Oct. 27, 1959 A. WHARTON 2,910,559

ELECTROMAGNETIC RELAY

Filed June 5, 1957

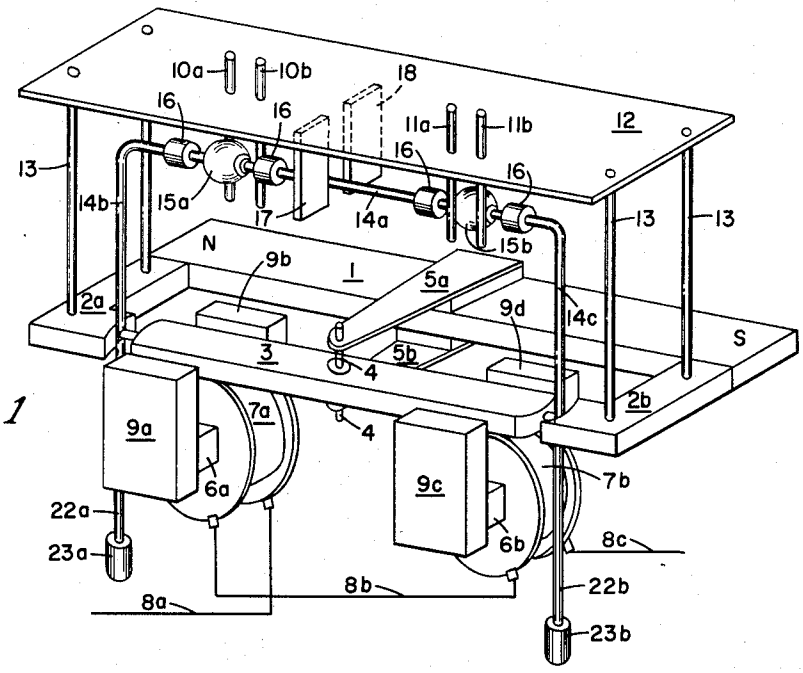


Fig. 1

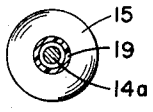


Fig. 2

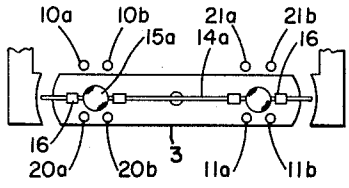


Fig. 4

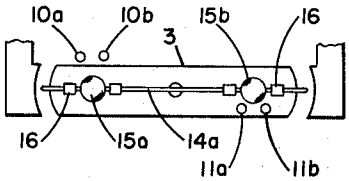


Fig. 3a

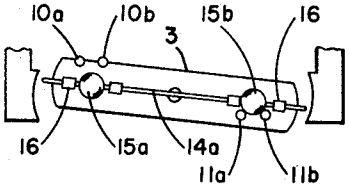


Fig. 3b

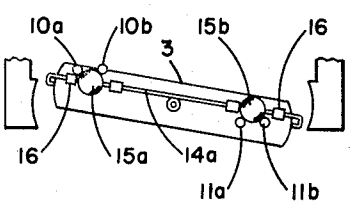


Fig. 3c

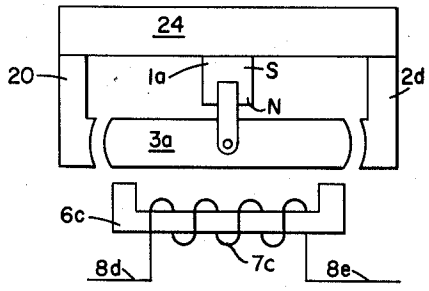


Fig. 5

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ELECTROMAGNETIC RELAY

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10 Claims. (Cl. 200—93)

My invention relates to improvements in electromagnetic relays in general and more particularly to low power, polarized relays.

It has been the practice to provide multicontact relays in which armature actuated contacts and their fixed contact counterparts are approximately tensioned and aligned by permanent mechanical adjustment. Such relays are dependent upon armature overtravel and the resulting contact "follow" to insure minimum operated tension between each pair of armature and fixed contact springs after the armature has become fully operated. In miniature and subminiature relays, where power available for operation is necessarily small owing to design or application limitations, it has been found that the use of contact follow to insure minimum pressure is not necessarily satisfactory because the energy required to obtain such follow may approach or even exceed the total power available for relay operation. Similarly, the dependence of conventional relays upon springs for the restoration of the armature to its normal position, where the force to be overcome during operation is at best proportional to the displacement of the armature from its normal position, adds substantially to the power requirements of the relay.

