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NEUTRAL RELAY

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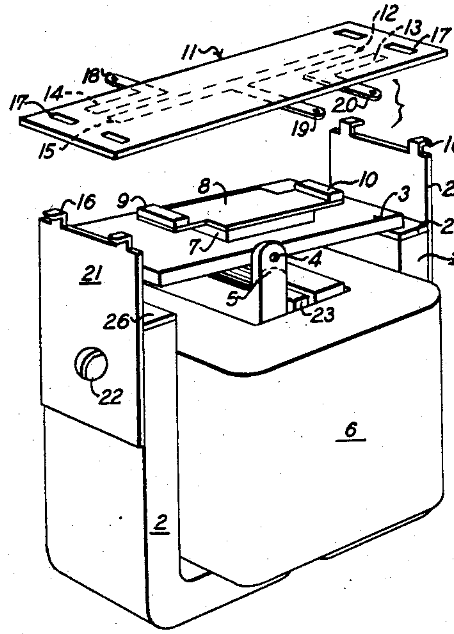

Fig. 1

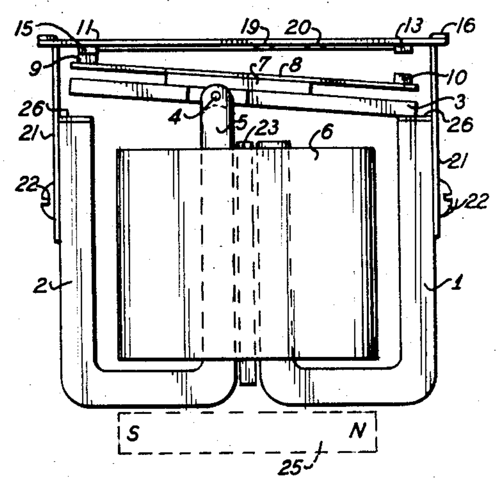

Fig. 2

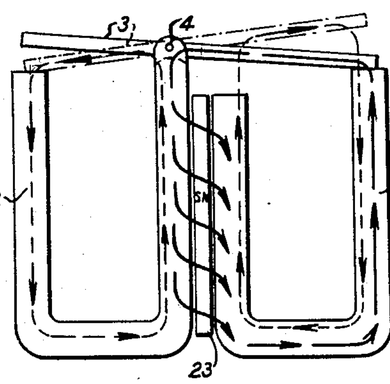

Fig. 3

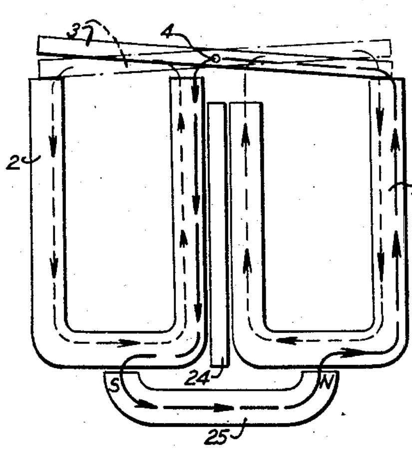

Fig. 4

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2,881,365

NEUTRAL RELAY

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Application November 4, 1955, Serial No. 545,012

20 Claims. (Cl. 317—171)

This invention relates to a magnetically biased electro-magnetic neutral relay.

Neutral relays have conventionally been constructed with a movable armature of magnetic material which is normally spring-biased to an open position and may be magnetically attracted to a closed position against the spring force by energizing an electro-magnet constituting part of the relay.

The flux produced by the electro-magnet must produce a sufficient force to overcome the inertia and frictional resistance of the armature and the elastic force of the biasing spring.

The use of the biasing spring is not completely satisfactory as the same may be subject to breakdown after extended use. The magnetic force created by the energizing coil in the relay must not only perform the useful work of moving the armature and maintaining the same closed with sufficient contact pressure, but must, additionally overcome the force of the biasing spring, which in connection with relays in which the spring effects the contact pressure on the back contacts, is not insignificant.

