United States Patent [19]

Linden

[11] **3,771,567**

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[54] **ELECTROMECHANICALLY ACTUATED FLUID SWITCH**

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[73] Assignee: **Bell Telephone Laboratories, Incorporated,** Murray Hill, N.J.

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[52] **U.S. Cl.** **137/625.44,** 137/597, 137/610, 137/822, 137/831

[51] **Int. Cl.** **F15c 3/08**

[58] **Field of Search** 137/597, 610, 612, 137/625.44, 822, 831

[56] **References Cited**

UNITED STATES PATENTS

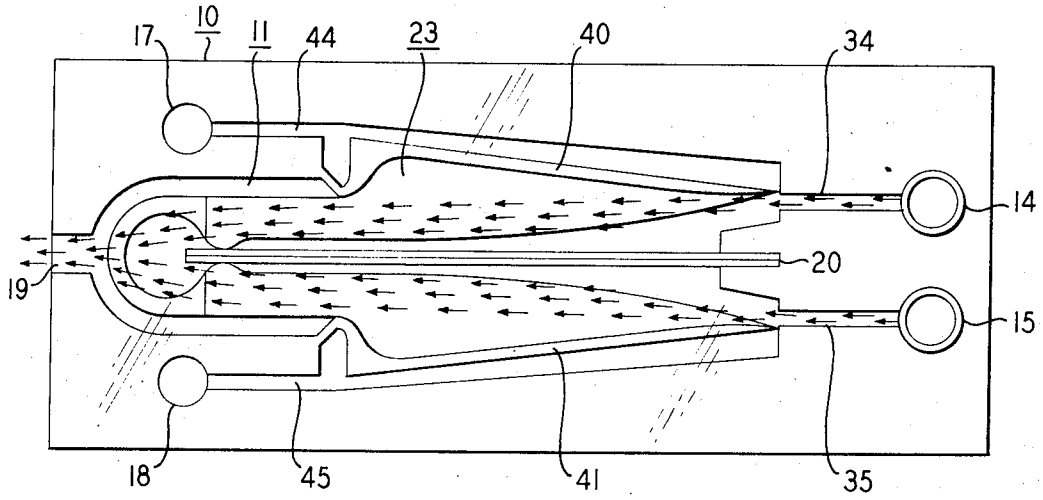
3,187,762	6/1965	Norwood	137/831
3,556,119	1/1971	Ankeney	137/831 X
3,457,933	7/1969	Craft	137/831
3,495,253	2/1970	Richards	137/822
3,605,780	9/1971	Kranz	137/610
3,628,568	12/1971	Green	137/610

Primary Examiner—Robert G. Nilson
Attorney—W. L. Keefauver et al.

[57] **ABSTRACT**

An electromechanically actuated fluid switch is disclosed in which the fluid output condition is tristable. The fluid output condition is selected by placing a voltage on a piezoelectric strip which, in turn, controls the position of the switching element. The three distinct fluid output conditions correspond to applied electrical signals of "+," "−" and "0." Since the switching function is not performed by the piezoelectric strip, but by a separate switching element, the configuration and surface finish of that element may be selected to provide desired fluid flow properties.

