Sept. 19, 1961 C. R. RHODES 3,001,048

MINIATURE MODULAR RELAY

Filed July 29, 1959

FIG. 1.

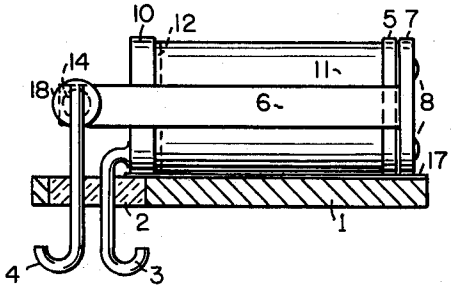


FIG. 3.

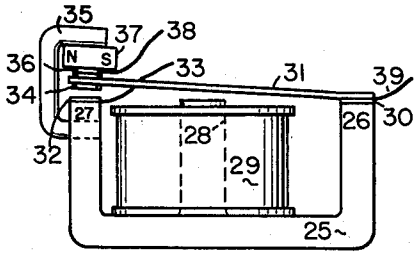


FIG. 2.

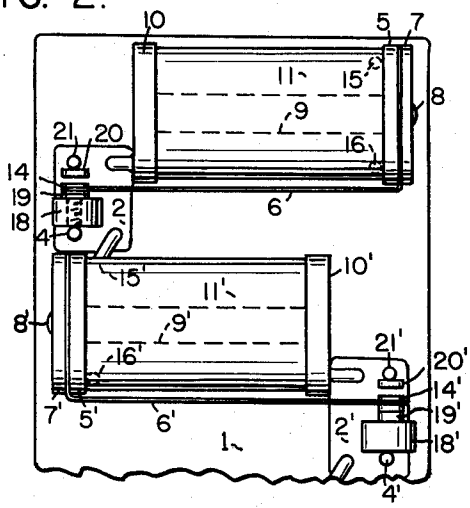
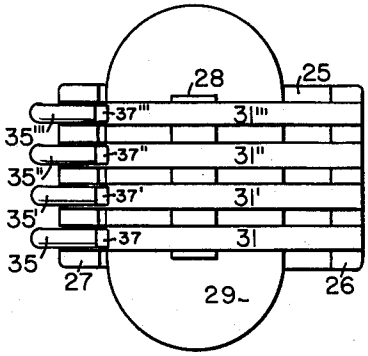


FIG. 4.



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MINIATURE MODULAR RELAY

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My invention relates to electrical relays and particularly to such having few parts to enable economical manufacture of high performance units of multiple nature.

While size and multiplicity per se do not lend novelty to a device it will be recognized subsequently herein that I have evolved embodiments directed to these ends which have easily recognized advantages over the prior art.

When it was desired to reduce the size of either a single or a multiple relay structure in the past it has been usual practice to merely scale down a previous larger embodiment. This practice results in certain of the parts becoming so small that microscopes or magnifying glasses have been required for the manufacture and assembly thereof. Such processing is expensive.

By a wide departure from this technique I have been able to make a small relay of very few parts, each of which is relatively large, so that my device may be easily and inexpensively fabricated and assembled. Furthermore, certain characteristics of my new structure are such that an improvement in operating performance has been achieved over the larger devices or even over the scaled down versions thereof of the prior art.

In the embodiments composed of multiples of a single relay unit I have been able to achieve further simplifications and an improvement in the performance of such devices.

Briefly, I form an armature exclusively of one piece of spring magnetic material. This is provided with an electrical contact, such as a small rivet of silver at the free end thereof and the other end is rigidly fastened to a stationary magnetic assembly. The latter has roughly a U-shape, with the extremity away from the rigid attachment of the armature adjacent to the free end of the armature and near the contact thereon. A coil surrounding the stationary magnetic member intermediate the extremities thereof provides actuating magnetomotive force to attract the armature. A permanent magnet having, for instance, the shape of a small cube, is positioned adjacent to the contact of the armature and that magnet is provided with a mating contact to that of the armature. The attraction of the permanent magnet upon the armature causes the two contacts recited to remain normally closed. A third contact is located adjacent to the contact on the armature but on the side thereof opposite to the permanent magnet. The third contact makes contact with the armature contact when the coil is energized. Because of the cantilever configuration of the armature-magnetic assembly and contacts and the inherent flexibility of the armature, a small but effective wiping action occurs at the contacts. The desirability of this wiping action is known.

