(12) UK Patent Application (19) GB (11) 2 228 831 (13) A

(43) Date of A publication 05.09.1990

(21) Application No 8905619.6

(22) Date of filing 03.03.1989

(71) Applicant
PED Limited

(Incorporated in the United Kingdom)

Botanic House, 100 Hills Road, Cambridge, CB2 1LQ, United Kingdom

(72) Inventor
Barry Shaun Cowley

(74) Agent and/or Address for Service
Keith W Nash and Company
Pearl Assurance House, 90-92 Regent Street, Cambridge, CB2 1DP, United Kingdom

(51) INT CL[5]
H01F 7/16, F16K 31/08

(52) UK CL (Edition K)
H1P PAC PBA P201 P212
U1S S1901 S2004 S2146

(56) Documents cited
GB 2175452 A GB 1196418 A GB 0958501 A
GB 0918447 A EP 0264619 A2 US 4533890 A
US 3504315 A US 3202886 A

(58) Field of search
UK CL (Edition J) H1P PAC PBA
INT CL[4] H01F

(54) Bistable actuator and fluid control valve incorporating said actuator

(57) The actuator comprises a stator in the form of a frame 44 of magnetisable material associated with two axially separated energisable coils 45, 46 for establishing axially spaced magnetic fields. An armature comprises a permanent magnet 52 axially movable under the influence of said magnetic fields, when at least one of the coils is selectively and temporarily energised, between two stable positions. The residual magnetic field acting on the armature when the coils are de-energised, in either one of the stable positions of the armature, acts to retain the armature in the stable position to which it has been displaced. The armature includes a brass sleeve 50 and a sealing disc 54 which engages a valve seat 32 to stop gas flow in a pre-payment gas meter.