A neutral relay is described in my United States Patent 2,702,841 of February 22, 1955, which overcomes the disadvantages of the spring biased relays.

The neutral relay as described in my said United States patent is a magneticaly biased relay in which the flux caused by a permanent magnet maintains the armature of the relay in one of its two positions, and the magnetic flux of the relay coil upon energization, at least partially neutralizes the biasing force of the permanent magnet while, at the same time, magnetically urging the armature to its other position.

While the neutral relay of my said United States patent completely overcomes disadvantages of the old spring biased relays, the same has been found to have certain disadvantages in use. The permanent magnet is positioned directly in the magnetic circuit of the electro-magnet so that when the electro-magnet is energized, the same has a strong demagnetizing effect upon the permanent magnet which may tend to permanently demagnetize the same so that after a period of use, the relay may change its operating characteristics by requiring a smaller operating current and also developing less contact pressure on the back contacts when de-energized.

Due to this possible permanent demagnetizing effect of the electro-magnet upon the permanent magnet, the current supply for energizing the electro-magnet, must be carefully controlled, and if much larger amounts of energizing current are used than are required to operate the relay, the detrimental demagnetization of the permanent magnet will occur, and the relay operating characteristics will change.

One object of this invention is an electro-magnetic relay, of the type described above, which has permanent magnetic biasing means which are not subjected to a strong permanent demagnetization effect by action of the electro-magnet.

A further object of this invention is an electro-magnetic

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relay of high sensitivity and magnetic efficiency. These, and still further objects, will become apparent from the following description read in conjunction with the drawings in which:

Figure 1 is a perspective view, partially exploded, of an embodiment of a relay in accordance with the invention;

Figure 2 is a side elevation of the relay shown in Figure 1;

Figure 3 is a diagrammatic representation showing the magnetic circuits of the relay shown in Figures 1 and 2, and

Figure 4 is a diagrammatic representation showing the magnetic circuits of a further embodiment of a relay in accordance with the invention.

The neutral relay in accordance with the invention, has a first magnetic circuit and a second magnetic circuit. Permanent magnet means are positioned outside these magnetic circuits and form a third magnetic circuit having a portion thereof common with the first magnetic circuit. The magnetic circuits include an armature normally biased to a first position by the magnetic flux produced by the permanent magnet in the third magnetic circuit. The armature is movable to its second position by energization of the second magnetic circuit and means are provided for electro-magnetically energizing the first and second magnetic circuits with a magnetic field opposing the magnetic field caused by the permanent magnet in the portion of the first magnetic circuit common with the third magnetic circuit, whereby the armature will be moved to its second position.

Referring to the embodiment shown in Figures 1, 2 and 3 of the drawing, the relay has two U- or horse-shoe-shaped magnetic cores **1** and **2** of magnetic material such as soft iron or the like. The two U-shaped cores **1** and **2** are positioned side by side to form a substantially E-shaped unit. Shims **26** of non-magnetic material are positioned on the ends of the outer legs of the unit in the conventional manner.

An armature **3** of magnetic material such as soft iron is pivotally mounted on the pivot joint **4** supported by the pivot posts **5** above the central legs of the E-shaped unit. The pivot joint **4** is preferably positioned directly above the inner leg of the U-shaped core **2** which is made longer than the other legs to provide a minimum air gap between this leg and the armature. The pivot joint may advantageously extend through the end of this leg. The armature is pivotally movable to a first position as shown in Figure 2 with one end in contact with the outer leg of the U-shaped magnetic core **1** and a second position in which its opposite end is pivoted in contact with the outer leg of the U-shaped core **2**. The second position is shown by dotted lines diagrammatically in Figure 3.

An energizable coil **6** is positioned around the central legs of the E-shaped unit. A plate of insulating material **7** is mounted on top of the armature **3** and has connected to its upper portions a further plate **8** of insulating material which has the electric contact **9** at one end and the electric contact **10** at the other end. The ends of the plate **8** which bear the contacts and extend past the under plate **7** are somewhat flexible.

