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(54) Bistable magnetic actuator.

(57) A bistable magnetic actuator having a housing (1) of magnetic material within which an armature (7) of magnetic material is axially movable between two stable positions, the ends of the housing being closed by pole pieces (4,5), the armature having a push rod (9) axially slidably guided through one or each of the pole pieces, the housing containing a magnet coil (3) which extends inside the housing substantially from one pole piece to the other, the axial dimension of the armature being such that when the actuator is in either of its stable positions, an end of the armature is in abutment with or in close proximity to a corresponding one of the pole pieces and there is an axial gap (14) between the other end of the armature and the other of the pole pieces, permanent magnets (12,13) being provided which act on the armature and pole pieces in such a way as to cause the armature to be magnetically retained in whichever of the two stable positions it is situated, without energization of the coil, energization of the coil by an appropriately directed electric current pulse causing an increase in flux density at the end of the armature adjacent the gap and a decrease in flux density at the other end of the armature, resulting in movement of the armature into the other stable position, where it will stably remain after the coil is de-energized.

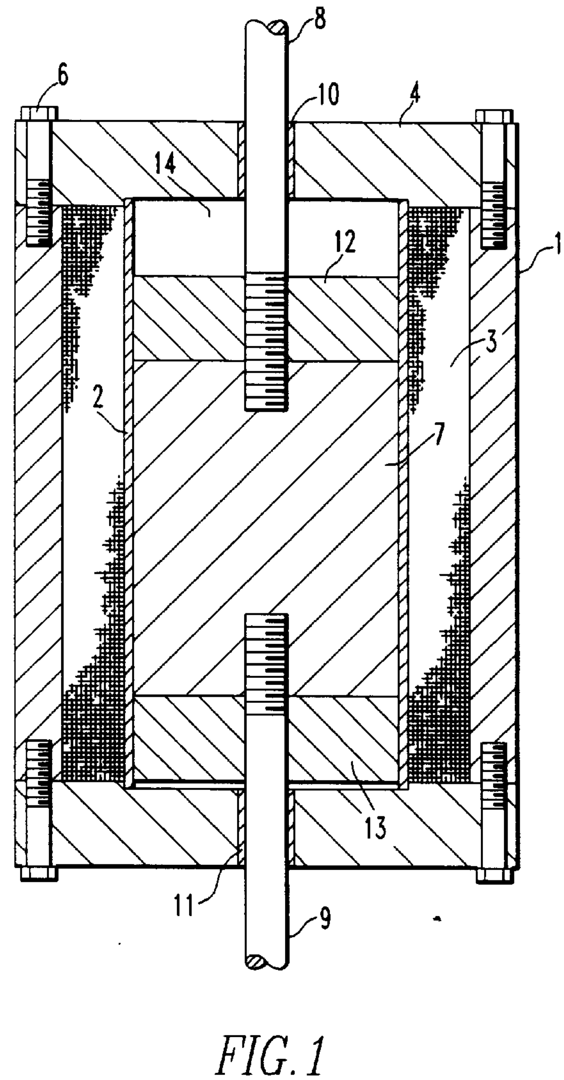

FIG. 1

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The invention relates to a bistable magnetic actuator.

Bistable magnetic actuators are used in electric circuit breakers and in other apparatus.

It is an object of the invention to provide a magnetic actuator which can retain either of its stable positions without needing electric energy to hold it in said position.

The invention consists in a bistable magnetic actuator having a housing of magnetic material within which an armature of magnetic material is axially movable between two stable positions, the ends of the housing being closed by pole pieces, the armature having a push rod axially slidably guided through one or each of the pole pieces, the housing containing a magnet coil which extends inside the housing substantially from one pole piece to the other, the axial dimension of the armature being such that when the actuator is in either of its stable positions, an end of the armature is in abutment with or in close proximity to a corresponding one of the pole pieces and there is an axial gap between the other end of the armature and the other of the pole pieces, permanent magnets being provided which act on the armature and pole pieces in such a way as to cause the armature to be magnetically retained in whichever of the two stable positions it is situated, without energisation of the coil, energisation of the coil by an appropriately directed electric current pulse causing an increase in flux density at the end of the armature adjacent the gap and a decrease in flux density at the other end of the armature, resulting in movement of the armature into the other stable position, where it will stably remain after the coil is deenergised.

