

[54] SWITCH DEVICE FOR FLUIDIC
LOGICAL CIRCUIT

[75] Inventor: Andre Wieme, Zwevegem, Belgium

[73] Assignee: N. V. Bekaert S. A., Zwevegem,
Belgium

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[51] Int. Cl.....F15c 1/08, F15c 5/00

[58] Field of Search137/81.5, 608; 235/201

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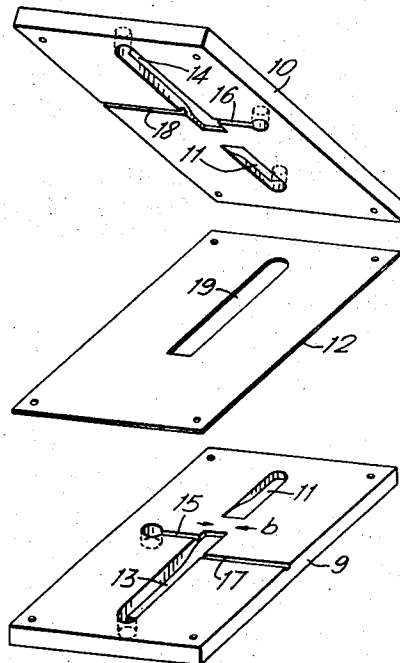
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Primary Examiner—William R. Cline
Attorney—Sparrow and Sparrow

[57] ABSTRACT

A switch device or element for a fluidic logical circuit, and more particularly to the construction of two air-tight combined bodies, e.g., plates, between which a perforated foil is present. The two combined bodies have recesses cooperating with openings through the foil to form a plurality of chambers and channels. Fluids passed through the chambers and channels then function as fluid logical circuit elements in the form of, for example, gates, amplifiers, etc.

7 Claims, 8 Drawing Figures



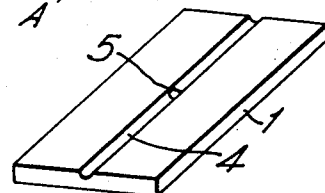
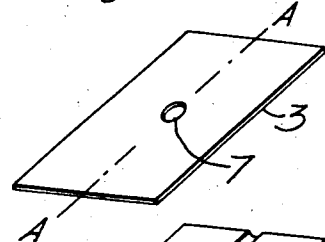
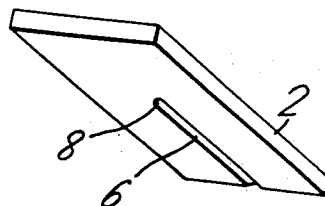
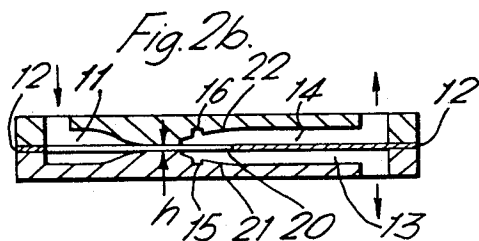
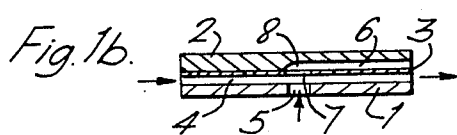


Fig. 1a.