By staggering the positions of plural such relay units upon a mount of magnetic material I am able to substantially eliminate malfunctioning of one unit upon the actuation of an adjacent unit. By magnetic material herein I refer to one having a permeability many times that of air.

By employing a ferrite material for the stationary magnetic member I am able to attach contacts directly thereto; the ferrite being an excellent electrical insulator while still having the properties of the defined magnetic material. This results in a simplified mechanical structure.

By widening the stationary magnetic member in an alternate embodiment and by providing plural armatures

I am able to form a multicontact relay in compact form.

An object of my invention is to provide a small electrical relay of few and relatively large parts.

Another object is to provide a relay of superior characteristics.

Another object is to provide a relay structure suited for multiple embodiment.

Another object is to form a relay of such materials as to attain novel electrical functioning and/or a simplified mechanical structure.

Another object is to provide electrical relay means that are easy and inexpensive to manufacture.

Other objects will become apparent upon reading the following detailed specification and upon examining the accompanying drawings, in which are set forth by way of illustration and example certain embodiments of my invention.

FIG. 1 shows an elevation of one unit of an embodiment of my invention with the base thereof in section,

FIG. 2 shows a plan view of two units of the same embodiment,

FIG. 3 shows an elevation of a ferrite core embodiment of my invention, and

FIG. 4 shows a plan view of a quadruple ferrite embodiment.

In FIG. 1 numeral **1** indicates the base of my relay structure. This is preferably of a magnetic material, such as iron or steel, while the portion **2** is a glass or ceramic electrical insulating material. These two kinds of materials are rigidly bonded together in the known manner of the "header" construction in this art. Embedded in the glass material are plural header pins, of which **3** and **4** are shown in FIG. 1.

The stationary magnetic path is provided mainly by a bobbin structure. This has an extremity **5**, to which armature **6** is rigidly fastened. The armature is formed of a magnetic spring material, of which I have found blue clock spring suitable. This is bent at a right angle at extremity **5** and is clamped between that extremity and a backup plate **7** by suitable fastening means such as rivets **8**.

The stationary magnetic path is further comprised of central core **9**, which is shown dotted in FIG. 2. The opposite extremity **10** is also magnetically connected to core **9**. Extremity **10** passes near armature **6**, as may be seen in FIG. 2. The gap here in a typical embodiment may be of the order of eight thousandths of an inch. FIG. 1 has been shown approximately four times full size for clarity.

Coil **11**, in the form of a multilayer solenoid, occupies the space on core **9** between extremities **5** and **10**, and provides actuating magnetomotive force when electric current is passed through it. This coil may be wound to the usual impedance for 28 v. D.C. operation, or for any other nominal voltage direct current operation. Also, shading coil shorted turn **12**, shown dotted in FIG. 1, may be employed for alternating current operation. Alternating current operation is particularly easily achieved in my relay, as will be explained below.

Because my armature **6** is so light in weight the operate time to change from normally closed to normally open contacts (or vice versa) is very short. It is from 0.5 to 0.7 millisecond in representative embodiments. The weight of my armature is of the order of 70 to 80 milligrams. The operate time of ordinary relays is of the order of 3 to 5 milliseconds and the weight of the ordinary armature, complete with contacting structure, etc., as much as a half ounce (14 grams).

Since the operate time of my relay is short the shading coil **12** may be of relatively minor dimensions and proper operation on alternating current is easily accomplished.

