

[54] **INK EJECTION PRINTING DEVICES**

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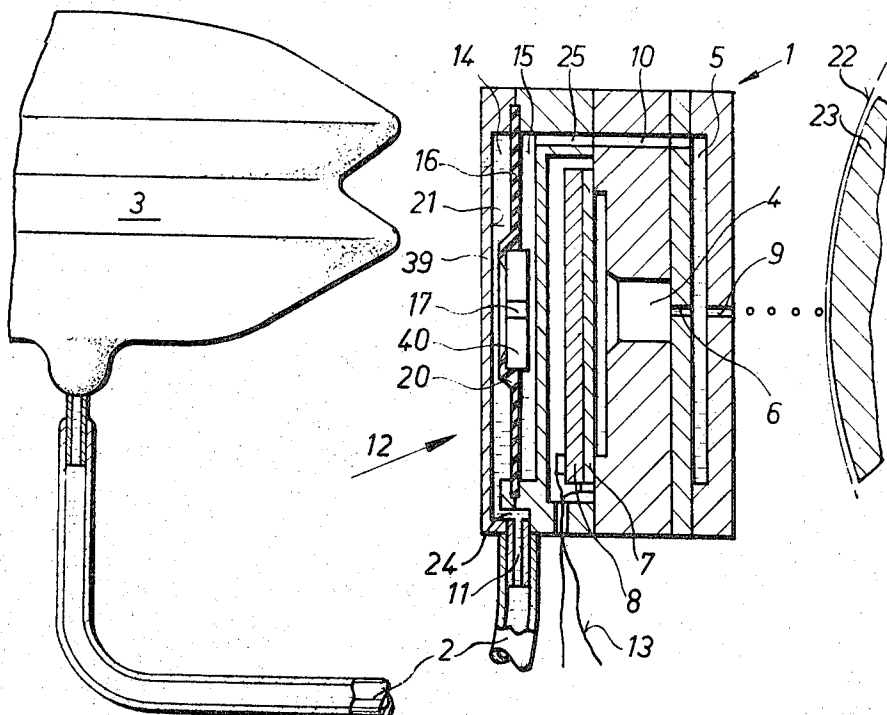
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