

[54] **FLUID SWITCHING DEVICE**

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[51] Int. Cl..... **F16k 31/145**

[58] Field of Search..... **251/28, 61.1; 137/83, 625.27, 625.6, 625.61; 235/201 ME**

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[57] **ABSTRACT**

A fluid switching device having a first chamber partitioned by a diaphragm into two chambers, a valve secured to said diaphragm, a nozzle which communicates with one of said chambers having an input passage to supply a pressure fluid to one side of said diaphragm, a thin film disposed in a second chamber, with or without the use of a sealing member to hold the periphery of the thin film in place, means to adjust the gap between said nozzle and film, and/or a solenoid which electrically brings the film into and out of contact with the nozzle orifice.

4 Claims, 7 Drawing Figures

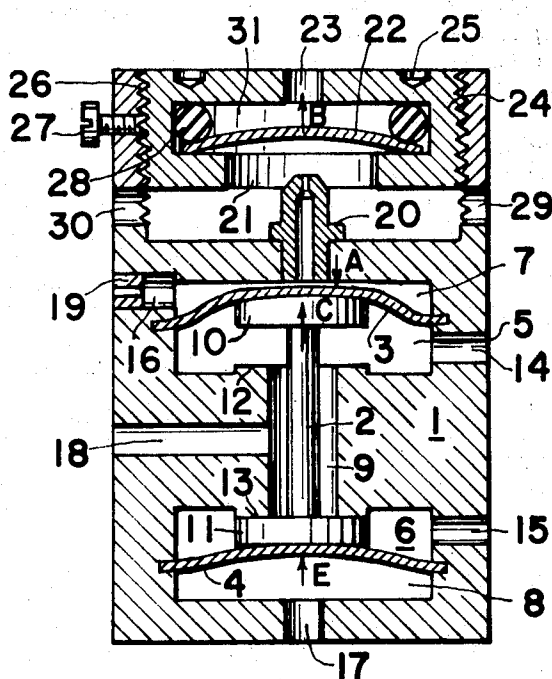


FIG. 1

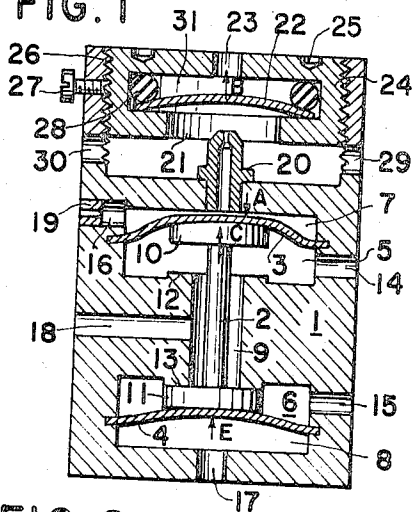


FIG. 2

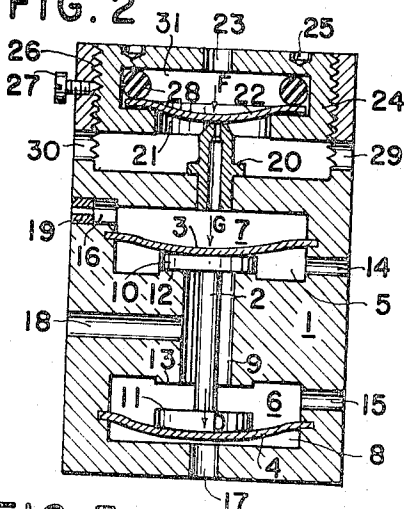


FIG. 3

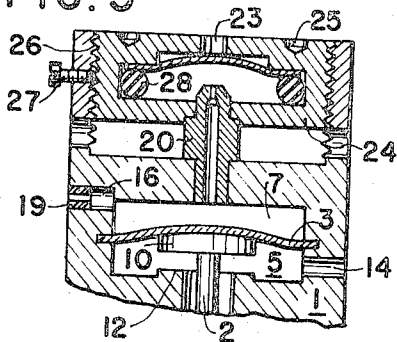


FIG. 4

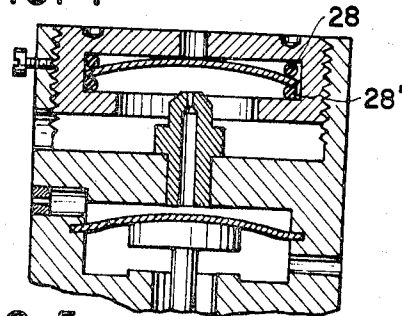


FIG. 5

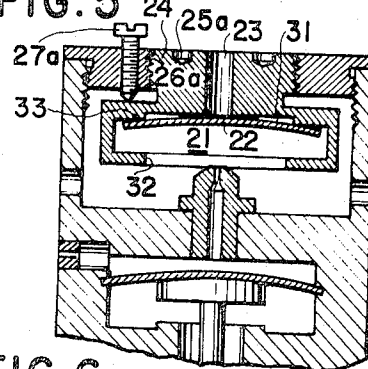


FIG. 6

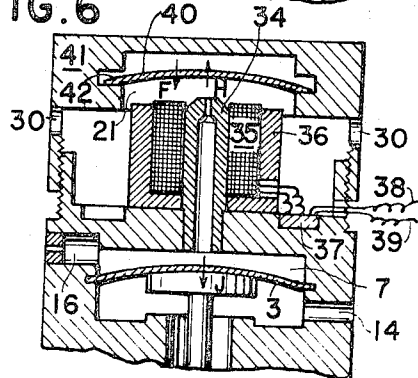
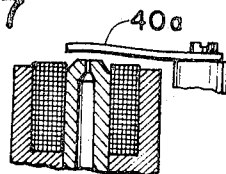


FIG. 7



FLUID SWITCHING DEVICE

This invention relates to a fluid switching device which functions in the same way as an ordinary electronic switching element or device by taking advantage of the flow and pressure of a fluid.

Generally, modern machine tools, process control systems and the like are being controlled electrically or electronically. The controlling operation is necessarily accompanied by an electric or electromagnetic noise or by formation of a magnetic field, which can have an adverse effect upon the work or measuring operation. In view of this and also on the ground that a fluid may be directly used as power, the control by means of a fluid has in recent years found diversified applications.

