March 17, 1964 W. J. RICHERT 3,125,652

MULTIPLE COIL ELECTROMAGNETIC RELAYS

Filed Dec. 28, 1960 2 Sheets-Sheet 1

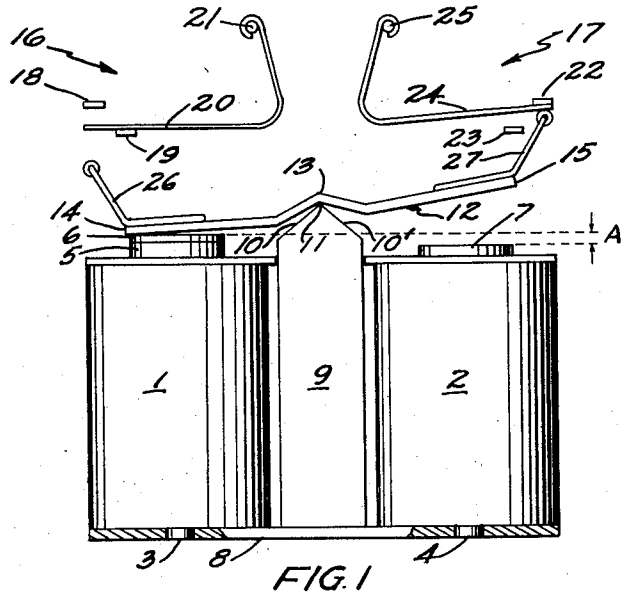


FIG. 1

FIG. 2

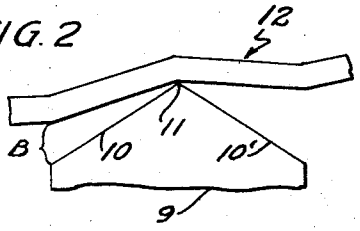
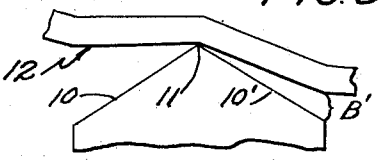


FIG. 3



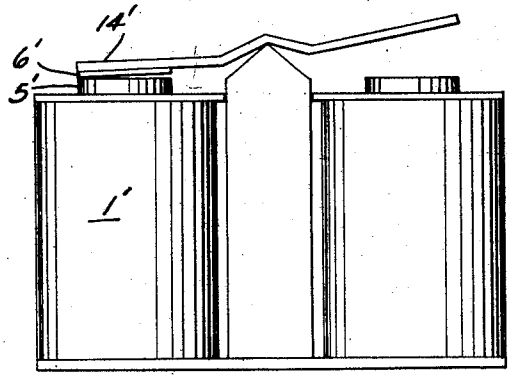


FIG. 4

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MULTIPLE COIL ELECTROMAGNETIC RELAYS

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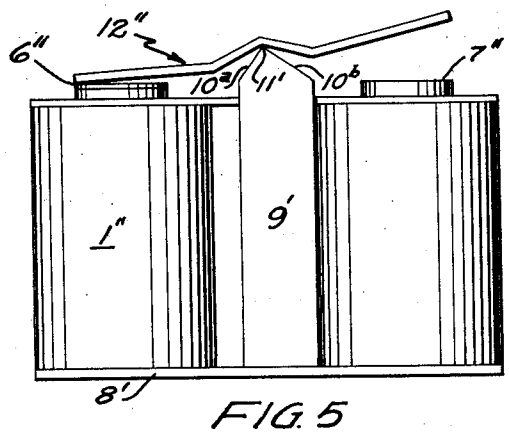