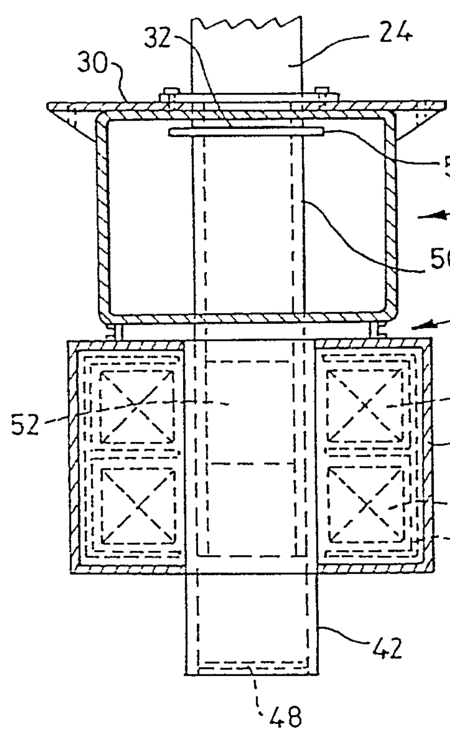

Fig.4

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

GB 2 228 831 A

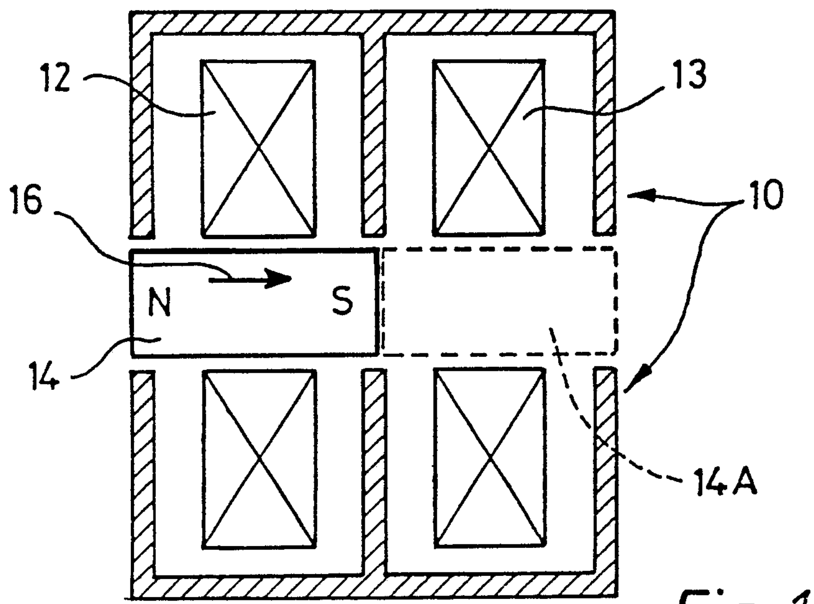

Fig. 1

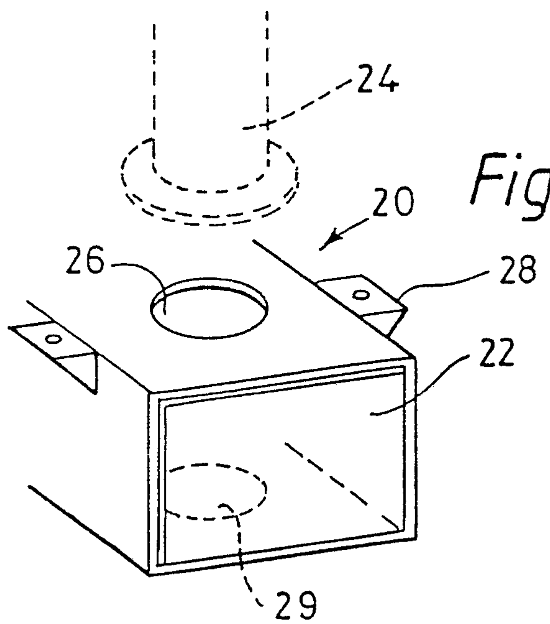

Fig. 2

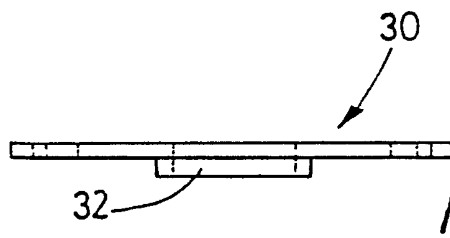

Fig. 3A

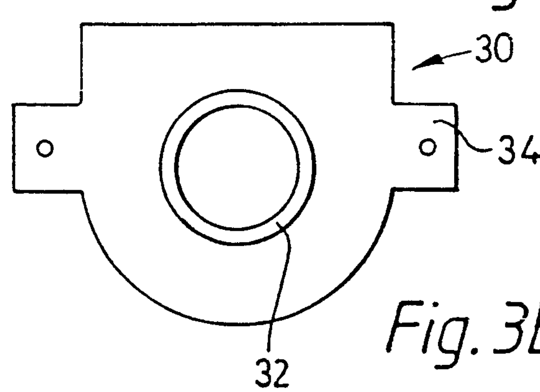

Fig. 3B

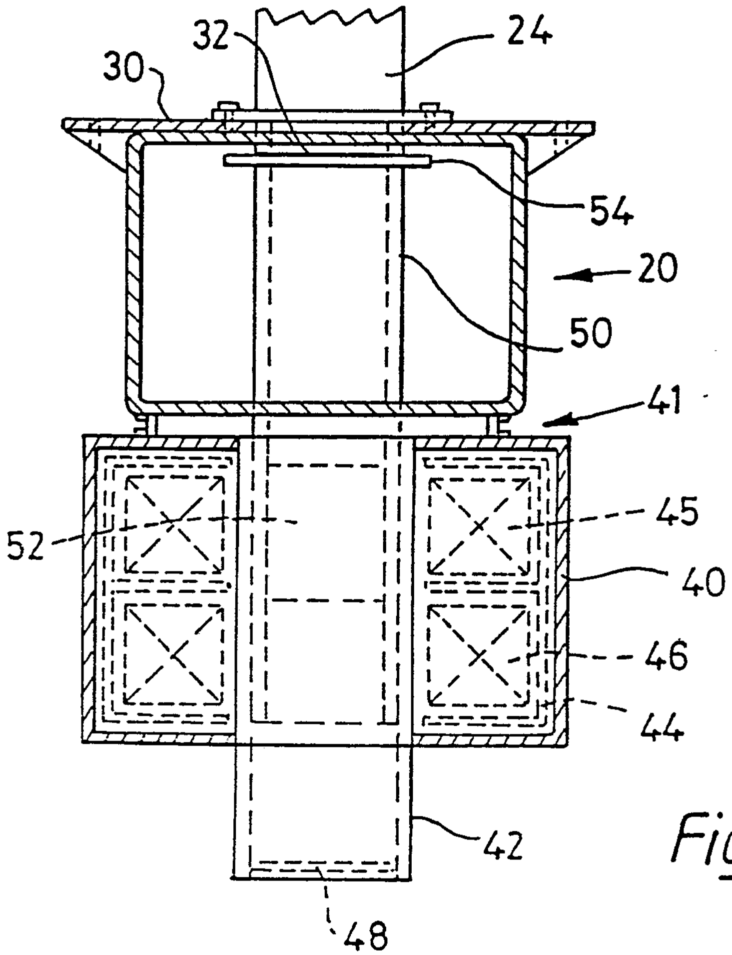

Fig. 4

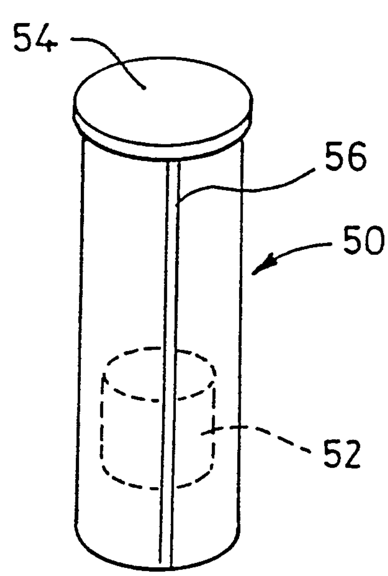

Fig. 5

C925/P

Title Bistable Actuator and Fluid Control Valve incorporating said Actuator

Field of the invention

This invention relates to a bistable actuator and also to the fluid control valve in which the bistable actuator can be incorporated.

Background to the invention

Actuators wherein one or more coils of electromagnet are energised to move an armature from one stable position to another are well known. In general however, consumption of power is required firmly to keep the armature in place, at least in one such position.

It is one object of the present invention to provide an improved linear actuator which minimises power consumption.

A further object of the invention is to provide a bistable actuator which is especially useful for controlling a fluid flow control valve, for example a gas flow control valve provided in conjunction with a pre-payment gas meter.

The invention

According to one aspect of the invention, there is provided a bistable actuator which comprises a stator and an armature axially displaceable relative to the stator between two stable positions, wherein the stator comprises a frame of magnetisable material associated with two axially separated energisable coils for establishing axially spaced magnetic fields, and the armature comprises a permanent magnet axially movable under the influence of said magnetic fields, when at least one of the coils is selectively and temporarily energised, between the two stable positions, the arrangement being such that the residual magnetic field acting on the armature when the coils are de-energised, in either one of the stable positions of the armature, acts to retain the armature in the stable position to which it has been displaced.

The magnetic frame is preferably cylindrically symmetrical, and has an E-shape when considered in a radial direction in an axial plane, whereby it defines two axially separated spaces respectively for accommodation of two energisable coils of annular form.

The permanent magnet is preferably a rare earth magnet, conveniently a samarium-cobalt magnet. Said magnet is preferably elongate in the axial direction, with North and South poles at its opposite ends.

Conveniently, limiting stops may be provided, each acting to limit movement of the armature, in either direction towards one of its stable positions, to a short distance ahead of the position which the armature would achieve under the influence of the magnetic fields in the absence of said stops.

The actuator may have a battery power source for energising the coils, providing power for temporary energisation of at least one coil by discharge through a capacitor.

The above-described linear activator is especially useful when incorporated in a fluid flow control valve.

Thus, according to another aspect of the invention, there is provided a fluid flow control valve in which the valve member is constituted by the armature of a bistable actuator as hitherto defined, with or without the optional features also hitherto described.

In an embodiment, in a fluid flow system, a fluid flow duct has an aperture in its wall for passage of gas and an associated internal valve slot around the aperture, and the armature comprises a valve member incorporating the permanent magnet and provided with a sealing element, said valve member being movable across the duct to displace the sealing element into and out of engagement with the valve seat.

