

April 13, 1965

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3,178,532

ELECTROMAGNETIC RELAY WITH CONTACT SUPPORTED ARMATURE

Filed Dec. 5, 1962

2 Sheets-Sheet 1

FIG. 1

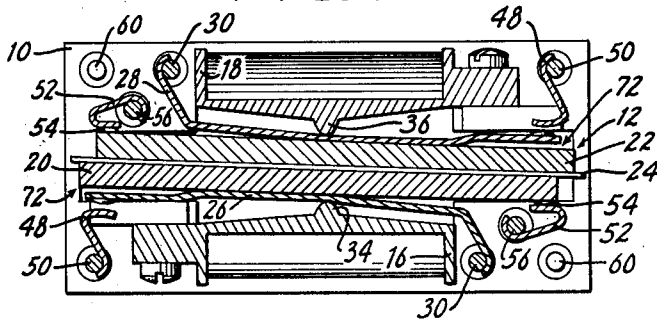
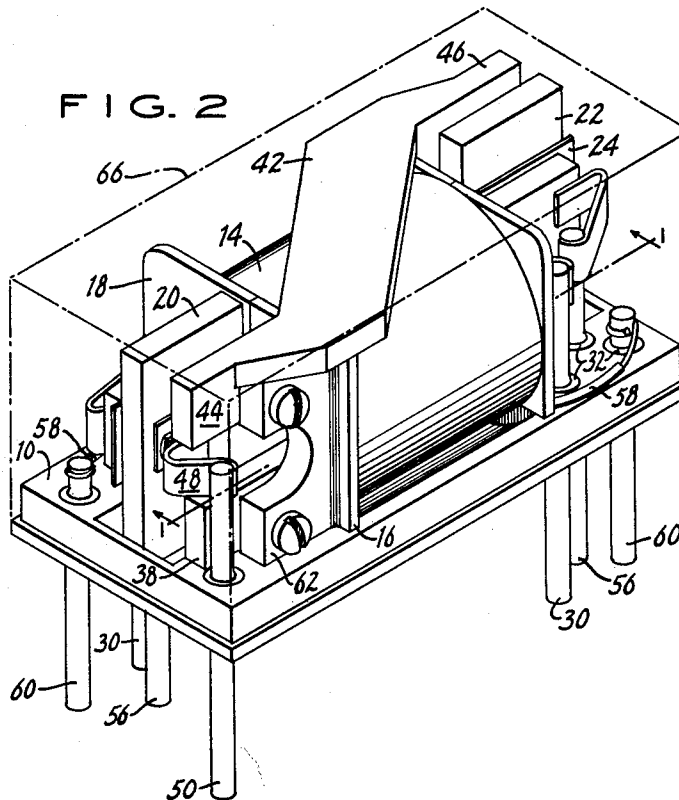


