Dec. 25, 1956 B. LAZICH 2,775,666

ELECTRICAL RELAYS

Filed April 19, 1951 2 Sheets-Sheet 1

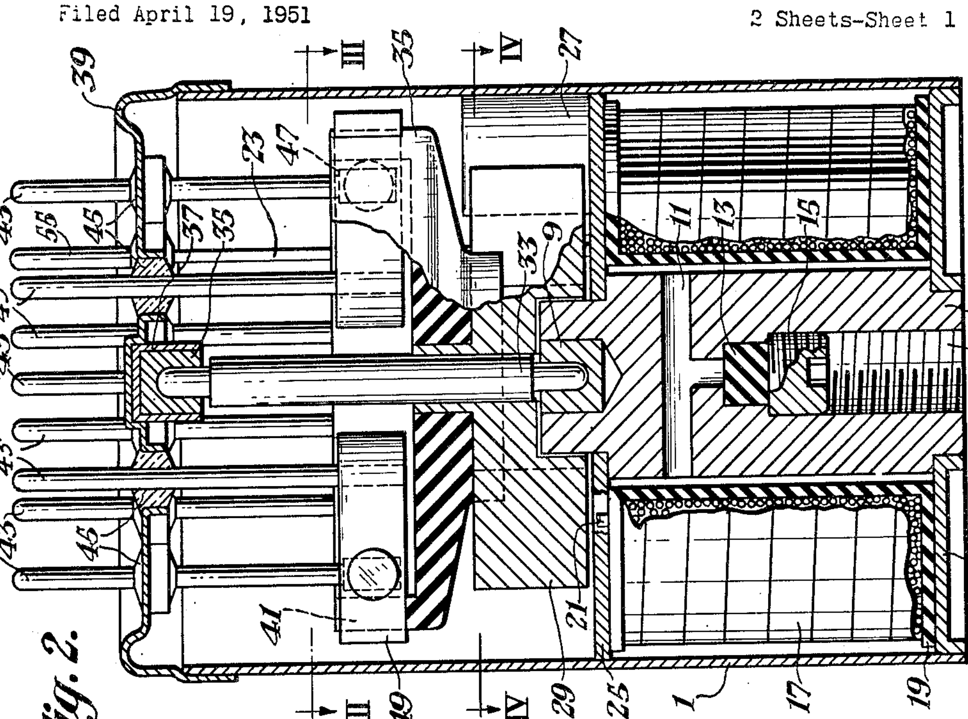

Fig. 2.

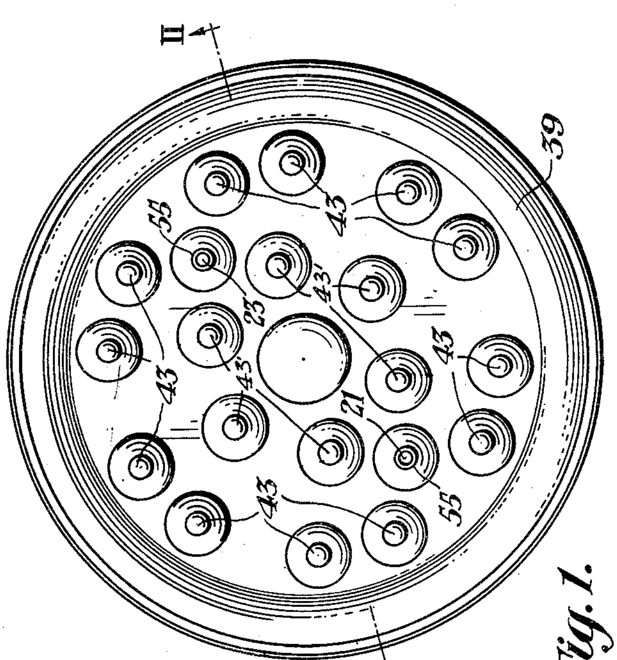

Fig. 1.

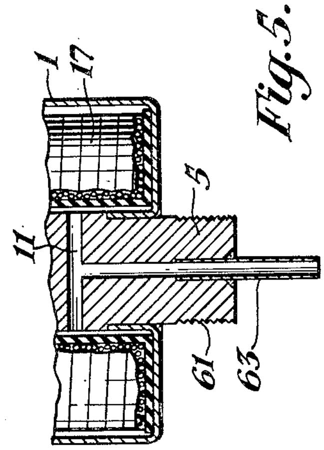

Fig. 5.

