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W. H. HOLCOMBE

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POLARIZED ELECTROMAGNETIC RELAY

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2 Sheets-Sheet 1

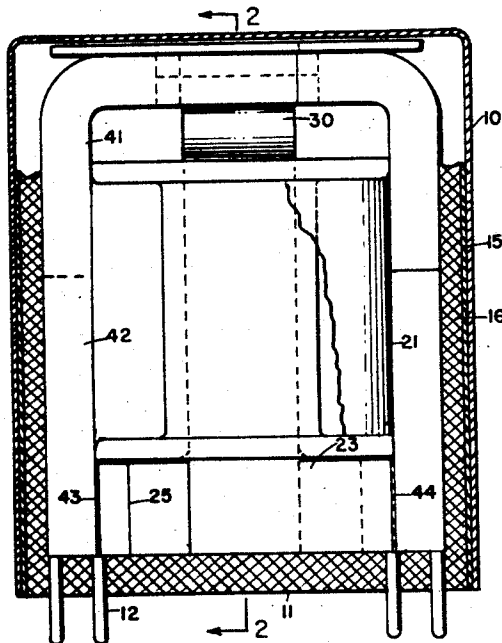


FIG. 1

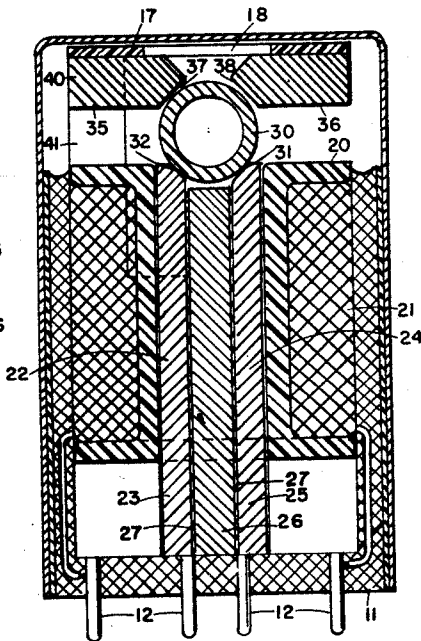


FIG. 2

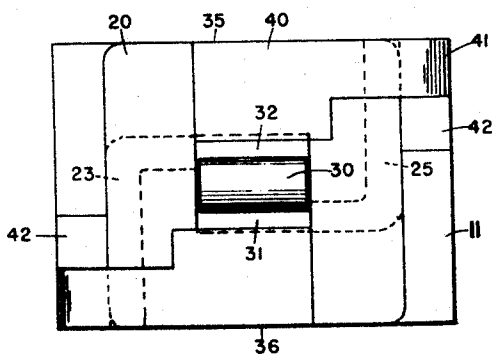
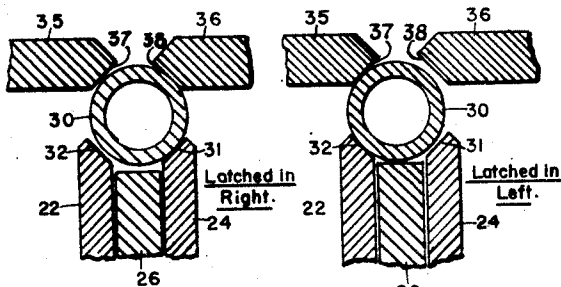


FIG. 3



ENERGIZED +
FIG. 7

ENERGIZED -
FIG. 8

INVENTOR.
Waldo H. Holcombe

BY *Moses, Nolle & Nolle.*

ATTORNEYS.

1

2,935,585

POLARIZED ELECTROMAGNETIC RELAY

Waldo H. Holcombe, Milton, Mass., assignor to Sigma Instruments, Inc., a corporation of Massachusetts

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17 Claims. (Cl. 200—93)

This invention relates to electromagnetic relays and particularly to a relay having an armature adapted to move into contact with selected pairs of pole pieces forming a cage for the armature.

An object of the invention is to provide a relay in which the polarizing flux and the coil flux are added in one flux path and subtracted in another flux path to operate the relay.

Another object of the invention is to provide an electromagnetic relay in which the armature is an electrical contactor adapted to open or close a plurality of circuits connected to the pole pieces.

Another object of the invention is to provide a relay which is capable of being latched in any one of its operating positions.

Another object of the invention is to provide an electromagnetic relay having a cylindrical or spherical armature positioned in a cage or chamber formed by four pole pieces in which the armature is stable in one or more of its operating positions.