FIG. 2



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FIG. 3

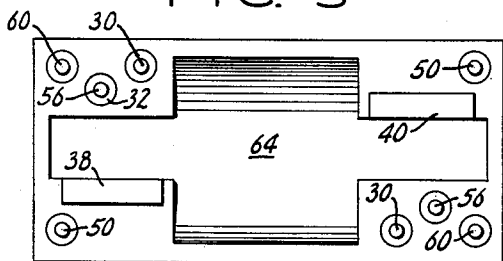


FIG. 5

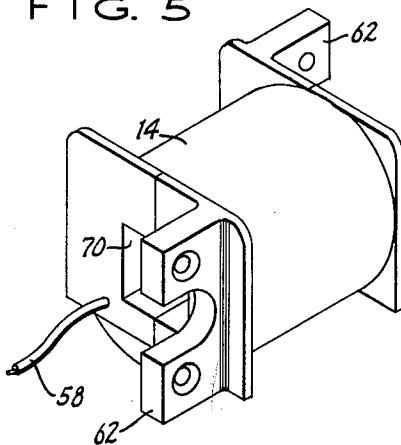


FIG. 4

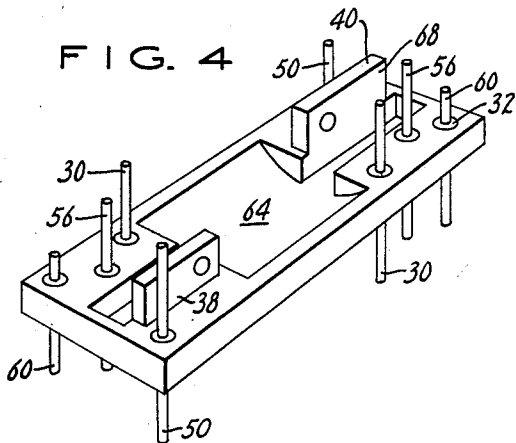
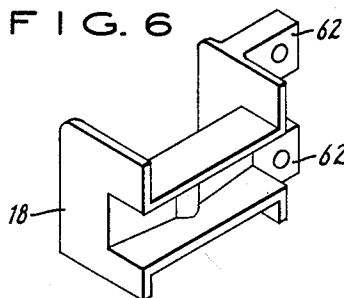


FIG. 6



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ELECTROMAGNETIC RELAY WITH CONTACT SUPPORTED ARMATURE

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22 Claims. (Cl. 200—87)

This invention relates to electromagnetic relays and more particularly to relays that can be made in extremely small sizes and weights.

In many applications of relays, as with other electrical and electromagnetic components, it is desirable to have the relays occupy as small a volume of space as possible. Accordingly, it is a primary object of this invention to provide a new and improved electromagnetic relay that occupies a very small volume of space without sacrificing its operating characteristics.

As a relay is made smaller, its parts get both smaller and weaker and, therefore, attempts in the past to make relays smaller by just making their parts smaller have been successful only up to a point at which the parts become too weak for the use contemplated. To make still smaller relays a new approach has been needed, and this invention provides one means by which relays can be made smaller without weakening their parts past acceptable limits.

Although the primary object of this invention is to provide means for achieving a relay that is extremely small in volume, without sacrificing its operating characteristics, other objects of the invention are to provide such a relay that will be resistant to shock and vibration, that can be easily made in a two-pole, double-throw electrical switching arrangement, and that can be hermetically sealed to meet military specifications and for use in hostile environments.

A still further object of this invention and an object that aids in obtaining the primary object is to provide a new and improved relay in which a number of the relay parts perform more than one function, or a relay in which the movable contacts in addition to performing their normal function also provide both a flexure pivot and a return spring for the relay armature, in which the armature acts as an electrical current path and as part of a movable contact, in which the coil bobbin supports the armature against translation or movement perpendicular to the longitudinal axis of the armature, in which the armature is also the core for the electromagnet circuit, and in which the relay header (the base of the relay through which the electrical leads are brought through seals to the outside of the relay and to which a cap or cover may be sealed to complete hermetic sealing of the relay) forms a return path for part of the electromagnet circuit, supports the entire relay structure, and includes a portion of the pole faces for the magnetic circuit of the relay.

It is thus another object of this invention to provide a new and improved relay of extremely small size in which the important parts of the relay perform more than one function and in which indispensable parts, such as the armature and the header, which is indispensable for hermetically sealed relays, perform other necessary functions in addition to their usual functions.

Additional objects and advantages of the invention will be set forth in part in the description that follows and, in part, will be obvious from that description, or may be learned by practice of the invention, the objects and advantages being realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the foregoing objects and in accordance with its purpose, as embodied and broadly described, this invention comprises an electromagnetic relay having means for achieving a relay of extremely small size and weight and having excellent operating characteristics. This invention also includes means for achieving a relay in which many of the key component parts perform other functions or multifunctions in addition to their normal functions.

The invention consists in the novel parts, constructions, arrangements, combinations, and improvements shown and described. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

FIG. 1 is a top plan view of the relay shown in section taken along the line 1—1 of FIG. 2 but with the pole pieces and coil leads removed for clarity;

FIG. 2 is a perspective view of the relay with its cover removed to expose the operating parts;

FIG. 3 is a plan view of the header of the relay with the operating structure removed;

FIG. 4 is a perspective view of the head of the relay with the operating structure removed;

FIG. 5 is a perspective view of the relay coil sub-assembly; and

FIG. 6 is a perspective view of a coil bobbin sub-assembly comprising one-half of the coil bobbin.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory but are not restrictive of the invention.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

The present preferred embodiment of the invention is shown in the drawings in greatly enlarged size. The relays of this invention are capable of being made in very small sizes, and the present preferred embodiment of the invention contemplates a size no larger than the cross-section of an ordinary wooden pencil.