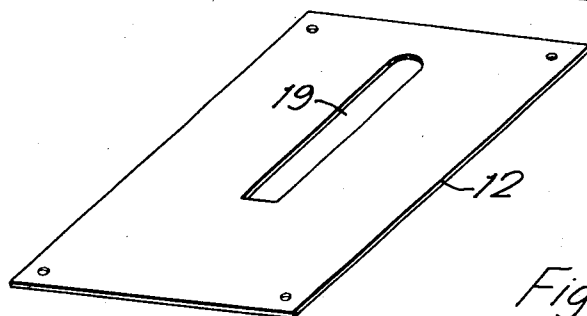
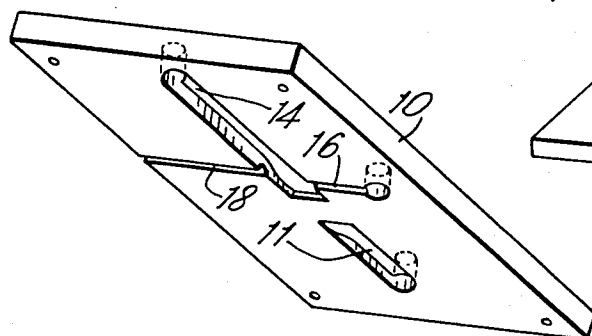
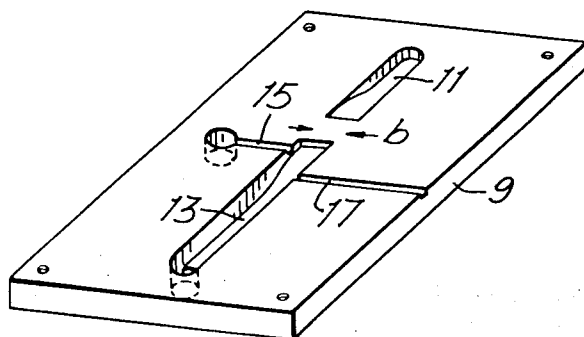


Fig. 2a.



INVENTOR
Andre Wieme
BY Sparrow and Sparrow
ATTORNEYS

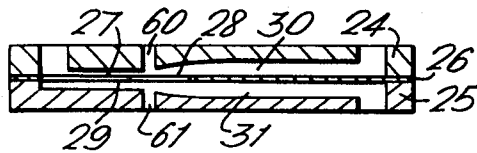


Fig. 3.

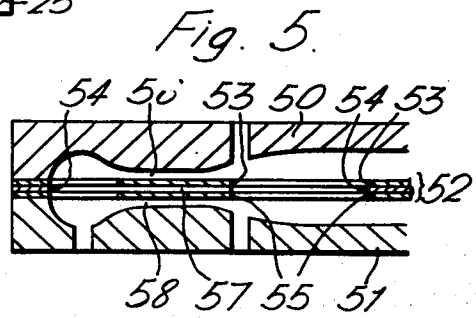


Fig. 5.

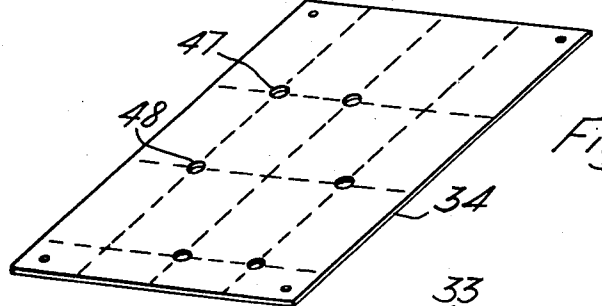
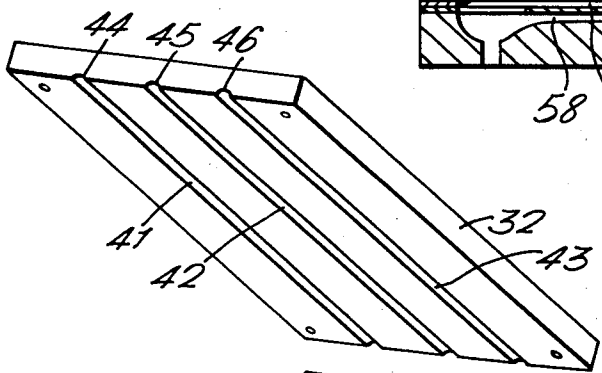


Fig. 4.

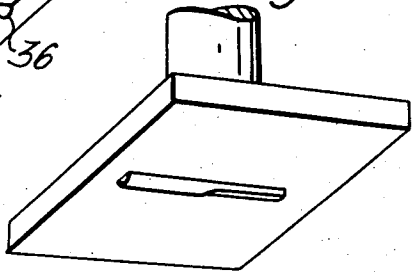
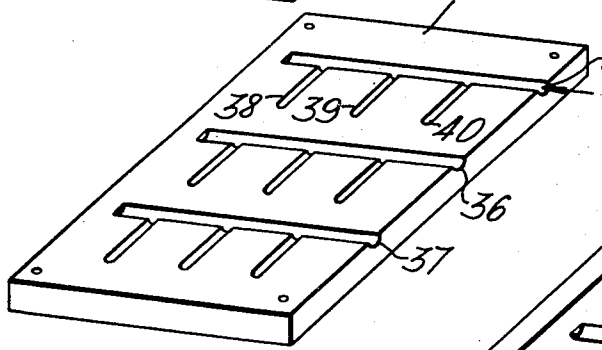


Fig. 6.