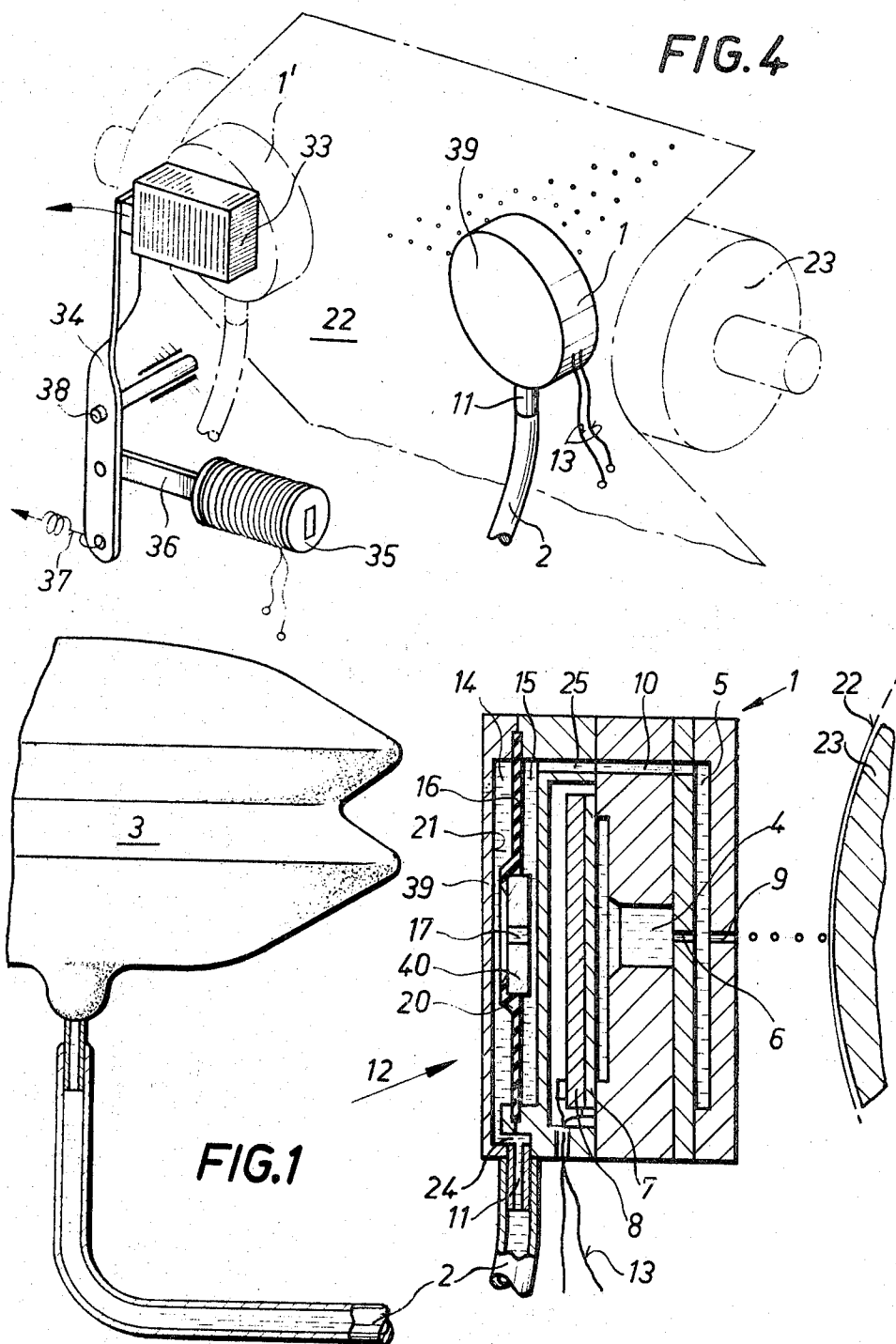
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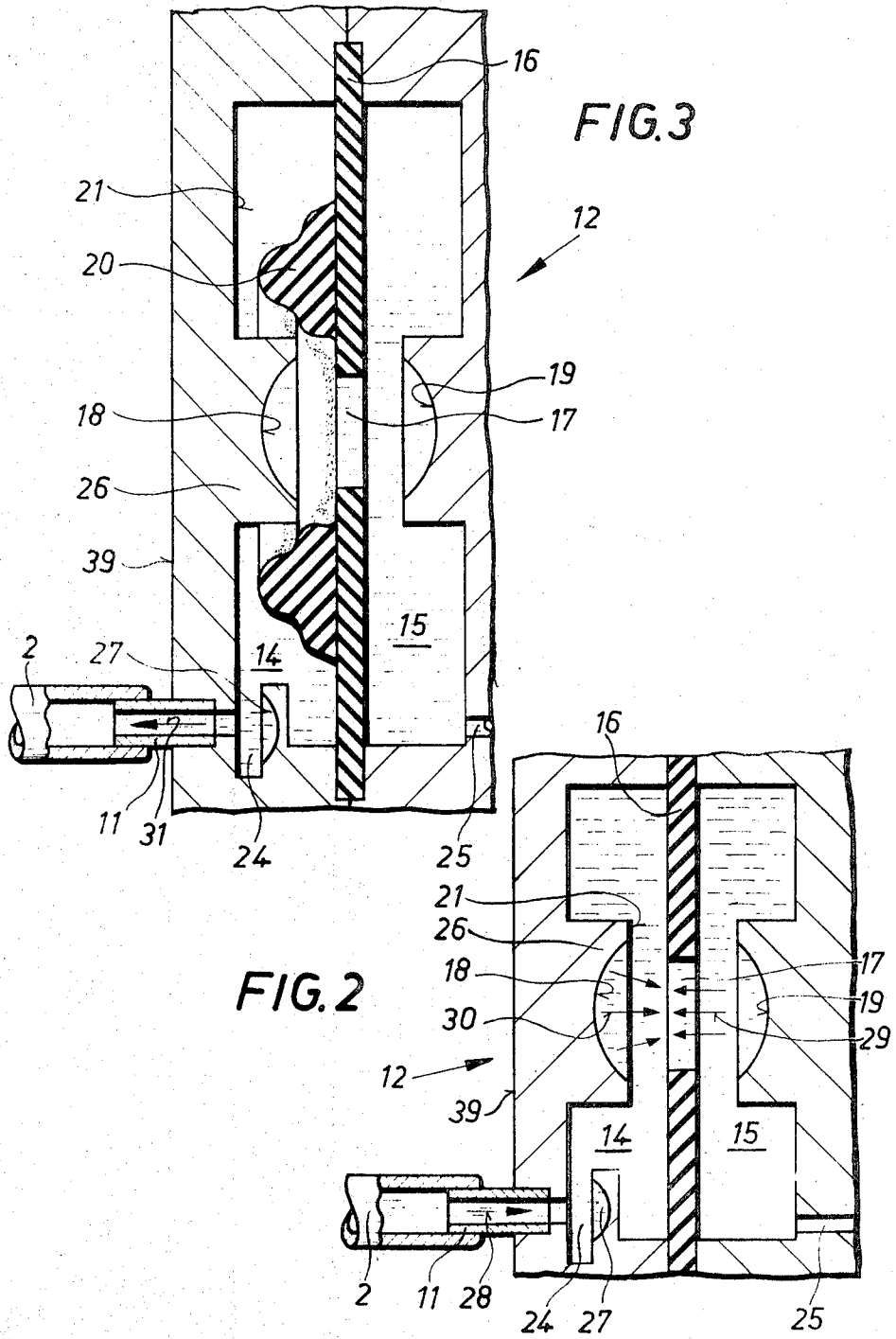
[57] **ABSTRACT**