As is readily apparent from FIG. 2, and in accordance with the invention, the entire relay structure is carried by the base or header 10. As best shown in FIGS. 1 and 2 the magnetic or motor portion of the relay comprises a moving core type magnet structure with the armature, shown generally at 12 (FIG. 1) comprising the movable core itself. As shown in FIGS. 1 and 2 the center portion of the armature 12 is surrounded by an electrical coil 14 that is wound on a bobbin that comprises two half bobbins 16, 18. A half bobbin 18 is shown in FIG. 6, and the two halves of the bobbin 16, 18 are preferably made of a light but strong plastic material, such as nylon.

In accordance with the invention, the armature 12 is formed from two pieces of magnetic material 20, 22. Each of these pieces 20, 22 resembles a hammer in shape (FIG. 2), and the reason for this will be made apparent shortly. To make up the armature assembly 12, the two pieces of magnetic material 20, 22 are placed back to back with a suitable high-grade electrical insulator between them, such as rubber or a plastic, such as Bakelite. This electrical insulator 24, in the present preferred embodiment, is very thin, but the pieces or strips of magnetic material 20, 22 are necessarily much thicker, since they must have sufficient area to carry the magnetic flux in the electromagnetic circuit.

Although these armature strips 20, 22 superficially resemble a typical laminated armature, in the present embodiment they serve a very different and desirable function. The electrical insulation is of high-grade mate-

rial chosen to have a high insulation resistance amounting to many megohms and with a high enough dielectric strength to stand surge voltages of many hundred volts. Because of these excellent insulating properties, it is possible to use the two strips of the armature 20, 22 as current-carrying members in the double-pole movable contact assembly of the present preferred embodiment. Thus, the same pieces 20, 22 are made to serve the functions of contacts as well as motor armature parts.

In accordance with the invention, the means for supporting armature for rotation comprises the movable contacts of the relay. As shown in FIG. 1, the relay movable contacts 26, 28 are securely fastened to the armature strips 20, 22 respectively. These movable contacts or resilient current carrying members 26, 28 are made of a suitable electrical conducting material which also has resilient properties, such as beryllium copper. Each of the movable contacts 26, 28 is carried by a movable contact terminal pin 30 (FIGS. 1 and 2), and each terminal pin 30 passes completely through the header 10 but is electrically insulated from it and hermetically sealed by a suitable insulating and sealing material, such as glass, as is shown at 32 (FIGS. 2-4).

In accordance with the invention, the movable contacts 26, 28 perform a triple function. They not only act as movable contacts for completing circuits and for carrying electrical current, but they also act both as the pivot for the rotary armature 12 and as the return spring for the armature. The armature 12 is thus carried by the movable contacts 26, 28 themselves, as is best shown in FIG. 1, i.e., the movable contacts 26, 28 which are secured to the sides of the armature assembly 12 are the sole direct support for the armature.

Because of their resiliency, it is possible to use the movable contacts to support the armature in a position in which it is free to rotate counterclockwise, as shown in FIG. 1, with the movable contacts 26, 28 themselves acting as a flexure pivot for the armature. Further, the resilient movable contacts 26, 28 are preset to hold the armature in the position shown in FIG. 1, so that when the armature rotates counterclockwise using the movable contacts as a flexure pivot in response to energization of the electromagnet, the set of the movable contacts 26, 28 resists this counterclockwise motion (FIG. 1). When the electromagnet is de-energized, the movable contacts 26, 28, thus act as a return spring and return the armature to its original position (shown in FIG. 1).

In accordance with the invention, means are provided for supporting the armature against translation, when the relay is subjected to forces of shock and vibration. As embodied, this means comprises projections 34, 36 on each half of the coil bobbin 16, 18 respectively, as shown in FIG. 1. These projections 34, 36 support the armature at its center of gravity and prevent translation approximately parallel to the short axis of the header 10, while the movable contacts 26, 28 themselves resist translation of the armature approximately parallel to the long axis of the header, and the armature is thereby essentially held in its desired operating position and locked against any translation in a direction which could cause false operation of the relay contacts under shock or vibration conditions.