The fluid switching devices so far introduced, each of which consisting of a pilot section and a main valve section, have disadvantages. The rubber film of the pilot section is securely fixed along its periphery by a flange and has such a material weight that it keeps weak fluid information from being sensitively detected and often cause a time lag of response and a difference in posture. Moreover, the devices are complicated to construct and expensive. Usually, in control circuits and process control systems, information processing and operation by means of a low-pressure fluid leads to a saving of the power cost, and, where air pressure is utilized, the exhaust noise of the air is advantageously reduced. Despite all such desirable features, however, it has been difficult with conventional fluid switching devices to control the fluid and guide the same into a power unit.

Also, with a fluid switching device which comes within the category of threshold elements, it has been customary to produce a reference bias pressure as by a needle valve in order to take out a threshold signal at a certain pressure value of the fluid as it undergoes a slight analog change, and then generate the threshold of the input information in view of the relation between the input information and the bias pressure. However, in the face of an input information at a pressure below the bias pressure as the reference (the minimum value being about 40 mm Aq), the construction of such a device makes it impossible to determine the threshold of the input information in the state above described, even if a bias pressure of zero (atmospheric pressure) is supplied.

The conventional fluid switching devices which are classified as electric fluid converters may be roughly divided into two groups, pilot type and directly operable type. The former, or pilot type devices, use the flapper mechanism of the pilot section combinedly as the core of an excitable solenoid. Accordingly the flapper section is so massive that it creates problems of response velocity and power consumption.

