[11] 3,586,022

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[54] MULTILEVEL FLUIDIC LOGIC

8 Claims, 2 Drawing Figs.

[52] U.S. Cl. 137/81.5
[51] Int. Cl. F15c 1/04
[50] Field of Search 137/81.5

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ABSTRACT: Three distinct pressure levels, corresponding to three respective digital signal levels, are selectively provided at an output passage of a fluidic element in accordance with input logic conditions. The fluidic element has a power stream which can be switched to three distinct positions; in one position the power stream aspirates fluid from the output passage providing a negative output pressure level thereat; in a second position the power stream is received by the output passage providing a positive pressure thereat; in the third power stream position the output passage is unaffected by the power stream and thus provides a zero pressure.

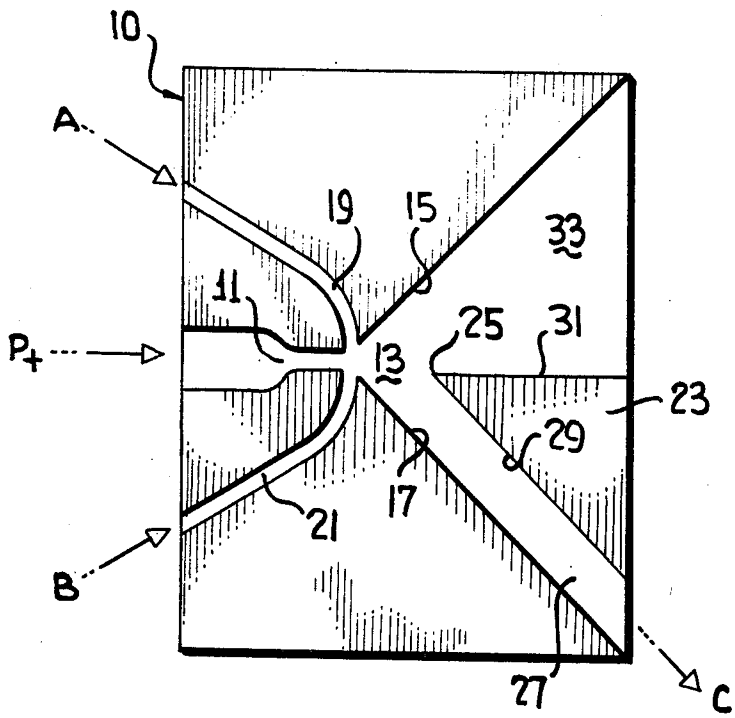

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FIG.1

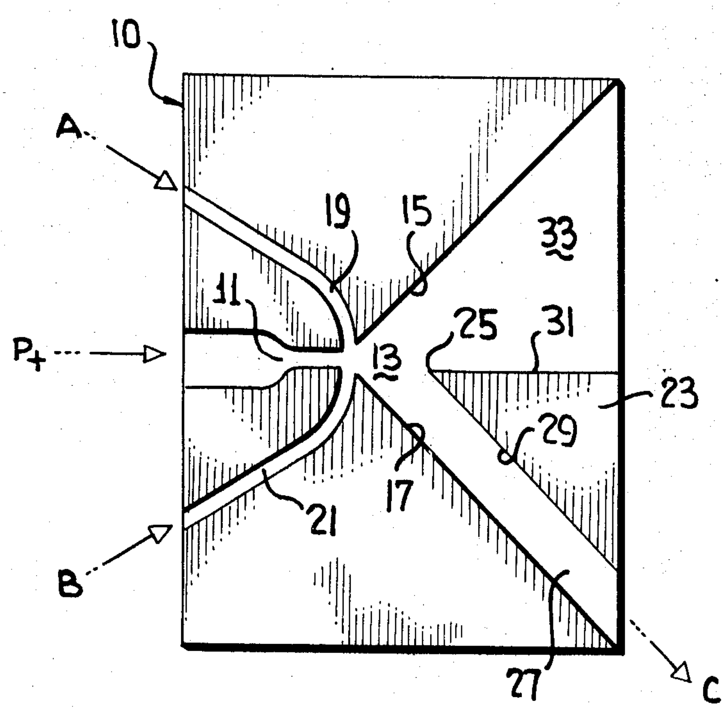

FIG.2

A	B	C
0	0	−
−	−	−
+	+	−
+	0	+
+	−	+
0	−	+
−	0	0
−	+	0
0	+	0

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MULTILEVEL FLUIDIC LOGIC

BACKGROUND OF THE INVENTION

The present invention relates to fluidic logic techniques, and more particularly to a method and apparatus for providing fluid logic signals at three or more distinct pressure levels.

Trinary logic, that is, digital logic employing three distinct signal levels, has found specialized utility in electronic logic systems and has resulted in the advantages of reducing the number of components, reducing the power consumption, and increasing operating speed as compared to binary systems. These same advantages are desirable in many fluidic logic applications, but prior to the present invention were not attainable due to the absence from fluidic technology of elements capable of providing three distinct fluid pressure levels corresponding to three respective logic conditions.

