

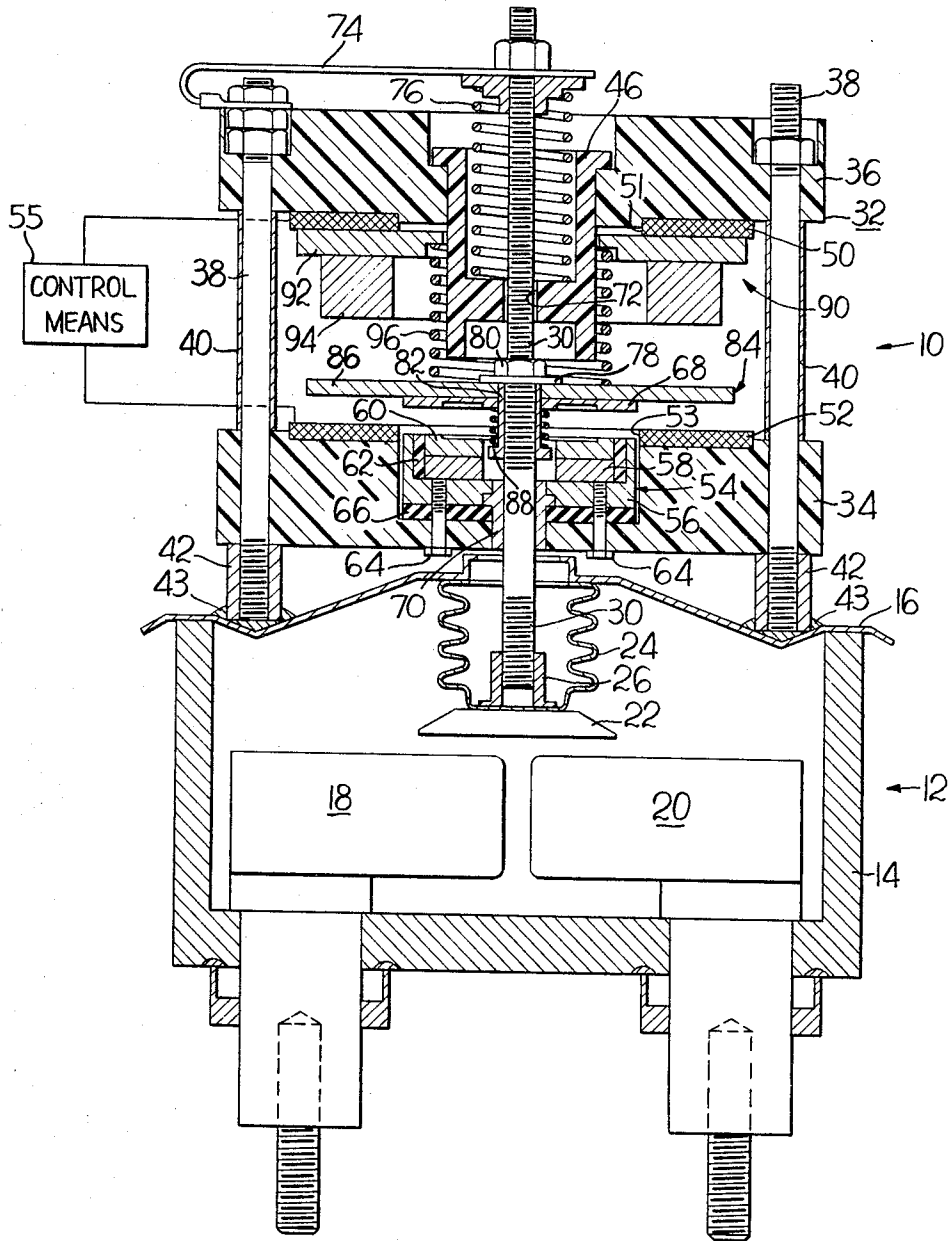
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MAGNETODYNAMIC ACTUATOR

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MAGNETODYNAMIC ACTUATOR

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ABSTRACT OF THE DISCLOSURE

A magnetodynamic actuator for operating a device, such as a vacuum switch, comprises a support upon which a pair of energizable coils are fixedly mounted in spaced apart relationship along an axis. A first electrically conductive member (aluminum disk) is mounted on a reciprocally movable shaft and is disposed adjacent one coil. A second electrically conductive member (copper disk) is movably disposed adjacent the other coil and is connected to the first disk by resilient means. Impulse energization of the said one coil repulses the aluminum disk away from the first coil and the shaft is moved to one position. Impulse energization of the said other coil repulses the copper disk and causes the resilient means to force the aluminum disk toward said first coil and the shaft is moved to its other position. Means are provided to latch the shaft in each of its several positions.