In a device for delivering drops of fluid to a surface, such as a printing head for delivering drops of ink, which device includes an ink ejector head provided with at least one chamber having an outlet channel and an inlet channel, a connector member arranged to be connected to a line for receiving ink fluid and for supplying such fluid to the inlet channel, and a member for applying pressure pulses to the fluid in the chamber, the operating reliability of the device is improved by the provision of a valve disposed in the ejector head in the fluid flow path between the connector member and the inlet channel for reducing pressure surges experienced by the fluid in both the forward and reverse fluid flow directions and for closing the fluid flow path between the connector member and the inlet channel when a pressure drop occurs in the line.

7 Claims, 4 Drawing Figures







INK EJECTION PRINTING DEVICES

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for applying drops of fluid to a surface, and particularly a printer having an ink ejection head. Such printers include at least one chamber with an outlet channel and an inlet channel for delivery of writing fluid from a reservoir through a tubular line, and a device for producing temporary pressure increases in the writing fluid in the chamber.

German Offenlegungsschriften [Laid Open Applications] Nos. 2,132,082 and 2,164,614 disclose ink ejection printers whose operation is based on the flow conditions produced during ejection and sucking in of the writing fluid in cooperation with the inertia and surface tensions in the outlet channel, i.e., arrangements which operate like valve-less pumps. In order to prevent air from entering the system through the outlet channel during the suction process, while assuring that the writing fluid will nevertheless flow from the ink reservoir, the dimensions of the fluid filled channels and thus the surface tensions at the outlet channel and the capillary forces of the writing fluid in the system are selected to be correspondingly large. In the case of mass produced printers in which the ejection heads are not moved, such a measure prevents the entrance of air into the system.

In printers with an ink ejection head which is moved in the direction of the printed line, acceleration surges will develop in the writing fluid disposed in the ejection head and in the tubular line, which surges cause a change in the pressure and force conditions in the cavities, so that the printing process is interrupted by the entrance of air. The entering air must be removed by evacuation in a vacuum system and the ink ejector head must be refilled with writing fluid. When the ink reservoir is exchanged and when the tubular lines are removed from the connecting stud at the ink ejection head, a subatmospheric pressure is produced in the ink-filled cavities which effects a return flow of the ink from the ejection head and favors the entrance of air.

U.S. Pat. No. 2,556,550 discloses an ejection device with valves which are manually closed after each ejection process and which must be reopened in order to refill the device. When, for example, there is a sudden power failure, the ejection head is connected with the ink reservoir via the tubular line so that pressure surges in the writing fluid due to improper handling of the printer will lead to excess ink discharges or to a return flow of the ink. Often such an apparatus, when in the switched-off state, will be moved to another location or will be handled during maintenance. In such cases a flow of writing fluid through the system formed by the cavities in the ink ejection head, the tubular line and the ink reservoir cannot be avoided.