Another problem encountered in relays which are magnetically polarized (i.e., having a magnetically biased armature with a neutral position and movable to first and second operated positions upon forward and reverse energization, respectively, of the relay winding or windings) is insuring restoration of the armature to neutral upon the denergization of the windings. The armatures of the previously designed relays have shown a tendency to remain in the last assumed operated position because the armature is suspended in the permanent magnetic field in an unstable equilibrium. Such relays require the use of power consuming restoring springs which tend to defeat the objectives of low power relay design.

Accordingly, it is an object of my invention to provide a new and improved relay.

Another object of my invention is to provide a new and improved relay having low power requirements.

Another object of my invention is to provide a new and improved relay restored to its normal position by a magnetic field.

Another object of my invention is to provide new and improved contact alignment arrangements suitable for relay use.

Another object of my invention is to provide a new and improved contact aligning arrangement requiring low power.

Another object of my invention is to provide a new and improved polarized relay.

Another object of my invention is to provide a new and improved polarized relay having a stably balanced, magnetically biased armature.

Another object of my invention is to provide a new and improved relay capable of use in the presence of vibration, shock, or acceleration.

I accomplish these and other objects in the apparatus set forth in the following description and in the claims attached to and forming a part of the present specification. In the following description, reference is made to the drawings affixed to and forming a part of the present specification, and in which:

Fig. 1 shows a perspective view of an assembled relay;

Fig. 2 shows an end view of a contact bead for the relay of the invention;

Figs. 3*a*, 3*b* and 3*c* show in skeletonized form the action of the apparatus within the relay shown in Fig. 1 during the contact equalizing operation;

Fig. 4 shows a skeletonized view of a relay similar to the one shown in Fig. 1, but having a different contact arrangement; and,

Fig. 5 shows a skeletonized view of a relay having a different magnetic circuit configuration from the relay shown in Fig. 1.

Referring to Fig. 1, the relay forming the preferred embodiment of my invention has a permanent magnetic circuit comprising a bar magnet **1** (having north and south poles labelled N and S, respectively) and leg portions **2***a* and **2***b*. The elements of the permanent magnetic circuit are arranged so that magnet **1** and legs **2***a* and **2***b* lie in a C-shaped configuration, with both leg portions extending from the ends and on the same side of magnet **1**. Opposite magnetic poles are therefore induced in the free ends of legs **2***a* and **2***b*. A soft iron high permeability bar-shaped armature **3** is suspended by pin **4** in the air gap formed between the jaws of the C-shaped magnetic circuit so that its ends are adjacent the free ends of legs **2***a* and **2***b*. The free ends of legs **2***a* and **2***b* have projecting portions extending in the direction of the ends of armature **3** so that flux is encouraged to enter the ends of armature **3** in a direction generally parallel to the longitudinal axis of the armature. The magnetic field existing between the free ends of legs **2***a* and **2***b* induce opposite poles in the opposing ends of armature **3**.

Pivot pin **4** extends vertically through the longitudinal axis and substantially at the midpoint of armature **3**. The pin is also located at substantially the midpoint of the above referred to air gap and lies on the mean magnetic flux path. Pin **4** is fixed relative to the permanent magnetic circuit by upper and lower support members **5***a* and **5***b*, respectively, which in turn are fixed to permanent magnet **1**. In this manner, armature **3**, which is symmetrical about its longitudinal axis, is oriented within the air gap so that it is in stable equilibrium when the longitudinal axis of armature **3** lies substantially parallel with a net magnetic flux path in the air gap. This stable equilibrium position is also the neutral position of armature **3**.

In order to rotate armature **3** about pin **4**, electromagnetic means comprising coils **7***a* and **7***b* wound on cores **6***a* and **6***b*, respectively, are fixed by means (not shown) relative to armature **3** and the permanent magnetic circuit and are oriented in the manner next described. Pole pieces **9***a* and **9***b* are fixed to the ends of core **6***a* and extend upwardly to the top of the left-hand end of armature **3**. The inward facing sides of pole pieces **9***a* and **9***b* are substantially parallel to and equally spaced apart from the adjacent ones of the sides of armature **3** when the latter is in neutral position. Pole pieces **9***c* and **9***d* attached to core **6***b* are similarly oriented with respect to the right-hand end of armature **3**.

Windings **7***a* and **7***b* are connected by wire **8***b* in such a manner that when a source of direct current, such as a battery, is connected between wires **8***a* and **8***c*, which are connected to the other terminals of coils **7***a* and **7***b*, respectively, current flowing through windings **7***a* and **7***b* creates magnetic fields between pole pieces **9***a*—**9***b* and **9***c*—**9***d* which are substantially at right angles to the longitudinal axes and at opposite ends of armature **3**. The flow

of current through each coil is such that like poles are induced in pieces 9*a* and 9*c* and in 9*b* and 9*d*, the polarity being determined by the direction of current flow between wires 8*a* and 8*c*.