Still another object of the invention is to provide an electromagnetic relay having a hollow cylindrical armature positioned in a contact chamber formed by four pole pieces and including a permanent magnet between at least two of said pole pieces so that the permanent magnet is not subject to de-magnetization due to overloading of the control winding of the relay.

The above and other objects and advantages are obtained by arranging two pairs of magnetic pole pieces so that their pole faces form a chamber or cage constraining a hollow cylindrical or spherical electrically conductive armature. One pair of pole pieces, consisting of bars of magnetic material, are positioned below the armature and are tapered at one end so as to form pole faces providing a seat for the armature. A second pair of pole pieces are positioned so that their pole faces are opposite the pole faces of the first pair of pole pieces and the distances between opposite pole faces are great enough to leave a slight gap between the armature and opposite pole faces. A permanent bar magnet, magnetized across its thickness, is positioned between the first pair of pole pieces, but preferably insulated from at least one of them. The first pair of pole pieces have bent end portions contiguous to the ends of the second pair of pole pieces so that the pole pieces having opposite pole faces are magnetically connected together, although preferably insulated from each other. A magnetizing winding surrounds the first pair of pole pieces and the magnet therebetween so that the magnetic field of the coil is transverse to the direction of magnetization of the magnet. Each of the pole pieces may be connected to an electrical terminal on the relay so that selected pairs of said terminals may be interconnected by energizing the winding to bring the armature into contact with selected pairs of said pole pieces.

Other advantages will be apparent to those skilled in the art from the following description and the drawing in which:

Fig. 1 is a front view of the relay partly in section;

2

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1;

Fig. 3 is a top view of the relay with the casing removed;

Fig. 4 is an exploded view of the relay; and

Figs. 5 to 8 are partial views illustrating the operation of the relay.

Referring to the drawing, the relay is enclosed in a housing comprising a housing or can 10 having a bottom closure 11 which may be formed of insulating material. A plurality of terminal pins 12 extend through the bottom 11 so that the relay may be a plug-in unit adapted to fit into a suitable socket. The sides of the can are lined with layers of insulating material 15 and 16 and contact with the top of the can is prevented by an insulating plate 17 having a central opening 18. A coil form 20 is supported within the housing and carries a winding 21. Coil form 20 has a rectangular opening in which are positioned a pair of cores 22, 24 formed of a magnetic material which is electrically conductive and preferably coated with a good contact material. The lower ends of cores 22 and 24 are electrically connected to two of the pin terminals 12. Cores 22 and 24 may be plates or bars of rectangular cross section. The relay may be assembled by being jig-cemented into sub-assemblies. Plates 17 may serve to hold one sub-assembly properly spaced. The sub-assemblies are then jig held in place while cast with an insulating potting material. This material also forms the sealant and insulator for the base pins 12. The potted assembly is then self-supporting and may be placed in a can or not as found desirable.

The bottom portions of the cores 22 and 24 are in the form of small L-shaped angles 23 and 25. Between plates 22 and 24 is placed a bar magnet 26 which is magnetized across its thickness so that the N-pole of the magnet is the face thereof adjacent core 22. The magnet is insulated from at least one of the cores 22, 24 by insulation 27. The upper ends of cores 22 and 24 form pole pieces for a floating armature 30 which may be a hollow cylinder or a ball and for this purpose the cores 22 and 24 are beveled to provide pole faces 31 and 32 tangential to the armature 30 and to form a seat for the armature. The armature itself is made of a magnetic material which is electrically conducting and coated with a good contact material which may be non-magnetic. A second pair of pole pieces 35 and 36, shaped as shown in Fig. 4, are above the armature and have pole faces 37 and 38 substantially tangential to the armature 30. The pole faces 31, 32, 37, 38 form a chamber which loosely confines the armature 30 therebetween. Pole piece 35 consists of a horizontally extending portion 40 which, at its outer end, is bent downwardly to provide a vertical portion 41 having a lower portion 42 of an increased width. The lower portion 42 is magnetically connected to the angular portion 25 of core 24 through a layer of electrical insulation 43. Pole piece 36 is constructed similarly to pole piece 35 and is magnetically connected to the angular portion 23 of core 22 through a layer of insulation 44. Pole pieces 35 and 36 are electrically connected individually to two of the terminal pins 12. It is understood that the cores and pole pieces 22, 24, 35 and 36 are preferably electrically conductive and insulated from one another and individually connected to terminal pins 12 and the two ends of winding 21 are also connected to a pair of terminal pins. Pole pieces 35 and 36 are also coated with a good conductivity material.

