

May 2, 1967

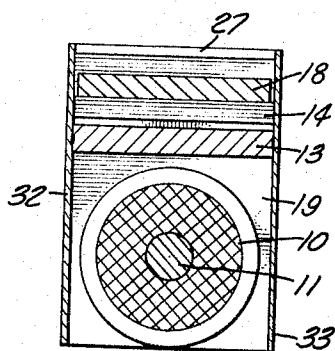
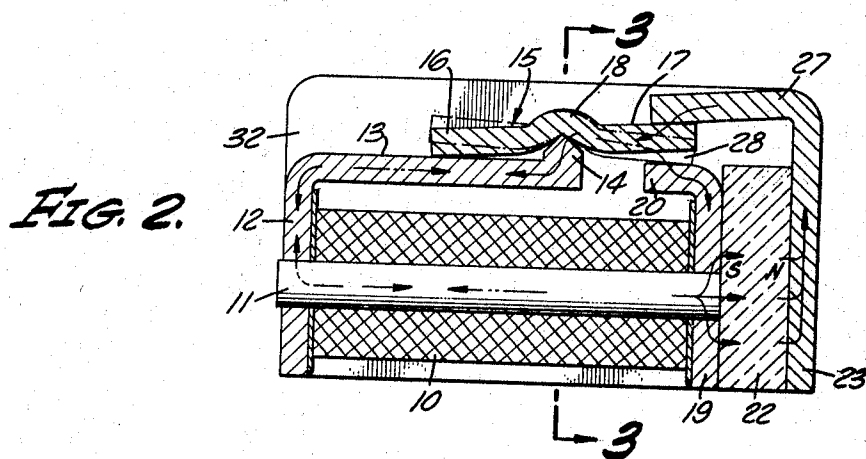
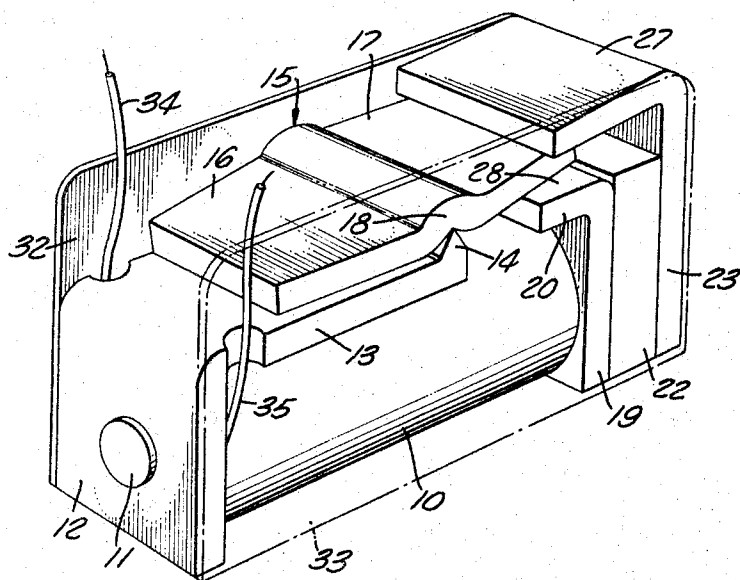
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3,317,871

MAGNETICALLY OPERATED ACTUATOR

Filed Sept. 20, 1965

2 Sheets-Sheet 1



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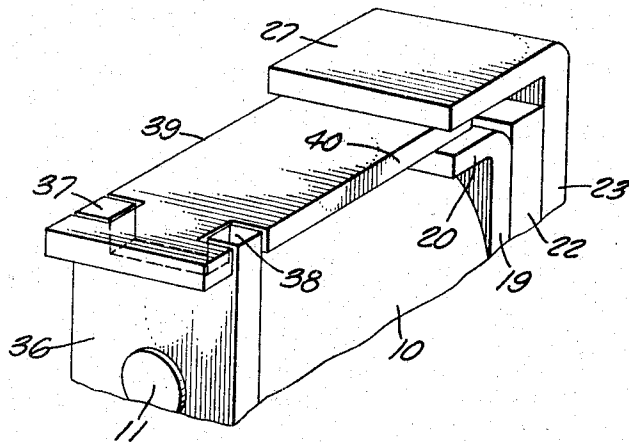


FIG. 4.

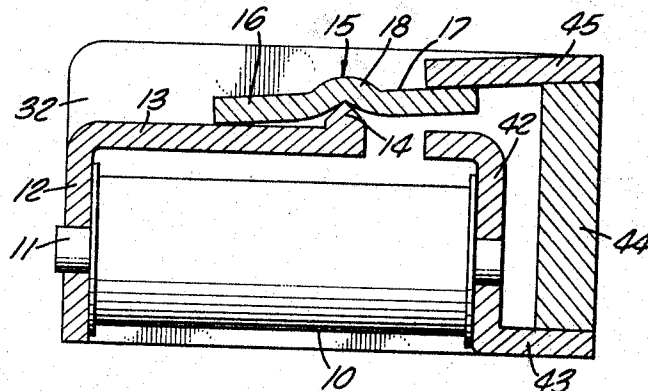


FIG. 5.