FIG. 5

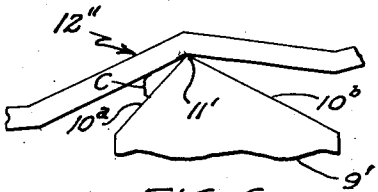

FIG. 6

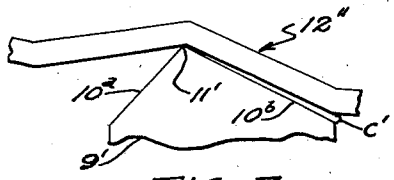

FIG. 7

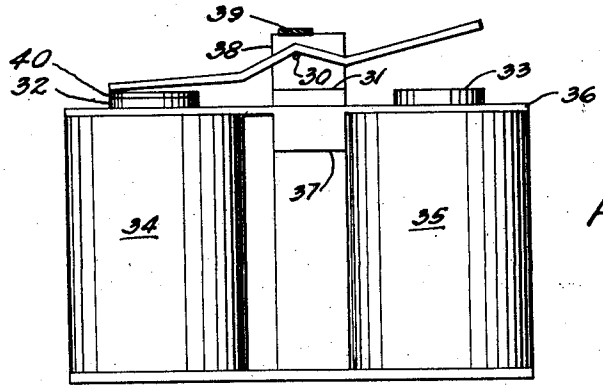

FIG. 8

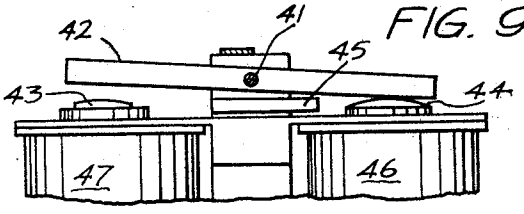

FIG. 9

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United States Patent Office 3,125,652 Patented Mar. 17, 1964

3,125,652

MULTIPLE COIL ELECTROMAGNETIC RELAYS

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Filed Dec. 28, 1960, Ser. No. 78,908
6 Claims. (Cl. 200—102)

This invention relates to electrical relays and more particularly to an improved electromagnetic relay of the type described in United States Patent No. 2,955,174, Walter J. Richert, issued October 4, 1960.

Relays of the type referred to comprise a permanent magnet and a pair of parallel electromagnets each having a core, the electromagnets being disposed each on a different side of the permanent magnet. An armature of magnetic material is employed, the armature being mounted to pivot about an axis at one end or pole portion of the permanent magnet. Means, such as a magnetic frame plate, magnetically interconnect the ends of the electromagnet cores and the permanent magnet opposite the armature, pivotal movement of the armature in at least one direction causing an end portion of the armature to come into engagement with an end of the core of one of the electromagnets, so that a magnetic flux path is completed via the permanent magnet, a portion of the armature, the core engaged by the armature and the means interconnecting that core and the permanent magnet at the end thereof opposite the armature. Completion of such flux path magnetically latches the armature in its pivoted position.

While, for many applications, it is desirable to so construct such a relay that pivotal movement of the armature in either direction will cause the armature to be magnetically latched in the manner just described, other applications require that pivotal movement of the armature in only one direction results in magnetic latching. It is this latter type of relay construction with which the invention is principally concerned.

Typically, relays constructed in accordance with the invention involve two electromagnets which are so arranged that energization of the relay results in pivotal movement of the armature in only one of its two possible directions of travel. Means, such as a non-magnetic shim, are interposed between the core of one of the electromagnets and the armature, so that magnetic latching of the armature cannot result when the armature is pivoted, as a result of energization of the electromagnets, toward the core carrying the non-magnetic shim. Upon deenergization of the electromagnets, the armature is pivoted in the opposite direction, into magnetic latching engagement with the core of the other electromagnet, this return motion of the armature being accomplished by the combined effect of the permanent magnet and spring forces developed in the contact structure. A relay of this particular type is illustrated in FIG. 8 of the aforementioned Patent 2,955,174.

While relay constructions of this type have proved to be highly satisfactory and advantageous, distinct problems in design arise because of the necessity for obtaining a positive return action of the armature upon deenergization of the electromagnets. Since this return action results entirely from contact spring forces, for example, and the magnetic forces provided by the permanent magnet, it is highly desirable to make maximum use of the capabilities of the permanent magnet for returning the armature.

