiring an extremely small operating current and capable of efficiently controlling the operation of an electrical circuit under conditions of wide variations in temperature.

One of the objects of my invention is to provide a construction of electric relay operative to efficiently control an electrical circuit where available space is extremely limited.

Another object of my invention is to provide a construction of miniature relay capable of operation on 2 volts over temperatures ranging from −90° to +60° C. ambient.

Still another object of my invention is to provide an efficient construction of miniature relay having a moving armature and contact system wherein the magnetic gap existing between the armature and the operating pole piece of the relay reduces its magnetic reluctance at an extremely rapid rate in order to derive maximum magnetic pull on the armature for associated circuit closing contact systems.

A further object of my invention is to provide a construction of miniature relay including a magnetic frame and a displaceable armature in which the displaceable armature is connected with the magnetic frame through a hinge construction which provides substantial continuous overlap between the movable armature and the magnetic frame of the relay to thus provide the lowest possible reluctance in the magnetic circuit and avoid introduction of high magnetic potential between the armature and the frame at the hinge junction.

A still further object of my invention is to provide an improved construction of interconnecting magnetic hinge for pivotally mounting the armature with respect to the magnetic frame structure of a miniature relay in which a portion of the displaceable armature is continuously coplanar with a portion of the magnetic frame structure of the relay.

Another object of my invention is to provide an arrangement of interconnecting hinge between the displaceable armature and the magnetic frame of a relay system in which a portion of the armature overlaps the magnetic frame of the relay adjacent the junction of the displaceable armature and the magnetic frame of the relay, the overlapping relationship being such that a selected magnetic gap is maintained between the overlapping portion of the armature and the magnetic frame of the relay for enabling rapid

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reduction in magnetic reluctance in the course of movement of the armature with respect to the magnetic frame of the relay.

Other and further objects of my invention reside in the improved structural features of the miniature relay as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a side elevational view of a miniature relay embodying my invention; Fig. 2 is a front elevational view of the relay shown in Fig. 1; Fig. 3 is a top plan view of the relay shown in Figs. 1 and 2; Fig. 4 is a rear elevational view of the relay illustrating the manner in which the relay armature overlaps the magnetic frame of the relay; Fig. 5 is a longitudinal sectional view through the relay illustrated in Figs. 1–4; Fig. 6 is a perspective view of the magnetic frame of the relay; Fig. 7 is a perspective view of the end plate of insulation material which confines the relay winding, centers the headed end of the magnetic core and supports the contact system; Fig. 8 is a perspective view of the armature of the relay of my invention; Fig. 9 is a perspective view of the return spring and contact arm associated with the armature system; Fig. 10 is a perspective view of the magnetic core, the headed end thereof and the insulated sleeve which is associated therewith for supporting the winding with respect to the core; Fig. 11 is a perspective view of the insulation member which is attached to the opposite end of the headed magnetic core for confining the operating winding with respect to the core; Fig. 12 is a side elevational view of one of the stationary contacts of the relay system; Fig. 13 illustrates one manner of mounting the stationary contacts in the contact support; and Fig. 14 is a perspective view of a modified form of contact bridge of insulation material which may be employed in the relay assembly of my invention.

My invention is directed to a construction of an efficient form of miniature relay which is extremely light in weight and very small in size and which requires a very small operating current. The relay has many applications because of its small size and weight and capabilities of relatively large magnetic pull. The particular application for which the relay of my invention was designed is "Raysonde" equipment in which the relay is carried by a free balloon for the operation of radio transmission equipment for transmitting signals proportional to climatic conditions. It will be appreciated that a relay carried by a free balloon at very high altitudes is subject to an extremely wide range of tempera-

tures and must be of small size and small weight. The relay of my invention meets all of these requirements and has been herein characterized as of "postage stamp" size, that is, of dimensions approximately $\frac{1}{8}$'' x $\frac{15}{16}$'' x $\frac{33}{32}$'' overall and of a total weight when assembled of .98 ounce. The relay has a coil resistance of 125 ohms and is capable of operation on 2 volts at temperatures ranging from −90° to +60° ambient.

Referring to the drawings in detail reference character 1 designates the magnetic frame of the relay system in a substantially right angular bend with the perforation 2 through the center of the base portion of the magnetic frame through which the reduced section end 3 of the magnetic core member 4 extends. The magnetic core member 4 has a flat headed end 5 of disc-like contour integral therewith and serves as a broad distributing head for the magnetic lines of force which thread the relay system. The reduced section end 3 of the magnetic core member is flattened against the external face of the magnetic frame 1 of the relay as represented at 6, thereby rigidly securing the core member in erect position substantially normal to the plane of the portion of frame 1 in which the core member is secured.