It is therefore an object of the present invention to effect the processing of information including input signals by means of a low-pressure fluid, and introduce the processed information into a power unit, thus constituting a complete system and reducing the overall power cost of the system.

Another object of the invention is to provide a fluid switching device with quick response and free of positional difference upon installation, which finds a threshold over a broad range including feeble input information and takes out a digital output signal of power flow.

Still another object of the invention is to provide a fluid switching device which controls a valve body in response to input information in terms of electric signals.

A further object of the invention is to provide a fluid switching device which has good responsiveness and is capable of sensitively catching the input information of a fluid at a particularly low pressure (30 mm Aq) and setting a threshold for the input information over an extensive pressure range, and which is small in size, compact in design, available at low cost, limited in power consumption, and not directional for installation.

The present invention will be described in more detail hereunder with reference to the accompanying drawing showing preferred embodiments of the invention, in which:

FIG. 1 is a sectional view showing the body of a fluid switching device embodying this invention;

FIG. 2 is a sectional view of a modified form of the device shown in FIG. 1;

FIGS. 3 and 4 are sectional views of other embodiments provided with sealing members;

FIG. 5 is a sectional view of another embodiment wherein the pilot section is adjustable;

FIG. 6 is a sectional view of still another embodiment in which the pilot section is electromagnetically driven; and

FIG. 7 is a fragmentary sectional view of a modified form of the embodiment shown in FIG. 6.

Referring specifically to FIGS. 1 and 2, the body of a fluid switching device is generally indicated at 1 as approximately H-shaped in cross section. It has cavities which are partitioned by diaphragms 3, 4 connected to each other with a connecting rod 2 into intermediate valve chambers 5, 6 and diaphragm chambers 7, 8 at both ends. The intermediate valve chambers 5, 6 communicate to each other through an output chamber 9.

Valves 10, 11 are, respectively, secured to the diaphragms 3, 4 and are opposed to valve seats 12, 13. The body is further formed with input passages 14, 15 for the intermediate valve chambers, input passages 16, 17 for the diaphragm chambers at the both ends, and an output passage 18 communicating with the output chamber 9. The input passage 16 is provided with a primary restrictor 19. The valves and valve seats are so arranged that when either combination, e.g., the valve 10 and the valve seat 12, is in tight contact, the other valve 11 is kept off from the other valve seat 13. In the upper part of the valve body 1 is provided a nozzle 20, which communicates at its lower end with the chamber 7 and protrudes upwardly into a fluid passage 21 and communicates at its upper end with the atmosphere through openings 29, 30.

Opposite to the upper end of the nozzle 20 is provided the body 24 of a pilot section having an input passage 23 at one end. The body 24 of the pilot section has tommy holes 25, an adjustable threaded portion 26, and a clamp screw 27. It has a chamber 31, which accommodates a flat thin film 22 of a high-tensile-strength material and a sealing member 28 disposed along the periphery of the film.

The operation of the device according to this invention will now be described. FIG. 1 shows the device without the supply of fluid through the input passage 23. A control fluid with a pressure P is led through the primary restrictor 19 into the input passage 16 and applied on the upper surface A of the diaphragm 3, a part

of the fluid being bypassed to the nozzle 20 into the chamber 21, thereby urging the thin film 22 upwardly in the direction indicated by an arrow B. The fluid issuing out of the nozzle 20 is partly released to the atmosphere. The input passage 14 of the intermediate valve chamber 5 is supplied with a fluid with a pressure P as a power flow, which in turn urges the diaphragm 3 upwardly in the direction indicated by an arrow C and, through the output chamber 9, it leases the output passage 18 as a fluid with a pressure P. Alternatively, the power flow may be supplied by introducing the fluid with a pressure P into the input passage 15 of the intermediate valve chamber 6 and the end input passage 17. In this case, the input passage 14 of the intermediate valve chamber 5 is open to the atmosphere, and the intermediate valve chamber 6 and the diaphragm chamber 8 are filled with the fluid. However, the fluid in the chamber 6 is kept from flowing into the chamber 9 by the valve 11 which is pushed up in the direction indicated by an arrow E, because the force in the direction E produced by the fluid in the chamber 8 is less than the force in the direction of an arrow D that is produced by the fluid in the chamber 6 as the fluid pressure acts on the diaphragm, by the component of the fluid pressure that works upon the surface area of the valve seat 13 rather than the total surface area of the diaphragm.

