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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :		(11) International Publication Number:
F16K 31/10, 31/34, 31/38, 31/385, 31/40, E03D 1/32, 1/33	**A1**	**WO 97/04260**
		(43) International Publication Date: 6 February 1997 (06.02.97)

(21) International Application Number: PCT/AU96/00461

(22) International Filing Date: 19 July 1996 (19.07.96)

(30) Priority Data:
PN 4225 19 July 1995 (19.07.95) AU

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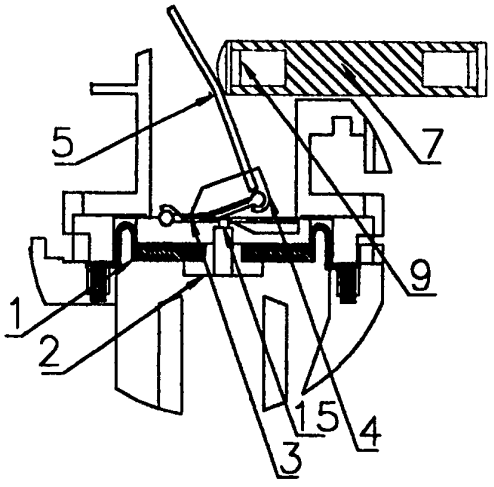
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: LOW POWER PILOT VALVE ACTUATED BY TRANSVERSE OR PERPENDICULAR ACTION

(57) Abstract

A valve (1, 2) of the kind that is caused to open and close in consequence of the opening and closing of a bleed orifice (15) by a movable pilot valve element (3, 4, 5), characterised in that said element (3, 4, 5) is displaced from sealing relationship with the orifice (15) by a torque resulting from a force applied (7, 9) to the element (3, 4, 5) along a line of action which does not extend through the orifice (15). Another embodiment of the pilot valve element consists of a cylindrical magnet housed in an elastomeric tyre actuated by a permanent magnet or electromagnet (Figures 5-8). Actuators of the torque causing force include a solenoid (Figures 1-2), float (Figure 3), and fluid pressure (Figure 4).



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LOW POWER PILOT VALVE ACTUATED BY TRANSVERSE OR PERPENDICULAR ACTION

TECHNICAL FIELD

This invention relates to fluid control valves, and in particular to improvements in the pilot stage of a hydraulically assisted fluid control valve. Such valves find applications in domestic toilet cisterns, stock water troughs and as electrically controlled shut off valves for garden water timers, for example.

BACKGROUND

Hydraulically assisted pilot operated valves are common in household appliances, such as in washing machines. These valves normally have a water inlet, a flexible sealing diaphragm and a water outlet. The flexible sealing diaphragm normally has some small apertures to permit the incoming water pressure to communicate with an upper chamber to force the valve closed. To permit the valve to open the diaphragm also has a slightly larger aperture communicating between the upper chamber and the valve discharge. This aperture is normally closed by a lightly spring loaded metallic plunger which is forced away from the aperture by means of an electromagnet to permit the valve to open.

Such a prior art valve is shown diagrammatically in figure 9a herewith. The water under pressure enters the inlet chamber marked "A" which communicates with the upper chamber marked "B" through the communicating holes 26 in the flexible sealing diaphragm 1 and its rigid diaphragm support 2. The bleed hole(or orifice) 15 to the valve discharge chamber marked "C", is normally sealed by the metallic plunger 34 which has an elastomeric sealing surface where it contacts the rigid diaphragm support 2.

As the bleed hole 15 from chamber "B" to chamber "C" is sealed the water pressure forces the diaphragm 1 and its support 2 to seal on the valve body 14 and thus prevents the flow of fluid through the valve.

When an electric current is passed through the solenoid 13 the metallic plunger 34 is drawn away from the diaphragm 1 and its support 2 to open the bleed hole 15. Since the bleed hole 15 is normally slightly larger in area than the communicating ports 26 the pressure in chamber "B" is reduced and thus the valve may open as shown in figure 9b.

When the electric current is cut off from the solenoid 13 the metallic plunger 34 once again seals the bleed hole 15 and the valve closes.

With this type of valve the valve requires a continuous supply of electric current to remain open.

With this type of valve the force which must be applied to the metallic plunger 34 to open the valve is the product of the water pressure and the area of the bleed hole 15. Typically the bleed hole diameter is 1 mm so at a water pressure of 1 MPa a force of 0.8 Newtons is required to open the valve.

The high forces to unseat the metallic plunger and the requirement of a continuous supply of electric current makes unsuitable for low voltage battery operated applications, such as garden irrigation systems, which are expected to operate for many months from a small dry cell battery.

Other known valves which are also not suitable for low voltage battery operated applications are disclosed in German Patent Application No. 3927611, International Patent Application Nos. PCT/GB92/00986 and PCT/US87/00214, Australian Patent Application Nos. 18576/88 and 55204/94 and United Kingdom Patent Application No.2149148.

An object of the invention is to overcome the limitations of the above mentioned valves by providing a valve which is suitable for use in low voltage battery operated applications.

SUMMARY OF INVENTION

In a first aspect the present invention is a valve of the kind that is caused to open and close in consequence of the opening and closing of a bleed orifice by a movable pilot valve element, characterised in that said element is displaced from sealing relationship with the orifice by a torque resulting from a force applied to the element along a line of action which does not extend through the orifice.

In preferred embodiments said force is applied to the body at a point and in a direction such that the minimum distance between the line of action of the force and the orifice is at least 3 times the maximum cross-sectional dimension of the orifice.

In a second aspect the invention relates to the use of curved surfaces and lever arms to provide a mechanical advantage to enable a major reduction in the forces required to open the bleed hole in pilot operated hydraulic valves to permit the valve to open or close. The curved sealing surface may be in the form of a ribbon wrapped around a curved rocker actuated by a lever or a hollow cylindrical tyre wrapped around a disk operating magnet actuated under the force of another actuating magnet.

With the major reduction in forces it becomes possible to construct valves which use electromagnetic actuators which are capable of operating from a 1.5 volt dry cell battery for extended periods of time as the valve may be latched open or closed when the current to the electromagnet is turned off.

The major reduction in forces enables the use of other actuators such as very small floats or pressure sensors to switch the valve to the open or close state.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1a is a cross-sectional view of a first embodiment of a valve according to the present invention, with the valve closed.

Figure 1b is a cross-sectional view of the valve shown in Figure 1a, with the valve shown at the point about to open.

Figure 1c a cross-sectional view of the valve shown in Figure 1a, with the valve open.

Figures 2a through 2c show enlarged views of the valve shown in Figures 1a through 1c, respectively showing the 'valve closed', 'at the point about to open' and 'with the valve open'.

Figure 2d shows an enlarged view of a portion of the valve components shown in Figures 1c and 2c.

Figure 3 shows a second embodiment of a valve according to the present invention, where the solenoid actuator shown in the first embodiment has been replaced by a float actuator.

Figure 4 shows a third embodiment of a valve according to the present invention, where the float actuator shown in the second embodiment has been replaced by a pressure sensing actuator.