In relays wherein the contact spring bias is related to the contact pressure, normal erosion of the contact surfaces can change the contact pressure and alter the force-distance characteristics of the spring system. Hence, it is highly desirable to increase the range during which

armature reset is aided by the force of magnetic attraction and thereby reduce the need for spring bias and minimize the effects due to changes in the spring system.

It is accordingly a general object of the present invention to provide an improved relay construction of the type just referred to which is characterized by the provision of a stronger armature return force but which does not require the provision of an increased spring force.

Another object is to provide improved means for establishing a positive and effective magnetic return force acting on the armature of such a relay.

A further object is to provide a relay having means for increasing the range during which armature reset is aided by the force of magnetic attraction and thereby reduce the need for spring bias and minimize the effects due to changes in the spring system.

In order that the manner in which these and other objects are attained, in accordance with the invention, can be understood in detail, reference is had to the accompanying drawings, which form a part of this specification, and wherein:

FIG. 1 is a simplified elevational view of a relay constructed in accordance with one embodiment of the invention;

FIGS. 2 and 3 are fragmentary elevational views, considerably enlarged as compared to FIG. 1, illustrating the relationship of the armature and a permanent magnet in the relay of FIG. 1, the armature being shown in one of its extreme positions in FIG. 2 and in the other in FIG. 3;

FIG. 4 is a simplified elevational view of a modified form of the relay seen in FIG. 1;

FIG. 5 is a view similar to view 1, illustrating a relay constructed in accordance with another embodiment of the invention;

FIGS. 6 and 7 are fragmentary elevational views, considerably enlarged with respect to FIG. 5, illustrating the relative positions of the armature and permanent magnet in the same fashion as in FIGS. 2 and 3;

FIG. 8 is a view, similar to FIG. 5, illustrating a relay constructed in accordance with still another embodiment of the invention; and

FIG. 9 is a view, similar to FIG. 8 but with portions removed, illustrating a relay constructed in accordance with another embodiment of the invention.

In general the objects of the invention are achieved by so relating the armature, the electromagnet cores and the permanent magnet that a stronger magnetic force of attraction exists between the armature and the permanent magnet when the armature has returned to its normal, latched position than when the armature occupies that position to which it is actuated as a result of energization of the electromagnets.

Referring now to the drawings in detail, and first to FIG. 1 thereof, it will be seen that the embodiment of the invention there illustrated comprises a pair of spaced parallel electromagnets **1** and **2** having cores **3** and **4**, respectively. At one end, core **3** has an exposed end portion **5** carrying a brass or other non-magnetic shim **6**, the shim being welded or otherwise suitably secured to the core end. The corresponding exposed end portion **7** of core **4** is plain, carrying no shim. Opposite the end portions **5** and **7**, the cores **3** and **4** have tips staked or otherwise fixedly secured in suitable spaced openings in a magnetic end plate **8** which extends between the electromagnets at right angles to the longitudinal axes of the cores. Disposed between and extending parallel to the electromagnets **1** and **2** is an elongated permanent magnet **9** connected at one end to the plate **8** in good magnetic relation, the magnet **9** being longitudinally magnetized and having a rectangular transverse core section.

At its end opposite plate **8**, magnet **9** has converging end faces **10** and **10'** which intersect to form a bearing edge **11** located generally between core end portions **5** and **7** and extending at right angles to a line defined by the centers of core end portions **5** and **7**. The armature **12** of the relay is elongated and formed of any suitable magnetic material. At its center armature **12** is provided with a hump or groove indicated at **13** which provides, on the face of the armature directed toward plate **8**, a surface portion disposed in pivotal engagement with the bearing edge **11**. The armature **12** is held in engagement with bearing edge **11** of magnet **9** by the magnetic effect of the magnet and is thereby mounted for pivotal movement about the axis defined by bearing edge **11**. It will be understood that pivotal movement in one direction about the axis defined by edge **11** will cause the end portion **14** of the armature to move into engagement with shim **6** (as shown in FIG. 1), while pivotal movement of the armature in the opposite direction about that axis will cause the end portion **15** of the armature to move into engagement with exposed end portion **7** of core **4**.