The device in the state where the input passage 23 is subjected to the input fluid pressure is shown in FIG. 2. The fluid pressure in the chamber 31 is applied to the thin film 22 and produces a force that works in the direction indicated by an arrow F. Meanwhile, a part of the fluid filling the chamber 7 is bypassed through the nozzle 20, but, because the force in the direction F that is applicable to the total surface area of the thin film 22 is greater than the force that is produced by the nozzle 20 in the direction B, the film 8 is urged downward in the direction F. Accordingly, the fluid in the chamber 7 is kept from flowing out of the nozzle 20, and the chamber 7 is filled with the fluid with a pressure P, which acts upon the total surface area of the diaphragm 3 and provides a force in the direction indicated by an arrow G. On the other hand, the input passage 14 of the intermediate valve chamber 5 is supplied with a fluid with a pressure P as a power flow, and the fluid exerts a force that works in the direction C, but, because the force is less than the force that works upon the total surface area of the diaphragm by the component of the fluid pressure that works upon the surface area of the valve seat 12, the valve 14 is urged down in the direction G and the fluid of the chamber 5 is not admitted into the chamber 9. Thus the overflow from the output passage 18 is ceased, and the variation of the low fluid pressure from the input passage 23 represents the variation of the fluid pressure P. The operation of the device according to the present invention will be now described in logical expressions. Let the state of fluid pressure at the input port 14 be represented by a variable a which assumes only two values of 1 and 0, the value 1 representing a higher fluid pressure and the value 0, a lower fluid pressure. Thus an expression $a = 1$ means that a higher fluid pressure is applied to the input port 14 and an expression $a = 0$ means that a lower fluid is applied to the input port 14. In like manner, let the states of fluid pressure at other input ports 15, 16 and 17 be represented by variables b , c and d respectively, the state at the input passage 23 by a vari-

able "IN," and the state at the output port 18 by a variable X. Then the state X at the output port 18 in relation with states a , b , c , d and "IN" is indicated in the following table;

a	0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1
b	0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1
c	0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1
d	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1
IN	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
X	0 1 1 1 0 1 0 1 0 1 1 1 0 1 0 1 0 1 1 1 0 1 0 1 0 1 0 1 1 0 1 1

This table may be represented by the following logical expression:

$$X = ac + b\bar{c} + a\bar{d} + bd + a\bar{IN} + b\bar{d}\bar{IN} + b\bar{d}IN.$$

In accordance with the present invention, therefore, the device may be used for various logical operation by changing the combination of values to be given to variables a , b , c and d respectively.

The thin film used in the embodiment just described was 18 mm in diameter and 10 to 75 microns in thickness. The nozzle orifice was 0.45 mm in diameter. The primary restrictor had a bore of 0.25 mm. The body had an outside diameter of 20 mm and an overall length of 20 mm.

The sealing member 28 prevents any leakage of input information from the chamber 31 and any flow of the fluid from the nozzle 20 into the chamber 31. Moreover, it facilitates the contraction of the thin film 22 due to its curving, so that input information of a fluid at a particularly low pressure (30 mm Aq) can be sensitively caught.

While the sealing member 28 is shown in FIG. 1 on the side of the film 22 closer to the input passage 23, it may be provided, instead, in contact with the underside of the film, or a pair of such sealing members may be provided on both sides of the film as illustrated in FIGS. 3 and 4, respectively, to attain the same effect as with the sealing member of FIG. 1. As a further alternative, it is possible to dispense with the sealing member or members and provide a film 22 in a free state, as shown in FIG. 5, in the chambers 21, 31 which have valve seats 32, 33, respectively.