SUMMARY OF THE INVENTION

It is an object of the present invention to render ineffective any oscillations which may occur to the writing fluid in the inlet channel of the ejection head and which might have an influence on the ejection process.

It is a further object of the present invention to prevent the penetration of air into an ink ejection head of the abovementioned type by reducing the pressure fluctuations occurring in the writing fluid.

A further object of the invention is to automatically separate the writing fluid which has entered into the ink ejection head from the writing fluid which comes from the ink reservoir through the tubular line when the inactive state has begun.

The invention substantially increases the operational dependability of such devices. Removal of the tubular line and replacement of the ink reservoir is possible for every position of the ejection head and can be performed by less skilled personnel.

The flow of writing fluid during operation of the ink ejector head continues without interruption as the valve experiences a pressure reducing action. The valve can be formed in an advantageous manner by means inserted opposite one another in the dividing planes of the ink ejector head, so that fabrication and installation can be effected easily and by unskilled labor. Inexpensive cutting tools and standardized parts can be used to divide the pressure chambers. The arrangement does not require any additional space and is weight-saving.

Further advantages of the present invention result from the fact that the flow of writing liquid is interrupted in the inactive state and that inflow of air due to the return flow of the writing fluid, which would require complicated refilling preceded by removal of the air in the chambers of a vacuum system and a discharge of ink due to excess writing fluid, is prevented.

The apparatus for operating the valve is made of simple components which can be carried only with the ink ejector head or may be stationary in the printer. When the inactive state occurs, no additional energy source is required to maintain the closed state of the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional elevational view of an ink ejector head according to the invention which is connected to an ink reservoir via a tubular line.

FIG. 2 is a cross-sectional view to a much larger scale of the valve in the area of the abutment surfaces, to illustrate the pressure conditions therein.

FIG. 3 is a cross-sectional view to a much larger scale of a further exemplary embodiment of the valve.

FIG. 4 is a perspective view of an arrangement for controlling the valve.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows an ink ejector head 1 which is in flow communication with an ink reservoir 3 via a flexible tubular line 2. The cavities of this system are filled with a writing liquid. Before the cavities are filled with the writing liquid, the air present in the cavities of the system is removed in a vacuum apparatus. In addition, any gas present in the ink is removed because encapsulated air would lead to malfunction of the ink ejector head if the air were carried along by the writing fluid into the cavities or if air were sucked into the ink ejector head through the outlet channel 9 provided for discharging drops to effect printing.

The ink ejector head 1 is provided with a chamber which is divided into two parts, i.e., an inner chamber 4 and an outer chamber 5, connected together via a connecting channel 6. The inner chamber 4 is bounded on one side by a unit for producing short-term pressure increases, or pressure pulses, in the writing fluid filling the cavities. This unit includes a metal plate 7 and a

piezo-electric crystal 8 which can be excited by a voltage applied via terminals 13. The outer chamber 5 includes the outlet channel 9 and an inlet channel 10. Each pressure pulse resulting from excitation of crystal 8 causes a drop of ink to be projected from channel 9 onto printing surface 22 guided around roller, or drum, 23.

The arrangement according to the present invention for eliminating oscillations in the writing fluid is disposed between the inlet channel 10 and the connector member 11 for the tubular line 2. This arrangement will hereinafter be called the valve and is generally designated as 12. Valve 12, two embodiments of which are shown in detail in FIGS. 2 and 3, includes an antechamber which is divided into two pressure chambers 14 and 15 by a diaphragm 16. The diaphragm 16 is provided with a bore 17 in its center region and may additionally be provided with a ferromagnetic plate 40, as shown in FIG. 1. A plurality of such bores may be present.

Each one of the pressure chambers 14 and 15 is provided with a respective one of abutment surfaces 18 and 19 which are disposed opposite one another in a pair in line with bore 17. The abutment surfaces 18 and 19 each have a concave curvature. A pliable sealing ring 20 is placed around bore 17 in diaphragm 16, as shown for the embodiments of FIGS. 1 and 3. The space between wall 21, defining a sealing surface, and the sealing ring 20 is less than the space between diaphragm 16 and abutment surface 18. The diaphragm 16 and sealing ring 20 is consisting of one part and consist of plastic material.