Rotation of armature 3 about pin 4 is achieved in the next described manner. The permanent magnetic circuit is effective for inducing south and north poles in the left- and right-hand ends, respectively, of armature 3. When the electromagnetic circuit is energized in a direction hereinafter referred to as "forward," north poles are induced in pole pieces 9*a* and 9*c* and south poles are induced in pole pieces 9*b* and 9*d*. The left-hand end of armature 3 is therefore attracted to pole piece 9*a* and repelled from pole piece 9*b*. Similarly, the right-hand end of armature 3 is attracted to pole piece 9*d* and repelled from pole piece 9*c*. Therefore, armature 3, viewed from the top, rotates in a counterclockwise direction. By a similar line of reasoning, it can be seen that when the flow of current through coils 7*a* and 7*b* is reversed, the ends of armature 3 are attracted to pole pieces 9*b* and 9*c* and repelled from pole pieces 9*a* and 9*d*, so that armature 3 is rotated in a clockwise direction.

The rotation of armature 3, in the above described manner, is used in the manner set forth in the following paragraphs for controlling first and second contact sets comprising pairs of vertical rods 10*a*—10*b* and 11*a*—11*b*, respectively. The rods in each pair are insulated from and fixed substantially parallel to each other by insulating board 12 which in turn is fixed by supports 13 a prescribed distance from the permanent magnetic circuit and armature 3. Thus the rod pairs constitute first and second devices maintained in fixed spaced relationship to each other and to the rest of the relay structure including armature 3. In the preferred embodiment of my invention, the relationship is such that the axis of pin 4 passes between the rod pairs and lies at substantially equal distances from each rod pair.

A relay actuator comprising armature 3 carries a pivotally mounted bail assembly including side members 14*b* and 14*c* and longitudinal member 14*a* and beads 15*a* and 15*b*. The bail is C-shaped, straight member 14*a* lying substantially parallel to the axis of armature 3 and from which side members 14*b* and 14*c* extend at substantially right angles. Member 14*a* is positioned transverse to the lengths of rod pairs 10*a*—10*b* and 11*a*—11*b*. The free ends of members 14*b* and 14*c* are pivotally connected by means including bearings (not shown) to the ends of armature 3 so that in the absence of other influences, member 14*a* rotates about pin 4 with the rotation of armature 3 and around the longitudinal axis of armature 3. The axis of rotation of the bail assembly is different from the axis of rotation of armature 3, the two being at substantially right angles in the preferred embodiment of my invention. Metallic beads 15*a* and 15*b* are threaded onto straight portion 14*a*. An insulating bushing 19 within the opening of each bead indicated in Fig. 2 is effective to electrically separate bead 15*a* from member 14*a* and the relay frame and from bead 15*b* in the event that member 14*a* is formed from electrically conducting material. Beads 15*a* and 15*b*, used in a manner to be described for establishing electrical connections between the rods in each of pairs 10*a*—10*b* and 11*a*—11*b*, respectively, are free to move along the length of member 14*a*. The motion is limited by the presence on member 14*a* of tightly fitting sleeves 16, one of which is placed on either side of each bead.

The bail assembly is provided with auxiliary members 22*a* and 22*b* which are extensions of side members 14*b* and 14*c*, respectively. The auxiliary members extend below the points at which the bail assembly is pivoted, and terminate in mass members 23*a* and 23*b*. The purpose of the auxiliary and mass members is to balance the bail member and the attached structure such as beads 15*a* and 15*b* in order to prevent disturbance of the contact members when the relay is subjected to shock, vibrations, or acceleration. Therefore, the moment of inertia of the combination of the auxiliary members 22*a* and 22*b* and mass members 23*a* and 23*b* is chosen so that it is equal to the moment of inertia of the bail assembly and the structure carried on bail 14.

Spaced apart retainers 17 and 18 fixed to the underside of board 12 are separated from each other by a distance substantially greater than the diameter of member 14*a*. Member 14*a* is received between members 17 and 18, the retainers being effective for preventing bail 14 from turning about its pivotal mounting on armature 3 to the point where the beads engage the corresponding ones of the rod pairs; however, the separation is sufficient so that retainers 17 and 18 do not interfere with the rotation of bail member 14*c* about its own pivotal axis to the point of preventing the next described contact equalization action.