INVENTOR
Andre' Wieme
BY Sparrow and Sparrow
ATTORNEYS

SWITCH DEVICE FOR FLUIDIC LOGICAL CIRCUIT

BACKGROUND OF THE INVENTION

A fluidic logical circuit consists of a configuration of fluid chambers and connecting channels. The fluid chambers are enclosed spaces into which one or more fluid jets can discharge and can be deviated in direction depending upon the shape of this space or upon the presence of other fluid jets.

It is known from U.S. Pat. No. 3,001,698 that fluid circuit may be fabricated with two combined plates between which a perforated plate is present. In the latter plate a number of shapes are punched. With the two other flat plates pressed on both sides, an arrangement is obtained which consists internally of a configuration of cavities and channels. This configuration is the same as that of the punched shapes. It is two-dimensional at the level of the perforated plate. In comparison with the configuration using casings and pipes, it is easy to design and fabricate.

SUMMARY OF THE INVENTION

The invention is aimed at obtaining a configuration of cavities and channels, with two combined recessed plates and one punched plate inserted between them, whereby this configuration is two-dimensional according to the level of the plates, and according to one level, perpendicular thereto as well. In this way, saving in space can in general be obtained. A structure according to the invention can also advantageously be chosen in cases where it is desired to obtain very narrow channels with accurate dimensions and close tolerances.

The device or element in accordance with the invention is characterized by the fact that a number of recesses are present in the contact surface of the two combined bodies, which together with the apertures in the punched plate or perforated foil form a configuration of fluid chambers and channels. At least one channel division is present with divided channels which lie on both sides of the perforated foil and proceed mainly in the same direction from the cavity formed by an aperture in the foil and the recesses on both sides. The channel to be divided off discharges, principally, in the same direction into this cavity.

The combined bodies are mostly small plates, and the recesses in the contact surface thereof do not run through the entire thickness of these plates, with the exception of the apertures used for the fluid supply and discharge. The plates with recesses may be milled and etched, or else cast. However, the recesses are preferably pressed into the surface by means of a press with hard steel die parts as is used for pressing into an aluminum surface. For pressing the channels, hard bent steel wires can be used.

Various further and more specific purposes, features and advantages will clearly appear from the detailed description given below taken in connection with the accompanying drawings which form part of this specification and illustrate merely by way of examples, embodiments of the device of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following description and in the claims parts will be identified by specific names for convenience,

but such names are intended to be as generic in their application to similar parts as the art will permit. Like reference characters denote like parts in the several figures of the drawings, in which

FIGS. 1a and 1b show a device that can be used as a NO circuit;

FIGS. 2a and 2b show a bistable device with Coanda effect;

FIG. 3 shows an amplifying device;

FIG. 4 shows a coding matrix with fluidic diodes at the points of intersection;

FIG. 5 shows a device the intermediate foil of which consists of several perforated sub-foils; and

FIG. 6 shows a press for the stamping of a channel.

FIGS. 1a and 1b show a device or arrangement that can serve for the execution of a NO-function. FIG. 1a shows the components prior to the combination. The device consists of two plates 1 and 2 between which the perforated foil or plate 3 is present. Plate 1 contains a groove 4 into which a supply channel 5 discharges. The channel 5 is drilled transversally through the plate. Plate 2 contains only a semi-groove 6 which runs in the same direction as the groove 4. When combining the two plates with the foil between them, care is taken to ensure that the aperture 7 in the foil and the extremity 8 of the groove 6 lie opposite the supply channel 5 and that both grooves 4 and 6 are parallel. FIG. 1b shows a cross-section in the direction AA, of the plates thus combined. A NO-function can be executed with the element or device as follows: an air current that is injected into the element or device via pipe 4 will flow straight through to the signal outlet, provided that no air current is injected via channel 5. In the latter case, all air is diverted to channel 6. This device thus contains a channel division. The divided channels (channel 6 and the right half of channel 4; FIG. 1b) lie on both sides of the foil and proceed from the cavity formed by the aperture 7 and the recesses in the plates 1 and 2. This cavity serves as interaction chamber where the two inflowing air currents can interact. The channel to be divided (left half of channel 4; FIG. 1b) discharges into this cavity in the same direction as the divided channels.