Figures 5a through 5c show a fourth embodiment of the valve where the seal ribbon and curved rocker of the first embodiment of the valve as shown in Figures 2a through 2c, has been replaced by a cylindrical tyre placed around a disk magnet.

Figure 5d shows an enlarged view of a portion of the valve components shown in

Figure 5b.

Figures 6a through 6d show the valve embodiment of figures 5a through 5d with actuating magnets added to impart forces on the disk magnet and tyre.

Figures 7a through 7d show the valve embodiment of figures 5a through 5d where one or more electro magnets are used to impart forces on the disk magnet and tyre.

Figures 8a and 8b show a fifth embodiment of the valve with the arrangement of communication ports in the valve body altered to those shown in the previous embodiments.

Figures 9a and 9b show a prior art solenoid operated valve

MODE OF CARRYING OUT INVENTION

Figures 1a through 1c show an electrically operated valve assembly where the use of a lever arm and rocker, to clear a seal ribbon from a bleed hole in a valve diaphragm to allow the valve to open, permits the use of a very small solenoid and permits the valve to remain open or closed after the supply of electric current is discontinued. With reference to figure 1a it can be seen that the valve body 14 and the sealing diaphragm 1 are the same as for the prior art solenoid operated valve shown in figures 9a and 9b.

The diaphragm support 2 is similar to a conventional valve but differs in shape on its upper surface.

The valve operation is the same as a conventional valve in that it has a communicating port 26, which is shown more clearly in figure 2d, and a bleed hole 15 to admit and release water from the upper chamber "B".

This invention does not have a metallic plunger to open and close the bleed hole as in the prior art valve, but instead uses a mechanical advantage and a rolling seal device to reduce the magnitude of the force which must be applied by an electric solenoid to open and close the valve.

The bleed hole is normally sealed with a seal ribbon 3 of elastomeric or other similar material. This is held in place by its attachment to the diaphragm support 2 and to a rocker device 4 which is attached to a lever 5.

Referring to figures 1a, 1b, 1c, and to figures 2a, 2b, 2c and 2d which are at a greater scale to show more detail the operation of the valve will be explained.

The electric solenoid 13 imparts a force on a magnetic material 8 which is normally a permanent magnet to force the plunger 7 forward to bear on the lever 5 which is also of a magnetically attractive material.

This force exerts a couple (or torque) on the rocker 4 to roll the seal ribbon 4 away from the bleed hole 15.

The mechanical advantage is very high as the moment which has to be applied to the seal ribbon to uncover the bleed hole is only the product of the water pressure and the area of the bleed hole multiplied by half of the bleed hole diameter. For a valve with a 1 mm bleed hole and a water pressure of 1 MPa this moment is in the order of 4 x 10-4 Newton metres.

For a valve where the lever arm 5 length is in the order of 20 mm, the force which must be exerted by the solenoid 13 on the plunger 7 is only in the order of 0.02 Newtons to open the valve. Such a force is readily applied by a solenoid operating at voltages as low as 1.5 Volts.

The plunger 7 is made of a permanent magnet material or alternatively of a non magnetic material with one or more permanent magnets mounted within it.

The plunger 7 shown is figure 1a is of a non magnetic material with two magnets 8 and 9 mounted within it. When the current flows through the solenoid the magnetic field generated exerts a force on the permanent magnet 8 to urge the plunger 7 forward against the lever 5. At this point the permanent magnet 9 is attracted to the lever 5

As the plunger moves forward and rolls the seal ribbon 3 away from the bleed hole 15 through the couple exerted on the rocker 4, the pressure in the chamber "B" is released permitting the diaphragm support 2 to rise and open the valve to permit the flow of fluid through the valve.

Once the plunger 7 is full forward and the seal ribbon is released from the bleed hole 15, the supply of electric current to the solenoid 13 may be discontinued and the valve will remain open as there is no restoring force on the ribbon 3 to close the valve.

If the direction of the magnetic field from the solenoid is reversed, by either reversing the electric current direction or having a second winding in the solenoid with the current flowing in the opposite direction to the first, then the plunger 7 will be attracted back to the solenoid. As the plunger 7 is attracted back to the solenoid the lever 5 is also attracted back as it is magnetically attracted to the plunger. This attractive force exerts a couple on the rocker 4 to lay the seal ribbon 3 back over the bleed hole 15 to close it off and thus close the valve.

In this embodiment of the valve, the lever 5 has a bend in it as shown in figure 1a, however, in other embodiments may be just a straight lever. With the bend in the lever 5, the rising of the diaphragm support 2 as the valve opens, exerts yet more displacement on the lever 5 and rotation of the rocker 4 to positively open the valve and prevent "dither" where the valve is only partially opened or opens very slowly as a device other than an electric solenoid is used to apply a force to the lever.

In a yet more detailed version of the valve a magnetic material or permanent

magnets 10 and 11 are attached to the valve housing as shown in figure 1a. These magnetic materials serve the purpose of latching the valve open or closed when the current is cut off from the solenoid.

When the plunger 7 is fully forward and the current to the solenoid is cut off the magnetic attraction between permanent magnets 9 and 10 is greater than the attraction between magnets 8 and 11, and thus the plunger is retained in its forward position and the valve remains open and resistant to accidental closure due to vibration or inertia forces due to the physical movement of the valve.

When the plunger 7 is fully retracted and the current to the solenoid is cut off the magnetic attraction between permanent magnets 8 and 11 is greater than the attraction between magnets 9 and 10, and thus the plunger is retained in its retracted position and the valve remains closed and resistant to accidental opening due to vibration or inertia forces due to the physical movement of the valve.

Although the valve as described uses a magnetic attraction between the lever 5 and the plunger 7 to exert a couple on the rocker 4 to close the valve, this might also be achieved by having a physical connection between the plunger 7 and the lever 5.

Although the valve as described uses permanent magnets 10 and 11 to latch the plunger 7 forward or retracted, the latch might also be achieved by the attraction of the plunger to a magnetic material other than a permanent magnet.

Although the valve as described uses one or more permanent magnets in the plunger to react with the solenoid to provide a force to the plunger, this force might also be achieved by the solenoid reacting with a magnetically attractive material in the plunger which is not a permanent magnet. In this case the forward and retraction motion of the plunger may be achieved by having two solenoids separated and energised separately, so that one solenoid attracts the plunger forward and the other attracts it back.

Although the valve as described remains open or closed on the cessation of current flow through the solenoid, the valve may also be made to either open or close on the cessation of current flow through the solenoid, by the use of a spring to apply a permanent force to the plunger to either urge it forward or urge it retracted.

Although the valve as described has the communication passage 26 between chambers "A" and "B" passing through the diaphragm 1 and the diaphragm support 2 this passage may just as effectively pass through another part of the valve body.

The valve as described to this stage exerts a force on the lever by the interaction of an electric solenoid with the plunger.

When used as a level control valve this force may well be provided by other means.