A disc of insulation material represented at 7 and apertured at 7*a* is inserted over the core member 4 and a sleeve of insulation material represented at 8 has its internal section aligned with aperture 7*a* of the disc of insulation material 7. A sheet-like member formed from insulation material shown at 9 is arranged as a confining head for the electromagnetic winding 13 of the relay and also as a carrier for the relay contact system. The sheet-like insulation material 9 is substantially rectangular in contour with a central recess 10 formed on the extreme edge thereof opposite the edge 9*a* thereof which abuts the wall of the magnetic frame 1. The sheet of insulation material 9 contains a central aperture 11 therein through which magnetic core member 4 extends. A counter-sunk recess 12 is provided in disc-like member 9 surrounding the aperture 11 therein and conforming with the disc-like contour of the flat headed end 5 of the magnetic core member 4. The flat headed end 5 of magnetic core member 4 projects slightly beyond the plane of the sheet of insulation 9 in a position in which the magnetic lines of force may thread through the movable armature 14.

The movable armature 14 is tapered from a relatively wide width at the end 14*a* thereof adjacent the hinged connection of the armature with the magnetic frame 1 of the relay to a rounded extremity at 14*b* which substantially conforms with the shape of the flat headed end 5 of magnetic core member 4. The magnetic armature 14 has its hinged end thereof formed by an end portion 14*c* which is bent into a plane which is slightly at an obtuse angle to the plane of the armature 14. To provide the hinged connection between the magnetic frame 1 of the relay and the armature 14, I provide recesses 15 and 16 in opposite edges of the armature 14 which extend between protruding tongues 17 and 18 of the magnetic frame 1 of the relay. Thus a rockable hinged connection is provided between armature 14 and the magnetic frame 1 of the relay in which a large area of armature 14 is continuously coextensive with a corresponding area of the magnetic frame 1 of the relay. In the normal position of the relay with the winding thereof deenergized, the end portion 14*c* of the armature 14 extends substantially parallel and coextensive

with the magnetic frame 1 of the relay as shown in Figs. 1 and 5. In the operated position of the relay with the winding thereof energized the end portion 14*c* of the armature 14 extends slightly at an acute angle with respect to the wall of the magnetic frame 1 of the relay because of the slightly obtuse angle divergence between the plane of the end portion 14*c* and the plane of the armature 14. Under both conditions, however, a hinged connection of extremely low magnetic reluctance is maintained.

The armature 14 is maintained in its non-operated position in spacial relation to the flat headed end 5 of the magnetic core member 4 by means of a flat spring member 20 which is looped in spacial relation around the hinged connection of the armature 14 with the magnetic frame 1 of the relay system and is riveted at 21 to the armature 14. One end of the spring strip 20 carries the double ended contact shown at 22 while the other end of spring strip 20 is secured to the magnetic frame 1 of the relay by terminal screw 23. A suitable connecting lug 24 is secured under the terminal screw 23, thereby enabling electrical connection to be made through the spring strip 20 to the double contact 22 without the introduction of any joints or soldered connections which are often electrically and mechanically troublesome especially under the conditions of low voltage and low current at which the relay of my invention operates. Thus no appreciable current is carried by the hinged joint or other moving parts or joints. This construction is particularly desirable for use in high frequency radio circuits as there is no coil spring or other irregularly shaped device which could in any way offer high impedance to the flow of radio frequency currents.

The contact system is mounted on the sheet of insulation material 9 in a transversely extending recess shown at 25. The transversely extending recess 25 is separated by the recess 10 at the edge of the plate 9 of insulation material and serves as mounting means for contacts of opposite potential. One contact carried by transversely extending strip-like member 26 is shown at 27 aligned with the movable contact 22 carried by spring 20. The transversely extending strip 26 is secured to the plate 9 of insulation material by suitable means such as rivet members 26*a* which pass through apertures 9*b* in the transversely extending recess 25 of plate 9. A coacting contact 28 is carried by a transversely extending strip-like member 29 which is shaped as a bracket for supporting the fixed contact 28 in alignment with the displaceable double contact 22. The movement of spring 20 is thus restricted in the non-operative position by abutment of one of the contacts 22 with contact 28 carried by bracket 29, while in the operated position the movement of spring strip 20 is restricted by abutment of the other movable contact 22 with fixed contact 27. Strip 29 is supported with respect to plate 9 of insulation material by suitable means such as rivets 29*a* extending through apertures 9*c* in the transversely extending recess 25 of plate of insulation material 9.