Assuming that the armature is in the position illustrated in Fig. 5 and assuming that magnet 26 is magnetized in the direction shown in Fig. 5 and remembering that the pole piece 35 is magnetically connected to core 24 and pole piece 36 is magnetically connected to core 22, the magnetic flux path will be as indicated by lines 50 and

3

51 in Fig. 5, when the winding is unenergized. As shown by line 51, one flux path will be through the magnet 26 to core 22 and then out through core 22 and through the lower portion of armature 30 to core 24 and then back to the magnet 26. Another flux path will be in the general direction of line 50, that is, through magnet 26 to core 22 then through pole piece 36 and armature 30 to pole piece 35, and since pole piece 35 is connected to core 24, the flux will flow from pole piece 35 to core 24 and back to magnet 26.

When winding 21 is energized, it alone produces a flux following the path 52 shown in Fig. 6, assuming that the current in winding 21 is in such a direction as to make the lower ends of core pieces 22 and 24 S-poles and the upper parts of cores 22 and 24 N-poles, as indicated by N' and S' in Fig. 6. As shown by path 52, magnetic flux will flow upward through core 22 then through armature 30 to pole piece 35 and through the magnetic connection extending to core 24, through core 24, and again through armature 30 to pole piece 36, and then back through the magnetic connection between it and core 22. It can be seen that the flux produced by winding 21 in accordance with Fig. 6, will combine with the flux indicated in Fig. 5 so that the two fluxes oppose each other at pole faces 31 and 38 and add to each other at pole faces 32 and 37. As a result, a predominant flux will flow through pole piece 35, and armature 30 will be caused to move into contact with pole faces 32, 37 as shown in Fig. 8. It will be apparent to those skilled in the art that when the armature is in the left position shown in Fig. 8, a low reluctance flux path is established between core 22 through armature 30 to pole piece 35 and back through pole piece 35 to core 24 and magnet 26. It will be evident that the relay can be designed so that the last described flux path will have a lower reluctance than the flux path between cores 22 and 24 through armature 30 when the armature is in its left position shown in Fig. 8. When this condition prevails, the armature will remain latched in its left position even after winding 21 is deenergized.

If current is passed in the opposite direction through winding 21, the flux path shown by path 52 in Fig. 6, will be reversed, that is, the arrows on path 52 would be in the opposite direction. It is apparent, then, that in this case the flux produced by winding 21 would combine with the flux produced by the magnet so that the fluxes in pole piece 35 would be opposed to each other and the fluxes in pole piece 36 would add to each other and, as a result, the armature would be attracted to the right as indicated in Figure 7. The relay may be designed so that the latching is tri-stable, that is, the armature will remain latched in either its right or left position when the coil is deenergized. Furthermore, it will return to the center position with a small amount of coil signal opposite to the previously applied signal. Furthermore, it will move to the opposite side upon application of a greater amount of opposite coil signal, and likewise be stable in that position. Furthermore, with this design, but different gaps and contact coating thicknesses, the relay may be made bi-stable, in which case the signal required to dislodge the armature from its right or left position is made so great that the center position is no longer stable and the armature continues to latch in left or right. If the relay is designed so that the flux path 51 has a lower reluctance than the flux paths which are effective in Figs. 7 and 8, the armature will return to its position shown in Figure 5 when winding 21 is deenergized. Under this condition, the armature will be latched in its lower position, or moved to its right, or its left position depending on whether the winding is un-energized or is energized in one direction or the other direction. The relay will then be stable only in the lower position. It will be apparent that the armature 30 forms a contact adapted to interconnect the terminals connected to cores 22 and 24 or the terminals connected to core 22

4

and pole piece 35, or the terminals connected to core 24 and pole piece 36.

It is noteworthy that the flux produced by winding 21 as illustrated in Fig. 6, will not traverse magnet 26. This is important since the magnet is then not susceptible to de-magnetization due to overloading or excessive energization of coil 21.

The relay of the present invention is useable for many purposes. It will be obvious that the armature may be used to operate various devices wherein a small, rapid, forceful movement is desired, such as in switches, valves, and other mechanical devices.

Although I have, for illustrative purposes, disclosed only one preferred embodiment of my invention, it will be evident to those skilled in the art, that many variations and modifications thereof may be made without departing from the principles of my invention as defined in the following claims.