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ELECTRICAL RELAYS

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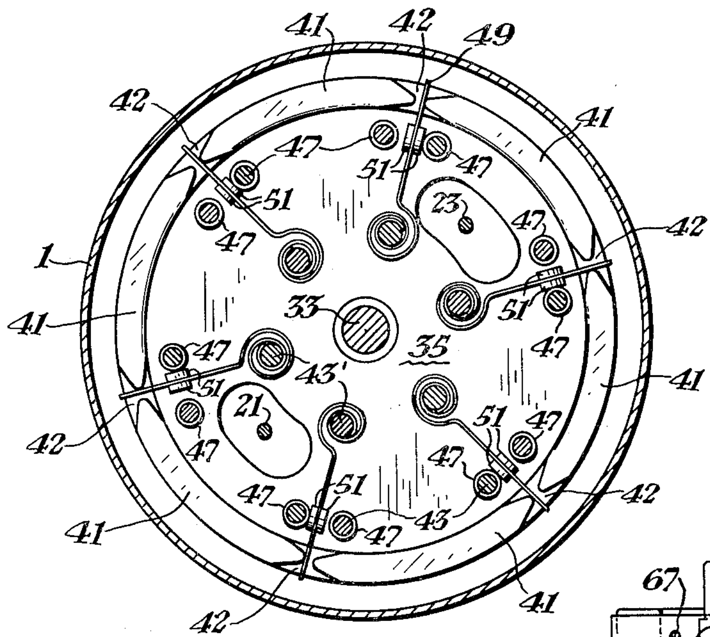

Fig. 3.

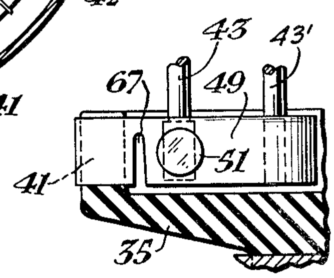

Fig. 6.

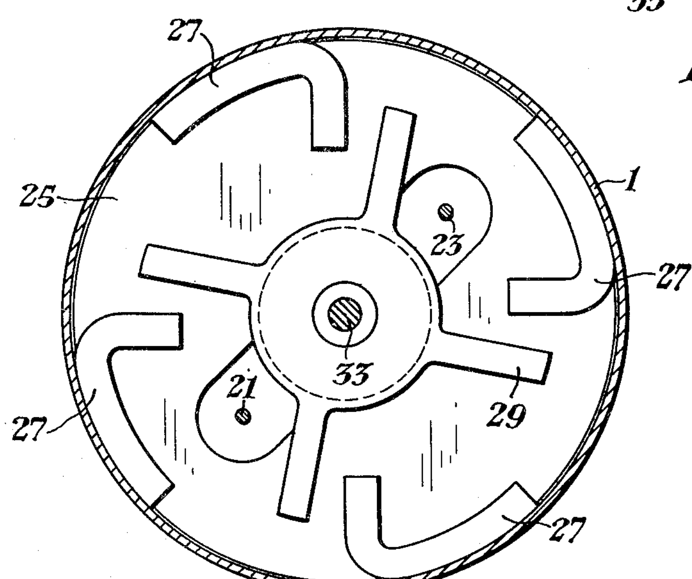

Fig. 4.

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ELECTRICAL RELAYS

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Application April 19, 1951, Serial No. 221,773

10 Claims. (Cl. 200—104)

My invention relates to electrical relays, and particularly to electrical relays suitable for applications requiring a small, lightweight relay, capable of being hermetically sealed, having a relatively large number of contacts, and capable of withstanding severe shocks and temperature changes.

One object of my invention is to provide a novel and improved electrical relay which may be extremely small in size, capable of being hermetically sealed, and constructed to withstand severe shocks and high ambient temperature.

Another object of my invention is to provide a relay of the type described which is reliable, efficient, and inexpensive to manufacture.

Other objects of my invention and features of novelty thereof will be apparent from the following description taken in connection with the accompanying drawings.