1 Claim, 5 Drawing Figures



2 Sheets-Sheet 1

FIG. 1

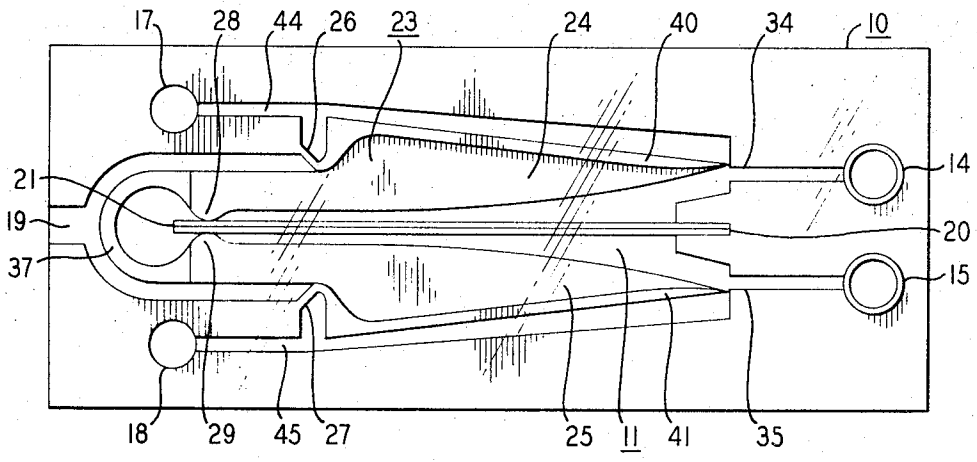


FIG. 2

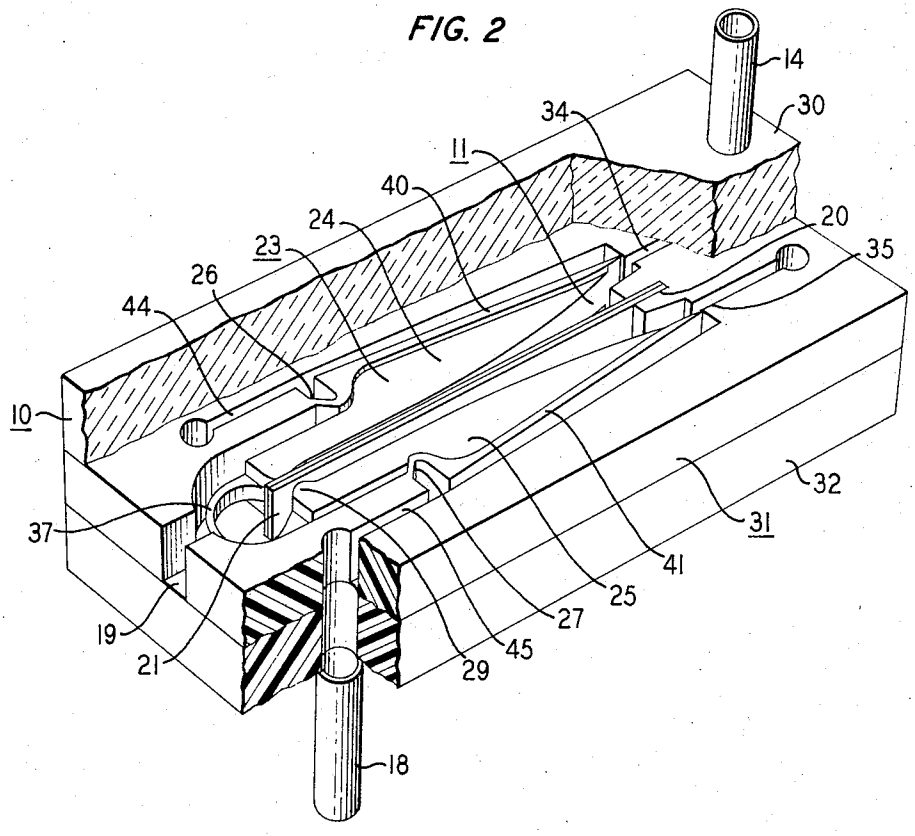


FIG. 3

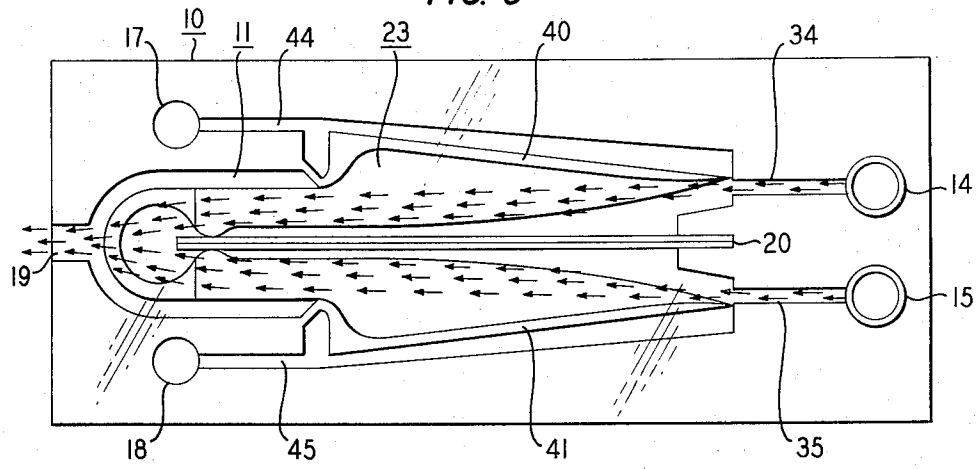


FIG. 4

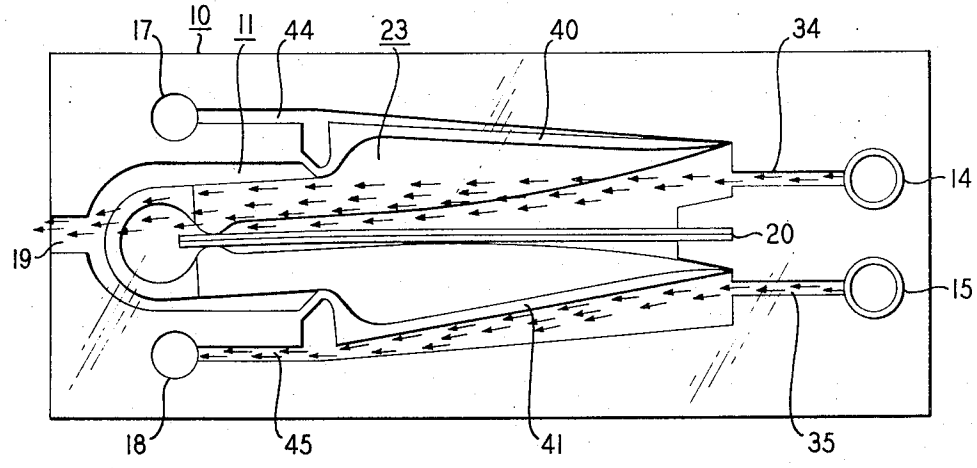
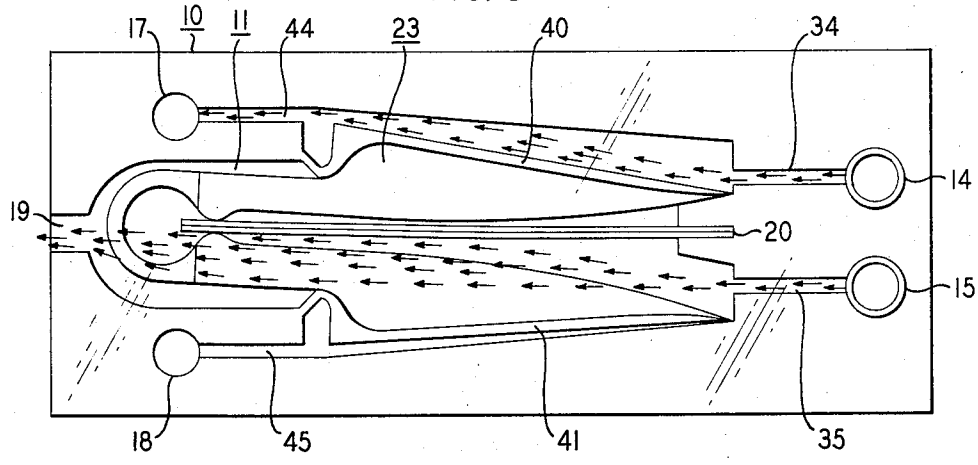


FIG. 5



ELECTROMECHANICALLY ACTUATED FLUID SWITCH

This invention relates to fluid switches and, more particularly, to electromechanically actuated fluid switches.

Background of the Invention

Fluid switches are used to provide a variety of logic functions depending upon the arrangement of the inputs and outputs. Typical of such switches are U. S. Pats. No. 3,187,762, issued to R. E. Norwood on June 8, 1965, 3,457,933, issued to D. J. Craft on July 29, 1969, and 3,605,780, issued to W. Kranz on Sept. 20, 1971. These devices are actuated either electromagnetically or piezoelectrically. As a result, the switching element, which is movable to selectively direct the input to a desired output, must be either magnetically responsive or must be fabricated from piezoelectric material.

Unfortunately, magnetic material and piezoelectric material frequently have a textured surface which interferes with the smooth flow lines desired in the switched fluid. The configurations of such elements are also frequently dictated more by the operating characteristics of the material than by the fluid flow patterns being controlled. For example, a magnetically actuated element may require a large surface area to provide sufficient magnetic attractive force, while only a small area is required, or even desired, for switching the fluid.

As the area of these elements increases, fluid impedance or resistance is introduced, resulting in an increase in the unrecovered input power. Similarly, the introduction of a textured surface into the fluid flow region will cause increased fluid resistance and turbulence. Not only is power thereby lost, but spurious fluid flow paths may result, producing fluid "noise" and degrading the quality of the fluid signals. Configurations which might be very beneficial from a fluid flow point of view may be impossible or impractical to provide due to the mechanical limitations of these materials.

Molded plastic has been found to be an excellent material for fabricating fluid devices. The device configuration may be very intricate without unduly increasing device cost. Surface finishes may be readily controlled to produce very smooth surfaces in the areas where fluid impinges. Substantial improvement in the performance of fluid switches could be anticipated by replacing the conventional switching element with an element fabricated from molded plastic.

It is therefore an object of my invention to provide a fluid switch in which the configuration and surface finish of the switching element are dictated by the fluid flow characteristics desired and not by the requirement of the actuating mechanism.