Operatively associated with armature **12** for actuation as a result of pivotal movement thereof are a pair of contact sets indicated generally at **16** and **17**. Contact set **16** comprises a pair of relatively fixed contacts **18**, **19**, spaced generally in the direction of pivotal movement of the armature, and a movable spring leaf contact **20** fixed at one end by a terminal pin **21** and having a free end portion disposed between contacts **18** and **19**. In relaxed position, movable contact **20** is so disposed that its free end engages relatively fixed contact **19**.

Similarly, contact set **17** comprises a pair of relatively fixed contacts **22**, **23**, spaced generally in the direction of travel of the armature, and a movable spring leaf contact **24** fixed at one end by a pin **25** and having a free end extending between contacts **22** and **23**. In normal or relaxed condition, spring contact **24** is so disposed that its free end engages relatively fixed contact **23**.

Armature **12** carries a pair of contact actuating pushers **26** and **27** arranged to actuate movable contact arms **20** and **24**; respectively. As will be clear from FIG. 1, the arrangement is such that, when the armature is in one of its extreme pivoted positions, with end portion **14** thereof engaging shim **6**, spring contact **20** is allowed to relax into engagement with fixed contact **19**, while pusher **27** serves to distort spring contact **24** out of its normal position into engagement with contact **22**. Being distorted, spring contact **24** applies to the armature a spring force tending to pivot the armature in a direction to move end portion **14** away from shim **6** and end portion **15** toward core end portion **7**.

When armature **12** is pivoted to its opposite extreme position, with end portion **15** thereof engaged with core end portion **7**, movable spring contact **24** is allowed to relax into engagement with contact **23** and pusher **26** distorts movable spring contact arm **20** out of its normal or relaxed position into engagement with contact **18**. With the armature in this position, spring contact **20** applies a force to the armature tending to pivot the same in a direction to move end portion **14** toward shim **6** and end portion **15** away from core end portion **7**.

The coils or windings of electromagnets **1** and **2** are provided with suitable leads (not shown) by which the electromagnets are connected to an operating circuit (not shown) in such fashion that the electromagnets can be energized with a polarity effective to drive the armature magnetically to the position shown in FIG. 1, with armature end portion **14** engaging shim **6**. With the armature in this position, the permanent magnet **9** tends to aid the driving effect of the electromagnets but, because of the presence of non-magnetic shim **6** and a spring bias, the armature does not remain magnetically latched to core **5** after the electromagnets are de-energized. The contact

sets **16** and **17** are so constructed and arranged that the spring force applied to the armature by spring contact arm **24**, when the armature is in the position seen in FIG. 1, is greater than the corresponding spring force applied to the armature by spring contact arm **20** when the armature is pivoted to that position in which end portion **15** thereof is engaged with core end portion **7**. Further, the spring force applied to the armature, when the armature is in the position seen in FIG. 1, by contact arm **24**, is made such as to assure that, when electromagnets **1** and **2** are de-energized, return pivotal movement of the armature toward its other extreme position, with end portion **15** engaging core end portion **7**, will occur.

During the initial portion of such return movement, permanent magnet **9** tends to retain the armature in the position seen in FIG. 1. This is because a magnetic flux path comprising the permanent magnet, one-half of the armature, core **3** and one-half of plate **8** is completed. At the same time, the magnetic flux path comprising magnet **9**, the other half of the armature, core **7** and the other half of plate **8** is interrupted by the substantial gap between end portion **15** of the armature and core **4**. Accordingly, the spring force applied by contact arm **24** to the armature is made to predominate at least to such an extent that the armature swings toward core end portion **7**.