A bistable device or arrangement with Coanda effect can be executed in accordance with FIGS. 2a and 2b (The effect is described, e.g., in "Systems Technology" of Sept. 2, 1967, pp. 2-3). FIG. 2a shows the device prior to the combination of plates 9 and 10 with intermediate foil 12, and FIG. 2b shows a longitudinal section. The input channel 11 for the compressed air converges to a narrow air fissure with height h . As there is no longer any recess in the contact surface of both plates at this location, the height of this air fissure is equal to the thickness of the foil 12. There is then a fluid chamber 20 with a channel division where both divided channels 13 and 14 lie on both sides of the foil 12. Two control channels 15 and 16 discharge into the space before the channel division, and at the level of the division itself there are also two ventilation channels 17 and 18. The aperture 19 in the foil makes possible the air circulation 11 to one of the two divided channels 13 and 14. The air introduced converges in the input channel 11 to a thin layer of air which is forced through the air fissure and proceeds further in the fluid chamber along one of the two walls 21 and 22,

respectively to the channels 13 and 14, in view of the Coanda effect. In order to detach the air layer from the wall selected, it is sufficient to direct an air current of low flow energy into the control channel which discharges along this wall. The air current then shifts from one wall to the other. Thus, if the device is in a position whereby the air current flows outward via channel 14, then it will be possible to bring the element into the other position with a control current which flows into the fluid chamber via channel 16. If need be, the changeover can also be effected by low-pressure suction via the other channel 15.

In general, the bistable devices or arrangements with Coanda effect have heretofore been manufactured in such a way, that the configuration of all channels was two-dimensional in a level or plane parallel with the plane or level of the plates. This configuration was formed by casting of the plates or by milling or else etching in the surface thereof. In the arrangement according to the invention, the configuration is, however, still to a large extent two-dimensional in a level or plane perpendicular to the level or plane of the plates (see, e.g. FIG. 2b). This has a great advantage. It is a well-known fact that, if it is desired to make the influence of the walls on the air current as great as possible, the ratio h/b (b ; see FIG. 2a, h ; see FIG. 2b) must be made as small as possible. For a configuration in a level or plane parallel with the level of the plates, a very thin and deep air fissure must therefore be milled, cast or etched. In this respect, a great degree of accuracy cannot be attained. For the configuration according to the invention, the height h of the air fissure is determined by the thickness of the foil 12, and the implementation of a thin air fissure is very simple and solely limited by the thickness of the foil.

Much saving of space can be obtained with the structure according to the invention. Thus, an element is no longer confined to being two-dimensional in a single plane or level, but can be situated partly in the level according to the plates (channels 15, 16, 17 and 18) and partly in a level perpendicular thereto (channels 13 and 14 in FIG. 2b). The dividing wall between the channels adjacent to each other in the last named level is the foil, and this can be kept thin.

It should further be noted that the top and bottom plates 9 and 10 of the device according to FIG. 2a, are entirely identical. With a structure with grooved plates that form a two-dimensional configuration, entirely in the plane or level of the plates, this is only possible for symmetrical configurations. The configuration which was implemented in the device according to FIG. 2 is however not symmetrical (see, indeed, FIG. 2b), and nevertheless it was possible, according to the invention, to design a structure with identical top and bottom plate.

It is possible to obtain according to the invention an arbitrary amplifier, the operation of which is based on the distribution of a high-powered current via two divided channels under the influence of a controlling low-powered current, with or without re-coupling. An amplifier of this type is shown in section in FIG. 3. It consists of two combined plates 24 and 25, with the intermediate foil 26. The input channel 27 for the high-powered current discharges into the interaction chamber 28, which is formed by a part of the aperture

29 in the foil and the recesses in the plates 24 and 25 on both sides. Two control channels 60 and 61 also discharge into the interaction chamber, the introduced flow of which ensures the deviation of the main jet which flows into the interaction chamber via channel 27. With groove-shaped recesses in the plates 24 and 25, the two divided channels 30 and 31 are formed on both sides of the foil 26, which run in the same direction as that in which the input channel 27 discharges into the interaction chamber 28.

