

Jan. 31, 1967

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3,302,146

ROTARY ARMATURE FLUX SHIFTING DEVICE

Filed March 2, 1965

2 Sheets-Sheet 1

FIG. 1
PRIOR ART

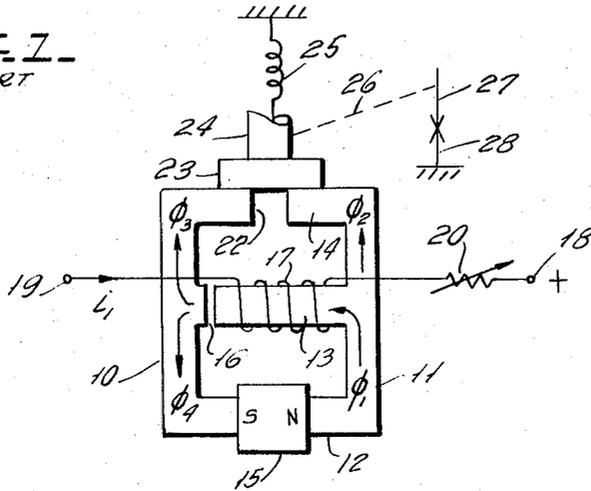


FIG. 4

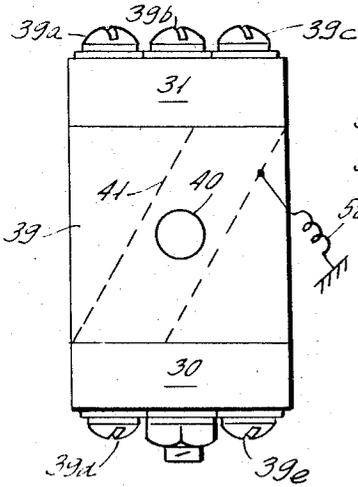


FIG. 3

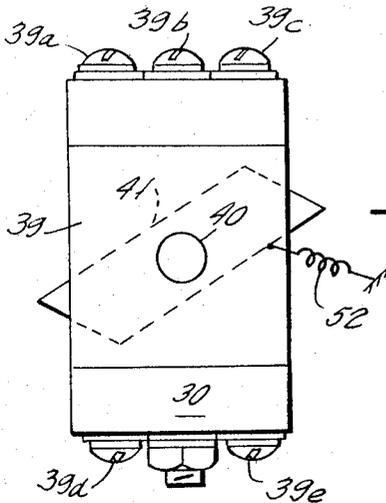
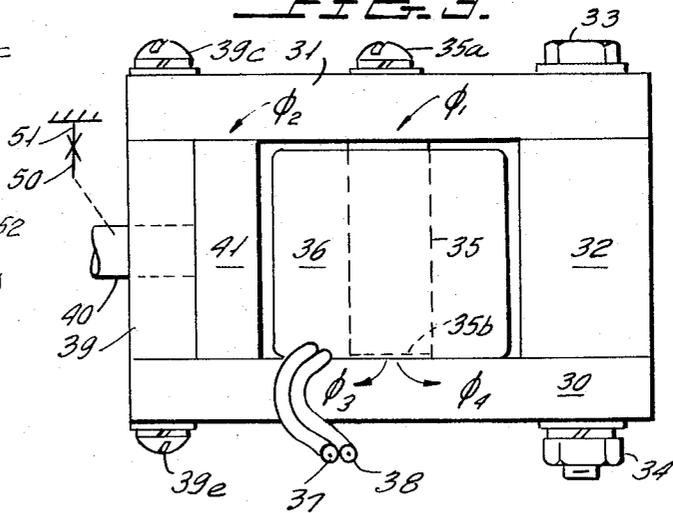