The objective of the present invention is to aid and make more positive such return movement of the armature. In this connection, it will be noted that, in the relay construction illustrated in FIG. 1, core **4** is shorter than the combination of core **3** and shim **6** so that, with plate **8** lying in a single plane, the combination of core **3** and shim **6** projects toward the armature further than does core **4**, this dimensional difference being indicated at A, FIG. 1. Because of this feature, the armature is not as close to face **10** of the permanent magnet, when end portion **14** of the armature engages shim **6**, as it is to face **10'** of the permanent magnet, when end portion **15** of the armature engages core end portion **7**. Hence, there is a stronger magnetic force of attraction between face **10'** of the permanent magnet and the armature when the electromagnets are de-energized and the armature returns toward that extreme position in which end portion **15** engages core **7**. On the other hand, there is a weaker magnetic force of attraction between the armature and face **10** of the permanent magnet when the armature occupies that position, seen in FIG. 1, to which it is actuated by energization of the electromagnets. Further, as return movement of the armature progresses, the effect of the permanent magnet **9** in aiding the return movement obviously becomes progressively stronger, while its opposite effect becomes rapidly weaker.

Referring to FIGS. 2 and 3, the strength of the magnetic force of attraction between the corresponding surfaces of the armature and the permanent magnet varies inversely as the extent of the gap B between the armature and face **10** of the permanent magnet or the gap B' between the armature and face **10'** of the permanent magnet. FIG. 2 illustrates the armature in the extreme position in which end portion **14** engages shim **6**. FIG. 3, on the other hand, illustrates the armature in the opposite extreme position, with end portion **15** engaging core end portion **7**. It will be obvious that, because of the difference A, FIG. 1, in projection of the combination of core **3** and shim **6**, on the one hand, and the core **7**, on the other hand, toward the armature, gap B' is very materially smaller than gap B, so that the stronger force of attraction between the permanent magnet and the armature, on this side of the pivot, is assured under the conditions of FIG. 3.

It will be understood that, for purposes of simplicity of illustration in FIG. 1, various structural and framing features have been omitted. In this connection, the relay

of FIG. 1 can embody the various structural features of the aforementioned patent.

While non-magnetic member **6** has been shown in FIG. 1 as fixed to the end of core **3**, it will be understood that, alternatively, it can be attached to end portion **14** of the armature. Thus, as seen in FIG. 4, a shim **6'** is welded or otherwise suitably fixed to the face of armature end portion **14'** directed toward electromagnet **1'**. In this construction, the two cores of the electromagnets can be of the same length, since the thickness of shim **6'** is interposed between the armature and core end **5'**, providing effectively the same space A hereinbefore referred to with respect to FIG. 1.

Referring now to FIGS. 5–7, it will be seen that the same advantage accomplished by the relay construction of FIG. 1, can be provided without requiring asymmetry between the end positions of pivotal movement of the armature. The relay construction of FIG. 5 includes precisely the same elements employed in that of FIG. 1, but it will be noted that, in FIG. 5, the end faces of shim **6''** and core end portion **7''** lie in a common plane parallel to frame plate **8'**. Here, the difference in the strength of the magnetic force of attraction between the armature **12''** and the permanent magnet **9'** is attained by reason of the fact that the converging faces **10^a** and **10^b** at the end of the permanent magnet are of distinctly different extent, so that the bearing edge **11'** defined by these faces is offset markedly from the center line of the permanent magnet toward electromagnet **1''**. Because of this, as will be seen in FIGS. 6 and 7, the reluctance of gap C between the armature and face **10^a** of the permanent magnet, existing when the armature engages shim **6''**, is markedly greater than that of gap C', between the armature and face **10^b** of the magnet, existing when the armature engages core end portion **7''**. Further, since the face **10^a** is of distinctly smaller extent than the face **10^b**, the armature is disposed adjacent a greater portion of the permanent magnet when in the position seen in FIG. 7 than is the case when the armature is in the position seen in FIG. 6, this difference also providing a stronger magnetic force of attraction between said surfaces of the armature and the permanent magnet when the armature is engaged with pole end portion **7''** than when it is engaged with shim **6''**.