The arrangement according to FIG. 1 may be used as a fluidic diode when channel 5 is sealed off or is not present. A current which is introduced into the device via the divided channel 6 will then flow out of the device again via the channel to be divided (left part of channel 4 in FIG. 1b). Conversely, however, the air which flows into the device via this channel to be divided, does not pass outward along channel 6, but via the other divided channel which lies in the extension of the channel to be divided and this serves as ventilation channel. These two channels, which lie in each other's extension, are limited, on the one hand, by the wall of one and the same groove in the body 1, and on the other hand, by the foil 3.

With such fluidic diodes, a coding matrix can be formed in a relatively simple way. An example of this is shown in FIG. 4. It consists of two combined plates 32 and 33, with the intermediate foil 34. One plate contains a number of wide pressure channels 35, 36 and 37 for the supply of compressed air. These channels correspond to the rows of the matrix. Each channel contains as many side-channels as there are columns in the matrix (e.g., channels 38, 39 and 40). The foil 34 contains a number of apertures (e.g. 47 and 48), arranged at certain points of intersection of rows and columns. These points of intersection lie at the level of the extremities of the side-channels. When combining the plates, the apertures must therefore fit just over the tongue-shaped end of the corresponding side-channel. Plate 32 contains in the contact surface as many parallel grooves as there are columns in the matrix.

When combining the plates, each groove must fit over the apertures in the foil of the corresponding column. Thus, at each point of intersection where an aperture was made, a diode is formed of the type described above. The diode of which, for example, aperture 47 forms part, consists of a channel division with channel 41 (channel to be divided and divided channel which lie in each other's extension) and the second divided channel 38. When channel 35 comes under pressure, then an air current flows via channel 38, aperture 47 and channel 41 to the outlet 44. The compressed air is not transmitted via aperture 48 to the pressure channel 36. The air current in channel 41 instead flows past this aperture and will not change direction by 180° if it can flow straight ahead.

If channel 35 is brought under pressure separately in this way, then the outlets 44 and 45 will supply an air current and outlet 46 will not. If subsequently channel 36 is brought under pressure separately, then outlets 44 and 46 emit a signal and outlet 45 does not. If, finally, channel 37 comes under pressure separately, then an output signal is obtained in 45 and 46, but not in 44. It is thus possible to obtain different signal combinations in succession at the outlets, by connecting successively

each pressure channel with the compressed air source. With such a matrix, with the necessary number of rows and columns, an arbitrary binary code combination can thus be generated, immediately or in a specific sequence, by a supply of compressed air to the corresponding row. The combination obtained depends on the combination of apertures in the corresponding row in foil 34. This foil may be a punched card or a piece of a punched tape. In this way, a certain sequence of code signals can thus rapidly be replaced by another sequence. These may, for example, be series of code signals which correspond to specific operations of machine tools or other machines. The work program of the machine is then determined by the punched card which serves as intermediate foil.

A characteristic feature of this coding matrix is the fact that, for the diodes, the groove for the channel to be divided and the divided channel lying in the extension is common for all diodes of the same column (e.g., groove 44) in one plate 32, while for the diodes of the same row, the grooves for the other divided channel (e.g., grooves 38, 39 and 40) discharge into a common channel 35 in the other plate 33. It is not necessary for side-channels to be made in this plate 45 at the place where there is no aperture in the foil (e.g., side-channel 40 is not necessary. However, when all side-channels are formed, this plate is usable for an arbitrarily inserted foil with arbitrarily punched code combinations. Hence, only one type of plate 33 must be designed.