The pressure chamber 14 is connected to provide flow between it and connector member 11 for the tubular line via a labyrinth-type channel 24. The presence of capillary channel 24 and of a preferably concave abutment surface 27 is of importance. Pressure chamber 15 is in flow connection with chambers 4 and 5 (FIG. 1) via a channel 25 having a capillary effect, and an inlet channel 10.

The valve 12 as shown in FIGS. 2 and 3 can operate in various ways. The acceleration and deceleration of the ink ejector head 1 during its movement in the direction of the line being printed produces, due to the inertia of the writing fluid in the system as well as because of deformations in the flexible tubular line 2, acceleration surges in the writing fluid so that the writing fluid is discharged irregularly and is interrupted when air enters through outlet channel 9. The entrance of air is possible, for example, if drops in pressure in the system are superimposed on the suction occurring during the return movement of the piezoelectric crystal 8 (FIG. 1) to its rest position.

Acceleration surges coming from tubular line 2 are partially absorbed in the labyrinth-type channel 24, and acceleration surges coming from ink ejector head 1 are partially absorbed in the capillary channel 25. The rest of the acceleration or pressure surge acts on diaphragm 16, as shown in FIG. 2, so that the diaphragm tends to bend through slightly in the direction of the acceleration surge. If an acceleration surge, in the direction of arrow 28 in FIG. 2, coming from tubular line 2 now acts on valve 12, its direction is changed when the surge abuts on abutment surface 27. The concave abutment surface 27 reflects the acceleration surge in such a manner that counterforces will converge substantially in its focal point.

Residual acceleration surges reaching pressure chamber 14 tend to move diaphragm 16 into the pressure chamber 15. This produces an equal pressure in pressure chamber 15 which is partially absorbed in capillary channel 25. Bore 17 of diaphragm 16 permits equalization so that writing fluid flowing from pressure chamber 15 into pressure chamber 14, in the direction of arrows 29, impinges on the abutment surface 18 and is deflected therefrom so that counterforces, in the directions of arrows 30, are produced which converge in the focal point of abutment surface 18. Acceleration or pressure surges coming from the ink ejector head system in valve 12 through capillary channel 25 are also equalized when diaphragm 16 tries to deflect into pressure chamber 14.

Upon disconnection of the flexible tubular line 2 from ink reservoir 3 and from tubular line connection 11 there will inevitably occur an effective enlargement of the cavities filled with writing fluid. This produces a sub-atmospheric pressure in valve 12, resulting from flow of fluid in the direction of arrow 31 in FIG. 3. The return flow of the writing fluid from ink ejector head 1 into tubular line 2 is prevented by the automatic contact of sealing ring 20 with sealing surface 21 in the embodiment of FIG. 3, or contact of diaphragm 16 with sealing surface 21 in the embodiment of FIG. 2.

FIGS. 1 and 4 also show the possibility of closing the valve when the printer is switched off (inactive state). The ink ejector head 1 in FIG. 4 is disposed in an ejection position. As shown in FIG. 1, a permanent magnet 33 is fastened to a rocker arm 34 which in the operating state of the printer is held in its pivoted-out position by the electromagnet 35 via an armature 36, so that the printing process can take place along the entire printing line without any influence on the ink flow. When the printer is switched off, or when there is no current, armature 36 of the electromagnet 35 drops so that rocker arm 34 is pivoted about fulcrum 38 by an energy store 37 and permanent magnet 33 is brought into contact with the outer wall 39 of the ink ejector head 1 once it has been moved to its lefthand position, represented by the dashed-line ink ejector head 1'. When magnet 33 is in this position, it attracts plate 40 to close the passage between diaphragm 16 and wall 21.

It is also conceivable, however, to carry the permanent magnet 33 along with the ink ejector head 1, thus moving along electromagnet 35 as well as fulcrum 38 of rocker arm 34 and power store 37. Upon occurrence of a sudden power failure, the permanent magnet 33 would abut at the outer wall 39 of the ink ejector head for any printing position of the ink ejector head 1, so that the valve 12 shown in FIG. 1 would close.