While, in the embodiments of FIGS. 1 and 5, the armature bears directly against a bearing edge provided by the permanent magnet, this in itself is not an essential feature of the invention. Thus, as seen in FIG. 8, the armature may be pivoted on an element **30** which is separate from the permanent magnet. In this embodiment, the permanent magnet has a plain end face **31** disposed at right angles to the longitudinal axis of the magnet. The two core end portions **32** and **33** of electromagnets **34** and **35** are interconnected by a non-magnetic frame member **36** having opposed dependent flanges **37** each disposed in face-to-face engagement with a different side surface of the permanent magnet. Secured to each flange **37** is a flat non-magnetic support member **38**, the two members **38** being interconnected by a cross bar **39** of non-magnetic material disposed above the armature to prevent the armature from being displaced under high shock conditions. Thus, members **38** are spaced apart by approximately the width of the permanent magnet and can be considered to be opposed across the magnet. In this embodiment, the element **30** providing the bearing edge to support the armature can be a piece of wire extending parallel to end face **31** of the magnet and having its ends each fixed in a different one of members **38**. Even though element **30** is spaced somewhat from the end of the magnet, the magnetic armature is still retained in pivotal engagement with the element **30** by the effect of the permanent magnet.

It will be noted that the element **30** is displaced markedly from the longitudinal center line of the permanent magnet toward electromagnet **34** in precisely the same fashion that bearing edge **11'**, FIG. 5, is displaced. Accordingly, it will be seen that the armature swings into a position closer to end face **31** of the magnet, when the armature engages the core end portion of electromagnet **35**, than when the armature moves in the opposite direction into contact with the non-magnetic element **40**. Further, the armature lies closely adjacent to a greater portion of end surface **31** when the armature engages the core end portion of electromagnet **35** than is the case when the armature engages element **40**. Accordingly, a substantially stronger magnetic force of attraction is established between the armature and the permanent magnet when the armature engages the core end portion of electromagnet **35** than when it engages non-magnetic element **40**.

The embodiment of FIG. 9 is similar to that of FIG. 8 since the armature is pivoted on an element **41** which is similar to element **30** shown in FIG. 8. However, the embodiment of FIG. 9 differs from that of FIG. 8 in the following manner. The armature is a flat bar **42** pivoted at its center on element **41** which extends through bar **42** and lies along an extension of the longitudinal axis of the permanent magnet. To accommodate the flat bar **42**, non-magnetic shim **43** and core **44** are rounded. Further, the permanent magnet is provided with a flat, soft iron pole piece **45** which extends at a right angle to the longitudinal axis of the permanent magnet and underlies the armature. Pole piece **45** extends toward electromagnet **46** a greater distance than it extends toward electromagnet **47** and thereby produces a flux pattern which alters the net torque by shifting the moment arm. Thus, when the armature engages the core end portion of electromagnet **46**, it lies closer to pole piece **45** than when the armature engages shim **43**. Consequently, the force of magnetic attraction is substantially greater when the armature engages the core end portion of electromagnet **46** than when it engages shim **43**.

In all of the embodiments of the invention shown and described, a stronger magnetic force of attraction exists between the permanent magnet and the armature when the electromagnets are de-energized and the armature is in its normal position than when the electromagnets are energized and the armature therefore in its other position. In the embodiments of FIGS. 1 and 4, wherein the axis of pivotal movement of the armature is centered between the electromagnets and with respect to the permanent magnet, the pivotal movement of the armature is greater when the armature returns and less when the armature is actuated electromagnetically as a result of energization of the relay, so that the armature approaches the permanent magnet more closely on return than upon energization of the relay. In the embodiments of FIGS. 5 and 8, the same general result is accomplished by having the pivotal axis of the armature offset relative to the permanent magnet. While not illustrated, it will be apparent that the features of either FIG. 5 or FIG. 8 with the pivotal axis of the armature offset from the longitudinal axis of the permanent magnet, can be incorporated in the relay constructions of FIGS. 1 and 4 so as to provide an even greater predominance of the magnetic force of attraction between the permanent magnet and the armature when the relay is de-energized. As will be understood by those skilled in the relay art, other changes and modifications can be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In an electrical relay of the type described, the combination of

two spaced parallel electromagnets each having a core of magnetic material;

an elongated longitudinally magnetized permanent magnet disposed between and parallel to said electromagnets;

an armature of magnetic material mounted for pivotal movement about an axis located at one end of said permanent magnet,