As will be evident from the above description and that which follows, the relay is of the rotary type which operates to close one set of contacts and open another set by means of a rotation of the armature. Since the most commonly encountered forms of shock and vibration are those which cause accelerating forces in translation, it is important that the relay be so designed that these forces cannot result in a component that would tend to rotate the armature and thereby cause false operation. Furthermore, since direct movement of the armature in translation could also cause false operation of a contact, it is necessary to prevent such translational movement. In accordance with the invention, both of these potential

causes of faulty operation are eliminated. Linear accelerating forces cannot cause rotation because the armature is supported at its center of gravity. In addition, the armature is prevented from translating in a direction which would cause contact operation by virtue of the projections 34, 36 which support the axis of the armature in spaced relationship to the contacts.

Further in accordance with the invention, the relay header 10 performs a number of important functions. The relay header in the embodiment shown is preferably formed from magnetic material so that the header 10 itself is magnetic. Although magnetic headers have generally created problems in reducing the size of relays in the past, because they presented paths for leakage flux, the relay of this invention is protected from any undesirable magnetic shunting effects, since its armature is inside the coil and it uses the magnetic header as a return path for the magnetic circuit.

In the present preferred embodiment of this invention, the lower portions of the poles of the electromagnet are formed integral with the header 10, and these lower portions of the poles 38, 40 are shown in FIGS. 2 through 4. In addition to forming part of the magnet return path, the header 10 also carries and supports the entire relay structure. The magnetic circuit of the relay is completed by a return path 42 (FIG. 2) which includes the upper portions of the poles 44, 46 at each end, as shown in FIG. 2. The return path 42 serves no other purpose than to act as a return path for the magnetic flux in the electromagnet.

In accordance with the invention and as described above, the relay operates by having the armature rotate at its center of gravity due to the action of oppositely disposed pole faces at its two ends. As described earlier, it is contemplated that this relay will provide double-pole, double-throw contacts. The contact structures forming the two electrical switching poles are identical to each other; hence, only one need be described in detail here. Referring to the movable contact 26 in FIG. 1, it will be seen that at rest position an external circuit attached to terminal 30 will be connected through the movable contact 26 to the magnetic material of the armature 20, thence through the contact button 54 to the fixed contact 52 from which it will pass out through the header by means of terminal 56. When the relay operates, the armature will return in a counterclockwise direction, thus separating the contact 54 from the fixed contact 52 and interrupting the circuit described above. This same counterclockwise rotation will bring the electrical contact on the end of movable contact 26 into contact with a fixed contact 48 which in turn is attached to terminal 50. Thus a circuit is completed from terminal 30 to terminal 50 at the same time that the circuit is interrupted from terminal 30 to terminal 56. The other electrical pole is identical in its action and for clarity, like parts have been given like numbers so that the above description will apply to it directly.

Means are provided for introducing electrical current into the coil of the magnet to energize it. As embodied, this means comprises the coil leads 58 (FIGS. 1 and 5) and the coil lead terminal pins 60 (FIGS. 1 and 2).

As described above, the coil bobbin is formed from two halves 16 and 18 (FIGS. 1 and 5), and the two halves of the bobbin can be provided with moulded tongues and recesses so that when the two halves are put together they are keyed into alignment. When the coil is assembled as shown in FIG. 1, the two projections 34, 36 on the coil bobbin grip the armature and help support it in its desired position. As can be seen from FIG. 1, the coil completely surrounds the central and major portion of the armature 12.

The coil bobbin halves 16, 18 also include projections, as shown at 62 in FIGS. 2, 5 and 6, and these projections are used with suitable fastening means to secure the coil to the lower portions of the poles 38, 40 and in turn to

secure the return path 42 to the coils at the upper portions of the poles 44, 46. This arrangement insures a small extremely compact relay in which the parts are tied together in a strong mutually supporting relationship.

In addition to its use as a support for the various parts of the relay structure and as a part of the magnetic path, the header 10 also serves its primary purpose of being a hermetic seal through which terminals may enter the relay enclosure. This enclosure is completed by the use of a cover 66 (shown in phantom line only in FIG. 2) which is sealed to the header by means of solder, cement, or other convenient means, thus protecting the relay parts from unfriendly environments.