SUMMARY OF THE INVENTION

This invention relates generally to magnetodynamic actuators. More particularly, it relates to such actuators having a movable armature member which is repulsed to one or several positions by momentarily energized coil means and which is maintained in each position by latching means.

Electromagnetic actuators having magnetically permeable armatures reciprocally movable in response to energization of a pair of spaced apart coils are sometimes employed to operate devices such as switches or the like. Some actuators of this type employ coils which are required to be continuously energized to magnetically attract and maintain the armature in either or both of its operating positions. Other electromagnetic actuators employ coils which respond to impulse energization to effect reciprocal armature movement by magnetic attraction and use a permanent magnet or spring biasing means to retain the armature in at least one of its operating positions.

In accordance with the present invention there is provided a magnetodynamic (as distinguished from an electromagnet) actuator having a reciprocally movable armature member which is repulsed to at least one operating position by means of impulse energization of an operating coil and which is maintained in its operating position by suitable biasing means. The latter type of actuator is powerful and positive in operation.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide improved magnetodynamic actuators of the latter type.

Another object is to provide such actuators wherein components are shaped and arranged so as to provide maximum accelerating forces for opening and closing operations.

Another object is to provide such actuators having improved means for absorbing the high energy resulting from forceful operation.

Other objects and advantages of the invention will hereinafter appear.

DESCRIPTION OF THE DRAWING

The accompanying drawing illustrates a preferred embodiment of the invention but it is to be understood that

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the embodiment illustrated is susceptible of modifications with respect to details thereof without departing from the scope of the appended claims.

In the drawing, there is shown a cross sectional view of an electromagnetic actuator in accordance with the present invention and a vacuum switch with which it is employed.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawing, there is shown magnetodynamic actuator 10 according to the present invention which is associated with a device which it operates, such as a vacuum switch 12.

Switch 12 comprises an insulating housing 14 having a cover 16 in which a vacuum is maintained. A pair of spaced apart contacts 18 and 20 are rigidly mounted within housing 14 and are adapted to be bridged by a reciprocally movable bridging contact 22. Bridging contact 22 is connected to a movable switch operator which comprises a bellows 24 which is connected to cover 16 and which is provided with a connector 26 for attaching contact 22 to a reciprocally movable shaft 30 of actuator 10, hereinafter described. Switch 12 is shown in open condition, i.e., contacts 18 and 20 are unbridged. It is to be understood, however, that switch 12 is closed when contacts 18 and 20 are bridged by downward movement of contact 22.

Magnetodynamic actuator 10 has a support or frame 32 comprising a lower member 34 and an upper member 36 which are secured together by means such as bolts 38 upon which tubular spacers 40 are mounted. Support 32 is rigidly connected to switch 12 by having the bolts 38 thread into mounting studs 42 which are connected at 43 to cover 16 of switch 12. A spring retaining means 46 cylindrical in form is shown associated with upper member 36 of support 32 and, if preferred, could be integral therewith.

A first repulsion coil 50 in the form of a flat pancake winding with a central opening 51 is rigidly secured to the lower face of upper member 36 of support 32, as by an adhesive.

A second repulsion coil 52, similar to coil 50 and having a central opening 53, is similarly secured to the upper face of lower member 34 of support 32.

The coils 50 and 52 are adapted to be selectively and individually energized by momentary DC electrical current pulses by a suitable control means 55 to effect reciprocal movement of a movable means of actuator 10 which, in turn, moves the operator of switch 12, as will hereinafter be described. The movable means of actuator 10 comprises a lower portion 84 and an upper portion 90.

Energization of coils 50 and 52, as hereinafter explained, effects reciprocal movement of the movable means which is located between the coils. The movable means comprises an electrically conductive member 86 which is mounted on shaft 30 and further comprises another electrically conductive member 92 which rests on a resilient means or spring 96 on member 86. Conductive members 86 and 92 are understood to be made of materials having high electrical conductivity and are adapted to have high currents induced therein when the coils 52 and 50, respectively, are energized. In the embodiment shown, the movable means preferably has a relatively low mass so that it can be rapidly accelerated in either direction. Accordingly, conductive member 86 is an aluminum disk and other movable components are made of lightweight materials. However, conductive member 92 is a copper disk which weighs substantially more than disk 86 so that the energy transferred to disk 86 by disk 92, as hereinafter explained, is sufficient to drive the movable means downward (with respect to the drawing) with high

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momentum and afterward continues to press upon disk 86 to reduce contact bounce.