A cover plate **11** is secured across the top of the relay by means of the support plates **21** which are screwed to the outer legs of the U-shaped cores **1** and **2** respectively, by the screws **22**. The support plates have tabs **16** which extend through the corresponding holes **17** of the cover plate and secure the same in place.

The cover plate **11** is of an electrically insulating material and has four electric contacts **12, 13, 14** and **15** thereon. The contacts **12** and **15** are electrically connected to the terminal **19** whereas the contact **13** is connected to the terminal **20** and the contact **14** to the terminal **18**.

The contacts and their connections to the terminals may be formed on the cover plate **11** by the known printed circuit technique allowing for economical production and, in conjunction with the extreme efficiency of the relay as a whole, for a remarkably small unit.

The contacts **14** and **15**, i.e. the back contacts, are so positioned that they will be short-circuited by the contact **9** when the armature is in its first position and the contacts **12** and **13** are so positioned that they will be short-circuited by the contact **10** when the armature is in its second position.

Due to the resiliency of the insulating plate **8** at its end, the contacts **9** and **10** may be resiliently pressed in contact position, allowing for a positive contact and easing the manufacturing tolerance requirements.

A flattened permanent magnet **23** is positioned between the inner legs of the U-shaped cores **1** and **2** respectively. This magnet has its opposed polar surfaces on the opposed surfaces of the largest area so that the same face the inner legs of U-shaped cores **1** and **2** as may best be seen in Figure 3. The lines of magnetic flux through the permanent magnet **23** therefore run transverse to the direction of the legs of the U-shaped units.

It has been found preferable to use a ferromagnetic ferrite magnet as the permanent magnet **23** though permanent magnets constructed of other conventionally known magnetic material may be used for this purpose.

The support posts **5** of the pivot joint **4** may, as mentioned, be constructed as part of the inner leg of the core **2** or may constitute separate posts positioned on either side of this leg or the permanent magnet.

As may best be seen in the diagrammatic showing of Figure 3, the U-shaped magnetic core **1** along with the portion of the armature **3** above it, forms a first magnetic circuit the path of which is shown by the dotted arrows in the drawing. The other U-shaped core **2** forms a second magnetic circuit with the portion of the armature **3** above it, the path of which may also be seen from the dotted arrows.

A third magnetic circuit is formed from the permanent magnet **23** and a portion of the other magnetic circuits. The path of this third magnetic circuit is represented by the solid arrows and extends through the permanent magnet **23** in its polar direction through the U-shaped magnetic core **1** through the armature **3** to the inner leg of the U-shaped magnetic core **2** and through this inner leg back to the permanent magnet.

It should be noted that the inner leg of the U-shaped core **1** is shorter than the other legs of the cores so that the air-gap between the end of this inner leg of the core **1** and the armature **3** is greater, in any position of operation of the armature, than the air-gap between the armature and the other legs of the core. As a result of this, the reluctance of the magnetic path between the armature and the end of the inner leg of the core **1** is greater than the reluctance between the armature and the other legs of the cores **1** and **2**. Due to these differences in reluctance, the flux from the permanent magnet will flow through the outer of the core **1** through a portion of the armature to the inner leg of the core **2** thus normally biasing the armature to its first position.

Within the broad scope of the invention, it is only necessary that the reluctances of the magnetic paths between the ends of the legs of the cores and the armature be so chosen that the reluctance of the magnetic path to the field of the permanent magnet is less with the armature in its first position than with the armature in its second position so that the armature will, when the coil is de-energized, always normally assume first position. Preferably the reluctance of the magnetic path to the field of the permanent magnet should progressively decrease upon the movement of the armature from the second position to the first position.

In the embodiment shown, the magnetic flux from the permanent magnet **23** will follow the course shown by the solid arrows and normally bias the armature **3** to its first position in contact with the outer leg of the core **1**. Even if the armature **3** is moved to its second position as shown by the dotted lines, the major portion of the magnetic flux from the permanent magnet will pass through the outer leg of the core **1** to the armature **3**, magnetically attracting the armature **3** to its first position.