Electrical connection may be established with the relay winding 13 through lugs shown at 31 and 32 which are supported between the turns of the relay winding 13 and internally connected to opposite ends of the winding. Electrical connection is established with the movable double contacts 22 through connecting lug 24 while connection is established with fixed contact 27 to

lug 26b of strip 26 and connection established to fixed contact 28 through lug 29b of strip 29. In Figs. 12 and 13 I have shown in more detail the construction of the fixed contact 28 and the manner in which the fixed contact 28 is secured in bracket 29 by up-setting and riveting the end thereof as represented at 28a in bracket 29. Thus good electrical conductivity is assured with considerable mechanical stability. There are no "pigtail" connections or joints to present conditions of high resistance.

In order to increase the mechanical rigidity of the fixed contact system, I may employ a construction of insulation plate as shown in Fig. 14. In this modified form of plate the over-all contour is substantially the same as that illustrated in Fig. 7 except that the plate is not reduced in section along one transverse edge thereof but instead the thickness of the plate is built up by a transversely extending bridge represented at 33 which serves as an abutment for the transversely etxending strips 26 and 29 and insures the alignment of fixed contact system between which the movable double contact 22 operates. The importance of the bridge wall 33 will be appreciated when it is realized that the relay must often be used under conditions of continuous vibration and agitation. Thus it is desirable to provide abutments which prevent displacement of the contact system.

Screw threaded mounting holes 34 and 35 are provided in the magnetic frame 1 of the relay which enables the relay to be readily mounted from the underside of a panel or from the top side of a panel without introduction of any metallic materials within the area of the field of the relay winding which might introduce disturbing electrical factors in the precision operation of the relay.

In the assembly of the relay structure of my invention it will be understood that the aperture 11 in plate 9, the internal diameter of sleeve 8 and the aperture 7a in insulated coil end 7 are a few thousandths of an inch larger than the magnetic core member 4. The assembly consists of inserting magnetic core member 4 through aperture 11 in plate 9 so that the flat headed end 5 enters counterbored recess 12 in plate 9. Sleeve 8 is then introduced over magnetic core member 4. The disc-like end 7 is then inserted over magnetic core member 4, the central recess 7a therein passing through magnetic core member 4. The end 7 is temporarily retained in position and the coil form thus prepared placed in a winding machine. In the form of my invention illustrated I have successfully wound the magnetic core member 4 with 2700 turns of #36 wire while giving a resistance of 125 ohms and 42 ampere turns with 2 volts applied to the coil. When the coil is completely wound the temporary securing means is removed and the assembled coil with the reduced end section 3 of magnetic core member 4 projecting therefrom passed through aperture 2 in magnetic frame 1 and the core secured therein by pressure applied against the end thereof as represented at 6. The magnetic circuit is constructed to be of extremely low reluctance. The gap existing between the armature 14 and the magnetic frame 1 reduces its reluctance at a fast rate in order to derive maximum pull on the armature, and the hinge arrangement is of the lowest possible reluctance so as not to introduce a high magnetic potential between the armature and the frame at the hinge junction.

The polar extension 5 of the magnetic core

member 4 is provided for the purpose of making the area of the gap existing between the core and the armature very large, which reduces the reluctance of the air gap existing in this portion of this magnetic circuit to a minimum and consequently increasing the generated number of lines of force in the total magnetic circuit. By using large areas in this magnetic gap the reluctance decreases at a high rate which improves the efficiency of the relay many times. This has been proven conclusively by the making of many models and numerous experiments and tests. This also applies to the hinge joint on which numerous experiments prove the conclusion that the coextensive arrangement of the end 14c of armature 14 with the magnetic frame 1 greatly reduces magnetic reluctance between the armature and the magnetic frame of the relay.

The over-all design of this relay has taken into consideration the mean average of magnetic circuit, coil space, ampere turns, current consumption and weight. The relay, as heretofore stated, is less than 1 ounce in weight and measures less than one inch in cubic dimensions and can be manufactured with a minimum of effort and with the widest of tolerances to make an efficient, reasonably priced, dependable relay that will be as nearly 100% failure-proof as possible for the use in "Raysonde" equipment and other equipment. This relay has been rendered free from the actions of the elements by using a special material in the spring and movable contact assembly that will require no plating and has the highest fatigue limit of any material available. The contacts are of pure platinum and are used very sparingly as the construction of the relay lends itself to close alignment of the contacts. Special provisions have been made for ease of attaching the wires to the contact arms and the soldering of same without affecting to any appreciable degree the insulation material. There are no compression joints in the relay circuit. Special attention has been given to straight lines so as not to present impedance to high frequency currents.