FIG. 5

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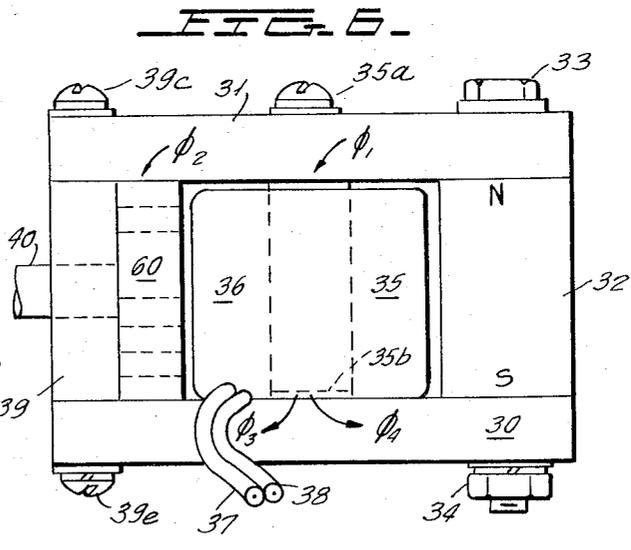
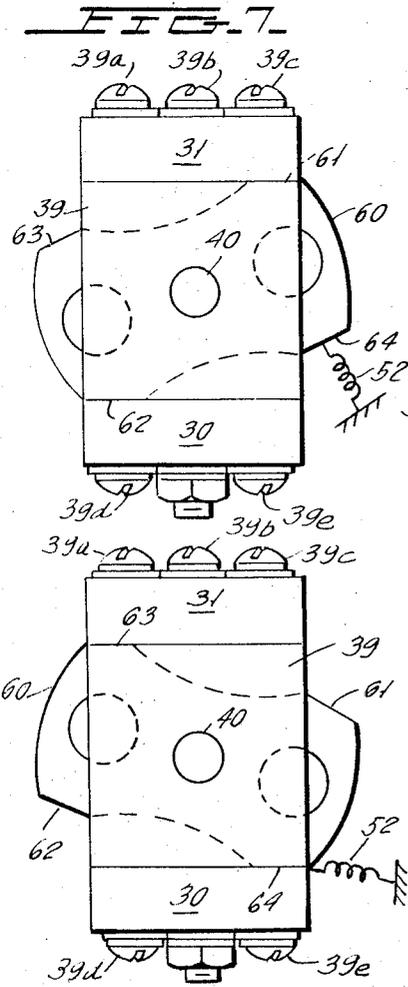
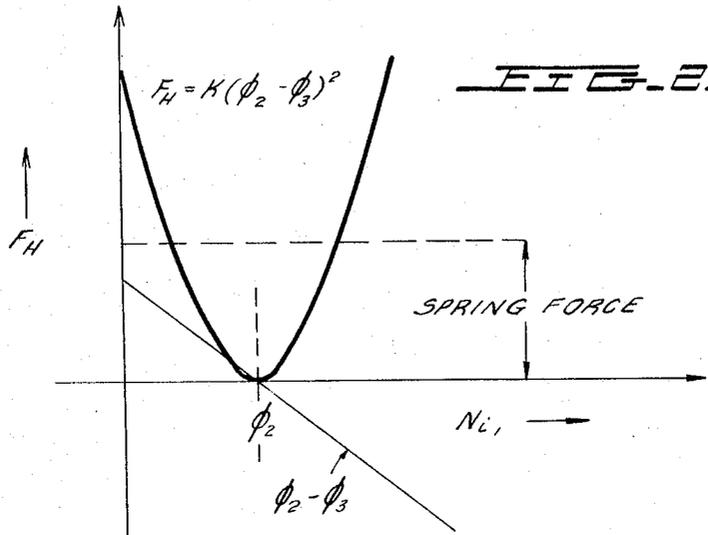


FIG. 8.

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ROTARY ARMATURE FLUX SHIFTING DEVICE
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Filed Mar. 2, 1965, Ser. No. 436,578

2 Claims. (Cl. 335-230)

This invention relates to a magnetic trip device for current interrupters, and more specifically relates to a magnetic trip device having a rotary armature.

Magnetic trip devices for circuit interrupters are well known to those skilled in the art, and are illustrated typically in copending application Serial No. 248,463, filed January 4, 1963, entitled "Static Overcurrent Relay," and assigned to the assignee of the instant invention. Generally, these devices include a magnetic body having an armature which can be sealed thereto with the armature ultimately controlling the motion of a pair of cooperating contacts whereby, when the armature is released from its magnet, this motion can permit or cause the contacts to be moved to their open position, while when the armature is sealed to its magnet, the contacts of the interrupter are retained in their engaged position.

In the prior art type devices, the magnet which seals the armature commonly is provided with two parallel magnetic paths which each include the movable armature. The first path is a relatively low reluctance path which has a suitable source of magnetic flux therein such as a permanent magnet. The other path, which is a relatively high reluctance path, then has a control winding therein which normally generates magnetic flux in such a direction as to decrease the flux passing to the armature. If now the current in this control winding is increased, the net flux through the armature will be further decreased to a point below the value required to seal the armature to the magnet body.