In place of providing the largest air gap between the armature and the inner leg of the magnetic core **1**, the greater reluctance of this path may be established in a different manner, as, for example, by inserting a body of non-magnetic material at this end of the magnetic core, etc.

With the armature **3** biased to its first position, the contact **9** short circuits the back contacts **14** and **15** whereas the contact **10** is in spaced relation from the contacts **12** and **13**, leaving these contacts insulated from each other.

When a direct current is passed through the coil **6** the magnetic cores **1** and **2** will be electro-magnetically activated and with a suitable selection of the direction of D.C. current, the magnetic flux will pass through the first and second magnetic circuits in a direction of the dotted arrows so that the magnetic field in the portion of the magnetic circuits common to the first and third circuits, will oppose the field produced by the permanent magnet, at least partially neutralizing the same.

Due to the activation of the second magnetic circuit, and the at least partial neutralization of the portion of the circuit common to the first and third magnetic circuits, with enough current passing through the coil, the armature **3** will be moved to its second position, causing the contact **10** to short-circuit the contacts **12** and **13** and separating the contact **9** from the contacts **14** and **15**. As long as the energizing current is applied to the coil **6**, the armature will remain in this position and as soon as the current is shut off, the biasing effect of the permanent magnet, will move the armature **3** back to its first position and maintain the same in that position until further current is supplied to the coil **6**.

With the pivot point **4** on the inner leg of the core **2** as shown in the embodiment in Figures 1–3, the armature **3** will not be pivoted about its center. In order to assure even contact pressure between both sets of contacts with this arrangement, the contacts themselves may be arranged on the armature equidistant from the pivot point **4**; the contacts **12** and **13** may be positioned in a somewhat higher plane than the contacts **14** and **15**, the spacing between the legs of the U-shaped core **2** may be larger than the spacing between the legs of the U-shaped core **1** so that the armature is pivoted at its center, etc. Furthermore, the armature should preferably be dynamically balanced.

Since the permanent magnet **23** is positioned outside the main magnetic circuits formed upon energization of the coil **6**, and since the same is centrally positioned in the coil with its polar direction extending substantially normal to the polar direction of the coil, the same is subjected to a very low demagnetization effect as compared with the strength of the fields effected in the first and second magnetic circuits. It is therefore easy to design the magnet so that the energization of the coil **6** will have no permanent demagnetization effect thereon even when the current load exceeds that normally intended for the relay, within limits likely to be encountered in normal practice.

It is not necessary that the permanent magnet be positioned directly between the inner legs of the E-shaped unit as shown in Figures 1–3. Within the broad scope of the invention, the permanent magnet may be positioned anywhere outside the main flux paths caused upon energization of the coil **6**, provided that the same forms a third magnetic circuit having a portion common with the first magnetic circuit, preferably including the gap between armature and outer leg so that the flux from the permanent magnet will normally bias the armature 3 to its first position.

In the embodiment as shown in Figure 4, the permanent magnet 23 is removed and replaced by a layer such as a bar or plate of non-magnetic material, as for example, brass. Within the broad scope of the invention, this layer may include any non-magnetic material including an air gap.

A permanent magnet 25 is positioned beneath the unit so that one of its poles is adjacent the bridging member of the core 1 while the other pole is adjacent the bridging member of the core 2. The magnet is preferably so positioned that an air gap remains between its poles and these bridging members.

In this arrangement, the first and second magnetic circuits will be identical to those described in connection with Figures 1, 2 and 3. The third magnetic circuit formed, however, will extend through the permanent magnet 25 in the polar direction thereof through the outer leg of the core 1, across the armature 3 to the inner leg of the core 2 and through this inner leg back to the permanent magnet. The flux produced by the permanent magnet through this circuit will normally bias the armature 3 to its first position and will move the armature 3 from its second position to its first position in the same manner described in connection with the embodiments of Figures 1, 2 and 3.