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MAGNETICALLY OPERATED ACTUATOR

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1 Claim. (Cl. 335—230)

This invention pertains to an actuating device operated by electromagnetic forces and especially adapted for use as a relay motor or the like.

The present invention provides a unique arrangement for rotating and holding a reciprocating armature, such as a relay armature. By this design, when the actuating coil is de-energized, the armature is held at one end of its stroke by the flux of a permanent magnet. When current is passed through the coil of the unit, the armature is rotated to its alternate position where a retaining force is applied only so long as the current is flowing. This contrasts with normal latching relays in which the armature is held at both ends of its stroke. The arrangement of this invention is characterized by a high holding force to retain the armature in its normal de-energized position, yet the armature rotates to the opposite direction quite rapidly and without the application of a particularly high force from the electromagnet.

This is accomplished by a construction wherein the armature is mounted on one pole piece of the coil and has an end that can engage the other pole piece of the coil. A permanent magnet is provided with a pole piece having an extension adjacent but spaced from the second pole piece of the electromagnet. The armature, therefore, can pivot between this extension and the second coil pole piece. When the coil is de-energized, the armature is held against the pole piece extension of the permanent magnet, with the flux circuit extending from the armature through the first pole piece and back through the core of the coil to the permanent magnet. Upon energizing the coil, the armature rotates to a position of engagement with the second pole piece of the coil, where it will be retained as long as the current is flowing. The flux generated by the coil opposes that of the permanent magnet, neutralizing the magnet flux and providing a force to pull the armature to its alternate position. This also results in a repelling force between the armature and the pole piece of the permanent magnet, which assists in the armature movement. This permits the use of a smaller coil than required by conventional relay motors, or the coil may be of normal size and result in a relay construction where there is a much greater retaining force than in previous designs. The necessity for a return spring is eliminated. The permanent magnet will not hold the armature in its alternate position, so that no appreciable retaining force is exerted at the second pole piece once the current is interrupted. Hence, while the permanent magnet strongly holds the armature in one position, there is no retaining force for the armature in the other position.

An object of this invention is to provide an improved motor device incorporating a pivotal armature.

A further object of this invention is to provide a motor having a reciprocative armature held at one end only of its stroke, and eliminating the need for a retaining spring.

Another object of this invention is to provide a motor device where the armature is retained securely at one end of its stroke, yet the retaining force is neutralized when the device is energized.

An additional object of this invention is to provide a motor exerting a high retention force on the armature at one end of its stroke, yet providing for rotation of the armature to its alternate position with the application of a relatively small force by the electromagnet.

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These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a perspective view of the device of this invention;

FIGURE 2 is a longitudinal sectional view of the arrangement of FIGURE 1;

FIGURE 3 is a transverse sectional view of the arrangement of FIGURE 2;

FIGURE 4 is a perspective view of a modification using a clapper-type armature instead of the balance armature of the previous embodiment; and

FIGURE 5 is a longitudinal sectional view of a modification utilizing a permanent magnet of a material having a lower coercive force than the higher coercive material employed in the other embodiments.

With particular reference to FIGURES 1, 2 and 3 of the drawing, the device of this invention includes an electromagnetic coil 10 having a core 11 extending axially through its center. At the left-hand end of the coil, as it is illustrated, the core projects outwardly and into a pole piece 12. This pole piece is bent at right angles, providing an extension 13 that is doubled back over the coil and is parallel to the coil axis. The end of the pole piece extension 13 is provided with a transversely aligned V-shaped element 14. This acts as the bearing support for the armature 15. Other armature mounting arrangements may be used as desired. In this embodiment of the invention, a balanced armature is provided, with the element 15 having portions 16 and 17 of equal length extending oppositely from the pivot support 14. Hence, the armature will not tend to rotate under its own weight or under the influence of gravitational forces. The armature is recessed on its underside at the central part 18 to properly locate it on the support 14.

At the right-hand end of the coil 10, as illustrated the core 11 extends outwardly into a second pole piece 19. This pole piece also includes an extension 20 at right angles to the portion of it that engages the core. The section 20 extends inwardly of the coil toward the pole piece extension 13, but is shorter than that pole piece and spaced from it. This positions the pole piece extension 20 beneath the end 17 of the armature 15.

Adjacent the pole piece 19 is a permanent magnet 22. This type of magnet is most efficient with flux lines through its shorter dimension, so that the magnet 22 is arranged with its transverse dimension normal to the pole piece 19.