Summary Of the Invention

In an illustrative embodiment of my invention, two fluid inputs and two fluid outputs connect to a chamber in which a piezoelectric actuating strip is mounted. A movable switching element is also mounted in the chamber and positioned to move responsive to the action of the piezoelectric strip. The end of this chamber opposite the inputs is vented to the atmosphere. In its unoperated position, or that position in which the piezoelectric strip has no net voltage acting on it, the output from the device is through the vent to the atmosphere. Upon the application of a positive potential to the piezoelectric strip, the strip will bend, thereby moving the switching element and diverting the flow from one input to a selected output port. If a negative voltage is applied to the piezoelectric strip, the switching element is moved to its third stable position and the flow from the other input is diverted to a second selected output.

Description of the Drawing

FIG. 1 is a plan view of a device embodying my invention;

FIG. 2 shows an upper perspective view of the device shown in FIG. 1 broken away to show the interior detail;

FIG. 3 shows the device of FIG. 1 with the fluid flow path indicated for a first position of the switch element;

FIG. 4 shows the device of FIG. 1 with the fluid flow path indicated for a second position of the switch element; and

FIG. 5 shows the device of FIG. 1 with the fluid flow path indicated for a third position of the switch element.

Description of the Illustrative Embodiment

Fluid devices may be constructed from any rigid, nonporous material including glass, ceramic, plastic, and metal. Such devices generally comprise a base into which the desired passages are molded, impressed, or etched, and a cover which provides a fluid-tight seal when secured to the base by any of a number of methods such as adhesives, fasteners, clamps, or the like. For ease of illustration, the drawings of FIGS. 1 through 5 depict a device having a glass cover. This was done to permit the interior of the device to be shown without the confusing presence of cross-section lines. This should in no way be interpreted as a limitation on a material suitable for use in a device, since any rigid, nonporous material is applicable.

The particular device **10** shown in FIGS. 1 and 2 comprises a first fluid input **14** and a second fluid input **15**, which connect to independent fluid flow sources (not shown). These sources provide fluid flow selectively, depending on system conditions. the inputs **14** and **15** communicate respectively by nozzles **34** and **35** with a cavity area **11**. The nozzles act to generate a fluid jet when fluid pressure is present at the respective inlet.

Positioned to substantially bisect cavity **11** is a piezoelectric strip **20**. Strip **20** may be deflected from its null position either in a positive direction (upward) or a negative direction (downward), depending upon the voltage potential applied to it (through means not shown, but which are well known in the art). The inlet, or upstream, end of strip **20** is firmly held in the body of device **10**. The downstream end **21** of strip **20** is cantilevered and free to move when the strip deflects in response to an applied voltage.

Positioned astride free end **21** is a flow diverter **23** comprising two diverter legs **24** and **25**. Legs **24** and **25** have rounded bearing surfaces **28** and **29**, respectively, which contact free end **21** and move in response to the movement of strip **20**. Legs **24** and **25** are hinged at hinges **26** and **27**, respectively, and are connected to each other by brace **37** so that they move together in response to any movement of strip **20**.

At the downstream end of cavity **11** are two fluid receivers **44** and **45**. Fluid receivers **44** and **45** connect respectively to fluid outputs **17** and **18** which, in turn, connect to additional parts of the system in which the output signals are used. These have not been shown, although they would be well known to one skilled in the art. Also, at the downstream end of cavity **11** is a vent passage **19** which connects to the ambient atmosphere.

Along the periphery of legs **24** and **25** is a high ridge, or rib, **40** and **41**, respectively. Ribs **40** and **41** define a passageway between nozzles **34** and **35** and the respective receivers **44** and **45**.

The operation of device **10** can be best understood by referring to FIGS. **3** through **5** which show the device in various operable states. In FIG. **3**, device **10** is shown in position with no voltage applied to strip **20**. This will be referred to as the "O" position. In this position nozzles **34** and **35** are isolated from receivers **44** and **45** by ribs **40** and **41**, respectively. Flow issuing from nozzles **34** and **35** is directed by ribs **40** and **41** through cavity area **11** to exit device **10** via vent **19**.

If a positive potential is applied to strip **20**, it will take the configuration shown in FIG. **4**. The movement of strip **20** will re-position flow diverter **23**. In this position, the fluid jet issuing from nozzle **34** is still isolated from receiver **44** by rib **40**. Therefore, the jet issuing from nozzle **34** is directed through chamber area **11** to exit device **10** via vent **19**. However, rib **41** is now positioned on the opposite side of nozzle **35** from the position it occupied in FIG. **3** when no potential was applied to strip **20**. In the new position, the fluid jet issuing from nozzle **35** is diverted by rib **41** to be received at fluid receiver **45** which connects to fluid output **18**. Thus, in this position, which will be referred to as the "+" position, fluid flow originating at fluid input **14** exits the device via vent **19** while flow originating at fluid input **15** exits the device via fluid output **18**.

