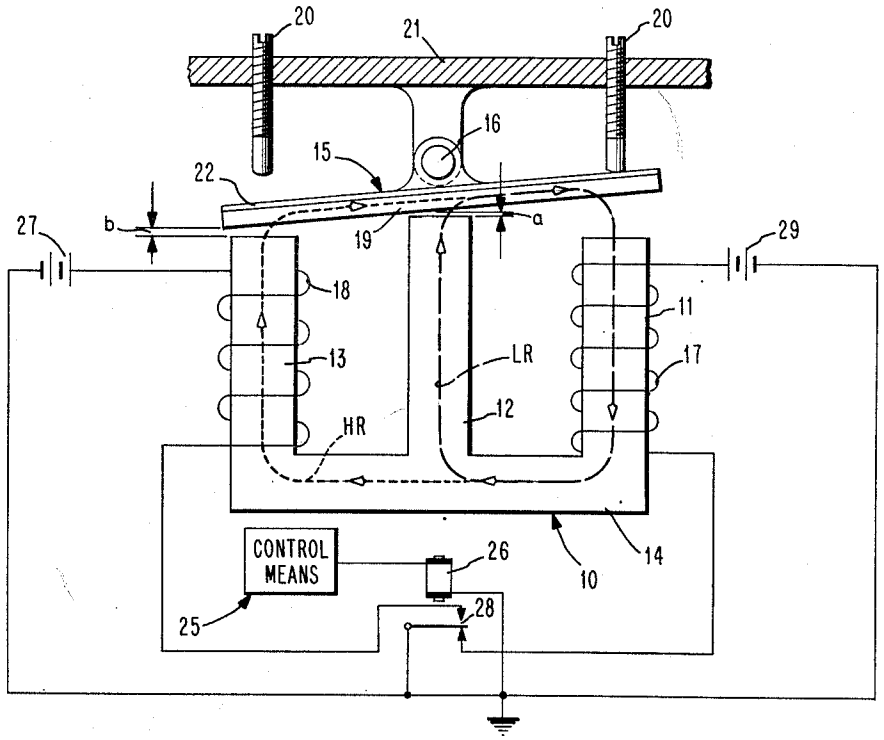
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DOUBLE-ACTING ELECTRO-MAGNETIC ACTUATOR

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DOUBLE-ACTING ELECTRO-MAGNETIC ACTUATOR

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This invention relates to electro-magnetic actuators, such as magnets, relays or the like, and relates more particularly to an improved double-acting electro-magnetic actuator having and E-type core and a rockable armature.

It is known to provide a double-acting electromagnetic actuator having a main coil and an auxiliary coil oppositely wound on one outer leg of an E-type core, and a single coil wound on the other outer leg of said core and series-connected with the auxiliary coil. If the main coil is de-energized and the single coil is energized, the flux induced in the leg surrounded by the auxiliary coil will oppose and tend to neutralize the residual or remanent flux in said leg remaining from previous energization of the main coil. This will cause said single coil rapidly to attract the armature to one position. However, when the main coil is energized and the auxiliary coil and single coil are de-energized, the flux induced in the outer leg surrounded by the main coil will be opposed by, and effectively reduced due to, the presence of the auxiliary coil. This undesirably results in a slower attraction of the armature to its other limit position. In this and other previously proposed arrangements, attempts to provide faster operation of an armature to one limit position are undesirably accompanied by a correspondingly slower operation of the armature to its opposite limit position.

It is therefore the principal object of this invention to provide an improved double-acting electro-magnetic actuator embodying only two coils and an armature which is attracted rapidly and positively to both of its two limit positions.

Another object is to provide an electromagnetic actuator wherein two coils are provided, each so wound around respective outer legs of a generally E-shaped core that, upon selective energization of one of the coils, the flux induced in the energized outer leg splits into two paths of different predetermined reluctances; wherein the majority of the flux is concentrated through the lower reluctance path including the center leg of the core, and a lesser portion of the flux leaks through the higher reluctance path to link the outer legs; and wherein the leakage flux is of such magnitude and direction as to oppose and substantially neutralize the remanent flux resultant from previous energization of the non-energized coil, thereby to provide rapid operation of the armature to both of its limit positions.

Still another object is to provide an improved electromagnetic actuator which is compact and extremely reliable in its operation and requires relatively few parts.