In practicing my invention, I provide a suitable shell of magnetic material closed at one end and having an axially disposed central core projecting inwardly from the closed end of the shell. At the other end of the shell there is provided a suitable header or closure disc, which is provided with radially arranged movable and stationary contacts, the supports of which extend through the header to afford means for making external connections to the contacts. An operating coil is disposed on the central core, with the coil leads arranged to be attached to terminals in the header to afford external connections. A perforated disc of non-magnetic material is disposed within the outer shell in such manner as to retain the operating coil in its proper position. Inwardly projecting tabs which act as pole pieces in the magnetic circuit of the relay are attached to the inner walls of the shell. An armature is provided including a shaft having one end journaled in a supporting member at the header end of the relay and the other end journaled in an insert of bearing metal in the central core. The armature is arranged to rotate between the inwardly projecting pole pieces and may be biased to a predetermined position by any suitable means, such as the spring force of the movable contacts, for example. A spider or contact operating member formed of insulating material is attached to the armature and is arranged to engage the movable contacts attached to the header, so that upon operation of the armature, the spider operates the movable contact arms into and out of engagement with the associated stationary contacts. The assembly is such that the relay may be hermetically sealed and evacuated, or filled with an inert gas.

I shall describe one form of an improved relay embodying my invention and the manner in which it is constructed and assembled, together with two variations in the structure which may be employed, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a top plan view of the relay.

Fig. 2 is a sectional elevation view taken substantially on the line II—II of Fig. 1.

Fig. 3 is a sectional view taken substantially on the line III—III of Fig. 2, showing the contacts and the spider.

Fig. 4 is a sectional view showing the armature and pole pieces, taken substantially on the line IV—IV of Fig. 2.

Fig. 5 is a fragmentary sectional view of a modification of the core structure of the relay.

Fig. 6 is a view of a modification of the contact structure of the relay.

In each of the various views, similar reference characters refer to similar parts.

Referring to the drawings, Figs. 1–4, the relay comprises an outer shell or housing consisting of a tube or cylinder **1** of magnetic material, cut to the desired length preferably from a welded tube of suitable diameter having predetermined magnetic characteristics, and closed at its lower end by a base or closure piece **3**. The base piece **3**, which is also of magnetic material, may be formed by punching from a sheet of suitable material, and may be pressed into the cylinder **1**. It is provided with a central core **5**, which in turn may be pressed into the base **3**. The core **5** is likewise made of magnetic material, and is provided with a tapped hole **7** at the end which is pressed into the base, to afford a means for mounting the relay. The other end of core **5** is drilled and reamed and provided with a bearing bushing **9** for one end of the armature shaft. The core **5** is drilled to provide a passage **11** between the tapped hole **7** and the interior of the relay to provide a passage for exhausting the air from the interior of the relay, this passage normally being closed by a sealing plug **13** of deformable or plastic material held in place by the threaded plug **15**.

Alternatively the shell or housing may be formed by deep drawing of a sheet of suitable magnetic material, and thereafter punching a hole in the bottom of the cup thus formed to retain the core **5**, as shown in Fig. 5.

After the tube **1** and base **3** have been assembled to form the shell, and the central core **5** has been pressed into the base **3**, the assembly may be placed in a hydrogen atmosphere oven, and the parts copper brazed, to form a durable, rigid, and airtight assembly.

The operating coil **17** for the relay is made by winding wire on a spool **19**, made of suitable insulating material, with the wire leads **21** and **23** projecting from one end of the spool as shown, to facilitate the further assembly of the relay. If it is required that the relay withstand high temperatures, the wire may be made of material suitable for use at high temperatures such as aluminum wire, which may be oxidized to provide insulation between turns and layers. Moreover, depending upon the design of the relay, the coil may be wound with heavy rectangular wire to form a self-supporting coil.

The coil **17** is inserted in outer shell **1**, with central core **5** projecting through the coil as shown in the drawings, and with projecting coil leads **21** and **23** aligned to pass through the coil lead tubes **55** in the header **39**, which will be subsequently described.

With the coil in proper position, a coil retaining plate **25**, which may be punched from a sheet of suitable non-magnetic material, is inserted in the shell as shown, over the core and coil. This coil retaining member or plate serves a dual purpose namely, to hold coil **17** in its proper position, and to act as a fixture or jig for properly aligning the pole pieces.

The pole pieces **27** are individually formed from suitable magnetic material, to the shape shown. The pole pieces are then assembled to coil retaining plate **25** by brazing or welding, so that when the coil retaining plate is inserted in the shell, the pole pieces will be in proper alignment with the shell and positioned to have the required relation to the armature arms, to be subsequently described.