Shaft 30 of the movable means of actuator 10 is reciprocally movable along its axis and is connected to movable contact 22 of switch 12. Shaft 30 is supported and aligned by a sleeve 70 on lower member 34 of support 32 and by an opening 72 in sleeve 46. Disk 86 is mounted on shaft 30 in such a way as to effect reciprocal movement of the shaft but is resiliently connected in such a manner as to allow for limited relative movement and overtravel. Thus, disk 86 is movable between a flange at one end of a sleeve 82 on shaft 30 and a washer 78 at the other end held by a nut 80. Disk 86 is biased against washer 78 by a spring 88 surrounding sleeve 82. As hereinafter, explained, repulsion between disk 86 and coil 52 effects upward movement of shaft 30 to switch open position.

Disk 92 rests on a resilient means such as a compression spring 96 which in turn rests upon disk 86. As hereinafter explained, repulsion between disk 92 and coil 50 effects downward movement of disk 92, compression of spring 96, downward movement of disk 86, and downward movement of shaft 30 to switch closed position. Because disk 92 is relatively heavy, it has high momentum when moving and exerts a high inertial force on disk 86. Shock absorber means in the form of a sponge rubber ring 94 is located between the disks 86 and 92 and is preferably attached to the latter.

Latching means are provided for maintaining the movable means in the several positions into which it is moved. Thus, spring biasing means are provided to maintain shaft 30 in its upward or switch open position and such means take the form of a compression spring 76 located in spring retaining means 46 and a resilient strap 74 connected between shaft 30 and support 32. Permanent magnet means are provided to maintain shaft 30 in its downward or switch closed position and such means take the form of a permanent magnet assembly 54 mounted on lower member 34 of support 32 and a magnetically permeable pole piece 68 mounted on disk 86. Permanent magnet assembly 54 is located concentrically of coil 52 and comprises a magnetically permeable cup 56 in which an Alnico magnet 58 is secured as by an adhesive 62. Cup 56 is secured by bolts 64 and has a rubber disk shock absorber 66 located therebeneath. Permanent magnet assembly 54 is adapted to shape the permanent magnet field in such a way as to concentrate the flux in pole piece 68 for improved latching.

Actuator 10 and vacuum switch 12 associated therewith operate as follows, assuming that both are initially in the open or first position shown in the drawing. In this position the movable means is latched in a position wherein disk 92 is adjacent coil 50. To move the movable means to closed or second position, upper coil 50 is momentarily energized by a pulse of D.C. current. This causes an oppositely flowing electric current to be induced in copper disk 92 and similar magnetic fields are thereby established between coil 50 and disk 92 causing repulsion. Disk 92 moves away from coil 50 and causes spring 96 to be compressed against aluminum disk 86 to force the latter to overcome the bias of spring 88. Iron pole piece 68 then makes contact with pole piece 60 of permanent magnet assembly 54. Continued downward motion (overtravel) of heavy disk 92 maintains pole piece 68 in position with respect to permanent magnet assembly 54 for a length of time sufficient for magnetic flux linkages to build up and latch it in closed position. Compression of spring 88 by downward movement of pole piece 68 and disk 86 causes a force to be exerted on sleeve 82 and shaft 30 is thereby moved downward to closed position wherein it causes contact 22 of switch 12 to bridge contacts 18 and 20. Upward rebound of disk 92 and its related components is of no consequence and does not effect latch release. When the movable means is latched in closed or second position, spring 88 is slightly compressed and consequently exerts

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a downward force on sleeve 82, shaft 30 and bridging contact 22 to force the latter against contacts 18 and 20.

To move the movable means back to its first or open position, shown in the drawing, lower coil 52 is momentarily energized by a pulse of DC current. This causes an oppositely flowing electric current to be induced in aluminum disk 86 and like magnetic fields are thereby established between coil 52 and disk 86. Disk 86 moves away from coil 52 and causes spring 96 to be compressed against copper disk 92. Upward movement of disk 86 also exerts a force against abutment 78 on shaft 30 thereby causing the shaft to move upwardly and open contact 22. The upward movement of shaft 30 is aided by the upward biasing action of spring 76. Spring 76 supplies sufficient force to overcompensate for all associated gravitational forces and to hold shaft 30 in open position. As disk 86 continues its upward movement it hits resilient component 94 on disk 92 and causes disk 92 to hit and come to rest against upper coil 50. Disk 86 then bounces off component 94 and upward movement of disk 86 is checked.