It is an object of the present invention to provide a method employing fluidic techniques for rendering trinary logic operable in fluidic systems.

It is another object of the present invention to provide a fluidic element having an output passage at which three distinct fluid pressures are provided in response to three different input logic conditions.

It is another object of the present invention to expand the horizons of fluidic technology by providing the capability of multilevel digital logic operation in fluidic systems.

It is still another object of the present invention to provide at least three different logic signal levels from a single fluidic element in response to various combinations of input logic conditions.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, a fluidic element is employed in which a power stream can assume any three possible positions in accordance with input signal conditions. An output passage is oriented with respect to the power stream to provide negative, zero and positive pressure output signals in response to the three respective stream positions. The power stream heavily aspirates fluid from the output passage when in one position to provide the negative output pressure. In a second position of the power stream the output passage is unaffected by power stream flow and provides a zero output pressure. In a third position the power stream is received by the output passage which, as a consequence, provides the positive output pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a plan view of a preferred embodiment of a trinary fluidic element;

FIG. 2 is a truth table indicating the operation of the element of FIG. 1 to all possible combinations to two trinary fluid input signals.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. 1 of the accompanying drawings, there is illustrated a trinary fluidic element comprising various fluid passages, nozzles and chambers to be described in detail below and which are formed by well-known techniques. A power nozzle **11** is responsive to application of pressurized fluid thereto for issuing a power stream of fluid into an interaction region **13**. A pair of opposed sidewalls **15**, **17** defined respective sides of region **13** and are disposed such that the power stream, when deflected by a control signal toward either sidewall, is attracted to that sidewall by boundary layer effects but does not remain stable in that position when the control signal is removed. The phenomenon by which such attraction occurs, often referred to as the boundary layer or Coanda effect, is well known in the fluidics art.

A pair of opposed control channels **19**, **21** communicate with interaction region **13** at its upstream end through respective sidewalls **15**, **17**. Channels **19**, **21** are each responsive to application of pressurized fluid thereto for issuing a control stream into region **13** in deflecting relationship with the power stream. such a control stream, as is well known, acts to deflect the power stream away from the control channel from which the control stream emanates and toward the opposing sidewall. In addition, application of a negative pressure or suction to either control channel tends to deflect the power stream toward that control channel.

A flow divider **23** of generally wedge-shaped configuration is disposed with its apex **25** located downstream of control channels **19**, **21** and points in an upstream direction. Divider **23**, disposed substantially closer to sidewall **17** than to sidewall **15**, defines an output passage **27** between one divider wall **29** and sidewall **17**. The other divider wall **31** and sidewall **15** define a vented region **33** which is open to ambient pressure at its downstream end. In addition, divider wall **31** is oriented relative to power nozzle **11** such that the power stream locks on thereto in the absence of a control signal tending to deflect the power stream toward either of sidewalls **15** or **17**.

When the power stream is locked onto divider wall **31** it effectively seals the mouth of output passage **27** (defined by divider apex **25** and sidewall **17**) from vented region **33**. In this position the power stream heavily aspirates fluid from output passage **27** providing a suction or negative pressure at the downstream end thereof.

When the power stream is attached to sidewall **17**, the stream is received by output passage **27** and provides a positive pressure at the downstream end thereof.

When the power stream is attached to sidewall **15**, the pressure at the downstream end of output passage **27** is substantially zero (or ambient) since in this position the power stream is neither received by output passage **27** nor can it aspirate fluid therefrom. The inability of the power stream to aspirate fluid from output passage **27** when the stream is attached to sidewall **15** is due to the fact that the mouth of output passage is wide open to vented region **33** which readily replaces any fluid near the mouth of passage **27** that tends to be entrained by the power stream. Vented region **33** is thus sufficiently large to maintain output passage **27** at ambient pressure.

As illustrated in FIG. **1**, the control signals applied to control passages **19** and **21** are designated A and B respectively. The output signal provided at output passage **27** is designated C. A truth table is provided in FIG. **2** to indicate the trinary level assumed by output signal C in response to the nine possible combinations of trinary input signals A and B. The negative, zero and positive trinary levels are represented by the symbols −, 0 and + respectively. It is noted that whenever signals A and B are at the same trinary level, signal C is negative, or −. Also, whenever signal A is at a more positive trinary level than signal B, signal C assumes the positive, or +, level. Similarly, whenever signal B is at a more positive trinary level than signal A, signal C assumes zero, or **0**, level.