This type of arrangement is highly desirable since the ampere turns generated by the control coil are not required to generate the holding flux, but merely control the holding flux from some other source. Thus, a relatively small number of ampere turns can release the armature. This flux shifting technique, however, has one serious disadvantage in that, as the control coil current is increased to buck down the flux in the armature path from permanent magnet or other suitable source, it is possible that the coil current can increase to a point where the armature flux passes through zero and thereafter increases in the opposite polarity. As this reversed flux increases, the holding force for the armature increases so that the armature can be pulled closed if it has not attained a large enough air gap during the period when the holding force was less than the opening force applied to the armature.

This "pull-in" problem becomes especially troublesome in environments where the latching mechanism is subject to mechanical shock, since the unbalanced armature which moves in a linear direction can be caused, through shock, to be moved toward the magnet body where it can be subject to this pull-in force.

The principle of the present invention is to provide a novel magnet structure using the concept of flux shifting described above where, however, the armature is a rotatable body which is dynamically balanced about its axis of rotation. Thus, mechanical shock forces will not cause the armature to move back toward the magnet pole faces, thereby decreasing the possibility of its being trapped by the pull-in force of the magnet due to the rapid increase of control current in the control winding.

As a further feature of the invention, the novel rotary armature is designed to have two pairs of poles at the

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respective opposite corners of the rotary member where-in a first diagonally arranged pair are normally sealed to the magnet structure, while, when the armature rotates, the second diagonal pair engage the magnet structure faces, thereby retaining the armature in its engaged position in the event that control current builds up to a sufficiently high value which would otherwise return the main diagonal pole faces to their sealed-in position.

Accordingly, a primary object of this invention is to provide a novel magnetic latch structure for circuit interrupters.

Another object of this invention is to provide a magnetic latch structure which has a rotatable armature.

A further object of this invention is to provide a novel armature for a magnetic latch structure which pivotally rotates about its center of inertia.

Another object of this invention is to provide a novel magnetic latch structure which is not subject to pull-in forces subsequent to release of the armature.

Still another object of this invention is to provide a novel rotary armature for a magnetic latch structure which is magnetically sealed in the armature open position as well as in the armature closed position.

These and other objects of this invention will become apparent from the following description when taken in connection with the drawings, in which:

FIGURE 1 schematically illustrates a typical prior art magnetic latch structure.

FIGURE 2 is a diagram of the magnetic holding force on the armature as a function of the ampere turns generated by the control winding in FIGURE 1.

FIGURE 3 is a side plan view of the novel latch structure of the invention.

FIGURE 4 is a side view of FIGURE 3 with the rotating armature in its sealed position.

FIGURE 5 is similar to FIGURE 4, and illustrates the armature of FIGURE 4 in its open position.

FIGURE 6 is a side plan view of a second embodiment of the invention.

FIGURE 7 is a side view of FIGURE 6 with the armature in its closed armature sealed position.

FIGURE 8 is similar to FIGURE 7, but illustrates the armature rotated to its sealed open position.

Referring first to FIGURE 1, I have schematically illustrated therein a typical prior art magnetic latch system using the flux shifting technique. Thus, in FIGURE 1, a magnetic structure is provided which has two yokes 10 and 11 connected by magnet legs 12, 13 and 14. The leg 12 has a permanent magnet 15 inserted therein, or some other suitable source of unidirectional flux such as a D.-C. winding.

The leg 13 then has an air gap 16 therein, and carries the control winding 17 which can be connected to positive and negative D.-C. terminals 18 and 19, which are connected to some suitable source and are in series with a circuit control means such as variable resistor 20.

The leg 14 has an air gap 22 therein for defining a flux path through a magnetic armature 23. Magnetic armature 23 is then connected to a suitable shaft 24 which is connected to a biasing spring 25, which is fixed at its upper end as illustrated, and pulls armature 23 away from the magnet structure with some predetermined spring force.

The armature 23 or its extending shaft 24 is then suitably connected, as illustrated by dotted line 26, to a movable contact 27 which moves into and out of engagement with stationary contact 28. That is to say, when armature 23 is sealed in the position illustrated in FIGURE 1, contacts 27 and 28 are closed. When, however, the armature 23 is moved away from its sealing position by spring 25, contacts 27 and 28 are open. Note that the armature

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23 could either operate the contacts directly or, alternatively, could operate a latch mechanism which, in turn, controls the contact position of contact 27.