When the coil 6 is energized with a suitable direct current, a magnetic field will be set up in the first and second magnetic circuits, which corresponds to the dotted arrows shown, and which opposes the magnetic field caused by the permanent magnet in the portion of their magnet circuits common to the first and third circuits, at least partially neutralizing this field. With sufficient current passing through the coil due to this partial neutralization, and the magnetic flux in the second magnetic circuit, the armature will be moved to and held in the second position as long as the current remains applied to the coil 6.

The reluctance of the magnetic path from the core 1 to the core 2 through the permanent magnet 25 by a suitable adjustment of the gaps between the permanent magnet and the cross-members of the U-shaped cores 1 and 2, is preferably greater than the reluctances through the cores themselves so that only a very small portion of the field, caused by the coil 6 will pass through the permanent magnet. The demagnetization effect of the electro magnetic field on the permanent magnet is therefore relatively low and with suitable magnet design and gap spacing, a current may be placed on the coil 6 far in excess of that normally intended without any demagnetization effect on the permanent magnet 25.

In the embodiment shown in Figure 4 the pivot 4 of the armature 3 is positioned above the inner legs of the cores 1 and 2 in a plane extending between these legs. Pivot joint may be mounted on an extension of the non-magnetic postal plate 24 which will be mounted on separate posts. The gap between the inner leg of the core 2 and the armature 3 in any position movement of the armature should be greater than the gap between the inner leg of the core 1 and the armature so that the reluctance of the magnetic path between the armature and the leg toward 2 is less than the reluctance of the inner leg of the core 1 and the armature.

It is of course also possible to construct the embodiment with the permanent magnet 25 so that the pivot joint 4 is on an extension of the inner leg of the core 2 in the same manner as the embodiments shown in Figures 1–3 just as it is possible to construct the embodiments shown in Figures 1–3 so that the pivot joint 4 is mounted on separate support posts or a non-magnetic extension of the magnet 23 and is positioned in a plane between two inner legs of the cores 1 and 2.

While the permanent magnet 25, shown in Figure 4, has a somewhat modified horse-shoe design for convenience and illustration, the same may, of course, have any other desired shape such as a bar magnet shape. Positioning of such a bar magnet is shown by dotted lines in the embodiment of Figure 2.

In all other respects, the constructions and operation of the relay as shown in Figure 4 may be identical to that shown and described in connection with Figures 1, 2 and 3.

The constructional details of the relay in accordance with the invention, other than in connection with the positioning of the permanent magnet, and other details as described, may substantially correspond to those as described in connection with my Patent No. 2,702,841.

In operation in both embodiments, with no current flowing in the coil 6, the permanent magnet will bias the armature 3 to its first position, pressing the contacts 9, 14, and 15 to the closed position with the contacts 12, 13 and 10 open.

If a D.C. current of correct polarity is caused to flow through the coil 6, a second magnetic flux will be generated corresponding to the dotted arrows as shown in Figures 3 and 4.

The flux flowing in the first magnetic circuit, at least partially neutralizes the flux produced in the portion of the third magnetic circuit which is also common to the first magnetic circuit. At the same time, the flux produced in the second magnetic circuit causes a magnetic attraction of the end of the armature 3 above the core 2.

As the energizing current flowing through the coil 6 increases, the pulling force exercised by the permanent magnet decreases continuously while the pulling force exercised by the magnetic core 2 on the armature 3 increases continuously until the point is reached where the second mentioned pulling force exceeds the first mentioned pulling force. At this point, the armature 3 will begin to rotate about its pivotal point 4, decreasing the air gap between the armature 3 and the outer leg of the core 2 and increasing the air gap between the armature 3 and the outer leg of the core 1. As this latter-mentioned air gap is increased, the pulling force of the permanent magnet on the armature 3 is correspondingly decreased so in direct contrast to a spring-biased relay, the armature moves to its second position against a decreasing biasing force. The movement of the armature 3 is stopped when it reaches its second position in contact with the outer leg of the core 2 with the contact 10 short-circuiting the contacts 12 and 13 or when halted by other mechanical means.

As may be seen in the operation of my novel relay, no retaining or resetting springs are required so that the energizing current in the coil 6 may be utilized very efficiently to effect the actuation of the relay contacts and, if desired, to effect useful work, as, for example, to move other mechanical apparatus, such as tripping devices of circuit breakers or the like.