Figure 3 shows a second embodiment of the valve where a float is used to provide the force, rather than a solenoid actuator. With reference to figure 3 it can be seen that the valve components are the same as shown in figure 1a. In the case of this float operated valve, the solenoid has been replaced by a float housing 16 and 26 which contains a float 27 which is attached by a carrier 28 to a permanent magnet 20 which in this diagram is a ring magnet. The float housing communicates with the fluid whose level is to be maintained by means of a tube attached to the port 25 on the housing.

As the level of fluid in the housing rises so does the float and the magnetic attraction between the ring magnet 20 and the plunger magnet 8 causes the plunger to rise thus exerting an attractive force upwards on the lever 5 by means of the magnet 9 which in turn exerts a couple on the rocker 4 to place the seal ribbon 3 over the bleed hole and thus close the valve.

As the fluid level falls the reverse action occurs and the valve opens.

Because of the very low forces required by the lever to actuate the valve the float

size required to operate the valve is very small.

As with the previous electrically operated version of the valve physical connection may be used in lieu of some of the magnetic connections to operate the valve. As with the previous electrically operated version, some of the permanent magnets may be substituted with magnetically attractive materials. As with the previous electrically operated version of the valve, the plunger may have only one magnet or may be comprised solely of magnetically attractive material.

Figure 4 shows a third embodiment of the valve where a fluid pressure actuator is used to supply the force to open or close the valve. With reference to figure 4 it can be seen that when the fluid pressure is applied to the tube 25 it exerts a force on the bellows assembly 21 and 22, which retains a permanent magnet 20 to interact with the plunger 7 in the same manner as for the float operated valve of the second embodiment. The force on the bellows assembly is resisted by a spring 18 which is adjusted by its retainer 19 and an adjusting screw 24. As the pressure rises the motion of the bellows assembly is to compress the spring and thus the permanent magnet moves to urge the plunger retracted and so closes the valve.

Figure 5 shows a fourth embodiment of the valve pilot stage where the rotational uncovering of the bleed hole is used to reduce the forces required to open the valve.

With reference to figure 5 it can be seen that the valve body and diaphragm 4 are the same as with the previously described embodiments. It can also be seen that the diaphragm support 2 is essentially the same as previously described, except that it does not have attachment points for the seal ribbon.

In the previously described valves the curved surface to reduce the forces required to open the bleed hole were achieved by the use of a seal ribbon and curved rocker. In this embodiment of the valve, the seal ribbon and curved rocker are combined into one component which is a hollow cylinder 28 wrapped around a permanent disk magnet 27. In physical terms the seal ribbon and rocker becomes a tyre 28 fitted to

the permanent tyre magnet 27.

A force exerted on the tyre magnet 27 causes the tyre 28 to roll over the bleed hole 15. The mechanical advantage can still be very high. For example if the tyre has a diameter of 20 mm, the force required to be exerted on the tyre magnet to open the valve for a bleed hole diameter of 1 mm and a water pressure of 1 MPa is in the order of 0.04 Newtons.

The operation of the valve is shown diagrammatically in figures 5 a through 5 c. When the tyre 28 is rolled over the bleed hole 15, the pressure in the upper chamber "B" rises and closes the valve. When the tyre is rolled away from the bleed hole the pressure in "B" falls and allows the valve to close.

Figure 6 shows the operation of this valve when an external device is used to exert a magnetic force on the permanent magnet 27.

With reference to figures 6a through 6c, a small permanent returning magnet 29 is used to urge the tyre magnet 27 and tyre 28 over the bleed hole 15. Another actuator magnet 30 is attached to the actuating device which may be a float or pressure operated actuating device as previously described.

In the closed position the actuating magnet 30 is sufficiently removed from the tyre magnet 27 that the net repulsive force on the tyre magnet by the returning magnet caused the tyre to be forced over the bleed hole 15 to close the valve.

As the actuating magnet 30 rises, it exerts a repulsive force on the tyre magnet to overcome the repulsive force of the returning magnet, and thus roll the tyre off the bleed hole to allow the valve to open.

Although the operation is described as repulsion between the various magnets, an attractive mode may also be used with suitable placement of the magnets. Although all of the magnetic elements are described as permanent magnets magnetically

attractive materials may be substituted for some of the magnets.

Although the valve is described as having a returning magnet 29 this may be omitted if the valve is orientated so that gravity forces are used to roll the tyre over the bleed hole.

Another version of the valve is shown in figures 7a through 7c. With reference to these diagrams the components are as previously described. The additional components are a small electromagnet 31 and keeper magnets 32 and 33.

In operation an electric current is passed through the electro magnet to repel the tyre magnet 27 and tyre 28 off the bleed hole 15, and thus permit the valve to open. When the tyre is forced off the bleed hole, the tyre magnet comes within the attractive force of the keeper magnet 32, which retains the tyre magnet and latches the valve in the open state. The current to the electro magnet may now be turned off and the valve will remain open.

When an electric current is passed through the electro magnet in the opposite direction the tyre magnet is attracted over the bleed hole to be retained by the keeper magnet 33 and close the valve. The current to the electro magnet may now be turned off and the valve will remain closed.

The keeper magnets need not necessarily be permanent magnets and may simply be of a magnetically attractive material.

Other arrangements of the electro magnet are possible so that more than one may be used to apply the forces to the tyre magnet. With suitable locations of electromagnet it is possible to replace the permanent tyre magnet with a magnetically attractive material.

Another embodiment of this valve is described in figures 8a and 8b, where the principles remain the same but the valve has a different physical layout. With reference to figure 8a and 8b it can be seen that the communication port between

chambers "A" and "B" is located within the diaphragm support. The bleed hole 15 between chambers "B" and "C" is within the valve body but the operating principles are still the same where the tyre is rolled over the bleed hole to close the valve and away from the bleed hole to open the valve.

In the above described embodiments, the surface of the sealing element ie. the seal ribbon or tyre which closes over the bleed hole is a convexly curved, to allow the sealing element to easily roll on and off the bleed hole. However, it should be understood that in other not shown embodiments the sealing element surface may be substantially flat or convexly curved with a large radius. In such embodiments the sealing element surface may be tilted over the bleed hole to allow for opening and closing of the valve.

CLAIMS:

1. A valve of the kind that is caused to open and close in consequence of the opening and closing of a bleed orifice by a movable pilot valve element, characterised in that said element is displaced from sealing relationship with the orifice by a torque resulting from a force applied to the element along a line of action which does not extend through the orifice.

2. A valve as claimed in claim 1, wherein said element has a convexly curved sealing surface.

3. A valve as claimed in claim 2, wherein said element is a seal ribbon.

4. A valve as claimed in claim 3, wherein said seal ribbon is associated with a rocker connected at one end of a lever, the opposite end of said lever being connected to an actuator adapted to provide said force.

5. A valve as claimed in claim 2, wherein said element is a hollow cylinder mounted on a cylindrical body.

6. A valve as claimed in claim 5, wherein said hollow cylinder is an elastomeric tyre and at least a portion of said cylindrical body is a magnet.