Coil **11** is insulated from stationary magnetic members

5, 9 and 10 as usual. However, in this case particular importance attaches to this because the common contact on the armature is completed through the magnetic assembly; i.e., electrical contact 14, armature 6 and the magnetic assembly are all connected electrically. As an alternate construction armature 6 may be clamped between thin slabs of insulating material between extremity 5 and backup plate 7. As shown in FIG. 1, external connection 3 is welded or soldered to extremity 10 and performs the dual function of external connection to contact 14 and means to hold the forward end of the stationary magnetic structure. Two other insulated external connections 15, 16 fasten the other end thereof and also act as the external connections to coil 11. These are shown dotted in FIG. 2. The stationary magnetic structure is insulated as a whole from base 1 by a thin slab of insulation 17. Armature 6 is held away from the pole piece extremity 10 by the magnetic action of permanent magnet 18. This is in the shape of a short cylinder in this embodiment and it may be magnetized with the orientation of the poles in almost any way. Armature 6 is also given a mechanical bias to assist in holding itself away from the pole piece. This is accomplished by proper forming of this part at the right angle of the same. The electromagnet (coil and stationary magnetic structure) is sufficiently strong to surely attract armature 6 to pole piece 10 which current is passed through the coil, despite the two restoring forces mentioned.

A silver contact 19 is screwed into magnet 18. The latter supports the pair by welded or soldered attachment to header pin 4.

In a similar manner, normally open silver contact 20 is supported by another header pin 21. The air gap between this contact and the mating one 14 on the armature is larger than the gap between pole piece 10 and armature 6 because of the cantilever relation between the two. Particularly if the armature is lengthened, this may be made of the order of fifteen or more thousandths of an inch and thus qualify my relay to break heavier currents than heretofore possible in such a small relay.

In the closing operation the attracted armature first closes contacts 14 and 20. The magnetic gap is made such that it is still open when this contacting of the contacts has been accomplished. Magnetic force then pulls the armature slightly further toward pole piece 10. This causes a slight curve to form in the armature and a slight wiping action on the contacted contacts. This provides a highly desirable wiping action on the contacted contacts each time the relay is operated. On the return stroke the relative flexibility of my thin armature causes inertia to give a wiping action between contacts 14 and 19.

Excluding the header pins and the base it is seen that my relay is constructed of but five parts; the stationary magnetic member, the coil, the armature, the magnetic normally closed contact and the simple normally open contact. An equivalent relay of conventional form would have perhaps fifteen parts.

There is a demand in the art for multiple relays when these can be made small in size. A common housing for such a group is often known as a "crystal case" because of prior art usage of such a case for mounting a single piezo electric crystal. I have found it possible to fit four of my individual relays in such a case (as per FIGS. 1 and 2) whereas the art has previously only been able to fit in two.

The dual structure shown in FIG. 2 is illustrative of my arrangement of any plurality of individual units commonly mounted. In this figure the second relay is identified by the same reference numerals as the first with the exception that each is "primed" (').

It will be recognized that the second relay unit is turned end for end with respect to the first and may have the armature placed on the opposite side of the stationary structure as has been illustrated. I place coils 11 and 11' with opposite direction of turns as shown for the particular reason that the magnetic material base 1 makes it possible to substantially eliminate an inductive kick in one relay circuit because of energization of an adjacent relay. Without this capability false or partial operation of one relay upon the actuation of one of its neighbors is a known undesirable result of placing relays very close to each other. With my arrangement and the coils connected correspondingly in parallel for a common return, unwanted actuation does not occur. A pulse of current is not induced in one coil circuit by actuation of an adjacent relay.

Rather than to employ the known Armco iron stationary magnetic member, which is a suitable material for the embodiments of FIGS. 1 and 2, I have also found that a ferrite may be used for this member. This makes possible even further structural simplifications. Such embodiments are shown in FIGS. 3 and 4. In these, stationary magnetic member 25 is formed in one piece. This is easily accomplished by the known method of compressing the ferrite powder in a suitably shaped die and then sintering the resulting cake in an oven to give the known ferrite magnetic composition and suitable mechanical strength.

Ferrites are known which have excellent insulating properties; from a hundred-thousand to one million ohms per centimeter cube. These are the nickel-zinc type with possible small amounts of manganese, cobalt or copper as representative of the former resistivity, and the nickel alone type for the latter mentioned resistivity.

Accordingly, I employ piece 25 as an insulating frame as well as for the stationary part of the magnetic circuit and mount all the electrical circuits on it.