said armature having a first portion on the side of said axis adjacent one of said electromagnets and a second portion on the side of said axis adjacent the other of said electromagnets,

pivotal movement of said armature in one direction about said axis causing one end of said armature to move toward an end of the core of said one electromagnet,

pivotal movement of said armature in the other direction about said axis causing the other end of said armature to move toward the corresponding end of the core of said other electromagnet;

means magnetically interconnecting said cores and said permanent magnet at the ends thereof opposite said armature, whereby engagement of one of said cores by said armature will complete a magnetic path comprising said permanent magnet, one-half of said armature, the one of said cores engaged thereby, and said last-mentioned means;

means interposed between said one end of said armature and the adjacent end of the core of said one electromagnet to stop said one end of said armature in a predetermined position in close proximity to but out of direct engagement with the adjacent end of the core of said one electromagnet; and

means provided in said relay for positioning said second portion of said armature nearer said permanent magnet when said other end of said armature is engaged with said corresponding end of the core of said other electromagnet than is said first portion of said armature when said one end of said armature is in said predetermined position,

whereby a stronger force of attraction exists between said armature and said permanent magnet when said other end of said armature is engaged with said corresponding end of the core of said other electromagnet than when said one end of said armature is in said predetermined position.

2. A relay in accordance with claim 1 and wherein said means interposed between said one end of said armature and the adjacent end of the core of said one electromagnet is a non-magnetic element carried by said core of said one electromagnet and having a surface directed toward said armature for contact thereby,

the combination of said core of said one electromagnet and said non-magnetic element projecting further toward said armature than does the core of said other electromagnet.

3. A relay in accordance with claim 2 and wherein the end portion of said permanent magnet adjacent said armature has two faces converging to define a bearing edge with which said armature is pivotally engaged,

said bearing edge defining said axis and being centered between said electromagnets.

4. A relay in accordance with claim 1 and wherein said axis is offset from the center of said permanent magnet toward said one electromagnet.

5. A relay in accordance with claim 1 and wherein the end portion of said permanent magnet adjacent said armature has two exposed faces of unequal extent,

said faces converging to define a bearing edge with which said armature is pivotally engaged,

said armature being nearer to one of said faces when said other end of said armature is engaged with said corresponding end of the core of said other electromagnet than to the other of said faces than when said one end of said armature is in said predetermined position.

6. In an electrical relay of the type described, the combination of

two spaced parallel electromagnets each having a core of magnetic material;

an elongated longitudinally magnetized permanent magnet disposed between and parallel to said electromagnets;

an armature of magnetic material mounted for pivotal movement about an axis located at one end of said permanent magnet,

said armature having a first portion on the side of said axis adjacent one of said electromagnets and a second portion on the side of said axis adjacent the other of said electromagnets,

pivotal movement of said armature in one direction about said axis causing one end of said armature to move toward an end of the core of said one electromagnet,

pivotal movement of said armature in the other direction about said axis causing the other end of said armature to move toward the corresponding end of the core of said other electromagnet;

means magnetically interconnecting said cores and said permanent magnet at the ends thereof opposite said armature, whereby engagement of one of said cores by said armature will complete a magnetic path comprising said permanent magnet, one-half of said armature, the one of said cores engaged thereby, and said last-mentioned means;

a soft iron pole piece disposed at said one end of said permanent magnet and extending transversely of the longitudinal axis of said permanent magnet,

said pole piece extending more closely adjacent to said other electromagnet than to said one electromagnet; and

means interposed between said one end of said armature and the adjacent end of the core of said one electromagnet to stop said one end of said armature in a predetermined position in close proximity to but out of direct engagement with the adjacent end of the core of said one electromagnet,

said second portion of said armature being nearer said pole piece, when said other end of said armature is engaged with said corresponding end of the core of said other electromagnet, than is said first portion of said armature when said one end of said armature is in said predetermined position, whereby a stronger force of attraction exists between said permanent magnet and said armature when said armature is engaged with said corresponding end of the core of said other electromagnet than when said one end of said armature is in said predetermined position.

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