A further object is to provide an electromagnetic actuator which, without disassembly to remove core pins, can be readily adjusted to provide no residual air gap, if such be desired.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawing, wherein the single figure is a schematic view of an electro-magnetic actuator embodying the invention and certain electrical circuitry associated therewith.

The electro-magnetic actuator illustrated in the drawing comprises an E-type core 10 having three parallel legs 11, 12, 13 formed integrally with or joined to a common base 14 of magnetic material. An armature 15 is rockably supported on a fixed pin 16 disposed centrally above the center leg 12 of the core.

Coils 17 and 18 are contained in separate electrical circuits presently to be described. They are wound around outer legs 11, 13, respectively, in such manner that when the coils 17, 18 are selectively energized, flux will flow through the energized leg 11 or 13 in the same direction. For example, as illustrated, the flux flows down through leg 11 when coil 17 is energized, and flows down through leg 13 when coil 18 is energized; and flux flows in the opposite direction (i.e., upward) through such legs when gap *a* between the center leg 12 and the lower part 19 of the armature is less than the minimum air gap *b* between the armature part 19 and respective outer legs 11, 13. For example, gap *a* may be about one-third of gap *b*.

When one of the coils, for example coil 17, is energized while the other coil 18 is de-energized, a flux is induced in the energized outer leg 11. The majority of this flux (hereinafter called the "driving flux") is concentrated through a low reluctance path LR linking center leg 12 and energized outer leg 11, and also including part of base 14, air gap *a*, and armature part 19. A certain minor portion of the flux (hereinafter called the "neutralizing flux") will leak through a higher reluctance path path HR linking the two outer legs 11, 13 in bypass of center leg 12. This path HR also includes a greater part of base 14, air gap *b*, and armature part 19. Since the coils 17, 18 are wound in the manner above stated, the neutralizing flux will oppose and tend to offset the residual or remanent flux remaining from previous energization of coil 18.

So that the neutralizing flux will exactly or substantially exactly equalize and offset the residual driving flux, the flux path LR and HR must be accurately proportioned. This proportioning will, of course, be governed by such considerations as the relative dimensions of the air gaps *a* and *b*, the cross-sectional area of center leg 12 as compared to that of outer legs 11, 13 of the core, the particular magnetic properties of the materials used for the core, etc.

Concurrent adjustment of the air gaps *a* and *b* can readily be effected without disassembly of the actuator by positioning adjusting screws 20 which are carried by a closure plate 21. These screws are selectively contactable by the hardened upper part 22 of armature 15 to define the opposite limits of rockable movement of the armature on pin 16 and thus define the relative values of gaps *a* and *b*. Gaps *a* and *b* also assure that the armature part 19 and core legs 12, 11, 13 (which are formed of soft magnetic material) will not physically contact each other. Repeated low-oscillation contact of these parts could undesirably cause corrosion and erosion which, in turn, would reduce their useful life. It would also alter the degree of rockable movement of the armature and change the relative reluctances of the paths LR and HR, with the result that the neutralizing flux would no longer equally offset the residual flux. Changing the amplitude of the swing of the armature would also affect the degree of movement of an actuated element (not shown) which is operatively connected to the armature for control thereby.

Although the embodiment illustrated is preferred for the reasons just stated, the screws 20 may, if preferred, readily be backed off or eliminated so that no air gaps like *a* or *b* are provided when the armature 15 is in its respective limit positions; in other words, the limit positions will be defined by contact of the armature 15 with one

of the outer legs 11 or 13. In such case, the center leg 12 should be of somewhat larger diameter or area than would be acceptable when the air gaps *a* and *b* are used. This is to concentrate enough driving flux through the center leg 12 to provide a flux path of sufficiently low reluctance and decrease the proportion of leakage or neutralizing flux. This arrangement would have the obvious advantage of not requiring any setting of residual air gap.

On the other hand, instead of using a nonmagnetic medium, such as air, to provide gaps *a* and *b*, another non-magnetic medium or element, such as copper, could be used as a spacer to provide gaps of the same relative widths. This spacer could, for example, be secured to the free ends of the core legs and engaged by the armature, if an actuator is desired of the type wherein no setting of residual air gap is required.

Also, the armature 15 could be rockably supported on a pin 16 which is carried by the center leg of the core. Or pin 16 could be carried by a yoke formed of a non-magnetic element and secured to the free end of the center leg.

It will thus be noted that I have provided a double-acting electro-magnetic actuator having an armature which is rapidly and positively actuated to both of its two limit positions when two coils 17 and 18 are selectively and successively energized.