As shown in the drawings, the armature 29 comprises a central hub portion with four outwardly extending arms or projections, equidistantly spaced on the hub, as will be clearly seen by reference to Fig. 4. The planes of these arms are offset from the center line of the hub by a distance such that when the armature is rotated toward pole pieces 27, the surfaces of the arms and the surfaces of the inwardly extending portion of the pole pieces will be in substantially parallel relation. It should be understood, however, that the number and arrangement of the arms is not limited to that shown, but the armature may be constructed to have any suitable number of arms, cooperating with a like number of pole pieces, provided that the arrangement is symmetrical with respect to the axis of the shell.

The armature 29 may be machined out of a single piece of suitable magnetic material, or it may be formed by the well-known process of sintering powdered material in a suitable mold. It will be noticed that the hub of the armature is counter-bored to receive the upper portion of the central core 5, which is reduced in diameter from the main portion of the core. Such an arrangement provides an air gap between the core and the armature which has sufficient area to afford a relatively low reluctance to the magnetic flux flowing between the armature and the core.

The armature 29 is rigidly attached to a shaft 33, to permit rotation of the armature in response to the energization of the relay winding. The shaft 33 is journaled in suitable bearings comprising the previously mentioned first bearing bushing 9, formed from suitable bearing material and pressed into a hole in the upper end of the core 5, and a second bearing bushing 35, which bushing is pressed into a small cup 37 which in turn is attached to the header or closure disc 39 by spotwelding or other suitable means.

Accordingly, it will be seen that armature 29 will be forced to rotate within a small arc as the result of the arms of the armature being attracted to the stationary pole pieces 27 when the coil is energized. If it is assumed, for example, that the coil is energized in such manner that the upper end of the core (as viewed in Fig. 2) becomes a North pole, the magnetic flux will follow a path from the upper end of the core, across the air gap between the core and the armature and will divide among the four arms of the armature, the four portions of the flux flowing through the arms of the armature, across the air gap between the armature arms and the four stationary pole pieces, through the pole pieces, through the outer shell and bottom portion to the lower end of the core as viewed in Fig. 2. It will be apparent that the magnetic circuit of the relay is short in comparison with total dimensions of the relay, and that the parts are arranged so that the leakage flux is maintained at a relatively small value, by making the path of the useful flux much shorter than the paths of the leakage flux. Also it will be apparent that the arrangement provides for a high degree of immunity to stray magnetic fields, since the magnetic outer shell will afford a low reluctance path to any extraneous fields, so that the extraneous fields cannot cause any pull to be exerted upon the armature. Conversely, the magnetic field produced by the relay will be confined to the shell and interior of the relay, so that adjacent apparatus will not be adversely affected by the relay's magnetic field.

The contacts of the relay are operatively connected to armature 29 by means of an operating member, or spider 35, which is formed from suitable insulating material capable of withstanding shock and large temperature changes, such as certain of the so-called "plastics." The spider is essentially formed in a cup-like shape, with the lower portion adapted to fit over the hub of the armature and to engage the arms of the armature. The shaft 33 passes through the spider, and when the spider is in place, it is rotated by the movement of armature 29. The upturned sides 41 of the spider are notched at various points 42 around the periphery to engage the movable contact members of the relay, as will be subsequently described. Suitable openings are provided in the spider to permit the passage of the lead wires 21 and 23 of the operating coil, as may be seen in Fig. 3.

The header may be built up from a punched metal disc 39 with properly spaced holes for the contact posts 43 and 43′. These contact posts may be of the well-known type in which a metal rod 43 or 43′ is inserted through a glass or ceramic bead 45 which is fused in the metal header, the metal of the contact parts and the header being of a type which has substantially the same coefficient of thermal expansion as the glass or ceramic material, so that an airtight seal may be obtained. One such type of metal is well-known in the art as "Kovar." Another suitable arrangement would result from the provision of a header formed with a metal flange and having rods of "Kovar" or other suitable material fused in a glass or ceramic disc retained in the flange. Other forms which the header may take will be obvious to those skilled in the art.

Upon the inwardly projecting end of certain of the contact posts 43, sleeves of suitable contact material, such as silver-platinum, are brazed or spotwelded, to provide the stationary contacts 47.

The movable contact fingers 49 are formed from suitable spring material spirally coiled at one end to provide additional spring action. Buttons 51 of suitable contact material are riveted or otherwise fastened to the movable contact fingers to cooperate with the stationary contacts 47. The coiled ends of the movable contact fingers are secured, as by brazing, soldering or spot-welding to selected pins 43′ in the header disc as can be seen from Fig. 3, and the free end of each movable contact finger is engaged in one of the slots 42 provided in the spider.