In operation, the permanent magnet 15 generates a flux having components ϕ_1 and ϕ_2 . The flux component ϕ_2 is substantially higher than ϕ_1 in view of the air gap 16 in leg 13. The control winding 17 then generates a flux having the components ϕ_3 and ϕ_4 shown in FIGURE 1, where the component ϕ_3 is in opposition to the flux ϕ_2 , while the component ϕ_4 is additive with component ϕ_1 .

So long as flux component ϕ_2 is sufficiently greater than ϕ_3 , the net flux through armature 23 will be sufficient to hold it sealed to the magnet body. When, however, it is desired to release armature 23, and thus open contacts 27 and 28, the current through coil 17 is increased as by appropriate adjustment of adjustable resistor 20 so that the net flux $\phi_2 - \phi_3$ decreases to a sufficiently low value to permit spring 25 to move the armature out of its sealed engagement with its magnet body. Alternatively, the connection of an additional D.-C. voltage signal to terminals 18 and 19 through some automatic sensing circuit, or the like, could cause the required current increase in coil 17 to decrease the net armature flux.

FIGURE 2 shows the holding force F_H as a function of the armature flux $\phi_2 - \phi_3$. The curve of armature flux $\phi_2 - \phi_3$ is a straight line which crosses zero flux and goes negative as N_{11} increases. F_H is obtained by squaring this armature flux $\phi_2 - \phi_3$, which results in the parabola shown.

A major difficulty with this type arrangement is schematically illustrated in FIGURE 2 wherein it is seen that the holding force holding the armature 23 against the magnet will decrease below the spring force to obtain release of armature 23 with a suitable increase of the ampere turns N_{11} , where, however, a continued increase in the ampere turns N_{11} will again cause the holding force to increase above the spring force of spring 25.

Under this condition, and if the armature 23 has not moved far enough away from the magnet at the time the holding force is increased beyond the spring force, the armature will inadvertently be pulled in. This condition is aggravated in the presence of mechanical shock forces which could tend to cause the armature 23 to be jarred toward the pole faces of the magnet, thus increasing the likelihood of recapture by the magnet after the control current is increased by a sufficient value.

In accordance with the present invention, a novel structure is provided wherein the armature 23 is caused to be a rotary armature which rotates around its center of inertia, whereupon mechanical shock forces are dynamically balanced and will not tend to move the armature back toward the magnet.

A first embodiment of the invention is illustrated in FIGURES 3, 4 and 5, wherein the magnet is formed of two magnetic yokes 30 and 31. The right-hand end of yokes 30 and 31 are then connected together through a permanent magnet 32 which has a North pole on its upper face and a South pole on its lower face. The connection between yokes 30 and 31 and permanent magnet 32 are effected by suitable bolts such as the bolt 33 in FIGURE 3 which is captured by nut 34.

A second leg connecting yokes 30 and 31 is the leg 35 which receives the control coil 36 which has extending leads 37 and 38. The leg 35 is secured to the upper yoke 31 by suitable screws such as screw 35a which extends into suitable tapped openings in leg 35. The leg 35 has a length less than the spacing between yokes 30 and 31 so that an air gap 35b is defined between leg 35 and yoke 30. Coil 36 is equivalent to coil 27 of FIGURE 1.

The left-hand end of yokes 30 and 31 are then joined by a nonmagnetic bearing block 39 which could be of brass and has a central opening therein. The bearing block 39 is secured between yokes 30 and 31 as by suitable screws 39a, 39b, 39c, 39d and 39e. This central opening rotatably receives a shaft 40 extending from the rotatable armature 41. The shaft 40 may then be op-

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eratively connected to a latching mechanism or may be connected directly to the movable contact 50 which cooperates with stationary contact 51, as schematically illustrated in FIGURE 3.

As further schematically illustrated in FIGURE 4, the armature 41 is operatively connected to the biasing spring 52 which biases armature 41 for rotation in a clockwise direction, and out of the sealing engagement shown in FIGURE 4 and toward the position of FIGURE 5. Note that the spring 52 could be connected to shaft 40, if desired.

The operation of the magnet structure of FIGURES 3, 4 and 5 is substantially identical to that of FIGURE 1, where FIGURE 3 indicates the flux components ϕ_1 , ϕ_2 , ϕ_3 and ϕ_4 in a manner similar to that of FIGURE 1. Thus, in operation, the leads 37 and 38 of coil 36 have impressed thereon a suitable current for generating a flux component ϕ_3 in opposition to the flux component ϕ_2 whereby a net flux passes through armature 41 which is sufficient to retain it in the sealed position of FIGURE 4. When, however, it is desired to open contacts 50 and 51, the current through coil 36 is increased, whereupon flux component ϕ_3 increases to buck down flux component ϕ_2 until the holding force on the armature 41 decreases below the spring force of spring 52, whereupon the armature is rotated to the position of FIGURE 5.