In one embodiment of the invention, the permanent magnets are axially magnetised magnets mounted at the ends of the armature so as to form part of the armature body. In this embodiment like magnetic poles of the said magnets confront the pole pieces. The armature may be slidable, with clearance, in a brass tube liner with the coil being disposed between the said liner and the housing.

In another embodiment of the invention the permanent magnets are axially magnetised magnets stationarily mounted between the armature and the coil. In this embodiment like magnetic poles of the magnets confront and engage the pole pieces. Preferably, the dimensions of the armature, pole pieces and magnets are such that when the armature engages one pole piece the extended plane of its end engaging with said pole piece passes through the associated magnet between the poles but closer to the pole engaging the pole piece, the extended plane of the other end of the armature passing through the other magnet between the poles thereof but closer to the pole thereof remote from the other pole piece.

In either embodiment, advantageously the magnets are made from sintered neodymium.

In order to make the invention more clearly understood, reference will now be made to the accompanying drawings which are given by way of example and in which:-

Fig. 1 is an axial sectional view through an embodiment of a bistable actuator according to the invention;

Fig. 2 is an axial sectional view through another embodiment of a bistable actuator according to the invention;

Fig. 3 is an end view of the actuator of Fig. 2; and

Fig. 4 is a transverse sectional view along the line IV-IV of Fig. 3.

The bistable magnetic actuator of Fig. 1 comprises an outer shell 1 of magnetic material such as mild steel, within which a brass tube liner 2 is disposed, a magnetic winding 3, herein referred to as a coil, being disposed in the space between the shell 1 and the liner 2. The ends of the shell 1 are closed off by pole pieces 4 and 5 of magnetic material such as mild steel, the pole pieces being secured to the shell by screws 6.

Inside the brass tube liner 2 an armature 7 is provided, which can slide in the axial direction of the shell and tube, the armature 7 being guided for sliding movement by stainless steel rods 8 and 9 which are secured to the armature 7 and which slide in cylindrical brass bearing liners 10 and 11 mounted centrally in the pole pieces 4 and 5 respectively. There is a small clearance between the armature 7 and the brass tube liner 2.

At each end of the armature 7 a permanent magnet 12,13 is mounted, the magnets being axially magnetised and arranged, for example, so that the magnetic poles facing away from the body of the armature 7 are the same, for example both North poles.

The axial length of the armature 7, including the magnets 12 and 13 is such that when one of the magnets is in contact with one of the pole pieces, for example the magnet 13 is in contact with the pole piece 5, then there is an axial gap 14 between the other magnet and the other pole pieces. It is the axial length of the gap 14 that determines the stroke of the actuator in moving from one stable position to the other.

Assuming that the actuator is in the position shown in Fig. 1, it will retain that position without the coil being energised. The firmness with which the position is held, depends on the magnetic force existing between the magnet 13 and the pole piece 5. Preferably, the magnets are of neodymium which allows extremely high flux densities to be retained in the permanent magnets 12 and 13.

To move the actuator into the other stable position, a pulse of electric current is applied to the coil 3. The duration of the pulse, its magnitude and direction is preferably controlled by an electronic switch in order to ensure a controlled velocity and a uniform acceleration of the armature.

The pulse of electric current in the coil 3 creates a magnetic flux in such a way as to increase the flux density at the end of the coil adjacent the gap 14 and decrease the magnetic flux of the permanent magnet 13 holding the armature to the pole piece 5. Thus, by means of the pulse of electric current, the armature is caused to move so as to bring the magnet 12 onto the pole piece 4, at the same time creating an axial gap between the magnet 13 and the pole piece 5. Thus, the armature is moved from its first stable position into its other stable position, which it retains without continued actuation of the coil 3.