7. A valve as claimed in claim 1, wherein said force is exerted by means of an actuator.

8. A valve as claimed in claim 7, wherein said actuator is a solenoid actuator.

9. A valve as claimed in claim 8, wherein said a solenoid actuator may be electrically operated at a low voltage.

10. A valve as claimed in claim 9, wherein said solenoid actuator may be latched in an open position when electric current is switched off.

11. A valve as claimed in claim 7, wherein said actuator is a float actuator.

12. A valve as claimed in claim 7, wherein said actuator is a fluid pressure actuator.

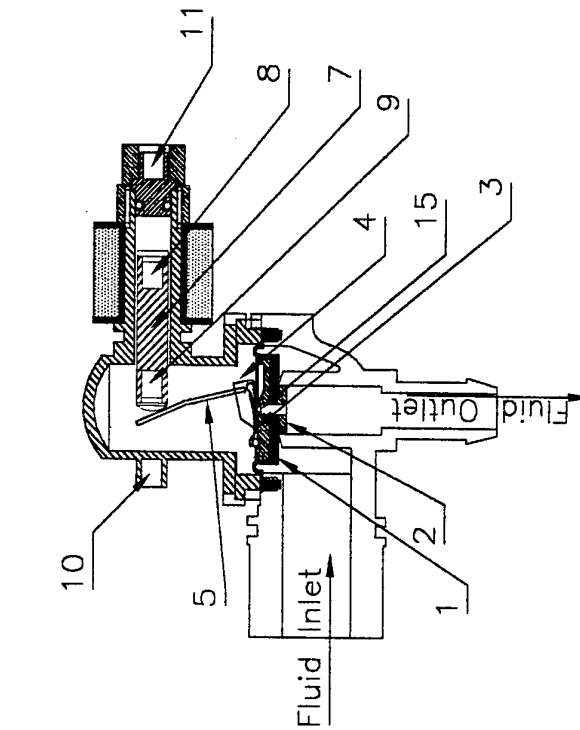

Fig 1b

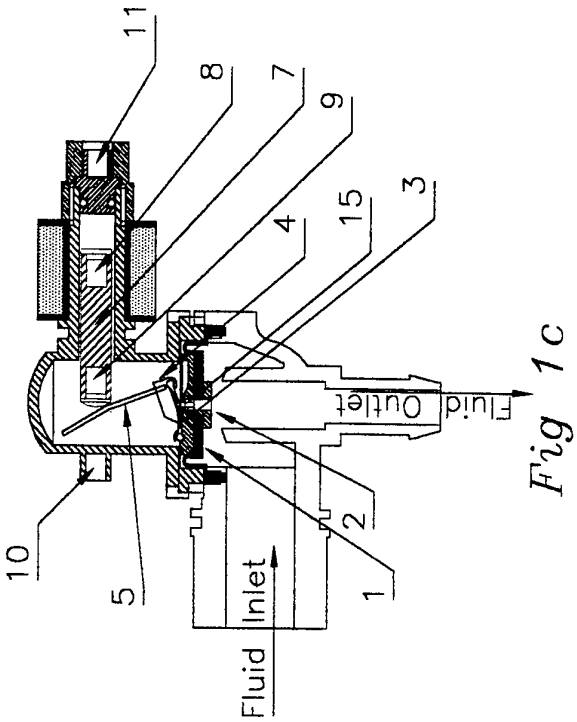

Fig 1c

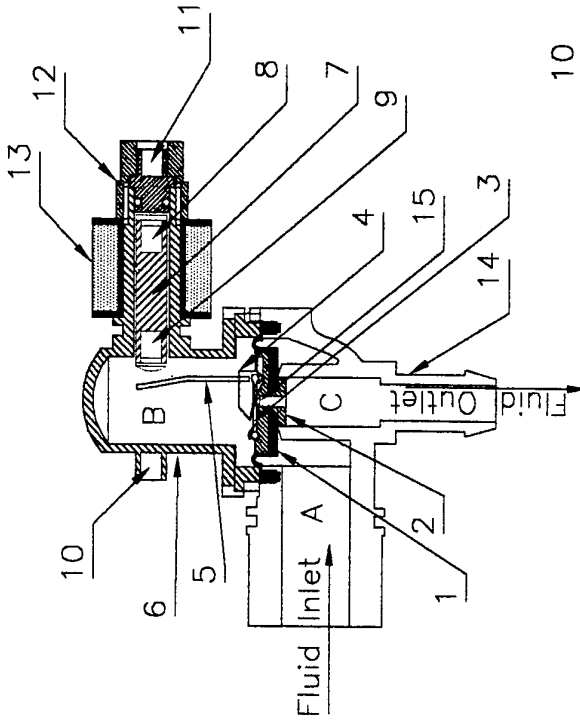

Fig 1a

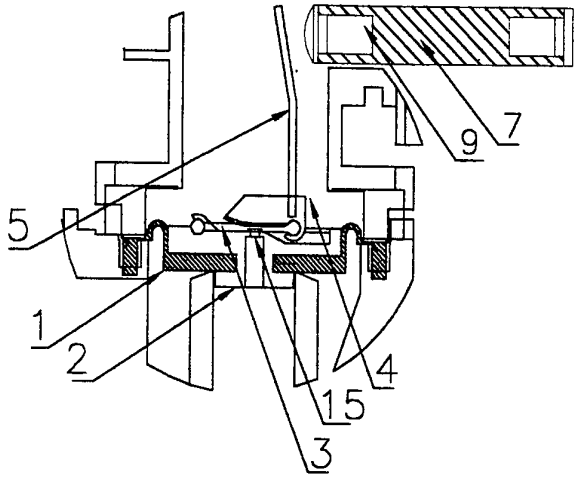

Fig 2a

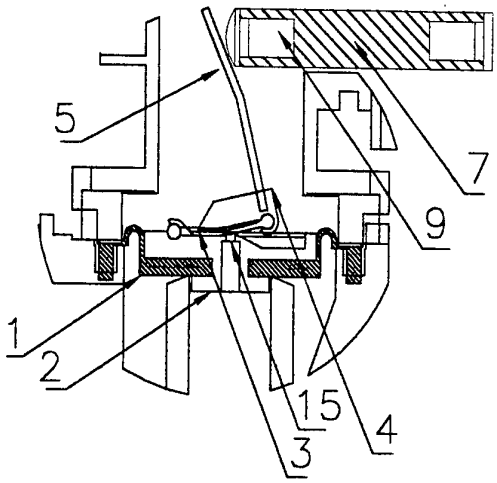

Fig 2b

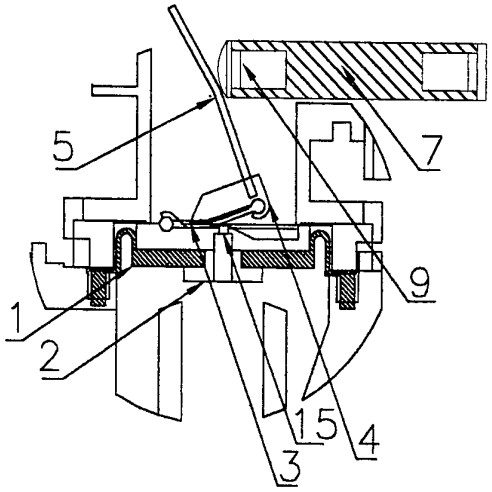

Fig 2c

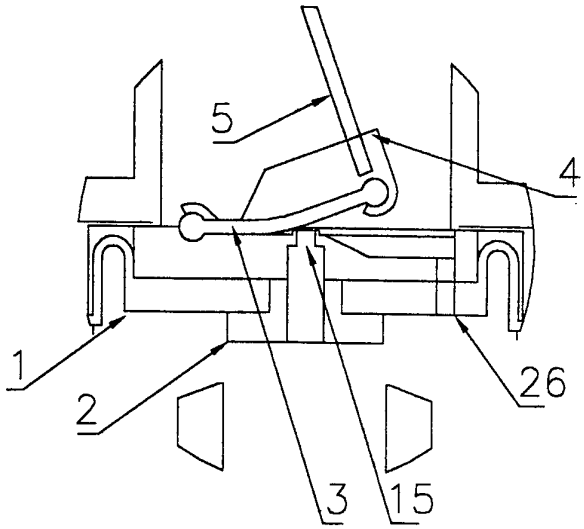

Fig 2d

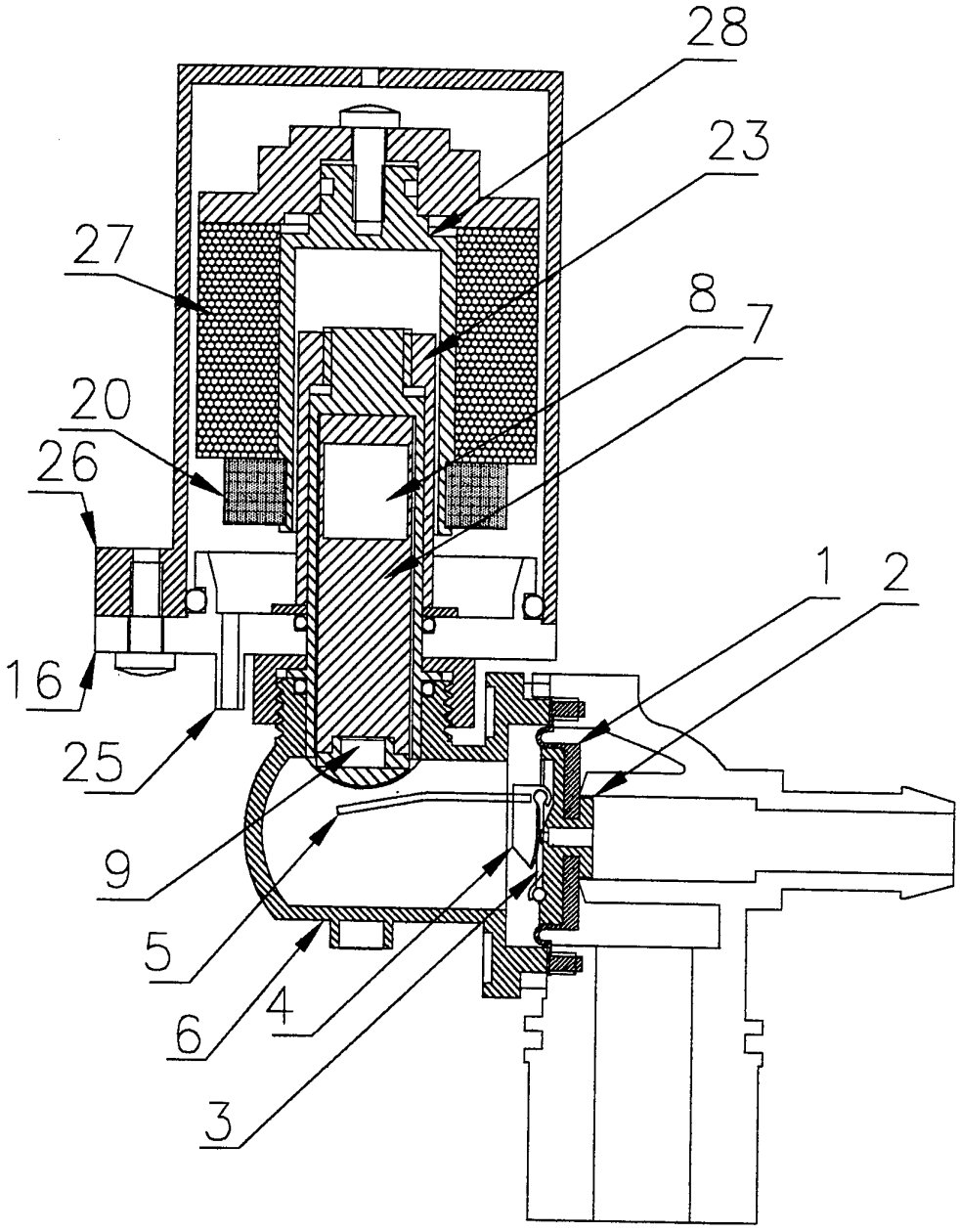

Fig 3

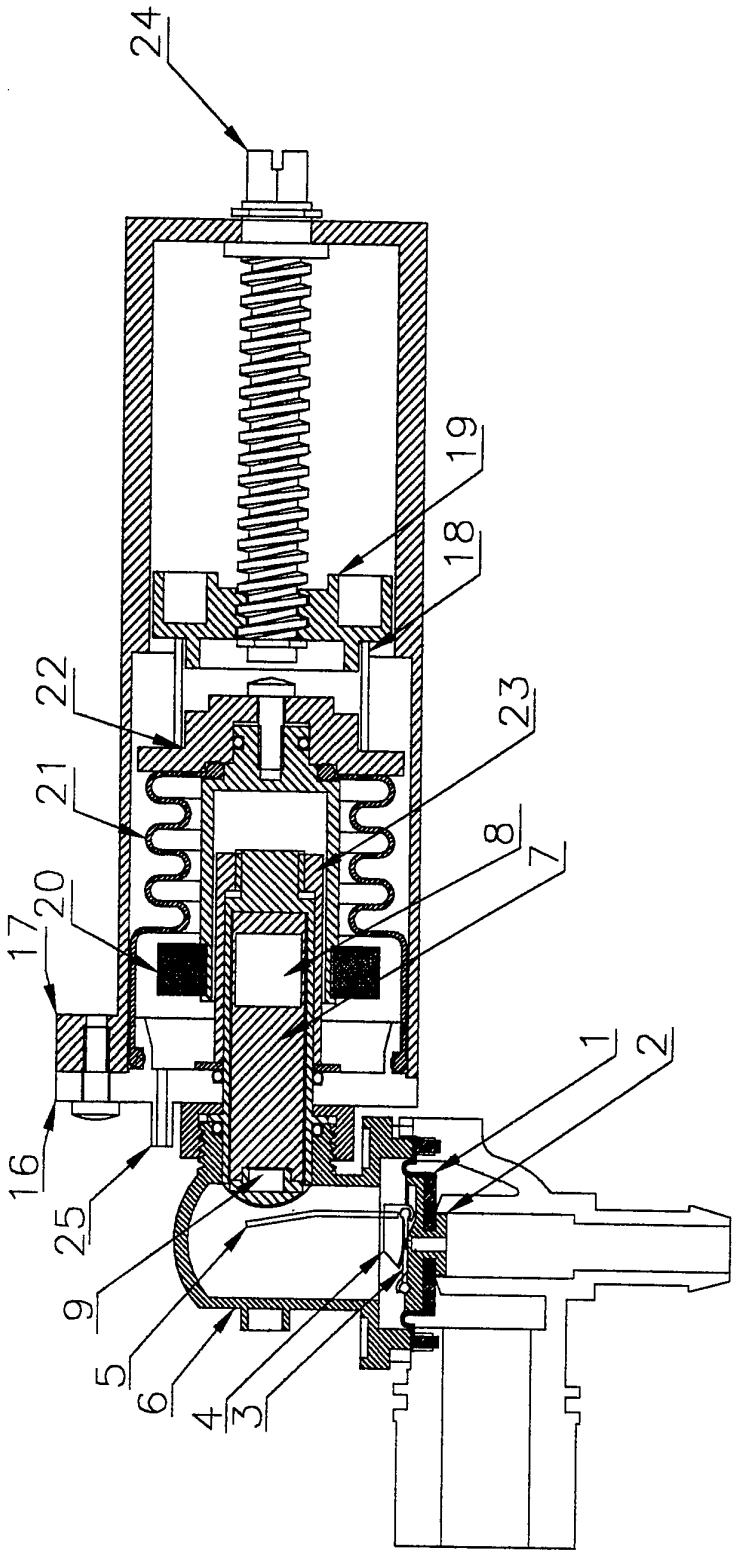

Fig 4

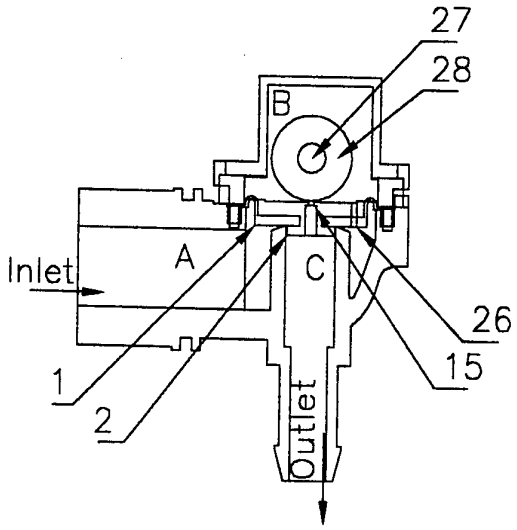

Fig 5a