In Fig. 6, there is shown a modification of the contact assembly which provides a greater degree of flexibility of the distal or free end of the movable contact fingers. As shown, a lateral slot 67 is cut into the movable contact spring 49 at a point near the free end of the spring which is engaged by the slot 42 in the spider 35. This lateral slot reduces the cross sectional area of the spring at the point involved, and thus permits the outer end of the spring to flex an additional amount. By arranging each of the movable springs in this manner, the armature spider may have a certain amount of overtravel, thus insuring that all the contacts of the relay will close properly when the relay is operated.

A plurality of contacts arranged in the manner described above are arranged in a radial fashion on the header disc, and it is contemplated that by the use of this novel arangement of contacts, as many as six separate sets of contacts may be provided in a relay measuring approximately 1⅛ inches in diameter and 1½ inches long.

After the contacts are assembled to header disc 39 the assembly is completed by placing the disc in the open end of the cylinder, with the movable contact arms 49 engaging the slots 42 in the periphery of spider 35. The upper end of armature shaft 33 is inserted in bearing bushing 35 attached to the header disc. The coil leads 21 and 23 are brought out through small tubes 55 sealed into the header disc in the same manner as the contact posts 43 and 43′. The header disc is then soldered or welded to the shell 1, preferably by means of high frequency electronic heating.

Referring now to Fig. 1, the air in the interior of the relay may be exhausted through the passage 11 in the core which connects the interior of the relay with the tapped mounting hole 7 in the core 5. This may be accomplished by mounting each relay upon a threaded pipe connection to an exhaust manifold, which pipe connection may be threaded to fit the mounting hole 7. After the air has been exhausted a suitable gas or gas mixture can be admitted to the interior of the relay. The gas may be one of the inert gases such as nitrogen, helium, etc., which serves to inhibit corrosion and erosion of the contacts due to sparking, and also to act as a heat transfer agent to equalize the temperature within the relay to the ambient temperature.

Thereafter, the passage 11 may be sealed by forcing the compressible plug 13 against its seat by turning the screw 15. This action can be accomplished by suitable means operating through the pipe connection to the manifold while the relay is still connected to the manifold.

Referring to Fig. 5, I have shown a fragmentary view of a modification of the core and shell assembly to provide a mounting stud and exhaust tubulature as integral parts of the core. The core 5 is shown as extending through the bottom or closed end of the relay shell 1, which shell is here shown as being drawn from a single piece of material. The core 5 is provided with a portion of reduced diameter, so that a shoulder is formed which engages the edges of the punched opening in the shell. The core is brazed or silver-soldered to the shell to provide a rigid, durable and air-tight connection therebetween. The portion 61 of core 5 extending out of the shell is threaded, to thereby provide a mounting stud for attaching the relay to any suitable support or surface, either by screwing the relay stud into a tapped hole in the support, or by passing the stud through a hole in the support and screwing a suitable nut on the stud.

The core is drilled as shown to provide a passage to the interior of the relay. An exhaust tubulature 63 which may, for example, comprise a short length of copper tubing, is silver-soldered or brazed into the opening in core 5. After the relay has been assembled, the exhaust tubulature 63 may be attached to a suitable vacuum system for exhausting the air from the relay and/or filling the interior of the relay with a suitable gas or mixture of gases. After the exhaustting process is completed, the tube 63 may be pinched off close to the core 5, and dipped in molten solder to thereby complete the hermetic sealing of the relay.

Other arrangements for evacuating the relay and filling it with gas will suggest themselves to those skilled in the art, and my invention is not limited to the arrangement shown and described above.

It will be obvious that the construction of the relay may be modified in numerous ways to suit particular operating conditions. For example, if it is not required that the relay be hermetically sealed, the header disc may be made of suitable plastic material with the contact pins, armature shaft bearing and coil lead tubes cast in place, and with the header assembled to the shell 1 by any suitable means, such as spinning.

It will be apparent that the relay is inexpensive to manufacture as outlined above, as the majority of the parts are punched or formed in such manner that relatively few machined parts are required.

The balanced arangement of the movable parts, including the armature, the spider, and the movable contact fingers is such that the relay has a high immunity to false operation by shock, since no external displacement can create a torque on the armature shaft. Moreover, the relay has a high degree of immunity to the effect of extraneous magnetic fields, due to the shielding effect of the case.