Referring to Fig. 3*a*, in the case chosen for illustration, armature 3 is assumed to be rotated in a clockwise direction, and that, owing to manufacturing tolerances, the distance between bead 15*b* and rod pair 11*a*—11*b* is smaller than the distance between bead 15*a* and rod pair 10*a*—10*b* when the armature is in the above described neutral position. Upon the rotation of armature 3 in a clockwise direction, bail member 14*a* also rotates in the above described manner so that the assembly including bead 15*b* is moved in the direction of rod pair 11*a*—11*b*. Bead 15*b* is positioned on member 14*a* by stops 16 so that it contacts the first of rod pair 11*a*—11*b* at a point lying between the axes of the rods, as shown in Fig. 3*b*. Thereafter, further rotation of member 14*a* about pivot pin 4 causes bead 15*b* to slide along the length of member 14*a* until the bead also contacts the other rod of pair 11*a*—11*b*. Thereupon, rotation of bail member 14 about pivot pin 4 is stopped, and further rotation of armature 3 causes bail member 14*a* to be rotated about its pivotal mounting points on armature 3 until bead 15*a* engages rod pair 10*a*—10*b*, as shown in Fig. 3*c*. Bead 15*a* is moved into contact with both conductors 10*a* and 10*b* in the same manner that bead 15*b* was aligned with both conductors 11*a* and 11*b*.

After bead 15*b* has been moved into engagement with both rods 11*a* and 11*b* and during the period that bail member 14*a* is being rotated about its own pivotal mounting on armature 3, the bead, 15*b*, is free to slide in a direction taken along the lengths of rods 11*a* and 11*b*. The rotation of armature 3 and bail member 14*a* about their respective pivotal mountings causes movement of member 14*a* along its own length with respect to rod pair 11*a*—11*b*. Therefore, bead 15*b*, having a rounded surface and being free to slide within limits along the length of portion 14*a*, is retained in contact with both rods of pair 11*a*—11*b*, so that the further rotational movement of armature 3 does not interfere with the electrical connection established between conductors 11*a* and 11*b* by bead 15*b*.

Upon the establishment of contact between each bead and its corresponding rod pair, torque thereafter exerted on armature 3 is transmitted through bail member 14*a* to force each bead into engagement with its corresponding rod pair. The ratio of the forces applied at beads 15*a* and 15*b* is inversely proportional to the length of the effective lever arm of the beads, i.e., the distance between each bead and the axis of rotation of armature 3. In the preferred embodiment of my invention, as indicated in Figs. 3*a*, 3*b* and 3*c*, the effective lever arms are substantially equal, so that the forces exerted at the above referred to first and second points (i. e., at rod pairs 10*a*—10*b* and 11*a*—11*b*) by the beads are also substantially equal.

Upon deenergization of the electromagnetic means, the above described torque exerting magnetic fields are removed from the ends of armature 3, so that armature 3 restores to the above described neutral position under the influence of the permanent magnetic circuit field only.

By constructing the relay so that bail member **14***a* comes into contact with the conductor rod pairs in the above described manner without allowing armature **3** to come into contact with any of pole pieces **9***a* through **9***d*, it is not necessary to provide non-magnetic members to stop the motion of the armature **3**, and makes easier the design of the relay with respect to the problem of insuring the restoration of armature **3** to normal position under the influence of the permanent magnetic circuit.

While I have described in the above paragraphs a relay having only two sets of make contacts operable when the armature is rotated in a clockwise direction, it is to be understood that other possible contact configurations, such as the one shown in Fig. 4, may be provided. The arrangement in Fig. 4 shows first pairs of contact rods **10***a*—**10***b* and **11***a*—**11***b* disposed in the above described manner to be actuated when armature **3** is rotated in a clockwise direction; additional third and fourth contact rod pairs **20***a*—**20***b* and **21***a*—**21***b*, positioned by member **12**, are oppositely disposed to rod pairs **10***a*—**10***b* and **11***a*—**11***b* with respect to the armature **3**. With this arrangement, contact between each of the rod pairs **20***a*—**20***b* and **21***a*—**21***b* is effected by beads **15***a* and **15***b* when armature **3** is rotated in a counterclockwise direction, the action of bail member **14** and beads **15***a* and **15***b* being substantially the same as that described above in connection with the relay shown in Fig. 1.

Similarly, while I have shown and described as the preferred embodiment of my invention a relay having a C-shaped magnetic circuit of the type shown in Fig. 1, Fig. 5 shows a circuit suitable for use in a relay of the type described in which the permanent magnetic circuit elements are arranged in an E configuration. With this arrangement, a permanent magnet **1***a* is provided as the middle member of the three projections from stem member **24**. Side members **2***c* and **2***d* project from the same side of member **24** as magnet **1***a*. Armature **3***a* is pivotally connected to the member **1***a* in a manner similar to the one in which armature **3** is connected to permanent magnet **1** shown in Fig. 1. Assuming that the free end of magnet **1***a* is the north pole in this arrangement, permanent magnet **1***a* induces north poles at the ends of armature **3***a*, and south poles in the free ends of each of members **2***c* and **2***d*. Thus, armature **3***a* assumes a neutral position in which its longitudinal axis most nearly coincides with the net permanent flux path through armature **3***a*.