Note that since the armature 41 is dynamically balanced around the center of shaft 40, mechanical shocks applied to the device will not tend to move the pole faces of armature 41 toward the corresponding pole faces of yokes 30 and 31, thus decreasing the likelihood of an inadvertent pull-in caused by the continued increase of current in coil 36 and the reversal of flux from yokes 30 and 31 through armature 41 to a value sufficient to pull in armature 41.

In order to further prevent the possibility of pull-in, a second embodiment of the invention illustrated in FIGURES 6 through 8 provides a second pair of pole faces for the rotating armature which insures that the pull-in force will retain the armature in its open position. Thus, referring to FIGURES 6, 7 and 8 wherein components identical to those of FIGURES 3, 4 and 5 are given similar identifying numerals, the shape of the armature has been altered to that shown for the armature 60.

Thus, in FIGURES 6, 7 and 8, the armature 60 has two pole faces 61 and 62 similar to the pole faces provided for armature 41 in FIGURES 3, 4 and 5, and, in addition has a second pair of diametrically opposed faces 63 and 64. The pole faces 61 and 62 in FIGURES 6, 7 and 8 are the diametrically opposite pole faces which normally seal-in the magnet.

If now the armature 61 is released due to increasing current through control coil 36 and the spring force of spring 52, and the armature is rotated in a clockwise direction in FIGURES 7 and 8, it will be observed that the auxiliary or seal-open pole faces 63 and 64 will approach the yokes 30 and 31. If the pull-in force generated by the continued increase of coil 36 exceeds the opening force of spring 52, the pole faces 63 and 64 will be adjacent yokes 30 and 31, and it is these pole faces which will be sealed to yokes 30 and 31, thus retaining armature 60 rotated in a clockwise direction, as shown in FIGURE 8, with the excessive and inadvertent pull-in force now aiding the spring 52 in retaining armature 60 in its counter-clockwise position.

Thus, the armature 60, when designed with two diametrically opposed pairs of pole faces, will be accelerated in a clockwise direction and retained in a clockwise direction by a "motor" action applied to armature 60.

Although this invention has been described with respect to its preferred embodiments, it is to be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited not by the

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specific disclosure herein but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. A magnetic latch structure comprising an armature of magnetic material and a magnet structure; said magnet structure comprising a first closed magnetic path including a pair of spaced pole faces and a source of unidirectional magnetic flux, and a second closed magnetic path including a variable source of ampere turns and said pair of spaced pole faces; said second closed magnetic path having a higher magnetic reluctance than said first closed magnetic circuit; said armature comprising a rotatable body of magnetic material having a pair of diametrically opposite pole faces; pivotal mounting means connected to a central portion of said armature; said armature being disposed between said pair of spaced pole faces of said magnet structure; said pair of diametrically opposite pole faces of said armature engaging respective pole faces of said spaced pole faces; said armature being rotatable about the said pivotal mounting means to move said pair of diametrically opposite pole faces away from their said respective spaced pole faces; and a second pair of diametrically opposed pole faces on said armature; said second pair of pole faces being movable into engagement with respective pole faces of said spaced pole faces when said pair of diametrically opposed pole faces move away from said spaced pole faces of said magnet.

2. A magnetic latch structure comprising a pair of spaced magnetic yoke members having first and second ends, an end leg magnetic member extending between said first ends of said pair of spaced magnetic yoke mem-

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bers, a central leg section extending between central portions of said spaced magnetic yoke members, a nonmagnetic spacer member extending between said second ends of said pair of spaced magnetic yoke members, and a rotatable armature pivotally mounted on said nonmagnetic spacer and between magnetic pole surfaces of said second ends of said magnetic yoke members; said end leg magnetic member including flux generating means therein; said central leg section having an air gap therein; said central leg section having a control winding wound thereon; said armature having first and second engaging surfaces engaging said respective magnetic pole surfaces of said second ends of said magnetic yoke members; said first and second engaging surfaces being disposed on opposite sides of the axis of rotation of said armature; said armature having third and fourth engaging surfaces disposed on opposite sides of the axis of rotation of said armature; said third and fourth engaging surfaces being rotatable into engagement with said respective magnetic pole surfaces of said second ends of said magnetic yoke members when said armature rotates about the axis thereof.

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