Because of the requirements for sound glass seals between the terminals and the header, the header must have a certain minimum thickness, typically $\frac{1}{16}$ to $\frac{1}{8}$ inch. Furthermore, as embodied in this relay, the header must have an adequate cross-section to carry the magnetic flux to the pole pieces 38 and 40. Because of the small size of the relay, the thickness of the header may represent $\frac{1}{4}$ to $\frac{1}{3}$ of all of the available space for the entire relay. This would unduly limit the volume of the coil and the area of the pole faces if a conventional construction for the header were used. In the present invention, however, a recess 64 is provided extending as deeply as is practical into the header 10 to provide additional space for both the coil 14 and the ends of the armature 12.

In operation, when the relay is energized by causing an electrical current to flow through the coil 14, magnetic flux is caused to flow around the magnetic circuit, i.e., through the armature, across the working air gaps to the lower portions of the magnet poles 38, 40, to the upper portions of the poles 44, 46, and through return paths formed by the header 10 and the return path 42. When the flux flows, the magnetic circuit tends to align itself in a position that will provide the lowest reluctance path. The ends of the rotary armature are thus magnetically attracted to the pole faces opposite them, and the armature is caused to rotate in a counterclockwise direction, as shown in FIG. 1. It will be noted that the armature strips 20, 22 are essentially hammer-shaped, as best shown in FIG. 2, with the handle of the hammer passing through the central aperture 70 formed between the coil bobbins. The hammerheads, so to speak, of the armature strips 20, 22 are directly opposite the upper and lower portions of the poles 38, 40, 44, 46.

In the above description it was earlier stated that the hammerhead shape was used for the armature parts for reasons that will be explained later. The reasons for this construction are as follows:

Ideally, all of the magnetic energy provided by the electromagnet should be delivered over the working stroke of the armature. If the area of the pole faces is small, the magnetic motor will develop a large proportion of its force at the end of its stroke where it is wasted. In order to develop substantial force early in the stroke, where it is needed to accelerate the armature and contacts rapidly for a quick break, it is necessary to have a large area presented by the pole faces. It is usually very inconvenient to get a large area here, and many relays commercially available are very inefficient for this reason. In the present embodiment, the hammerhead construction of the armature parts provide a desirably large area in spite of the very small overall size of the relay and also in spite of the fact that part of the space that might have been used for pole faces is necessarily occupied by the contacts 48.

When the armature rotates, the contacts 54 on the armature move out of engagement with the normally-closed fixed contacts 52, and the movable contacts 26, 28 are moved into engagement with the normally-open fixed contacts 48. The relay is shown in the de-energized position in FIG. 1, and it will be seen that in this position the path of current flow is from the terminal pin 30 through the movable contact 26, 28, and from there through the armature strips themselves 20, 22 to the contacts 54, then to

the normally-closed fixed contacts 52, and finally to the terminal pins 56. In accordance with the invention, the armature itself thus serves as a portion of a movable contact, when the relay is in the de-energized position.

Additional features of the invention are that when the relay is in the energized position, overtravel of the movable contacts 26, 28 is provided through their inherent resiliency and the space 72 (FIG. 1) provided between the movable contact and the armature strips. Also, by arranging the poles of the magnet with an upper 44, 46 and lower 38, 40 portion, space is created between these two portions and this space is utilized for the positioning of the normally-open fixed contacts 48.

From the foregoing description, it will be seen that this invention makes possible the achievement of an exceedingly small and compact relay, in which the number of distinct functional parts necessary has been significantly reduced by making certain parts perform more than one function. Functions which would normally be performed by different parts are thus performed in this relay by only one part. Further, the relay of this invention in spite of its very small size can be made in the form of a two-pole, double-throw relay. It will also be observed that the relay is preferably balanced, i.e., with the exception of the coil 14, which is symmetrical, each part of the relay is duplicated in the embodiment shown so that the parts are in balanced arrangement on the header 10.

The invention in its broader aspects is not limited to the specific details shown and described, but departures may be made from such details within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. An electromagnetic relay comprising a header, a coil carried by the header, a rotary armature, a pair of resilient movable contacts carried by the header, the resilient movable contacts supporting the armature within the coil and providing a flexure pivot for the armature, means providing a return path for magnetic flux outside the coil, the means providing a return path including a magnet pole at each end of the coil, each end of the armature being disposed adjacent to one of the poles, at least one fixed contact carried by the header and adapted to engage and disengage one of the movable contacts responsive to movement of the armature.