For the intermediate perforated plates 3, 12, 26 or 34, the word "foil" has been used, to mean thereby that a small plate is used which is sufficiently thin to ensure that the air current could flow away via both divided channels, without appreciable loss of kinetic energy—which is the consequence of a collision against the wall of the aperture. The shape and structure of this foil are thus of no importance in the definition of the term "foil." Thus, the inserted foil may consist of several accumulated sub-foils, which together still correspond to the interpretation of "foil" referred to above. Apertures can still be made in these plates in such a way that after accumulation thin channels are still present inside the foil. This is shown in cross-section in FIG. 5. Such an element or device consists of the bodies to be combined 50 and 51 which contain recesses in the contact surface and a laminated foil 52 which consists of the sub-foils 53, 54 and 55. By virtue of the arrangement of the apertures in the sub-foils, care has been taken to ensure that the channel to be divided consists of three narrow fissure-shaped channels 56, 57 and 58. This reduces the turbulence possibility of the fluid and the humming of the air flowing through.

It is not absolutely necessary for the bodies assembled to each other to be flat plates. Thus, the system according to FIG. 4 can be made cylindrically, whereby plate 33 is replaced by a cylinder.

Aluminum plates will preferably be used. The recesses are then stamped therein by means of a press with shapes in hard steel. In particular, for the stamping of semi-cylindrical grooves (such as groove 6 in FIG. 1b), which only gradually reach the full depth at the extremity 8, a soft iron plate can be used as a die, in which one half of a hard steel wire is fully pressed in, while the other half is only pressed in for part of the full thickness (FIG. 6).

The channel division will always consist of a channel to be divided and the divided channels, whereby the direction in which these channels discharge into the cavity which is formed by the aperture in the foil and the recesses on both sides thereof, is the same. Devices with slight directional variances, which can be applied without inadmissible loss of energy through the change in direction, however, also belong to the devices according to the invention, as the channels then nevertheless have mainly the same direction.

The devices can be used with an arbitrary fluid, liquid or gas, and the applications are not limited to compressed air alone.

A switch device according to the invention may, if need be, consist of more than two bodies with a perforated foil between them. Thus, one of the two bodies may be combined, on another side, with yet another body, with or without foil in between. These bodies may also be arranged in layers, whereby the required shape is obtained by stacking several thin plates on top of each other.

The possible designs and functional devices according to the invention are not limited to the examples listed here. Decoding equipment with successive interaction chambers and interpolated amplifiers, comparative circuits with a number of exclusive-OR circuits in parallel, followed by an AND-circuit and whereby at least one of the functions is performed in a channel division according to the invention, are evidently also possible.

While the invention has been described and illustrated with respect to certain preferred examples which give satisfactory results, it will be understood by those skilled in the art after understanding the principle of the invention, that various changes and modifications may be made without departing from the spirit of the invention.

What is claimed is:

1. A fluidic logical element comprising, in combination, two plates each having in a face thereof a groove-shaped recess extending in the direction of fluid flow, a foil having therein at least one aperture and being hermetically sealed between said two plate faces so as to define two chambers by means of the separation of said foil from the bottoms of said two groove-shaped recesses, said foil having an edge acting to divide the fluid flow delivered to said chambers, inlet means for introducing fluid to said foil aperture being configured upstream of said edge to constrict said fluid flow, outlet ports communicating respectively with said chambers, and at least one of said groove-shaped recesses having its bottom surface gradually increasing in depth in the direction of fluid flow so as to promote divergence of fluid flow delivered thereto.

2. The logical element as defined in claim 1, wherein said configuration of said inlet means narrows to said aperture in said foil, for forming a constriction in the direction perpendicular to said foil substantially equal to the thickness of said foil.

3. The logical element as defined in claim 1, including at least one other recess formed in the face of one of said plates communicating with said chambers at a point adjacent to said edge for forming one controlled channel arranged to feed a control fluid flow signal into said chambers, and control input means communicating with said other recess.

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4. The logical element as defined in claim 3, wherein said control input means discharges said control fluid flow signal into said chambers in a direction for assuring deviation of said fluid flow.

5. The logical element as defined in claim 3, wherein both of said groove-shaped recesses are shaped with varying depths for interacting with said fluid flow to

generate a substantial Coanda effect.

6. The logical element as defined in claim 1, wherein said foil is substantially flat-shaped.

7. The logical element as defined in claim 6, wherein said plates are substantially flat-shaped.

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