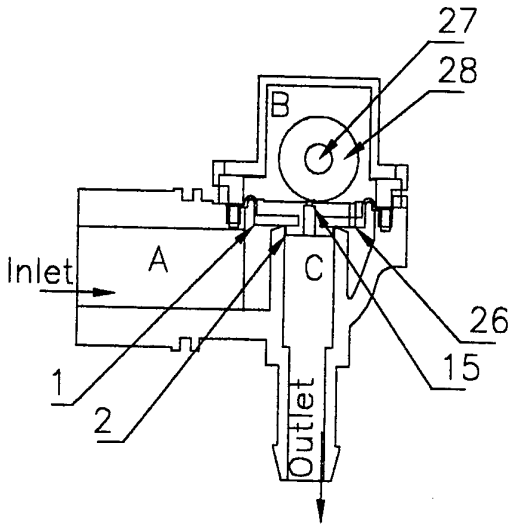

Fig 5b

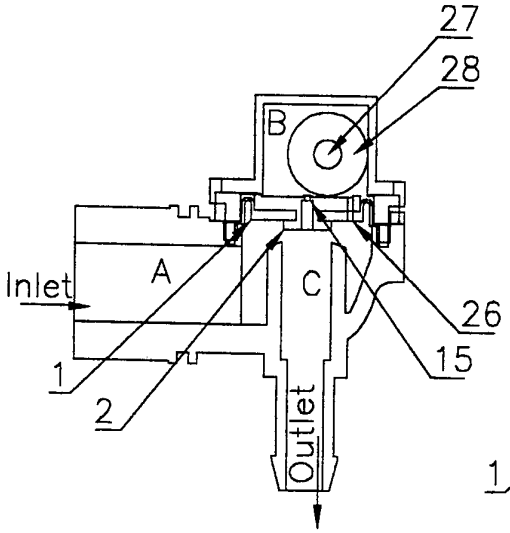

Fig 5c

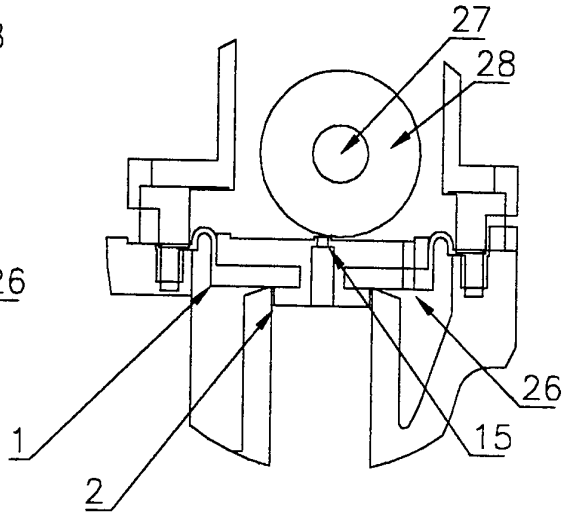

Fig 5d

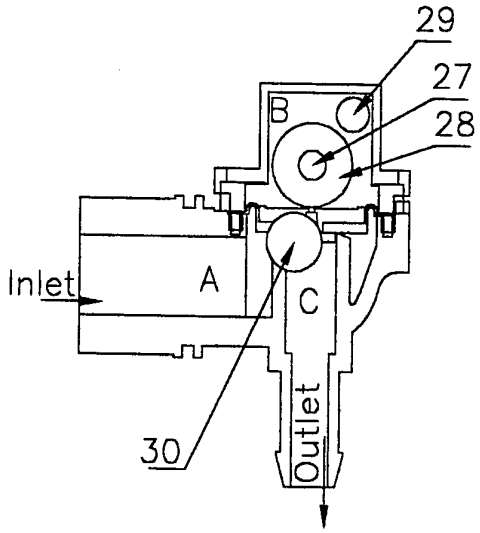

Fig 6a

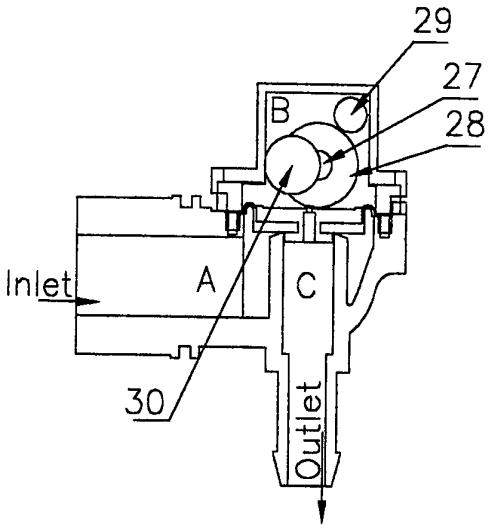

Fig 6b

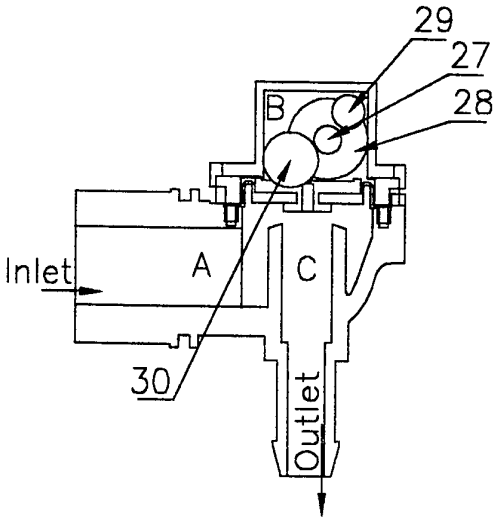

Fig 6c

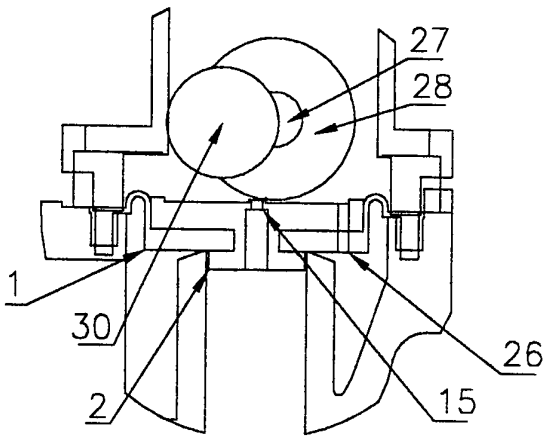

Fig 6d

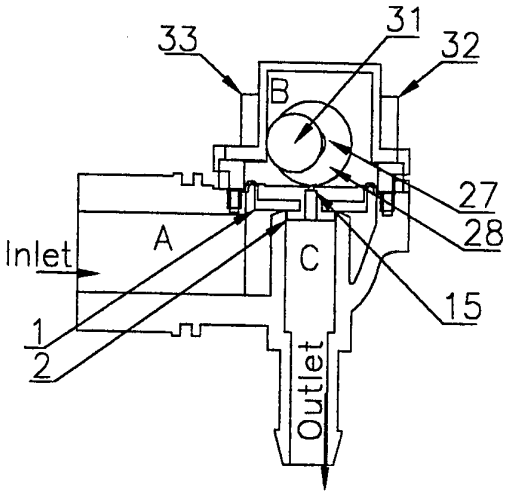

Fig 7a

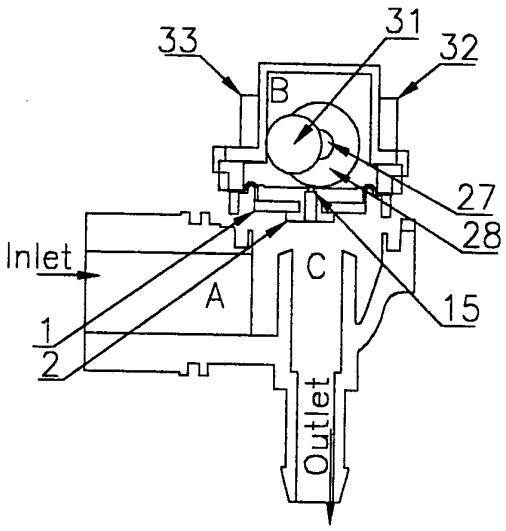

Fig 7b

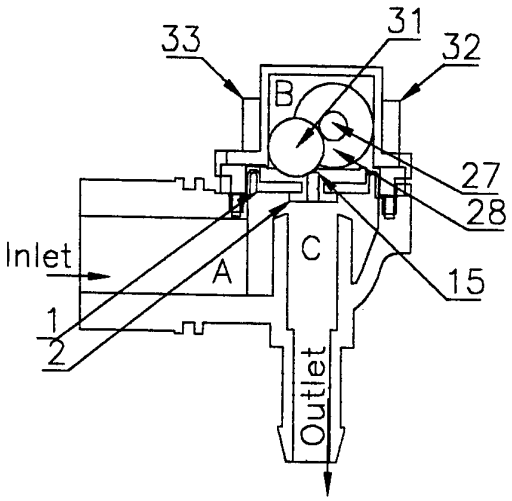

Fig 7c

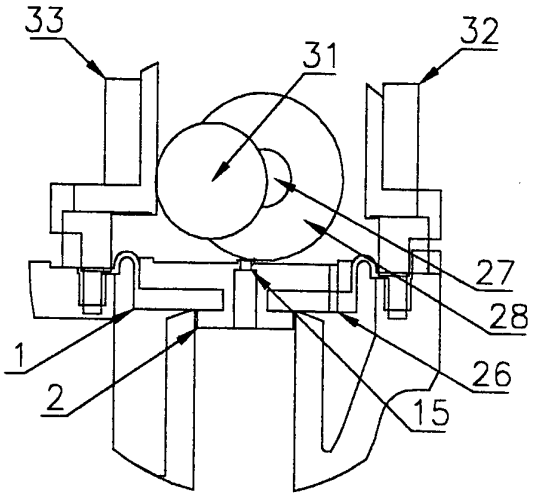

Fig 7d

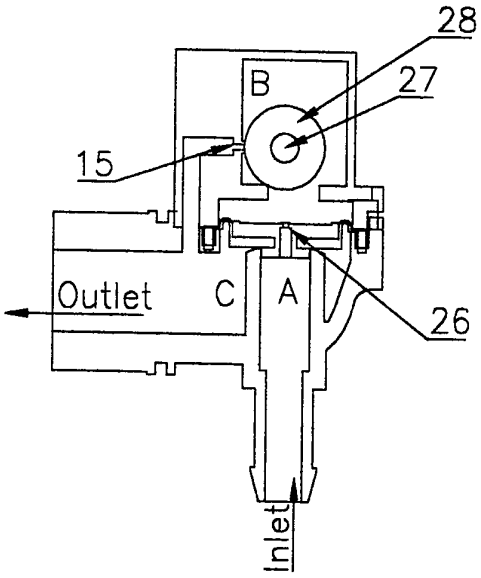

Fig 8a

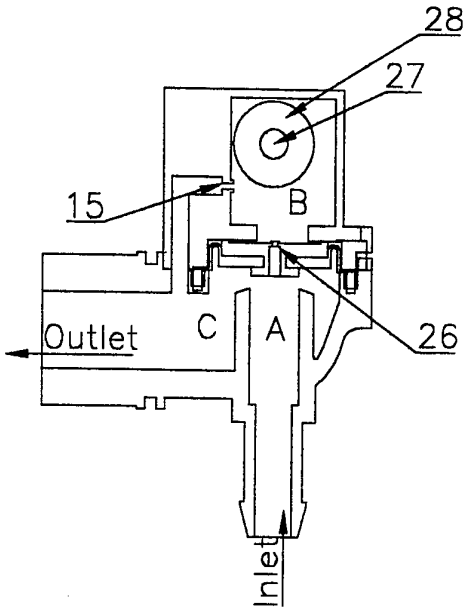

Fig 8b

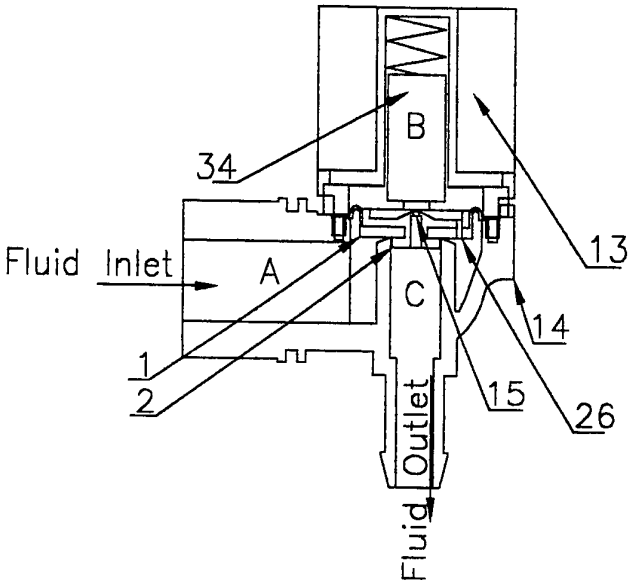
B
34
13
Fluid Inlet
A
C
14
1
2
15
26
Outlet
Fluid

Fig 9a

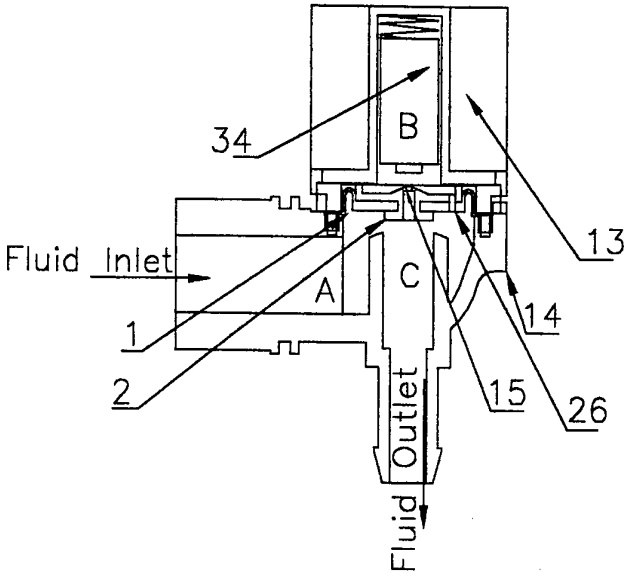
B
34
13
Fluid Inlet
A
C
14
1
2
15
26
Outlet
Fluid

Fig 9b

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00461

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: F16K 31/10, 31/34, 31/38, 31/385, 31/40, E03D 1/32, 1/33

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16K 31/10, 31/34, 31/38, 31/385, 31/40, E03D 1/32, 1/33