In this embodiment, the said valve seat may conveniently constitute one of the afore-mentioned limiting stops, so that the residual magnetic field acting on the armature continues to urge the sealing element into engagement with the valve seat when the coil or coils are de-energised.

The bistable actuator may conveniently be accommodated in a housing externally secured to the duct on the opposite side of the duct to the aperture and associated valve seat, the valve member having a stem which projects through a second aperture in the fluid flow duct, aligned with the first aperture, which stem extends across the housing and carries the sealing element for engagement with the valve seat at its end remote from the actuator housing.

The said valve stem may be constituted by a sleeve, for example of brass, fixedly accommodating the permanent magnet on its interior. In this case, the actuating housing may have fixed within it a second sleeve, again of brass, which is considered part of the stator and in which the valve stem is slidable. The second sleeve may carry the second of the above-mentioned limiting stops for the movement of the armature, whilst a groove, aperture or like means may be provided in the cooperating surface of one of the two brass sleeves to eliminate any dashpot effect during movement of the valve stem in the second sleeve.

The above-described fluid flow control valve may be used, in combination with a gas pre-payment meter to control the supply of gas into a domestic supply pipe, energisation of the actuator coils being controlled responsively to insertion of a coin and to consumption of the amount of gas which has been paid for.

However, although the bistable actuator of the invention finds particular use in a fluid flow control valve, it is not limited to such an application, and may be used for various other purposes, such as pumping a liquid for example, or for telemetry control of a gas or water supply.

Description of embodiment

The invention will now be exemplified with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic view of a bistable actuator;

Figure 2 shows part of a fluid flow duct;

Figures 3A and 3B show an intermediate plate in side elevation and in underplan view;

Figure 4 shows a valve assembly fitted to the duct; and

Figure 5 shows an armature of a bistable actuator employed in the valve asembly of Figure 4.

The bistable actuator illustrated in Figure 1 comprises a stator in the form of a hollow, externally cylindrical frame 10 of magnetisable material. When seen in axial cross-section, the frame 10 comprises two E-shapes facing one another, enabling the frame to accommodate two cylindrical coils 12, 13 in axially separated relationship. A strong permanent magnet 14 constitutes an armature axially displaceable relative to the stator by selective energisation of the coils 12, 13. The magnet 14 is a strong rare earth magnet, conveniently a samarium-cobalt magnet.

In operation of the bistable actuator, coil 12 is so energised that the north/south polarity generated by the action of the electromagnet (the stator) propels the permanent magnet (the armature) in the direction of the arrow 16, to assume the dotted position indicated by reference 14A. Thus, it will be appreciated that, after the N-pole passes the midway point of the coil, the permanent magnet 14 will be attracted into its displaced position, in alignment with the second coil 13, which if desired may simultaneously be energised with such polarity that, after the S-pole of the permanent magnet passes the midway point of the second coil 13, the attraction of the magnet into the displaced position 14A is reinforced.

Subsequently,the second coil 13 may be energised so that the permanent magnet is propelled back to its original position, in the opposite direction to the arrow 16, and this action may also be reinforced by appropriate simultaneous energisation of the first coil 12.

The coils are only energised for a few milliseconds to displace the permanent magnet 14 from one of its two stable positions to the other. In this connection, it will be appreciated that residual magnetism in the frame 10 will firmly hold the permanent magnet 14 in the position into which it is displaced during energisation of the coil or coils. Thus, there is no energy consumption required to hold the magnet 14 in either one of its two stationary stable positions.

Valve seats, conventional solenoid clevis and cross-holes, push-rods and/or any other known and convenient solenoid coupling technique can form part of the construction. More, the magnetic frame 10 may be constructed in any one of a number of ways, but the better the magnetic circuit the greater is the magnetic efficiency, both for displacing the armature and for holding it in a set position without consumption of power.

The above-described bistable actuator can find application as a fluid flow control valve, for example a control in a domestic gas supply.

Thus, referring to Figures 2 to 5, Figure 2 shows the end of a duct 20 connected to a gas supply main. Gas flows towards the illustrated end of the duct, which is sealed and closed by a blanking plate 22. Flow of gas out of the duct 20 into a gas pipe 24 is via an aperture 26 in the top wall of the duct, and it is at this point that a control valve assembly, incorporating a bistable actuator as above-described, is provided.