The coils 17, 18 are shown as being energized in the following simple manner. A control means 25 is provided which, for example, may be a sensing means that detects the presence or absence of certain coded information on a conventional record card or check. Under one condition, the control means 25 picks a relay 26 and thus completes a circuit from a battery 27 through coil 18 and the normally open point of a relay contact 28 to ground to energize said coil. Under the other condition, the control means 25 breaks the relay circuit to drop relay 26 and thus open the energizing circuit for coil 18 and complete another circuit for energizing coil 17. This last circuit includes a battery 29, coil 17 and the normally closed point of contact 28. Thus, the coils 17 and 18 are selectively and alternately energized; i.e., each coil is energized the instant the other coil becomes de-energized. The control means 25 would thus control positioning of the armature 15 which, in turn, may for sake of illustration be operatively connected to a pocket selector gate (not shown) that controls whether or not a card or check is diverted into a particular sort pocket.

The simple circuitry herein shown is disclosed for the purpose of simplified illustration only. It will be apparent to those skilled in the art that a transistorized circuit could readily be substituted for the circuitry herein disclosed to provide more rapid change of energization of the coils and thus take greater advantage of the rapid response times available with my actuator.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A double-acting electro-magnetic actuator comprising core means having three spaced legs joined to a comomn base, an armature rockably supported on a pivot near the free end of the intermediate leg, two coils each in different electrical circuits and each being the only coil wound around a different one of the outer legs, said coils being wound and the legs being configured such that upon selective energization of either one of the coils a flux will be induced, the major portion of which will go through a low reluctance path including the intermediate leg and energized outer leg to attract one end portion of the armature, and a minor portion of which will leak through a higher reluctance path including both outer legs and bypassing the intermediate leg to oppose and tend to neutralize the holding force exerted on the other end portion of the armature by the residual driving flux remaining from previous energization of the other coil.

2. A double-acting electro-magnetic actuator comprising core means having three spaced legs joined to a common base, an armature rockably supported on a fixed pivot and spaced by a non-magnetic medium from the free end of the intermediate leg, two coils each in different electrical circuits and each being the only coil wound around a different one of the outer legs, said coils and legs being so wound and configured respectively that upon selective energization of either one of the coils a flux will be induced, the major portion of which will go through a low reluctance path linking the intermediate leg and energized outer leg to attract one end portion of the armature, and a minor portion of which will leak through a higher reluctance path linking both outer legs in bypass of the intermediate leg, said minor portion being of such magnitude as to substantially neutralize the holding force exerted on the other end portion of the armature by the residual driving flux remaining from previous energization of the other coil.

3. A double-acting electro-magnetic actuator of the type comprising an armature rockably mounted on a pivot adjacent the free end of the intermediate leg of an E-type core, characterized by the provision of two coils each in separate circuits and each being the only coil wound around a different one of the outer legs, said coils being so wound and said legs being so configured that upon selective energization of either one of the coils the flux induced in the energized outer leg splits up into two paths, the major portion of the flux going through a low reluctance path including the intermediate leg and base of the core and the armature to attract the armature, a lesser portion of the flux going through a higher reluctance path including the non-energized outer leg and the base and armature to oppose and substantially neutralize the residual flux remaining in the latter leg from previous energization of the other coil, the flux paths being such that when one outer leg is energized the flux will flow in one direction through such leg, and when the other outer leg is energized the flux will flow in said one direction through said other leg.

4. A double-acting electro-magnetic actuator comprising core means having three spaced legs joined to a common base, an armature rockably supported on a pivot and spaced by non-magnetic medium from the free ends of the intermediate leg and outer legs, the minimum distance between the armature and intermediate leg being smaller than that between the armature and outer legs to provide a lower reluctance flux path through the intermediate leg than through the non-energized outer leg, two coils each in different electrical circuits and each being the only coil wound around a different one of the outer legs, said coils and legs being so wound and configured respectively that upon selective energization of either one of the coils the flux induced in the energized leg splits up into two paths, the major portion of the flux going through the lower reluctance path to attract the armature, a minor portion of the flux leaking through the higher reluctance path and being of such magnitude and direction as to substantially neutralize the residual flux remaining in the latter leg from previous energization of the other coil.

5. The combination according to claim 4, wherein the non-magnetic medium is a gas such as air, and including adjustable means for limiting oscillation of the armature to permit preselection and concurrent adjustment of said minimum distances.

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