I claim:

1. An electromagnetic relay comprising an armature, a first pair of magnetic cores having a pair of adjacent pole pieces spaced a distance less than the width of the armature, said pole pieces being formed at one end to provide a seat for said armature, a second pair of magnetic cores having a second pair of adjacent pole pieces spaced from the first pole pieces and from each other a distance less than the width of the armature, whereby the armature is loosely confined between the four pole pieces, each magnetic core of the first pair being substantially magnetically connected to one magnetic core of the second pair, means for establishing a permanent polarizing magnetic flux between the first pair of cores, and a magnetizing winding wound round both cores of said first pair for producing a magnetic flux therethrough in the same direction.
2. A relay according to claim 1, wherein the pole pieces are arranged so that the magnetic flux between the first pair of pole pieces is greater than the flux between a pole piece of the first pair and an adjacent pole piece of the second pair when the winding is deenergized and the armature is between the first pair of pole pieces, and when the armature is between one pole of the first pair and the adjacent pole of the second pair, the flux between those pole pieces is greater than the flux between the first pair of pole pieces, whereby said relay is tri-stable.
3. A relay according to claim 1, wherein the geometry of the pole pieces is such that the position of the armature between the first pair of pole pieces is an unstable position, whereby the relay is bi-stable.
4. A relay according to claim 1, wherein all four cores are insulated from another and an electrical terminal is connected to each core.
5. A relay according to claim 1, wherein the first pair of cores are parallel bars and said means for establishing a magnetic flux is a permanent bar magnet magnetized across its thickness and having its N-magnetic face adjacent one of said parallel bars and its S-magnetic face adjacent the other parallel bar.
6. A relay according to claim 5, wherein the first pair of cores and the permanent magnet extend through the winding.
7. A relay according to claim 1, wherein the armature is a hollow empty cylinder.
8. A relay according to claim 7, wherein alternate pole pieces have faces diametrically opposite each other.
9. A relay according to claim 8, wherein said faces are tangential to the armature.
10. A relay according to claim 1, wherein the magnetic cores of the first and second pairs are magnetically connected so that alternate pole pieces are substantially magnetically interconnected through their respective cores to provide low reluctance paths between alternate pole pieces.
11. An electromagnetic relay comprising an armature, a first pair of bar-shaped magnetic cores having pole

5

pieces spaced a distance less than the width of the armature, said pole pieces being positioned below the armature and formed at one end to provide a seat for said armature, a second pair of magnetic cores having pole pieces spaced from the first pole pieces and from each other a distance less than the width of the armature, whereby the four pole pieces form a cage loosely confining the armature, a permanent bar magnet magnetized across the thickness and disposed between the first pair of cores and having its N-pole adjacent one core and its S-pole adjacent the other core of said first pair of cores, a magnetizing winding round said bar magnet and said first pair of cores, means for insulating the cores from one another and external electrical terminals connected to each core.

12. A relay according to claim 11, wherein the pole pieces are arranged so that the magnetic flux between the first pair of pole pieces is greater than the flux between a pole piece of the first pair and an adjacent pole piece of the second pair when the winding is deenergized and the armature is between the first pair of pole pieces, and when the armature is between one pole of the first pair and the adjacent pole of the second pair, the flux between those pole pieces is greater than the flux between the first pair, whereby said relay is tri-stable.

13. A relay according to claim 11, wherein the geometry of the pole pieces is such that the position of the armature between the first pair of pole pieces is an unstable position, whereby the relay is bi-stable.

14. A relay according to claim 11, wherein said armature is a hollow cylinder.

15. A relay according to claim 11, wherein the cores having non-adjacent pole pieces are magnetically interconnected so that each pair of non-adjacent pole pieces is connected by a low reluctance path.

6

16. A relay according to claim 11, wherein the pole pieces are arranged so that the magnetic flux between the first pair of pole pieces is greater than the flux between a pole piece of the first pair and an adjacent pole piece of the second pair when the winding is deenergized and the armature is between the first pair of pole pieces, and when the armature is between one pole piece of the first pair and the adjacent pole piece of the second pair, the flux between those pole pieces is less than the flux between the first pair of pole pieces, whereby said relay has three operating positions and is stable in its center position.

17. A relay according to claim 11 wherein the pole pieces are so arranged that the flux between a pole piece of the first pair and an adjacent pole piece of the second pair is so great when the armature is between them that, when the coil current is sufficient to dislodge the armature it creates a flux between the other two pole pieces greater than the flux between the first pair of pole pieces, whereby the relay is bi-stable.

References Cited in the file of this patent

UNITED STATES PATENTS

25	2,135,809	Fruth	Nov. 8, 1938
	2,412,123	Carpenter	Dec. 3, 1946
	2,678,360	Bellis	May 11, 1954
	2,756,380	Diebold	July 24, 1956
	2,764,652	Debuit	Sept. 25, 1956
30	2,774,920	Kesselring	Dec. 18, 1956
	2,794,178	Reynolds	May 28, 1957

FOREIGN PATENTS

35	654,405	Germany	Dec. 22, 1937
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