First, an intermediate plate 30, see Figures 3A and 3B, is secured to the top of the duct around the aperture 26. This plate 30 fixedly carries or is integrally formed with a ring 32 which is received into the aperture 26 at the periphery thereof and which projects downwardly below the interior face of the top wall of the duct to enable it to act as a valve seat. Fixing means for fastening the intermediate plate in position are indicated at 28 on the duct and 34 on the plate.

The gas pipe 24 for receiving gas from the duct fits down on to the top of the intermediate plate. However, it will be appreciated that if it is necessary or required for any reason, the pipe 24 can be disconnected to enable the intermediate plate 30 to be replaced by a blanking-off plate.

Second, an aperture 29 is formed in the bottom wall of the duct 20 in alignment with the aperture 26. The control valve assembly fits beneath the duct around this second aperture 29.

Thus, referring to Figure 4, the control valve assembly comprises an annular housing 40 secured at 41 beneath the duct 20 and accommodating the bistable actuator. The annular housing 40 is closed at its inside diameter by a brass sleeve 42 fixed to said housing and projecting downwardly for a short distance below it. The stator of the bistable actuator comprises a magnetic frame 44 and coils 45, 46, accommodated in the housing 40 around the fixed brass sleeve 42, which itself should also be considered as part of said stator. The armature of the actuator is shown separately in Figure 5, and comprises a displaceable brass sleeve 50 having a permanent magnet 52 of samarium-cobalt fixed within it and a top plate carrying a sealing disc 54 of nitrile rubber or other suitable material for sealedly closing against the valve seat 32 just beneath the top wall of the duct. Thus, the displaceable brass sleeve 50, which is surmounted by the sealing disc 54 and is axially slidable in the fixed brass sleeve 42, extends upwardly out of the latter, through the bottom aperture 29 in the duct 20 and upwardly through the duct towards the valve seat 32.

A dashpot effect between the fixed and movable brass sleeves is relieved by an external groove 56 in the wall of the movable sleeve (see Figure 5), or alternatively a central hole along the sleeve.

In use, when the coils are selectively energised, the armature 50, 52, 54 is displaced either into its first stable position in which the sealing disc 54 closes tightly against the valve seat 32 to prevent gas flowing from the duct 20 into the pipe 24, or into its second stable position in which the sealing disc is retracted from the valve seat to permit gas flow from the duct into the pipe.

As will be clear from previous description, only very temporary energisation of the coil or coils is necessary to shift the valve between its open and closed positions, and no energy consumption is required to maintain the valve in either one of its stable positions.

As relatively little energy consumption is required overall, a battery power source may be employed for energisation of the coils, providing power by discharge through a suitable electrolytic capacitor.

However, it is important, for ensuring an absolutely sealed closure in the first stable position, and also to ensure that the armature tends to be displaced in the correct direction from either stable position when the coil or coils are energised, that the fully closed and fully open positions occur very slightly before the final positions which the armature would assume in the absence of any mechanical constraints. For ensuring that this is the case in the fully open condition, a stop 48 is provided at the bottom of the fixed brass sleeve 42. Thus, in both the fully closed and fully open conditions, the residual magnetic field of the de-energised electromagnet is acting to urge the armature a very small distance further in the axial direction, and this ensures that an absolute sealed closure of the valve seat 32 is obtained in the closed condition.

The above-described control valve is useful, for example, in conjunction with a pre-payment gas meter. In such a case, it can be arranged that insertion of a coin actuates a switching circuit operative to open the valve, the switching circuit being reversed to close the valve when the paid for amount of gas has been consumed.

Finally, however, it should be made clear that the bistable actuator of this invention is not restricted to use as part of a fluid control valve assembly. For example, a succession of actuators, as described with reference to Figure 1, can be arranged in line and operated in appropriate sequence to drive a piston or like means for pumping liquids or gases.

Although the parts 24 and 30 have been shown as separate elements and in turn have been shown as being separate from the duct 20, it is to be understood that these three elements may be combined into a single member (ie a composite duct) or into two subassemblies as appropriate.