The stainless steel rod 8 serves to transfer the axial movement of the armature 7 onto a switching device, for example a circuit breaker.

The embodiment of Figs 2 to 4, comprises an outer shell 101 of magnetic material such as mild steel within which an annular coil 103 is disposed. The opposite ends of the shell 101 are closed off by pole pieces 104 and 105 of magnetic material such as mild steel, the pole pieces being secured to the shell 101 by screws 106.

Inside the coil, an armature 107 is provided, which can slide in the axial direction of the shell, the armature 7 being guided for sliding movement by non-magnetic rods 108 and 109, for example of stainless steel, running in bearings 110 and 111 in the pole pieces 104 and 105. The armature 107 slides in a cylindrical brass liner 112 which is coaxial with the coil 103 and the shell 101. There is a small clearance, for example 1mm, between the armature and the inside of the brass tube liner 112.

Between the coil 103 and the brass liner 112, two annular disk magnets 113 and 114 are provided, the magnets being axially magnetised and arranged so that their North pole faces engage the respective pole pieces 104 and 105. Preferably, the magnets are made of sintered neodymium segments. Such magnetic material enables extremely high magnetic forces to be provided by a small volume of material.

Between the opposed South pole faces of the magnets, filling material 115 and a brass packer 116 are provided.

The dimensions of the above-described components are such that when the armature is in one of its stable positions, with the armature abutting for example the pole piece 104, there is an axial air gap 117 between the armature 107 and the other pole piece 105.

Because of the magnetic action exerted on the armature by the magnets, the armature will remain stably in the position illustrated in Fig. 2, without the coil 3 being energised, until an appropriate pulse of electric current is applied to the coil 103. The electric current pulse in the coil 103 creates a magnetic flux in such a way as to increase the flux density at the end of the actuator where the air gap 177 is, and decrease the magnetic flux of the permanent magnet holding the armature against the pole piece 104. Thus, by means of the electric current pulse, the armature 107 is caused to move into the other stable position, the air gap 117 no longer being present, but a corresponding air gap appearing between the pole piece 104 and the armature 107.

Although reference has been made herein to the armature abutting one or the other pole piece, there may be a small clearance between the armature and pole pieces when in the 'abutting' position, as a result of limit stops provided in a linkage to which the actuating rods 8, 9 or 108, 109 may be connected.

This invention is in respect of the bistable actuator. Any known means for providing the controlling electric current pulses may be used.

Claims

1. A bistable magnetic actuator having a housing of magnetic material within which an armature of magnetic material is axially movable between two stable positions, the ends of the housing being closed by pole pieces, the armature having a push rod axially slidably guided through one or each of the pole pieces, the housing containing a magnet coil which extends inside the housing substantially from one pole piece to the other, the axial dimension of the armature being such that when the actuator is in either of its stable positions, an end of the armature is in abutment with or in close proximity to a corresponding one of the pole pieces and there is an axial gap between the other end of the armature and the other of the pole pieces, permanent magnets being provided which act on the armature and pole pieces in such a way as to cause the armature to be magnetically retained in whichever of the two stable positions it is situated, without energisation of the coil, energisation of the coil by an appropriately directed electric current pulse causing an increase in flux density at the end of the armature adjacent the gap and a decrease in flux density at the other end of the armature, resulting in movement of the armature into the other stable position, where it will stably remain after the coil is deenergised.

2. An actuator as claimed in claim 1, wherein the permanent magnets are axially magnetised magnets mounted at the ends of the armature so as to form part of the armature body.

3. An actuator as claimed in claim 2, wherein like magnetic poles of the said magnets confront the pole pieces.

4. An actuator as claimed in claim 1, 2 or 3, wherein the armature is slidable, with clearance, in a brass tube liner with the coil being disposed between the said liner and the housing.

5. An actuator as claimed in claim 1, wherein the permanent magnets are axially magnetised magnets stationarily mounted between the armature and the coil.