It will further be seen that the relay may be arranged so that the contact parts and coil tubes plug into a socket of a type similar to those well-known in the electron tube art, to provide a "plug-in" relay, with the advantages of quick and fool-proof replacement of relays.

Although I have herein shown and described only one form of electrical relay embodying my invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. A relay comprising a shell of magnetic material closed at one end, an axially disposed core of magnetic material extending inwardly from the closed end of said shell, an armature of magnetic material pivotally supported adjacent the inward end of said core to rotate on an axis which coincides with the axis of said shell and said core, stationary pole pieces extending inwardly from the inner surface of said shell, an operating coil mounted on said core, said armature and said pole pieces being disposed and arranged so that said armature is rotated through a predetermined arc by attraction to said pole pieces when said operating coil is energized, a header disc for closing the open end of said shell and including terminal posts extending through said header disc, a plurality of contacts mounted on said terminal posts to be located inside said shell when the disc is attached to said shell, each of said contacts including a movable contact member and at least one stationary contact member, and a contact operating member movable with said armature for operating said movable contact members when said armature rotates through said predetermined arc.

2. A relay comprising a cylindrical shell of magnetic material closed at one end and provided with a cylindrical core extending inwardly from said one end of said shell, an operating winding disposed on said core, inwardly projecting pole pieces of magnetic material attached to said shell, an armature of magnetic material mounted for rotation on an axis which coincides with the axis of said core and disposed to be rotated through a predetermined arc when a difference of magnetic potential exists between said pole pieces and said core as the result of the energization of said operating winding, a header disc adapted to form a closure for the other end of said shell, a plurality of contacts mounted on the inwardly positioned surface of said disc on terminal posts extending through said header disc, and contact operating means movable with said armature for operating said contacts when the armature rotates through said predetermined arc.

3. A relay comprising a cylindrical shell of magnetic material closed at one end, a core of magnetic material magnetically connected to said one end of the shell and concentrically disposed within said shell, a plurality of inwardly projecting pole pieces attached to said shell and symmetrically arranged around said shell, an armature comprising a hub and a plurality of symmetrically disposed radial projections equal to the number of said pole pieces, said armature hub being mounted on a suitably journaled shaft to provide rotation in a plane perpendicular to the axis of said shell and said core, and in flux carrying relationship to said core and said pole pieces, a closure disc adapted to close the open end of said shell, a plurality of terminal posts extending through said header disc and insulated therefrom, a plurality of electrical contacts mounted on said terminal posts on the inward surface of said closure disc and disposed in a symmetric relationship to the axis of said shell, and contact operating means movable with said armature for operatively connecting said contacts to said armature, said assembly providing a high degree of immunity to operation of said contacts by translational movements of the assembly.

4. A relay comprising a shell of magnetic material closed at one end, an axially disposed core of magnetic material extending inwardly from the closed end of said shell and magnetically connected therewith, an armature of magnetic material rotatably mounted at the inner end of said core and magnetically connected therewith, an operating coil mounted on said core, a non-magnetic coil-retaining plate disposed within said shell, stationary pole pieces of magnetic material attached to said coil retaining plate and initially positioned thereby within said shell, said pole pieces being subsequently attached to said shell, said armature and said pole pieces being disposed and

arranged so that said armature is rotated through a predetermined arc by attraction to said pole pieces when said operating coil is energized, a closure disc for the open end of said shell, a plurality of radially-disposed contacts attached to said closure disc within said shell and including movable contact fingers having their free ends disposed away from the axis of said relay, a rotary actuating member pivotally mounted within said shell for rotation about an axis which coincides with the axis of said shell and said core, said rotary actuating member being operatively connected to said armature for rotation therewith and to the free ends of said movable contact fingers, whereby said contacts are actuated in response to rotation of said armature.

5. A relay comprising a cylindrical shell of magnetic material closed at one end and provided with a cylindrical core axially disposed in said shell and extending inwardly from the closed end of the shell, an operating winding disposed on said core, inwardly projecting pole pieces of magnetic material attached to said shell, an armature of magnetic material mounted for rotation on an axis which coincides with the axis of said core and disposed to be rotated through a predetermined arc when a difference of magnetic potential exists between said pole pieces and said core as the result of energization of said operating winding, a header disc adapted to form a closure for the other end of said shell and provided with a plurality of terminal posts extending therethrough and insulated therefrom, a plurality of contacts mounted on the inner ends of said terminal posts, each of said contacts including a radially extending resilient contact member having its inner end fixed to a terminal post and having portions intermediate its ends cooperating with fixed contact members in the form of sleeves mounted on other terminal posts, said resilient contact members being symmetrically arranged about the axis of rotation of said armature and contact operating means operatively connected with said armature and with the free ends of said resilient contact members for operating said resilient contact members when the armature rotates through said predetermined arc.