In addition the valve closure plate 54 may be rigidly secured to the sleeve 50 as is implied from the drawings or may be mounted on the sleeve 50 with a limited amount of relative movement to accommodate any uneveness or misalignment of the valve seating.

Lastly although the magnet 52 has been shown as a separate member within the sleeve 50, it is to be understood that where the magnet is formed from a material of suitable strength, it may replace part or all of the sleeve.

C925/P

CLAIMS

1. A bistable actuator comprising a stator and an armature axially displaceable relative to the stator between two stable positions, wherein the stator comprises a frame of magnetisable material associated with two axially spearated energisable coils for establishing axially spaced magnetic fields, and the armature comprises a permanent magnet axially movable between the two stable points under the influence of the magnetic field established when one of the coils is selectively energised, the arrangement being such that the residual magnetic field acting on the armature when the coils are de-energised, with the armature in either one of its two positions, acts to retain the armature in the stable position to which it was last displaced.

2. An actuator according to claim 1 in which the magnetic frame is cylindrical and symmetrical, and has an E-shape when considered in a radial direction in an axial plane, whereby two axially separated spaces are defined respectively for accommodation of two annular coils.

3. An actuator according to either claim 1 or claim 2 in which the permanent magnet is a rare earth magnet.

4. An actuator according to claim 3 in which the magnet is a samarium-cobalt magnet.

5. An actuator according to any of the preceding clams in

which the magnet is elongate in the axial direction with North and South poles at its opposite ends.

6. An actuator according to any of the preceding claims in which the actuator further comprises two or more travel-limiting stops, each acting to limit movement of the armature, in either direction towards one of its stable positions, to a short distance ahead of the position which the armature which the armature would achieve under the influence of the magnetic fields in the absence of the stops.

7. An actuator according to any of the preceding claims in which the actuator includes a battery power source for providing power for temporary energisation of at least one coil by discharge through a capacitor.

8. A fluid flow control valve incorporating an actuator according to any of the preceding claims, the valve having a valve member comprising the armature of the actuator.

9. A fluid flow control system comprising a fluid flow duct having an aperture in its wall for the passage of gas or fluid, an internal valve seat around the appeture and a fluid flow control valve according to claim 8 in which the valve member includes a sealing element and is movable across the duct to displace the sealing element into and out of engagement with the valve seat.

10. A system according to claim 9 in which the valve seat constitutes a travel-limiting stop, so arranged that the residual magnetic field acting on the armature continues to urge the sealing element into engagement with the valve seat when the coil or coils are en-energised.

11. A system according to claim 9 or claim 10 in which the bistable actuator is accommodated in a housing externally secured to the side of the duct opposite to the aperture and associated valve seat, the valve member having a stem which projects through a second aperture in the fluid flow duct, aligned with the first aperture, which stem extends across the housing and carries the sealing element for engagement with the valve seat at its end remote from the actuator housing.

12. A system according to claim 11 in which the said valve stem comprises a sleeve, fixedly accommodating the permanent magnet on its interior.

13. A system according to claim 12 in which the actuator housing has fixed within it a second sleeve which constitutes part of the stator and in which the valve stern is slideable.

14. A system according to claim 13 in which the second sleeve carries one of the limiting stops as defined in claim 6.

15. A system according to claim 13 or claim 14 in which a groove or aperture is provided in one of the two brass sleeves to eliminate any dashpot effect during movement of the valve stem in the second sleeve.

16. A gas pre-payment meter having a fluid flow system according to any of claims 9 to 15 for controlling the supply of as into a domestic supply pipe, energisation of the actuator coils being controlled responsively to insertion of a coin and to consumption of the amount of

gas which has been paid for.

17. A bistable actuator substantially as described herein with reference to, and as illustrated in, Figure 1 of the accompanying drawings.

18. A fluid flow system substantially as described herein with reference to, and as illustrated in, the accompanying drawings.

19. A fluid flow control valve substantially as described herein with reference to, and as illustrated in, the accompanying drawings.

Published 1990 at The Patent Office. State House. 66 71 High Holborn. London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch. St Mary Cray. Orpington. Kent BR5 3RD Printed by Multiplex techniques ltd. St Mary Cray. Kent. Con. 1/87