6. An actuator as claimed in claim 5, wherein like magnetic poles of the magnets confront and engage the pole pieces.

7. An actuator as claimed in claim 5 or 6, wherein a brass liner in which the armature is slidable, with clearance, is provided between the magnets and the armature.

8. An actuator as claimed in claim 5, 6 or 7, wherein the dimensions of the armature, pole pieces and magnets are such that when the armature engages one pole piece the extended plane of its end engaging with said pole piece passes through the associated magnet between the poles but closer to the pole engaging the pole piece, the extended plane of the other end of the armature passing through the other magnet between the poles thereof but closer to the pole thereof remote from the other pole piece.

9. An actuator as claimed in any one of claims 1 to 8, wherein the magnets are made from sintered neodymium.

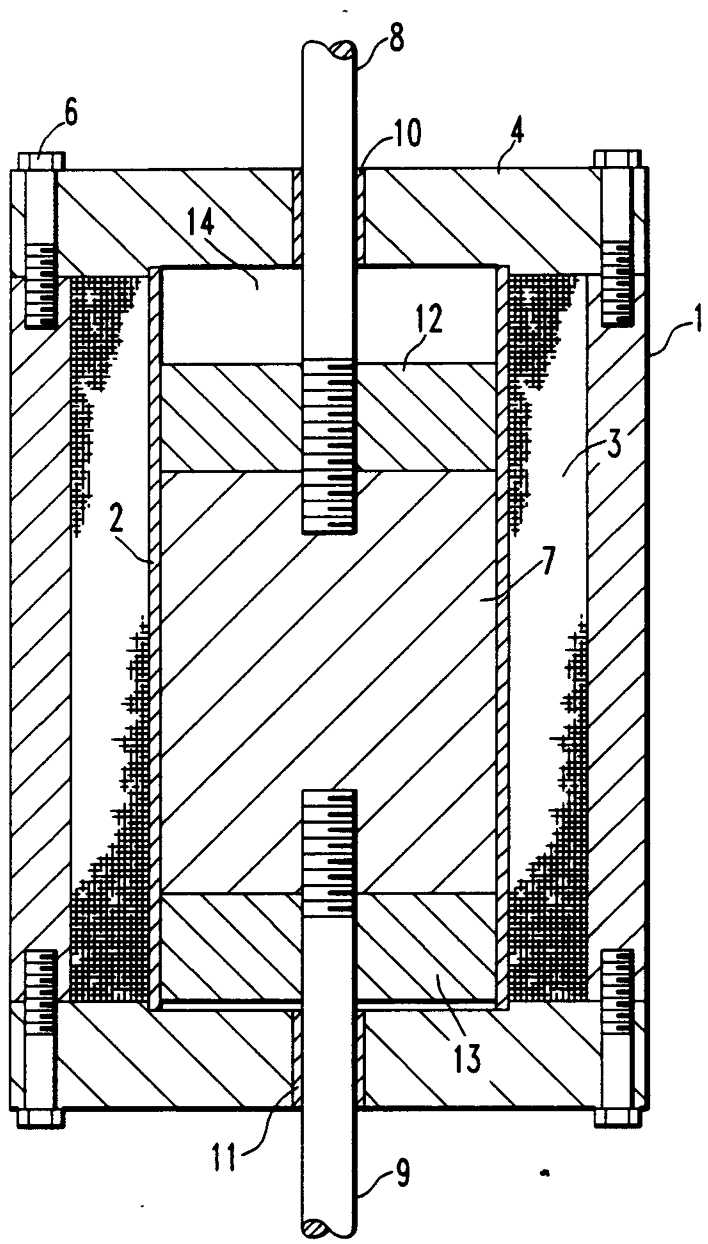

FIG. 1

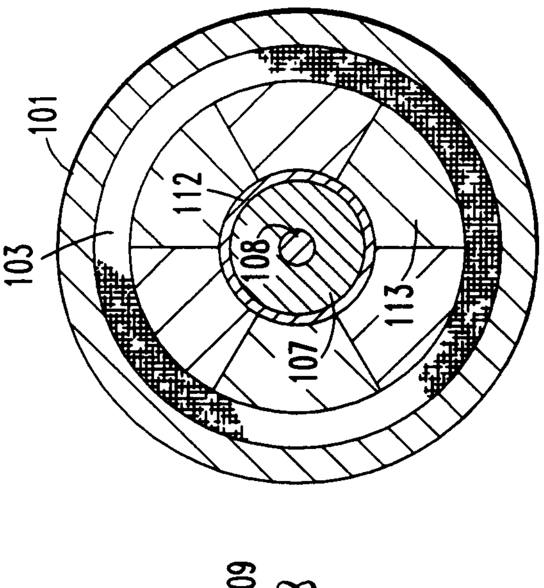

FIG. 4

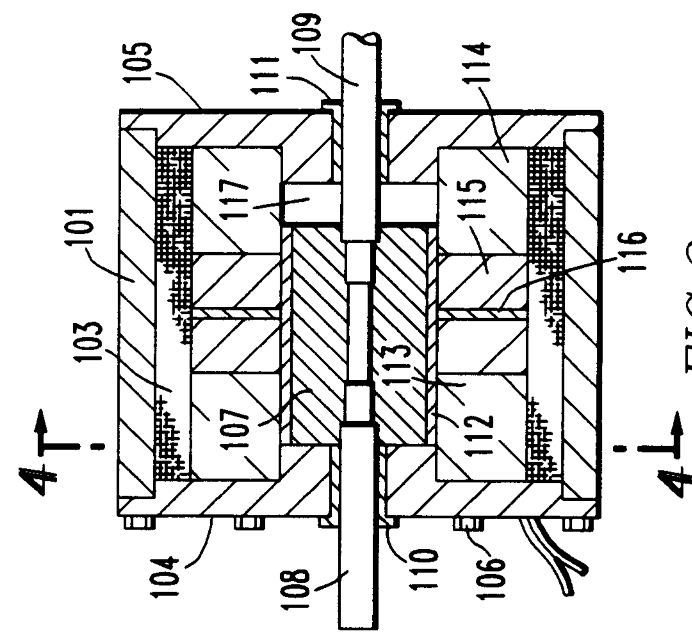

FIG. 2

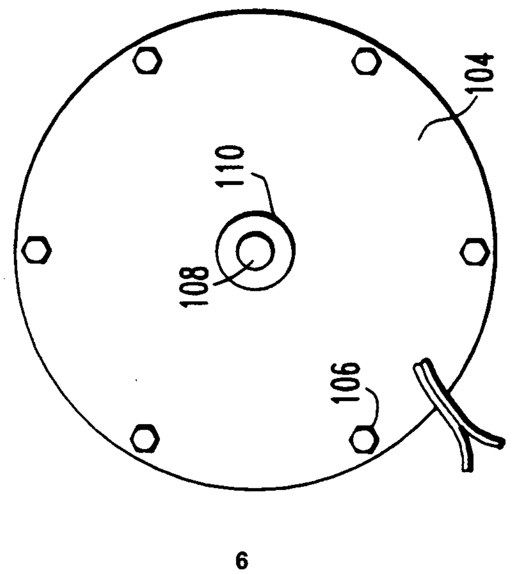

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 30 3851

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 040 217 (CLARY CORPORATION) * column 3, line 9 - column 4, line 37 * ---	1,5,6,8	H01F7/16
A	DE-A-3 206 687 (CORNELIU, LUNGU) * figures 4,5 * ---	2,3	
A	US-A-3 461 412 (JOSEPH LUCAS) * column 2, line 19 * ---	4,7	
A	DE-A-3 241 254 (MOOG INC.) ---		
A	FR-A-2 031 901 (DE VALROGER ET LAVET) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
H01F H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03 SEPTEMBER 1993	VANHULLE R.

CATEGORY OF CITED DOCUMENTS

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