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC : AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT : (F16K 31/IC OR E03D 1/IC) AND (LOW (W) VOLTAGE# OR BATTER:)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4951915 A (PIAO), 28 August 1990 whole document	1, 2, 5, 7-12
X	AU 10023/88 (611405) B (A.B.X.), 14 July 1988 whole document	1, 2, 7-12
X	AU 36672/89 (626879) B (A.B.X.), 4 January 1990 whole document	1, 2, 7-12

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 September 1996	03.10.96
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (06) 285 3929	Authorized officer SIMON OCHSENBEIN Telephone No.: (06) 283 2380

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00461

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3982562 A (PICKETT), 28 September 1976 whole document	1, 2, 7-12
X	AU 35258/93 (654460) B (AUTOMATIC SWITCH COMPANY), 23 September 1993 whole document	1, 2, 7-12
X	US 5226629 A (MILLMAN et al), 13 July 1993 column 4 lines 17-54; figure 3	1, 7-12
X	GB 645013 A (TRUBERT), 25 October 1950 figures 1-3	1, 7-12
X	US 1545150 A (LUNDBERG), 7 July 1925 figures 1-3	1, 7-12
X	GB 2085123 A (OWATONNA TOOL COMPANY), 21 April 1982 whole document	1, 7-12
X	AU 67750/90 (631034) B (PLASTRO TECHNOLOGIES (1989) LTD et al), 8 August 1991 page 2 line 19 - page 3 line 30; page 7 line 16- page 9 line 19; all the figures	1, 7-12
X	AU 86789/91 (644695) B (ELDOM ROTHRIST AG), 7 May 1992 page 3 line 27 - page 4 line 5; page 4 line 18 - page 5 line 17.	1, 7-12
X	AU 57981/94 A (ARAN ENGINEERING DEVELOPMENT LTD et al), 6 October 1994 whole document	1, 7-12
X	AU 20713/29 B (LEVY), 18 September 1930 figure 1	1, 7-12

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00461

Box 1 Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 3-4
Pilot valve element having a seal ribbon and rocker lever

2. Claims 5-6
Pilot valve element having a cylindrical magnet and tyre

(see extra sheet for continuation)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00461

Box BOX II

3. Claims 8-10
   Pilot valve element actuated by a solenoid actuator

4. Claim 11
   Pilot valve element actuated by a float actuator

5. Claim 12