In the embodiment of the invention disclosed herein, magnetodynamic actuator 10 comprises two repulsion coils and two electrically conductive members or disks 86 and 92. It is to be understood, however, that a greater or lesser number of coils and disks could be employed in accordance with the invention. Similarly, whereas the electrically conductive members are shown as solid metallic disks, it is apparent that these members could have some other form, for example, such as a member made of insulating material having a thin coating or plating of electrically conductive material such as gold. Finally, it will be apparent that other forms and arrangements of latching means might be provided.

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

1. In a magnetodynamic actuator for operating a device having movable operator,

a support,

at least one repulsion coil on said support adapted to be momentarily energized by an electrical pulse, movable means relatively movable with respect to said support and adapted to effect movement of said movable operator of said device,

said movable means comprising at least one electrically conductive member wherein electric currents are induced to generate a magnetic field of like field to that generated by said one repulsion coil, said conductive member having a first position adjacent said one repulsion coil and having at least a second position whereto it is repulsed in response to momentary energization of the latter,

and latching means on said support and on said movable means for maintaining the latter in its several positions.

2. An actuator according to claim 1 wherein said latching means comprises permanent magnet means for maintaining said movable means in at least one of its several positions and further comprises biasing means for maintaining said movable means in at least another of its several positions.

3. An actuator according to claim 2 wherein said permanent magnet means maintains said movable means in said first position and said biasing means maintains said movable means in its said other position.

4. In a magnetodynamic actuator for operating a device having a movable operator,

a support,

first and second spaced apart repulsion coils on said support,

each coil adapted to be momentarily energized by an electric pulse,

movable means relatively movable with respect to said support and adapted to effect movement of said movable operator of said device,

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said movable means comprising first and second electrically conductive members,

each electrically conductive member adapted to have electric currents induced therein to generate a magnetic field of like field to that generated by the repulsion coil associated therewith,

said movable means having a first position wherein said first electrically conductive member is adjacent said first repulsion coil and having a second position wherein said second electrically conductive member is adjacent said second repulsion coil,

said movable means being movable to either of its positions in response to repulsion of that electrically conductive member adjacent its respective coil when the latter is momentarily energized,

and latching means on said support and on said movable means for maintaining the latter in each of its several positions.

5. An actuator according to claim 4 wherein said first and second electrically conductive members are movable with respect to each other and wherein said movable means further comprises resilient means associated with both electrically conductive members whereby each of said electrically conductive members when repulsed by its respective repulsion coil drives the other electrically conductive member to the latter's position adjacent its respective repulsion coil.

6. An actuator according to claim 5 wherein said latching means comprises biasing means which biases one of said electrically conductive members into a position away from its respective repulsion coil and simultaneously causes said resilient means to bias the other of said electrically conductive members into its position adjacent its respective repulsion coil.

7. An actuator according to claim 6 wherein said latching means further comprises permanent magnet means for biasing the said one of said electrically conductive members into a position adjacent its respective repulsion coil.

8. An actuator according to claim 7 including shock absorber means mounted between said electrically conductive members.

9. In a magnetodynamic actuator for operating a device having a movable operator,
a support,
first and second spaced apart repulsion coils on said support,
each coil adapted to be momentarily energized by an electric pulse,

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a shaft mounted on said support and movable from a first position to a second position to effect operation of said movable operator of said device,

one electrically conductive member mounted on said shaft to effect movement of the shaft to first position when said second coil is momentarily energized, biasing means connected between said support and said shaft to latch the latter in said first position, permanent magnet means supported by said support and said shaft to latch the latter in said second position,

another electrically conductive member disposed between said first coil and said first electrically conductive member,

and a resilient means disposed between both of said electrically conductive members upon which said other electrically conductive member rests to effect movement of said shaft to second position when said first coil is momentarily energized.

10. An actuator according to claim 9 wherein said other electrically conductive member has substantially higher mass than said one electrically conductive member so that the energy transferred to said other member by said first coil is sufficient to drive said shaft to its second position.

11. An actuator according to claim 10 wherein said one electrically conductive member is resiliently connected to said shaft to allow for limited relative movement therebetween.

12. An actuator according to claim 11 wherein shock absorber means are mounted between both of said electrically conductive members.

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