On the outside of the permanent magnet 22 opposite from the pole piece 19 is an additional pole piece 23. The pole piece 23 is generally L-shaped, including an extension 27 projecting toward the armature to a position above the extension 20 of the second pole piece of the coil. Consequently, the end 17 of the armature is rotatable in the gap 28 between the pole piece extension 27 and the pole piece extension 20.

When the coil 10 is de-energized, the permanent magnet 22 provides a flux field that holds the armature in the position shown in FIGURES 1 and 2. The flux of the permanent magnet flows, as indicated by the solid-line arrows, through the pole piece 23 to the armature 15, and from the armature through the pole piece 12 into the core 11. The flux is conducted back to the permanent magnet through the core 11 and the pole piece 19. Hence, there is a closed circuit for the flux of the magnet 22 so that the magnet 22 securely holds the armature against the pole piece extension 27.

The coil 10 is connected in its electrical circuit so that it will produce a flux field through the core 11 in a direction opposite from the flux of the permanent magnet 22, as indicated by the phantom-line arrows in FIGURE 2. Therefore, when energized, the coil produces

flux which opposes the flux of the permanent magnet. As the coil flux increases from energization of the coil, it reduces the net holding force of the magnet because the fluxes are bucking each other.

Ultimately the coil flux will build up to where it completely nullifies the flux of the magnet. Eventually the coil flux field also will cause the gap 28 between the extensions 27 and 20 to become a lower reluctance path for the magnet's flux than its original circuit through the armature and core as indicated by the solid-line arrows. Hence, some of the permanent magnet flux will be diverted across the gap 28 between the pole piece extension 27 and the pole piece extension 20, to flow through the pole piece 19 into the magnet 22. Consequently, as the coil flux builds up, it neutralizes the flux of the magnet and diverts its path so that the magnet no longer retains the armature. Beyond this point, added coil flux across the gap 28 causes an attractive force to be exerted at the pole piece extension 20. Therefore, the coil flux will pull the end 17 downwardly to rotate the armature to its alternate position. The coil also creates a repelling force between the armature and the pole piece extension 27. This is because the flux of the permanent magnet produces one polarity in the extension 27, while the oppositely flowing flux of the coil produces the same polarity at the adjacent face of the armature. Hence, another increment of force is imposed on the armature, again urging its rotation to the alternate position. There is a combined effect on the armature as a result of this as the forces work to move the armature in the same direction.

At some established point, therefore, the combined forces on the armature provided by the coil's flux causes the armature to trip over to the position shown in phantom lines where the armature end 17 is in engagement with the pole piece extension 20. This movement will take place with rapidity when the critical point is reached. Nevertheless, by bucking the flux of the permanent magnet, providing an attracting force at the pole piece 20 and a repelling force at the pole extension 27, the coil need not be a size to generate an especially large force. In fact, the coil itself may exert a lesser force on the armature than does the magnet when the coil is de-energized. It is through the arrangement of neutralizing and diverting the permanent magnet flux and applying torque to the armature as described above that this phenomenon can be accomplished.

When the armature reaches its phantom-line alternate position, it will be held with appreciable force only so long as current is passed through the coil. When the coil current is interrupted, only a small amount of residual magnetism will tend to retain the armature in its alternate position. Consequently, the armature can be returned easily to its original position.

The invention is illustrated in FIGURE 1 with nothing attached to the armature 15, although naturally it will be utilized in imparting motion to some other device. Frequently, it will be incorporated in a relay, and the motion of the armature employed in shifting contacts between open and closed positions. In addition to the arrangement for moving the contacts or the like, which is not shown, the unit will include some further structure such as the light sheet metal sides 32 and 33 which can be used to hold the unit together and prevent the armature from slipping off its knife-edge support 14. In FIGURE 1, the leads 34 and 35 for the coil also may be seen.

When used for a relay, therefore, the actuator of this invention serves to hold the relay in its de-energized position by means of a permanent magnet instead of a spring. For a coil size comparable to conventional designs, the corresponding permanent magnet will hold the relay in the de-energized position with far greater force than is possible when utilizing a spring. This means that there is a high retention force to overcome the

effects of shock and vibration, and consequently the relay has superior environmental capabilities. In using the present actuator, it is not necessary to overcome a strong spring force in rotating an armature. Instead, the permanent magnet which serves to retain the armature is, in effect, turned off by the opposing flux of the coil. The retaining means, therefore, does not continue to work against the actuating force as in conventional designs, but instead is eliminated when the coil is energized. As a result, the coil can exert a much higher force on the armature and can hold the armature in its alternate position likewise with greater force.