With the absence of the biasing spring, the relay is more sensitive and will react quicker than analogous spring loaded relays, since as is well-known, the use of the spring when the same effects contact pressure on back contacts causes a certain time delay due to the forces which must be overcome. Since, with the armature 3 in its second position, the permanent magnet does not exert any appreciable force on the armature, the current flowing through the coil is efficiently utilized to maintain the contact pressure of the armature in its second position.

In the same manner, when the current is removed from the coil 6, there is no force opposing the force of the permanent magnet to move and maintain the armature in its first position.

While my invention has been described in detail with reference to the specific embodiments shown, changes and modifications will become apparent to the skilled artisan which fall within the spirit of the invention and scope of the appended claims.

I claim:

1. A neutral relay comprising means defining a first magnetic circuit, means defining a second magnetic circuit, permanent magnet means positioned outside said magnetic circuits and forming a third magnetic circuit having a portion thereof common with said first magnetic circuit, said means defining said magnetic circuits including an armature normally biased to a first position by the magnetic flux produced by said permanent magnet means in said third magnetic circuit, and movable to a second position by energization of said second magnetic circuit, and means for electro-magnetically energizing said first and second magnetic circuits with a field opposing the magnetic field caused by said permanent magnet in the portion of said first magnetic circuit common with said third magnetic circuit to thereby move said armature to said second position.

2. Neutral relay, according to claim 1, in which said means defining said first magnetic circuit includes a first U-shaped magnetic core, and said means defining said second magnetic circuit includes a second U-shaped magnetic core, said magnetic cores being positioned side by side to form a substantially E-shaped unit, said armature being pivotally mounted above the central legs of said E-shaped unit, the reluctance of the magnetic path between the end of the inner leg of said first U-shaped magnetic core and said armature being greater than the reluctance of the magnetic path between the ends of the inner leg of said second U-shaped magnetic core and said armature at any position thereof, said permanent magnet means comprising a substantially flattened permanent magnet positioned between said inner legs with its poles facing said legs.

3. Neutral relay, according to claim 2, in which the inner leg of said first U-shaped magnetic core is shorter than the other legs of said magnetic cores.

4. Neutral relay, according to claim 3, in which said means for electro-magnetically energizing said first and second magnetic circuits includes an energizable winding surrounding at least a portion of the central legs of said E-shaped unit.

5. Neutral relay, according to claim 4, in which said permanent magnet is positioned substantially in the center of said energizable winding with its poles substantially normal to the axis of the winding.

6. Neutral relay according the claim 5 in which said armature is pivotally mounted on an extension of the inner leg of said second U-shaped magnetic core.

7. Neutral relay, according to claim 1 in which said means defining said first magnetic circuit includes a first U-shaped magnetic core and said means defining said second magnetic circuit includes a second U-shaped magnetic core, said magnetic cores being positioned side by side to form a substantially E-shaped unit, a layer of non-magnetic material positioned between the central legs of said E-shaped unit, said armature being pivotally mounted above the central legs of said E-shaped unit, the reluctance of the magnetic path between the end of the inner leg of said first U-shaped magnetic core and said armature being greater than the reluctance of the magnetic path between the end of the inner leg of said second U-shaped magnetic core and said armature in any position thereof, said permanent magnet means comprising a permanent magnet positioned with one pole adjacent the lower portion of one U-shaped magnetic core and the other pole adjacent the lower portion of the other U-shaped magnetic core.

8. Neutral relay, according to claim 7, in which said permanent magnet is positioned with an air gap between it and said U-shaped cores.

9. Neutral relay, according to claim 8, in which the inner leg of said first U-shaped magnetic core is shorter than the other legs of said magnetic cores.

10. Neutral relay according to claim 9 in which said armature is pivotally mounted on an extension of the inner leg of said second U-shaped magnetic core.

11. Neutral relay, according to claim 9, in which said means for electro-magnetically energizing said first and second magnetic circuits includes an energizable winding surrounding at least a portion of the central leg of said E-shaped unit.