6. In a hermetically sealed relay comprising an enclosing housing provided at one end with a metal header, a plurality of metal posts extending through said header and insulated from said header by insulating beads having the same coefficient of expansion as said header, the outer ends of said posts serving as terminals for the relay, said posts being arranged in inner and outer concentric circles with twice as many posts in the outer circle as there are in the inner circle, a plurality of contact sleeves, one secured to the inner end of each contact post disposed in the outer circle, a plurality of flexible contact fingers, one secured at one end to each post disposed in the inner circle and extending radially outwardly between the contact sleeves on two of the posts disposed in the outer circle for cooperation therewith to form electrical contacts, said fingers all being provided with an initial bias in the same direction so that each of the fingers normally makes contact with a corresponding one of the associated sleeves, said contact fingers being provided with an area of reduced cross section at their outer ends, and motor means in said housing cooperating with said fingers at their outer ends for at times moving the fingers in unison to positions in which each finger moves out of contact with the sleeve it normally contacts and into contact with the other associated sleeve.

7. A hermetically sealed relay comprising a shell of magnetic material closed at one end, a core of magnetic material magnetically connected to said one end of said shell, an operating winding disposed on said core, an armature rotatably mounted on said core and provided with a plurality of equally spaced radial projections, a plurality of inwardly projecting pole pieces attached to said shell for cooperation with said armature projections, said pole pieces and said armature projections being disposed and arranged so that the cooperating surfaces of said pole pieces and said armature projections are in a substantially parallel plane relationship when said armature projections are attracted to said pole pieces by the flux set up when said operating winding is energized, a plurality of electrical contacts disposed within said shell, contact operating means for operatively connecting said armature to said contacts, closure means for closing the open end of said shell to form a hermetically sealed enclosure within said shell, and including a plurality of insulated terminal posts providing external connections for said contacts and said operating winding, and means including a sealable passage in said core for exhausting the air from the interior of said shell.

8. A hermetically sealed relay comprising a shell of magnetic material closed at both ends, a core of magnetic material attached to one end of said shell and concentrically disposed within said shell, a plurality of contacts mounted within said shell on terminal posts extending through and insulated from the other end of said shell, an operating winding disposed on said core and having its leads connected to other terminal posts extending through and insulated from said shell, an armature pivotally mounted at the inner end of said core for rotation about an axis which coincides with the axis of said core, contact actuating means operatively connecting said armature and said contacts, the assembly providing an airtight enclosure within said shell, a passage extending from the interior of said shell to the exterior of said shell through said core, said passage terminating on the exterior of said shell in a tubulature, whereby the interior of said shell may be evacuated of air and the tubulature may be sealed to provide a hermetically sealed and evacuated relay.

9. A relay comprising a shell of magnetic material closed at both ends, a plurality of electrical contacts within said shell mounted on terminal posts extending through and insulated from one end of said shell, a core of magnetic material concentrically disposed within said shell and magnetically connected at one end with the end of said shell opposite the end carrying the terminal posts, an operating winding disposed on said core, a shaft journaled for rotation on a first journal disposed in the inner end of said core and a second journal in said one end of said shell; the axis of said shaft, said core and said shell being coincident; an armature of magnetic material mounted on said shaft, stationary pole pieces attached to the inner wall of said shell, said armature being attracted by said pole pieces when the operating coil is energized to thereby cause rotation of the armature on said shaft through a predetermined arc, and contact actuating means for operatively connecting said armature and said contacts.

10. A relay comprising a cylindrical shell closed at both ends, motor means disposed within said shell, said motor means including an armature having radial projections and arranged for rotation about an axis which coincides with the axis of said shell, a plurality of electrical contacts disposed within said shell including movable contact members each located on a radius of the axis of said shell and having the free end of the member adjacent the inner surface of the shell, and a contact actuating member for operatively connecting said armature and the free ends of said movable contact members, said contact actuating member comprising a disc of insulating material having slots cut in one face for receiving the radial projections of said armature and slots cut in the other face for receiving the free ends of said movable contact members.

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