As the invention illustrated in FIGURE 4, an unbalanced clapper-type armature is utilized instead of the balanced armature of the previously described arrangement. In other aspects this design is the same as that of FIGURES 1, 2 and 3. Hence, at the right-hand end of the relay the same pole piece 19, permanent magnet 22 and pole piece 23 are provided. At the left-hand end, however, a straight pole piece 36 connects to the core 11 and extends laterally outwardly with respect to the core. This pole piece 36 is recessed across the central part of its outer edge to provide ears 37 and 38 at the corners. The armature 39 is a straight member, having notches in its edges so that it fits between the ears 37 and 38 and is pivotally retained by the pole piece 36.

The outer end 40 of the armature 39 is interposed between the pole piece extensions 20 and 27, and these pole pieces limit the stroke of the armature movement. The circuitry for the magnetic flux is basically the same as before. When the coil is de-energized, the flux passes from the magnet through the pole piece 23 to the armature 39, to pole piece 36 and the core 11. When energized, the reverse flux of the coil opposes the flux of the permanent magnet and gain neutralizes the holding force of the magnet. Hence, the coil will create a combination of forces that will drive the armature rapidly through its stroke to the point of engagement with the pole piece extension 20, where the armature will remain until electric current is removed.

The arrangement of this invention can incorporate a low coercive type of permanent magnet, such as an alnico magnet or one of similar material, if desired instead of utilizing a magnet of high coercive type material, such as a ceramic magnet. The appropriate magnet will be selected to suit the particular circumstances that the motor device of this invention will encounter. Ceramic magnets have the disadvantage of being somewhat temperature sensitive, which is not the case for alnico magnets. On the other hand, ceramic magnets are not as subject to discharge from the presence of a strong magnetic field as are metal magnets.

A different mounting arrangement is necessary for a low coercive magnet when the magnet is of the usual type magnetized through its longitudinal dimensions. As shown in FIGURE 5, the pole piece 42 at the right-hand end of the coil is made substantially Z-shaped to provide a bottom end portion 43 abutting the permanent magnet 44. This engagement is at one end, and hence at one pole of the magnet 44. The other end of the magnet 44 projects laterally to one side with respect to the coil, and a pole piece 45 is fastened to the magnet at that location. The remaining components of the unit of FIGURE 5 are the same as those in FIGURES 1, 2 and 3. Again, the flux circuit is substantially unchanged. With the coil deenergized, flux flows from the magnet 44 through the pole piece 45 to the armature 15, the pole piece 12 and into the core 11. Out of the core 11 the flux returns to the magnet through the pole piece 42, entering at the bottom end of the magnet. The action of the coil in rotating the armature to its alternate position is the same as described before.

From the foregoing it may be seen, therefore, that I have provided an improved motor design which is capable of variations to suit the purpose at hand. In every in-

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stance, however, it provides for rapid armature rotation when the coil is energized and the permanent magnet is turned off. The permanent magnet will serve to securely hold the armature at one end of its stroke only, and is neutralized so that it will not resist rotation of the armature when the coil is energized.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claim.

I claim:

A motor drive comprising:

- (a) a selectively energizable electromagnet having a coil, a core in the coil, a first pole piece and a second pole piece, the pole pieces being spaced apart and in magnetic flux-conductive contact with the core at opposite ends thereof, the first pole piece having an extension extending inwardly over the coil from one end thereof approximately parallel with the axis of the core, the second pole piece having an extension extending inwardly over the coil from the other end thereof approximately parallel with the axis of the core, the extensions of the pole pieces being spaced apart from each other;
- (b) a permanent magnet having a north and a south magnetic pole and a pole piece member, one of the magnetic poles of the permanent magnet being in magnetic flux-conductive contact with the first pole piece of the electromagnet, the pole piece member of the permanent magnet being in magnetic flux-conductive contact with the other magnetic pole of the permanent magnet and having at least a portion extending inwardly over and approximately parallel with the extension of the first pole piece of the electromagnet, such portion being spaced apart from the

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extension of the first pole piece of the electromagnet to define a gap;

- (c) an armature pivotally mounted in magnetic flux-conductive contact on the second pole piece of the electromagnet, the armature having an end extending into the gap between the first pole piece of the electromagnet and the portion of the pole piece member such that the armature is in magnetic flux-conductive contact with such portion when the electromagnet is not energized, such contact establishing a flux path through the magnetic pole of the permanent magnet in contact with the pole piece member, the pole piece member of the permanent magnet, the armature, the second pole piece of the electromagnet and the core to the other magnetic pole of the permanent magnet; and
- (d) means for energizing the electromagnet to produce a flux path opposed to the flux path of the permanent magnet such that the armature is repulsed from the pole piece member and attracted towards the first pole piece of the electromagnet for magnetic flux-conductive contact with such first pole piece.

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