Now if the clamp screw 27 of the device shown in FIG. 1 is loosened and the pilot section 24 is turned by use of the tommy holes 25, the distance for approach or gap between the orifice of the nozzle 20 and the film 22 can be suitably set, and the pressure of the fluid entering the input passage 23 permits the fluid with a pressure P from the input passage 14 or 15 to flow out into the output passage 18.

The gap between the orifice of the nozzle 20 and the film 22 may be adjusted as well by loosening the screw 27a and turning the pilot section 24 by use of the tommy holes 25a.

While the nozzle 20 and the pilot section 24 in the embodiment above described are shown as provided on the diaphragm end chamber 7, it will be readily understood by those skilled in the art that the same object can be realized by providing the both in one of the other chambers 5, 6, 8 which have input passages.

FIG. 6 illustrates another embodiment of this invention, in which a chamber 7 formed with an input passage similar to the one of the above embodiment is provided with a nozzle 34 of a soft magnetic material, and a solenoid coil 35 is wound around the nozzle, and it is,

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in turn, surrounded with a yoke member 36. Also provided are a coil terminal base 37 and lead wires 38, 39.

Reference numeral 40 designates a member of soft magnetic material provided opposite to the nozzle 34, the periphery of which being fitted in a groove 42 of the housing 41. The shape of the member 40 and means for supporting the same are not limited to those shown but the member may be supported at one end like a cantilever, as shown in FIG. 7.

The embodiment shown in FIG. 6 is operated in the following manner. The device is shown with the coil 35 yet to be supplied with electricity. The fluid with a pressure P from the input passage 16 is being partly admitted through the nozzle 34 into the chamber 21, and thence released to the atmosphere through the opening 30. A part of the fluid pressure is forcing the member 40 upward in the direction indicated by an arrow H. When the coil 35 is supplied with electricity, the member 40 is attracted by the nozzle 34 so that the issuing from the nozzle is discontinued and the fluid in the chamber 7 urges the diaphragm 3 in the direction indicated by an arrow J, with the result that the fluid with a pressure P from the input passage 14 or 15 begins to flow out of the output passage 18.

I claim:

1. A fluid switching device comprising:

a main body defining therein a cavity of a substantially I-shaped cross section containing a pair of opposed first chambers and an output chamber which communicates at its ends with said first chambers, a diaphragm disposed in each of said first chambers to partition the same into an outside pressure chamber and an inside pressure chamber communicating with said output chamber, said main body having four input ports each opening into a respective one of said outside and inside

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pressure chambers and an output port provided for said output chamber,

a valve mechanism operatively connected to said diaphragms for selectively switching fluid communication between said output chamber and one of said inside pressure chambers in response to displacement of said diaphragms,

a pilot body coupled with said main body and defining therein a second chamber adjacent to one of said outside pressure chambers,

a nozzle for exhausting pressure fluid within said one of said outside pressure chambers into said second chamber,

an input port provided in said pilot body in opposite relation with said nozzle for introducing variable low pressure fluid into said second chamber,

a generally flat thin film formed of a high tensile strength material disposed in said second chamber to partition the same axially, whereby said thin film is displaced into and out of contact with the outlet of said nozzle in accordance with variation of fluid pressure introduced through said input port into said second chamber so as to change the fluid pressure in said one of outside pressure chambers to switch said valve mechanism.

2. A fluid switching device according to claim 1 wherein the thin film member is lightly pressed around its periphery with a sealing member against the surrounding wall of said second chamber.

3. A fluid switching device according to claim 1 wherein the thin film is disposed without restraint in said second chamber.

4. A fluid switching device according to claim 1, wherein said pilot body is adapted to be displaced axially with respect to said main body so as to adjust the gap between said nozzle and said thin film.

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