The application of a negative potential to strip **20** is shown in FIG. **5**. Due to this applied voltage, strip **20** moves in the direction shown. This causes flow diverter **23** to also move as shown within chamber area **11**. In this position, rib **41** once again isolates fluid receiver **45** from nozzle **35**. As a result, the fluid jet issuing from nozzle **35** passes through chamber area **11** and exits device **10** via vent **19**.

Rib **40** is now positioned on the opposite side of nozzle **34**. The fluid jet issuing from nozzle **34** is now isolated from chamber area **11** by rib **40** which diverts the issued jet to be received at receiver **44**. Thus, in this position, which will be called the "−" position, fluid flow originating at fluid input **14** is received at fluid receiver **44** and exits device **10** via fluid output **17**. Flow originating at fluid input **15** passes through the device **10** and exits via vent **19**.

It will be apparent that the device just described is nonlatching. That is, if either the + potential or the − potential is removed from strip **20**, it will return to the "**0**" position as shown in FIG. **3**. It should be equally clear that this is not a limitation of the device and is not a requirement, since by properly positioning of hinges **26** and **27**, a device could be made latching. That is to say, a device could be so arranged that, upon application of a + potential, flow diverter **23** would remain in the + position until a − potential were applied. At that point, flow diverter **23** would switch to the − position and remain there until a + potential is applied to the device. Thus, a latching device could be made bistable as opposed to the embodiment described above, which is tristable. Application of a negative potential less than the − potential would return strip **20** to the O position without causing the strip to move all the way to the − position. Thus, it can be seen that if tristable operation is desired, this can also be achieved with a latching device.

Referring again to FIG. **2**, it can be seen that the embodiment described includes a top plate **30**, an active layer **31** and a bottom plate **32**. Active layer **31** has been shown as a single piece of molded plastic into which strip **20** may be positioned. It should, of course, be apparent that this specific embodiment is not the only available arrangement. For example, plate **30** and layer **31** could readily be made in a single molded piece with flow diverter **23** being a separately molded item which is then positioned in cavity area **11** when strip **20** is assembled into the device. Although flow diverter **23**, hinges **26** and **27**, and the remainder of the active layer **31** are shown as being molded from a single piece, this is not a requirement since flow diverter **23** could readily be made as a separate item and assembled into layer **31**.

Although inputs **14** and **15** have been described as being connected to independent fluid flow sources, it should be apparent that a single common fluid flow source could also be connected to both inputs. It should be equally apparent that outputs **17** and **18** could also connect to a single common output. With independent inputs and a common output, device **10** would function as an OR logic gate. With independent outputs and either independent or common inputs, device **10** functions as a transducer.

Although it is not necessary that device **10**, or, for that matter, even active layer **31**, be fabricated by molding or even fabricated from plastic material, it should be apparent that this is a signal advantage of this arrangement. The advantage being that material comprising flow diverter **23**, and, in particular, ribs **40** and **41**, and the edge surfaces of chamber area **11** may be selected solely on the basis of the surface finish and its effect upon fluid resistance and the flow patterns established in moving through device **10**. Since the surface of an active element, such as strip **20**, is not involved in the movement of fluid through the device, the localized turbulence and fluid resistance created by the irregularities and surface imperfections of such materials will not have an effect on the active signals of the device.

What is claimed is:

1. A fluid switch comprising

a first nozzle for generating a first fluid jet;

a second nozzle for generating a second fluid jet;

a switching chamber forming a cavity into which the generated jets flow;

a first fluid receiver communicating with the switching chamber to receive the first jet;

a second fluid receiver communicating with the switching chamber to receive the second jet;

a vent connected to the switching chamber through which fluid exits the switch;

a flow diverter located within the switching chamber and selectively movable to three positions, in a first position the diverter isolates the first and second receivers from the generated jets and diverts the jets to exit the switch via the vent, in a second position the diverter isolates the first receiver from the

first jet and diverts the first jet to exit the switch via the vent while simultaneously directing the second jet to the second receiver, and in a third position the diverter isolates the second receiver from the second jet and directs the second jet to exit the switch via the vent while simultaneously directing the first jet to the first receiver; and

means responsive to applied electrical signals to selectively control the positioning of the flow diverter, said means moving the diverter to the first position when a first signal is present, to the second position when a second electrical signal is applied, and to the third position when a third electrical signal is present.

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