The advantage of the permanent magnetic configuration shown in Fig. 5 is that the relay can be energized by a single electromagnet. The electromagnet shown includes core **6***c* bearing a winding **7***c* to which wires **8***d* and **8***e* are attached. Core **6***c* is disposed so that the pole faces at its ends are adjacent to the ends of armature **3***a*. When potential is placed across conductors **8***d* and **8***e*, current flowing in winding **7***c* induces north and south poles in opposite ends of core **6***c*, the polarity being determined by the direction of current flow in winding **7***c*. Because like poles are induced in the ends of armature **3***a* by permanent magnet **1***a*, one of the ends of armature **3***a* is repelled from and the other end attracted to the corresponding faces of core **6***c* when winding **7***c* is energized. In this manner, armature **3***a* may be caused to rotate in a clockwise or counterclockwise direction, depending upon the direction of current flow through the coil **7***c*.

While I have shown and described specific embodiments of my invention, other modifications will readily occur to those skilled in the art. I do not, therefore, desire my invention to be limited to the specific arrangements shown and described, and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim is:

1. In a relay, first and second contact sets maintained in spaced relationship to each other, a bar shaped armature symmetrical about its longitudinal axis and pivoted to rotate about a point taken through the center of its longitudinal axis, electromagnetic means for rotating said armature, an assembly pivotally attached to said armature to rotate about an axis different from the rotational axis of said armature for engaging said first and second contact sets in order to transmit torque applied to said armature to said contacts and means including a permanent magnetic circuit disposed to urge said armature into its normal position whereby said armature and said assembly are restored to normal position when said electromagnetic means is deenergized.

2. The relay set forth in claim 1 in which the axes of rotation of said armature and said assembly are at substantially right angles to each other.

3. The relay set forth in claim 2 wherein the axis of rotation of said armature passes between said contact sets and the distance between each of said contact sets and the axis of rotation of said armature are substantially equal.

4. The relay set forth in claim 3 wherein said assembly comprises a bail pivoted to rotate about the longitudinal axis of said armature.

5. The relay set forth in claim 4 wherein said first and said second contact sets comprise first and second pairs of parallel spaced apart rods, respectively, and said bail has first and second beads threaded thereon for engaging said first and said second rod pairs, respectively, said beads being slidable along the length of said bail, whereby the first of said beads to engage one of the corresponding one of said rod pairs is retained between the rods as said armature and said bail are rotated about their respective axes to the point where the other of said beads engages its corresponding rod pair.

6. In a relay, first and second contact sets maintained in spaced relationship with each other, an armature pivoted to rotate about an axis intermediate said contact sets, torque applying means for rotating said armature and a contact assembly pivotally attached to said armature to rotate about an axis substantially perpendicular to the rotational axis of said armature for contacting said first and second contact sets whereby torque applied to said armature is transmitted through said assembly to said contacts.

7. The relay set forth in claim 6 wherein said armature comprises a bar pivoted to rotate about a point on its longitudinal axis and said assembly comprises a bail pivoted to rotate about the longitudinal axis of said armature.

8. The relay set forth in claim 7 wherein said first and said second contact sets comprise first and second pairs of parallel spaced apart rods, respectively, and said bail has first and second beads threaded thereon for engaging each of said rods in said first and said second rod pairs, respectively, said beads being slidable along the length of said bail, whereby the first one of said beads to engage one of the corresponding one of said rod pairs is retained between the rods as said bar and said bail are further rotated about their respective axes to the point where the other of said beads engages its corresponding rod pair.

9. An electrical contact comprising a pair of conductive rods fixed substantially parallel to and insulated from each other, a wire transverse to the length of said rods, a metallic bead slidably threaded on said wire for making electrical connection between said rods, and means for moving said wire along its own axis with respect to said rods and toward said rods, whereby said bead is retained in engagement with both said rods after contact between said bead and said rods has been established and as said wire is moved along its own length with respect to said rods.

10. The device set forth in claim 9 and having in addition motion limiting means carried by said wire for positioning said bead to initially contact either of said rods at a point lying between the axes of said rods in order to

insure the movement of said bead along the length of said wire to the point where said bead is in contact with both said rods.

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