2. The invention as defined in claim 1, in which the relay includes two means for providing a magnetic return path and in which the first means includes the header itself and the second means is spaced above the header.

3. The invention as defined in claim 1, in which the coil includes a coil bobbin and the coil bobbin has a central aperture, and in which the coil bobbin also has projections into the central aperture to support the rotary armature against translation.

4. The invention as defined in claim 1, in which the coil has an axis, and in which the armature has an axis of rotation that is substantially perpendicular to the coil axis.

5. The invention as defined in claim 1, in which the header includes a recess that accommodates a portion of the coil, whereby the overall mounting height of the relay is reduced.

6. The invention as defined in claim 1, which also includes a cover carried by and sealed to the header, and in which the cover encloses the entire relay operating structure.

7. The invention as defined in claim 1, in which the rotary armature is formed from two pieces of magnetic material with a layer of high-grade insulating material sandwiched between them.

8. The invention as defined in claim 1, which includes a plurality of pairs of fixed contacts, one contact of each pair of fixed contacts being a normally-open fixed contact and the other contact of each pair being a normally-closed fixed contact, each pair of fixed contacts being

spaced apart with one of the ends of the armature between them.

9. The invention as defined in claim 8, in which the ends of the armature are in contact with the normally-closed fixed contacts, and the rotary armature comprises two pieces of magnetic material with a high-grade electrical insulating material sandwiched between them along their long axis.

10. The invention as defined in claim 1, in which a portion of each magnet pole is formed from the header itself.

11. The invention as defined in claim 1, in which the header includes a recess that accommodates a portion of each end of the armature, and in which each end of the armature is shaped substantially like a hammerhead.

12. An electrical relay comprising a header, a coil carried by the header, a balanced rotary armature, a pair of resilient movable contacts carried by the header, a plurality of pairs of spaced fixed contacts carried by the header, means providing a return path for magnetic flux outside the coil, the armature being supported for rotation by the resilient movable contacts which provide a flexure pivot for the armature, the armature being rotatable within the coil and acting as a movable core thereof, the means providing a return path including magnet poles at its end, the ends of the armature being disposed adjacent to these poles, the resilient movable contacts biasing the armature against a normally-closed fixed contact of each pair of fixed contacts when the armature is in its de-energized position, the ends of the armature moving out of engagement with the normally-closed fixed contact and the movable contacts moving into engagement with the normally-open fixed contact of each pair of fixed contacts when the armature rotates responsive to energization of the relay.

13. The invention as defined in claim 12, in which the relay includes two means for providing a magnetic return path and in which the first means includes the header itself and the second means is spaced from the header.

14. The invention as defined in claim 12, in which the coil includes a coil bobbin having a central aperture, and in which the coil bobbin has projections into the central aperture that support the armature against translation relative to the header.

15. The invention as defined in claim 12, in which the coil has an axis, and in which the armature has an axis of rotation that is substantially perpendicular to the coil axis.

16. The invention as defined in claim 12, in which the header includes a recess that accommodates a portion of the coil, whereby the overall mounting height of the relay is reduced.

17. The invention as defined in claim 12, which also includes a cover carried by and sealed to the header and in which the cover encloses the entire relay operating structure.

18. The invention as defined in claim 12, in which the rotary armature is formed from two pieces of magnetic material with a layer of high-grade insulating material sandwiched between them.

19. The invention as defined in claim 18, in which the two pieces of magnetic material are shaped like a hammer, and in which each end of the armature is shaped like a hammerhead, with the hammerhead portions of the armature opposite the magnet poles.

20. The invention as defined in claim 12, in which the ends of the armature are in contact with the normally-closed fixed contacts of each pair, and in which the rotary armature comprises two pieces of magnetic material with a high-grade insulating material sandwiched between them along their long axis.

21. The invention as defined in claim 12, in which a portion of each magnet pole is formed from the header itself.

22. An electromagnetic relay comprising a header, a coil carried by the header, a rotary armature, a pair of resilient current carrying members carried by the header, the resilient current carrying members supporting the armature within the coil and providing a flexure pivot for the armature, means providing a return path for magnetic flux outside the coil, the means including a magnet pole at each end of the coil, each end of the armature being disposed adjacent to one of the poles, at least one fixed contact carried by the header and adapted to engage and disengage the armature responsive to its movement.

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