Piece 25 has one extremity 26, an opposite extremity 27 (giving a U shape) and a central projection or pole 28. A coil 29, of the same general characteristics as coil 11 of the prior embodiment, is wound on a suitable form or in a self-supporting encapsulated form and is slipped down over the central pole 28. The latter is of elongated form in order that the quadruple form of the relay shown in FIG. 4, specifically, may be accommodated. While the embodiment of FIG. 3 may be taken as the elevation view of FIG. 4 it also illustrates any embodiment from a single armature one to any desired multiple of independent armatures. The coil 29 is fabricated of appropriate width as noted in FIG. 4 to accommodate the multiplicity desired.

Extremity 26 of the ferrite core is provided with one metallized area 30 for each armature to be employed. This may be a silver electroplating and the corresponding armature 31 is silver soldered thereto. Other sputtering or metal-buildup metallizing may be employed. The armature 31 is again of blue clock spring or equivalent, and is given a slight upward initial set that is exaggerated in FIG. 3 for sake of clarity.

A similar metallized area is also included at 32 on opposite extremity 27 of the ferrite, and this serves as a normally open contact. A flexible connecting lead 33 is shown connected thereto for an external connection. A riveted silver contact 34 is provided in the free end of armature 31, as before, although this armature may be heavily silver plated on both sides to give an equivalent contact.

A U-shaped support 35 is provided to hold the normally closed contact 36 and permanent magnet 37. Support 35 may be a stout piece of metal wire that is pressed or molded into ferrite 25 near extremity 27. Since the ferrite is a good insulator an electrical short will not be established to the other contact 32. In this embodiment permanent magnet 37 is of rectangular form, having a north magnetic pole at one end and a south magnetic pole at the other as indicated by the "N" and "S" in FIG. 3. Silver contact 36 may be welded or threaded into magnet 37 and the magnet spot welded to support 35. Flexible lead 38 connects to contact 36 for external connection

thereof and flexible lead **39** to armature **31** to make the common connection of the relay thereto.

The cantilever action of armature **31** previously described will be seen to apply to the embodiment of FIG. 3, and even to a greater degree than before. Of course, the proportions of either embodiment may be altered to give any degree of such effects as will be apparent from a study of the figures.

In FIG. 4 the same general structure described in connection with FIG. 3 is to be found, but repeated four times over. Thus, identifying numerals have been given one, two or three prime marks for corresponding elements. It will be seen that this embodiment differs from that of FIG. 2 in that in FIG. 4 all the armatures **31**, **31'**, **31''** and **31'''**, are actuated at once upon energization of coil **29**, while in FIG. 2 separate coils **11**, **11'**, etc. may provide separate energization.

In any of my embodiments I have found the contacting function substantially free of "bounce" by means of oscilloscopic measurements. This is because of the wiping action of the contacts, as has been described.

In FIG. 4 all of the contacts may be paralleled by carrying the areas **30** and **32** all across the respective extremity faces **26** and **27**. In this way increased reliability of operation and increased current carrying capacity may be achieved. As shown in FIG. 4, with the separate contacts along each extremity, each contact can be connected to a separate circuit, although the actuation of all the armatures is common because of the one coil **29**. This circuit is a four pole double throw switch. With common contacts the circuit is a single pole double throw switch.

In representative embodiments the power required for actuation is of the order of milliwatts. Of course, for large embodiments switching many amperes the actuation power is of the order of watts.

By employing Teflon insulated wire for coils **11**, **29**, etc., the high temperature rating of these relays is increased to several hundred degrees F.

Because the free length of the armature is short when the relay is actuated and the force of the permanent magnet is considerable when the relay is non-actuated, my relay embodiments are superior in withstanding undesired effects due to external vibration. The light weight of the armature is also a favorable factor in this performance.

Various other modifications may be made in the arrangement, size, proportions and shapes of the illustrative embodiments shown and in certain substitutions of elements from one embodiment to another without departing from the scope of my invention.