   Pilot valve element actuated by a fluid presure actuator

The international application does not comply with unity of invention a posteriori because it does not relate to a group of inventions so linked as to form a general inventive concept.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 96/00461

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	10023/88	CA	1325577	DK	97/88	EP	277055
		ES	2034279	FI	880116	FR	2609518
		HK	1134/93	JP	63243575	NO	880059
		PT	86522	US	4986308	ZA	8800117
AU	36672/89	CA	1333170	DE	68908036	DK	3240/89
		EP	349377	ES	2045494	FI	893213
		FR	2633695	HK	1457/94	IL	90689
		JP	2051672	NO	892682	NZ	229653
		PT	91026	SG	1352/94	US	5027857
		ZA	8904892				
AU	35258/93	DE	4308678	FR	2688854	GB	2265205
		IT	1261276	JP	6207677	NL	9300479
		US	5205323				
AU	67750/90	EP	441096	IL	93256	JP	4210171
AU	86789/91	AT	110242	CH	681685	CN	1061143
		EP	483700	ES	2057713	JP	6339432
		US	5207149				
AU	57981/94	EP	623673	JP	7133880		
US	3982562						
US	4951915						
US	5226629						
GB	2085123	DE	3131451	FR	2491580	IT	1171555
		JP	57065462	US	4351362		

END OF ANNEX