The valve arrangements shown in FIGS. 2 and 3 can be used, in combination with this device if they are provided with a ferromagnetic plate 40. In the inactive state the ferromagnetic plate 40 is pulled against the sealing surface 21 of the outer wall 39 under the magnetic force of the permanent magnet 33 which is placed against the outside of the outer wall 39 so that the writing fluid disposed in the cavities of the ink ejector head 1 is separated from the writing fluid in tubular line 2. It is also conceivable to hydraulically or pneumatically control the valve by way of varying pressure relationships.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are in-

tended to be comprehended within the meaning and range of equivalents of the appended claims.

We claim:

1. In a device for applying a fluid in drop form to a surface, which device includes a fluid ejector head provided with at least one chamber having an outlet channel, connector means and an inlet channel arranged to be connected to a line for receiving fluid from a reservoir and for supplying such fluid to the inlet channel, and means for applying pressure pulses to the fluid in the chamber, the improvement comprising a valve disposed in said ejector head in the fluid flow path between said connector means and said inlet channel, said valve constituting means for reducing pressure surges in the fluid in the forward direction of fluid flow and those in the direction opposite the flow, and for closing the flow path between said connector means and said inlet channel when there is a drop in pressure in such line.

2. An arrangement as defined in claim 1 wherein said valve comprises: an antechamber formed in said ejector head and disposed in the fluid flow path between said connector means and said inlet channel; a diaphragm located in said antechamber to divide said antechamber into first and second pressure chambers, said diaphragm having a bore communicating with at least said first pressure chamber; and means defining an abutment surface in each said pressure chamber, each said abutment surface being in line with said bore, said abutment surfaces being opposite one another, and at least said abutment surface in said first chamber including a surrounding abutment portion facing the part of said diaphragm which surrounds said bore, said diaphragm being deflectable at least toward said abutment portion surrounding said abutment surface in said first chamber; said arrangement further comprising a capillary channel forming the fluid outlet from said second pressure chamber.

3. An arrangement as defined in claim 2 wherein said ejector head is further provided with a passage defining the inlet to said valve and communicating with said first pressure chamber, said passage having the form of a labyrinth and including means defining a further abutment surface located to be struck by fluid flowing into said valve.

4. An arrangement as defined in claim 3 wherein said abutment surfaces and said further abutment surface

each have a concave curvature.

5. An arrangement as defined in claim 2 wherein said valve further comprises a sealing ring located in said first pressure chamber to surround said bore in said diaphragm, and wherein said first pressure chamber is provided with a sealing surface located to come into sealing engagement with said ring when said diaphragm is deflected toward said abutment surface in said first chamber, thereby closing said valve.

6. An arrangement as defined in claim 1 wherein said device is switchable into an inactive state, said valve comprises: an antechamber formed in said ejector head and disposed in the fluid flow path between said connector means and said inlet channel, said antechamber being located adjacent, and bounded by, an outer wall of said head; a diaphragm disposed in said antechamber and provided with a bore forming part of said fluid flow path; a ferromagnetic plate carried by said diaphragm and surrounding said bore; and a sealing member carried by said diaphragm and surrounding said bore; said sealing member facing the bounding surface of said antechamber defined by said outer wall of said head, and said diaphragm being deflectable in a direction to bring said sealing member into sealing engagement with said bounding surface so as to place said valve in its closed state; and said arrangement further comprises a magnet located outside said head and movable into a position adjacent said outer wall at which the magnetic field of said magnet exerts an attractive force on said ferromagnetic plate sufficient to deflect said diaphragm toward said outer wall to bring said sealing member into sealing engagement with said bounding surface.

7. An arrangement as defined in claim 1 wherein said device is switchable into an inactive state, said valve comprises an antechamber presenting a sealing surface, and a valve body displaceably arranged in said antechamber to come into sealing engagement with said sealing surface so as to place said valve in its closed state, and said arrangement further comprises control means operatively associated with said valve body and movable into a position for bringing said valve body into sealing engagement with said sealing means, and spring means connected to move said control means into such position when said device is switched into its inactive state.

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