Having thus fully described my invention and the manner in which it is to be practiced, I claim:

1. In a relay structure having one magnetic member of an insulative ferrite material and means to magnetize said member for the actuation of said relay, plural armatures of magnetic spring material each rigidly fastened to one extremity of said member to extend to the opposite extremity of said member as a cantilever for attraction to said member upon energization of said means to magnetize, a magnet of fixed magnetomotive force adjacent the free end of each said armature to attract the free end of each said armature away from said opposite extremity save when said means to magnetize is excited, a first contact upon each said magnet, a second contact mating therewith upon the free end of each said armature and a third contact mating with said second contact oppositely to said first contact, the spring of each said armature causing a wiping action at each pair of mating contacts.

2. In a relay structure having a stationary magnetic member and means to magnetize said member for the actuation of said relay, at least one armature of spring magnetically attractive material stiffly attached to one extremity of said member to overhang the opposite extremity of said member as a cantilever for flexural attraction to said member upon energization of said means to magnetize, a permanent magnet adjacent to the free end

of said armature positioned to hold said free end of said armature away from said opposite extremity save when said means to magnetize is excited, a first electrical contact upon said magnet, a second electrical contact mating therewith upon the free end of said armature and a third electrical contact mating with said second contact oppositely to said first contact, each pair of mating contacts being given a wipe action upon coming together by the flexural characteristic of said armature in combination with the geometry of said stationary magnetic member and said armature as a magnetic circuit.

3. A relay structure comprising at least one magnetic path, at least one spring armature, said armature attached to one extremity of said magnetic path and extending over the other extremity of said path for magnetic attraction thereto, only one coil surrounding said stationary path between the extremities thereof, an armature electrical contact upon the free end of said armature, a first stationary electrical contact adjacent to said armature on the side of said armature toward said stationary magnetic path, a second stationary electrical contact adjacent to said armature contact on the side away from said stationary magnetic path, said first contact spaced to contact said armature contact when said magnetic path is energized by magnetic flux and to impart a sliding motion to said armature contact by virtue of the spring characteristic of said armature, said second contact spaced to contact said armature contact when said magnetic path is not energized, and magnetic means adjacent said second contact to attract said armature to said second contact when said magnetic path is not energized.

4. A relay structure comprising at least one stationary magnetic path, at least one leaf spring armature, said armature rigidly attached to one extremity of said stationary magnetic path and extending over and beyond the other extremity of said path for magnetic attraction thereto, only one coil of wire surrounding each said stationary path intermediate the two extremities thereof, an armature electrical contact directly upon the free end of said armature, a normally open stationary electrical contact aligned with said armature contact on the side of said armature toward said stationary magnetic path, a normally closed stationary electrical contact aligned with said armature contact on the side away from said stationary magnetic path, said normally open contact spaced to contact said armature contact when said coil is energized with electric current and to impart a sliding motion to said armature contact by virtue of the spring characteristic of said armature as the magnetic attraction of said stationary magnetic path is continued upon said armature, said normally closed contact spaced to contact said armature contact when said coil is not so energized, and a permanent magnet adjacent said normally closed contact to attract said armature to said closed contact when said coil is not so energized.

5. A multiple electric relay structure comprising plural individual similar magnetically operated relays each having a coil and a magnetic circuit, a base of magnetic material common to all said relays, each magnetic circuit of adjacently mounted said relays oppositely mounted in magnetic proximity to and on one side of said base, each coil of adjacently mounted said relays having turns wound in opposite directions in relation to said base, said coils having a common electrical circuit; the recited magnetic configuration effective to inhibit spurious actuation of a relay upon the actuation of an adjacent relay because of the recited relation between the coil circuits and the magnetic circuits of said multiple electric relay structure.

6. An electrical relay comprising a magnetic core of ferrite, a coil upon said core, electrically conductive areas formed upon extremities of said core, a conductive spring armature attached to one said area upon one of said extremities, said armature formed for magnetic attraction to said core upon the electrical energization of said coil and to pass adjacent to the opposite of said extremities,

a contact upon said armature at said opposite extremity to mate with said conductive area thereon, means to support attached to said opposite extremity, a magnet attached to said means to support adjacent to said armature and across said armature from said conductive area upon said opposite extremity, another contact mounted upon said means to support to mate with said armature contact; said magnet coactive with said armature to retain said armature in contact with said other contact save when said coil is energized; in the recited structure said ferrite acting as an insulating frame in addition to a magnetic core.