The specific configuration illustrated in FIG. 1 is not necessarily the only configuration which will provide trinary operation in fluidic systems in accordance with the principles of the present invention. In fact, many configurations are possible wherein a power stream can be selectively deflected to three predetermined positions in which negative, zero, and positive pressure signals appear at an output passage. For example, in my copending U.S. Pat. application Ser. No. 703,659, filed Feb. 7, 1968 and entitled "Pure Fluid Amplifier Having A Stable Undeflected Power stream," I disclose a fluidic element whereby two power streams are issued in side-by-side relation such that they are mutually attracted and result in a single stream which is stable when undeflected. Divider wall **31** of the present invention would not be required to provide stability when such a power stream is undeflected. By orienting an output passage so as to be heavily aspirated by such a stable undeflected stream, and such that zero and positive output pressures are provided when the stream is in its other two respective positions, the device of my prior application can be utilized in accordance with the principles of the present invention.

It is also to be understood that if memory features are desired for a trinary element, the sidewalls 15 and 17 of FIG. 1 can be modified such that once the power stream attaches neither sidewall it locks on thereto, remaining stable in that condition until deflected by a control signal.

While I have described and illustrated specific embodiments of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A trinary fluidic logic element comprising:
a power nozzle responsive to application of pressurized fluid thereto for issuing a power stream of fluid;
control means responsive to a plurality of input logic conditions for selectively deflecting said power stream to any of three discrete positions;
an output passage having an ingress orifice disposed such that for one of said three discrete positions of said power stream said power stream is received by said output passage, for a second of said three discrete positions of said power stream fluid is heavily aspirated from said output passage by said power stream, and for the third of said discrete positions of said power stream the latter is neither received by nor aspirates fluid from said output passage.

2. The trinary fluidic element according to claim 1 wherein said control means comprises a pair of control channels responsive to application of pressurized fluid thereto for issuing a respective pair of oppositely directed control streams in interacting relationship with said power stream such that when the pressure at a first of said control channels exceeds the pressure at the second of said control channels said power stream assumes said one of said three discrete positions, when the pressures at said first and second control channels are equal said power stream assumes said second discrete position, and when the pressure at said second control channel exceeds the pressure at said first control channel said power stream assumes said third discrete position.

3. The trinary fluidic element according to claim 2 further comprising a large region vented to ambient pressure toward which said power stream is directed when in said third position, said power stream when in said third position being sufficiently removed from the ingress orifice of said output passage to permit free fluid communication between said output passage and said large vented region.

4. The trinary fluidic element according to claim 2 further comprising a generally wedge-shaped flow divider separating said output passage and said large vented region, said flow divider having an apex pointing upstream and two divider walls diverging from said apex in a downstream direction, one of said divider walls comprising a wall of said output passage, the other of said divider walls being disposed such that power stream attaches thereto when in said second discrete position, said power stream sealing fluid communication between said output passage and said vented region when in said second discrete position.

5. A fluidic logic element having at least one output passage and responsive to predetermined combinations of input logic conditions for providing at least three distinct pressure levels at said output passage, said element comprising:
means for issuing a power stream of fluid;
control means responsive to said predetermined combinations of input logic conditions for deflecting said power stream to any of at least three predetermined positions;
means responsive to said power stream in one of said three predetermined positions for heavily aspirating fluid into said element via said output passage;
means responsive to said power stream in a second of said three predetermined positions for providing ambient pressure in said output passage;
means responsive to said power stream in a third of said predetermined positions for directing said power stream into said output passage.

6. The method of providing fluid logic signals in a fluid passage at three discrete pressure levels in response to predetermined combinations of input logic conditions, said method comprising the steps of:
issuing a power stream of fluid;
providing a positive pressure at said fluid passage by directing said power stream into said fluid passage in response to at least one combination of said input logic conditions;
providing a negative pressure at said fluid passage by directing said power stream across the ingress orifice of said fluid passage to heavily aspirate fluid therefrom in response to at least a second of said input logic conditions; and
providing zero pressure at said fluid passage by maintaining ambient pressure in said fluid passage in response to at least a third of said input logic conditions.

7. A trinary fluidic logic element comprising:
an interaction region having an upstream end, a downstream end, and first and second opposed sidewalls diverging from said upstream end toward said downstream end;
means responsive to application of pressurized fluid thereto for issuing a power stream of said fluid into said interaction region at said upstream end, said sidewalls diverging at such an angle as to attract said power stream when the latter is deflected toward either sidewall but to prevent stable attachment of said power stream to said sidewalls in the absence of additional deflecting force applied to said power stream;
a wedge-shaped flow divider disposed in said interaction region between said sidewalls and having an apex pointing toward said upstream end and first and second divider walls diverging from said apex in a downstream direction, said first divider wall being disposed such that said power stream attaches thereto when otherwise undeflected, said second divider wall defining an output passage with said first interaction region sidewall, the upstream end of said interaction being disposed such that said power stream aspirates fluid therefrom when said power stream is attached to said first divider wall; and
control means for selectively deflecting said power stream toward said first and second sidewalls.

8. The element according to claim 7 wherein said control means comprises first and second control channels communicating with said interaction region through said first and second sidewalls, respectively, each control channel being arranged to issue fluid applied thereto to deflect said power stream toward the opposite sidewall.