While I have described my invention in certain of its preferred embodiments I realize that modifications may be made in the construction and arrangement of the parts of the relay system of my invention and I intend no limitations upon my invention other than may be imposed by the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is:

1. A relay comprising a magnetic frame structure, a core member carried by said frame structure, an electromagnetic operating winding associated with said core member, a panel of insulation material extending transversely of said core member and confining said electromagnetic operating winding in position, said panel being recessed in one edge thereof, said core member having a flat disc-like head recessed into said panel and an armature member having a portion extending in overlapping relation to said magnetic frame structure and a portion substantially conforming in contour with said flat dis-like head with a portion of reduced section interconnecting the aforesaid portions, a pair of projecting lugs adjacent opposite edges of said frame structure, the portion of said armature of reduced section extending between said lugs and a spring member secured to said frame structure and to said armature member and carrying contacts adjacent the end thereof and sets of fixed contacts trans-

versely supported on each side of the recessed edge of said panel and coacting with the contacts carried by said spring member.

2. A relay comprising a magnetic frame structure, a core member carried by said frame structure, an electromagnetic operating winding associated with said core member, a panel of insulation material extending transversely of said core member and confining said electromagnetic operating winding in position, said panel being slotted adjacent one edge thereof, said core member having a flat disc-like head recessed into said panel and an armature member having a portion extending in overlapping relation to said magnetic frame structure and a portion substantially conforming in contour with said flat disc-like head with an interconnecting portion of reduced section therebetween, a pair of confining ears on said frame structure extending on opposite sides of the reduced section portion of said armature and a spring member secured to said frame structure and to said armature member and carrying contacts adjacent the end thereof, said panel of insulation material being transversely recessed adjacent the slotted edge thereof and sets of fixed contacts mounted in the transverse recess on opposite sides of the slotted edge and aligned with the contacts adjacent the end of said spring member.

3. A relay comprising a magnetic frame structure, a core member carried by said frame structure, an electromagnetic operating winding associated with said core member, a panel of insulation material extending transversely of said core member and confining said electromagnetic operating winding in position, said panel terminating in a pair of projecting portions, said core member having a flat disc-like head recessed into said panel and an armature member having a portion extending in overlapping relation to said magnetic frame structure and a portion substantially conforming in contour with said flat disc-like head with an interconnecting portion of reduced section therebetween, said frame structure having a projecting lug portion extending on each side of the reduced section of said armature, and a spring member secured to said frame structure and to said armature member and carrying opposed contacts adjacent the end thereof, said panel of insulation material having a projecting transverse ledge thereon and sets of fixed specially related opposed contacts secured in position adjacent the projecting transverse ledge on each of the projecting portions of said panel and aligned on opposite sides of the opposed contacts adjacent the end of said spring member.

4. A relay comprising a magnetic frame structure, a core member carried by said frame structure, a panel member of insulation material extending in a plane normal to said magnetic frame structure and terminating in a pair of spaced end portions, the said core member having an enlarged magnetic head recessed into said panel member, an electromagnetic operating winding associated with said core member, an armature member having one end aligned with said core member and having the other end extending into a plane displaced at a slight obtuse angle to the plane of the first mentioned end thereof and overlapping with said frame structure to form a pivotal magnetic juncture of low magnetic reluctance, a spring strip fixed both to said frame structure and said armature member, a pair of opposed movable contacts carried by said spring strip and a set of coacting fixed contacts respectively mounted on the spaced end portions of said panel member and aligned with said opposed movable contacts.

5. An electromagnet comprising a magnetic frame of L shaped section centrally apertured in one face of said section, a coil support of insulation material having a pair of coil ends of insulation material interconnected by a sleeve of insulation material with an electromagnetic winding thereon, one of said coil ends being centrally recessed, a magnetic core having an enlarged head and a cylindrical shank insertable through said centrally recessed coil end, said sleeve and said other coil end with an end section on said shank of reduced diameter extendible through the apertured face of said L shaped magnetic frame the thickness of the enlarged end of said magnetic core being substantially equal to the depth of the recess in said first mentioned coil end and means for securing said shank therein for confining said coil support against said L shaped magnetic frame with the top of the enlarged head of said magnet core substantially co-planar with the face of said first-mentioned coil end.

6. An electromagnet comprising a magnetic frame of L shaped section, a coil support of insulation material including a pair of coil ends of insulation material interconnected by a sleeve of insulation material, with an electromagnetic coil winding thereon, one of said coil ends and said L shaped section terminating in substantially the same plane and being centrally recessed, a magnetic core having an enlarged head and a cylindrical shank insertable through the sleeve of said coil support, the coil of insulation material in the plane of the terminus of said L shaped section being recessed to receive the enlarged head of said magnetic core whereby said enlarged head terminates in substantially the plane of the terminus of said L shaped section, said cylindrical shank having an end of reduced section extending through an aperture in said L shaped section, means for securing said reduced section in said L shaped section whereby said coil support is maintained in position with respect to said L shaped section, and an armature pivotally mounted with respect to said L shaped section and coacting with the enlarged head of said magnetic core.

OSBORNE I. PRICE.

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