7. An electrical relay comprising an E-shaped magnetic core of a nickel ferrite, a coil on the middle arm of said E, one electrically conductive area plated upon each of the outer arms of said E, a spring steel armature rigidly and conductively attached to one said area upon one said outer arm, said armature formed to pass adjacent to the middle arm of said E for magnetic attraction thereto upon the energization of said coil with an electric current and also to pass over said other outer arm, a contact upon said armature opposite said other outer arm to mate with the conductive area thereon in a normally open contact configuration, means to support attached to said other outer arm, a permanent magnet attached to said means to support adjacent to said armature and oppositely said normally open contact configuration, a normally closed contact mounted upon said magnet to mate with said armature contact, said permanent magnet and a mechanical bias upon said armature coactive to retain said armature in contact with said normally closed contact save when said coil is energized; in the recited structure said ferrite acting as an insulating frame in addition to a magnetic core.

8. An electrical relay comprising a high resistivity ferrite magnetic core having two ends, magnetomotive-producing means upon said core, plural separate metallized areas formed upon each said two ends aligned oppositely one to the other, plural separate conductive spring armatures each attached to one of said plural separate metallized areas upon one said end, each said armature formed to pass over an aligned separate metallized area upon said other end, a contact upon each said armature to mate with said aligned separate metallized area, a magnet adjacent to each said armature and opposite to the mating said aligned separate metallized area, another contact adjacent to each said magnet and adjacent said contact upon each said armature to mate therewith, means to support said magnets and said other contacts from said core, each said magnet coactive with said armature adjacent to it to retain said armature against said magnet save when said magnetomotive-producing means is energized; said ferrite forming an insulating frame for the electrical conductors attached thereto.

9. The electrical relay of claim 8 in which the metallized area upon each of said ends of the magnetic core are common to the said plural separate armatures to provide multiple operating elements to a single pole contact of said relay.

10. A multiple electrical relay comprising an E-shaped magnetic core of a zinc-nickel ferrite, an oval cross-section coil upon the center arm of said E, plural separate electrically conductive areas formed upon each outer arm of said E along the major axis of said oval coil and aligned oppositely on one said outer arm with respect to the other, plural separate armatures of spring conductor firmly attached to said corresponding plural separate conductive areas of one said outer arm, each said armature rectilinearly formed to pass over said center arm of said E and also over an aligned separate conductive area upon said opposite outer arm, a contact upon each said armature to mate with said aligned separate conductive area, plural means to support attached to said opposite outer arm, a permanent bar magnet attached to each said means to support adjacent to each said armature and opposite to the mating said aligned separate conductive area, another contact attached to each said magnet adjacent said contact upon each said armature to mate therewith, each said magnet coactive with the said armature adjacent to it to retain said armature against said magnet save when said coil is energized; said ferrite core constituting an insulating frame of said relay for all the electrical conductors attached thereto.

11. A multiple electric relay comprising plural magnetically operated relays each having a magnetic circuit and means to actuate the same, a base of magnetic material common to all said relays, the magnetic circuit of each adjacently mounted relay oppositely mounted in magnetic proximity to said base, said means to actuate of adjacently mounted said relays constituted to produce magnetomotive forces in opposite directions in relation to said base, the recited magnetic configuration effective to inhibit spurious actuation of a relay upon the actuation of an adjacent relay, and a mechanical configuration in which the various elements are mounted exclusively on header pins embedded in an insulator having the electrical and physical properties of glass, said insulator disposed in holes in said common base.

References Cited in the file of this patent

UNITED STATES PATENTS

1,731,188	Avery	Oct. 8, 1929
1,858,562	Schedlbauer	May 17, 1932
2,061,920	Piffath	Nov. 24, 1936
2,275,531	Lakatos	Mar. 10, 1942
2,504,101	Reifel	Apr. 18, 1950
2,810,039	Every	Oct. 15, 1957
2,863,018	Rommel	Dec. 2, 1958
2,898,422	Peek	Aug. 4, 1959
2,917,600	Smith	Dec. 15, 1959