12. A neutral relay comprising a first substantially U-shaped magnetic core, a second substantially U-shaped magnetic core, said cores being positioned side by side to form a substantially E-shaped unit, an armature of magnetic material pivotally mounted above the central legs of said E-shaped unit for movement to a first position with one end portion adjacent the outer leg of said first U-shaped magnetic core, and a second position with the other end portion adjacent the outer leg of the second U-shaped magnetic core, said first U-shaped magnetic core forming a first magnetic circuit with a portion of said armature above it, said second U-shaped magnetic core forming a second magnetic circuit with a portion of said armature above it, the reluctance of the magnetic path between said armature and the inner leg of said first U-shaped magnetic core being greater than the reluctances of the magnetic paths between said armature and the other legs of said cores at any position of said armature, a flattened permanent magnet positioned between the inner legs of said U-shaped magnetic core with its poles facing said legs and forming a third magnetic circuit extending in the polar direction thereof through said permanent magnet through said first U-shaped magnetic core, through said armature to the inner leg of said second U-shaped magnetic core and through said leg back to said permanent magnet, the magnetic flux produced in said third magnetic circuit by said permanent magnet being sufficient to normally bias said armature to said first position and means for electro-magnetically energizing said first and second magnetic circuits with a field opposing the magnetic field caused by said permanent magnet in the portion of said first magnetic circuit common with said third magnetic circuit to thereby move said armature to said second position.

13. Neutral relay, according to claim 12, in which the end of the inner leg of said first magnetic core is spaced at a greater distance from said armature in any position of operation than the other legs of said cores.

14. Neutral relay according to claim 13 in which said armature is pivotally mounted on an extension of the inner leg of said second U-shaped magnetic core.

15. Neutral relay, according to claim 12, in which said means for electro-magnetically energizing said first and second magnetic circuits comprises a winding at least partially surrounding the central legs of said E-shaped unit.

16. A neutral relay comprising a first substantially U-shaped magnetic core, a second substantially U-shaped magnetic core, said cores being positioned side by side to form a substantially E-shaped unit, an armature of magnetic material pivotally mounted above the central legs of said E-shaped unit for movement to a first position with one end portion adjacent the outer leg of said first U-shaped magnetic core and a second position with the other end portion adjacent the outer leg of said second U-shaped magnetic core, said first U-shaped magnetic core, forming a first magnetic circuit, with a portion of said armature above it, said second U-shaped magnetic core forming a second magnetic circuit with a portion of said armature above it, the reluctance of the magnetic path between said armature and the inner leg of said first U-shaped magnetic core being greater than the reluctances of the magnetic paths between said armature and the other legs in any position of operation of said

armature, a permanent magnet positioned with one of its poles adjacent the lower portion of one U-shaped magnetic core and the other of its poles adjacent the lower portion of the other U-shaped magnetic core, and forming a third magnetic circuit extending in the polar direction through said permanent magnet through the outer leg of said first U-shaped magnetic core through said armature to the inner leg of said second U-shaped magnetic core and through said leg back to said permanent magnet, the magnetic flux produced in said third magnet circuit by said permanent magnet being sufficient to normally bias said armature to said first position and means for electro-magnetically energizing said first and second magnetic circuits with a field opposing the magnetic field caused by said permanent magnet in the portion of said first magnetic circuit common with said third magnetic circuit to thereby move said armature to said second position.

17. Neutral relay, according to claim 16, in which the end of the inner leg of said first U-shaped magnetic core is spaced at a greater distance from said armature in any position of operation thereof than the ends of the other legs of said cores.

18. Neutral relay, according to claim 16, in which said permanent magnet is positioned to form a gap between it and said magnetic cores.

19. Neutral relay, according to claim 16, in which said armature is pivotally mounted on an extension of the inner leg of said second U-shaped magnetic core.

20. Neutral relay, according to claim 16, in which said means for electro-magnetically energizing said first and second magnetic circuits includes a coil at least partially surrounding the central legs of said E-shaped unit.

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