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(54) **FLUID SYSTEM**

(57) A fluid system (100) includes a fluid active region (10), a fluid channel (20), a convergence chamber (30), a sensor (40) and a plurality of valves (50, 50a, 50b, 50c, 50d). The fluid active region (10) includes at least one fluid-guiding unit (10a). The fluid-guiding unit (10a) is enabled under control, so as to transport fluid and discharge the same out through an outlet aperture (160) thereof. The fluid channel (20) is in communication with the outlet aperture (160) of the fluid active region (10), and includes a plurality of branch channels (20a, 20b, 21a, 22a, 21b, 22b) for splitting the fluid discharged from the fluid active

region (10). The convergence chamber (30) is in communication with the fluid channel (20). The sensor (40) is disposed in the fluid channel (20) for measuring the fluid. The valves (50, 50a, 50b, 50c, 50d) are disposed in the corresponding branch channels (20a, 20b, 21a, 22a, 21b, 22b), wherein the fluid is discharged out through the branch channels (20a, 20b, 21a, 22a, 21b, 22b) by controlling open/closed states of the valves (50, 50a, 50b, 50c, 50d). The fluid system (100) of the present disclosure is capable of acquiring required flow rate, pressure and amount of the fluid to be transported.

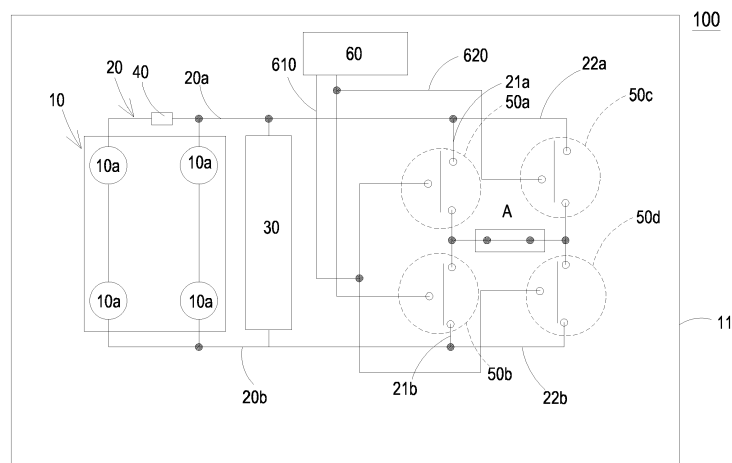


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The present disclosure relates to a fluid system, and more particularly to a miniature integrated fluid system.

BACKGROUND OF THE INVENTION

[0002] Nowadays, in various fields such as pharmaceutical industries, computer techniques, printing industries or energy industries, the products are developed toward elaboration and miniaturization. The fluid transportation devices are important components that are used in, for example micro pumps, micro atomizers, print heads or industrial printers. Therefore, how to utilize an innovative structure to break through the bottleneck of the prior art has become an important part of development.

[0003] With the rapid development of science and technology, the applications of fluid transportation devices are becoming more and more diversified. For example, fluid transportation devices are gradually popular in industrial applications, biomedical applications, medical care applications, electronic cooling applications and so on, or even the most popular wearable devices. It is obvious that the fluid transportation devices gradually tend to miniaturize the structure and maximize the flow rate thereof.

[0004] Although the miniature fluid transportation device is capable of transferring gas continuously, it is difficult to improve the miniature gas transportation device to increase the amount of the transportation when it comes to its miniature chambers or flow channels with limited volume which have more design requirements. For solving the above drawbacks, it is important to provide a gas transportation device with a valve to control the continuation or interruption of the gas transportation, control the gas to flow in one direction, accumulate the gas in the limited-capacity chamber or fluid channel and increase the amount of the gas to be discharged.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide an integrated fluid system to address the issues that the prior arts can't meet the requirements of the miniature fluid system. The fluid system includes a fluid active region, a fluid channel, a convergence chamber, a sensor and a plurality of valves. The valves may be active valves or passive valves. The fluid active region includes one or a plurality of fluid-guiding units. Each fluid-guiding unit has an outlet aperture. The fluid channel is in communication with the outlet apertures of the flow-guiding units of the fluid active region. The fluid channel includes a plurality of branch channels. The fluid discharged from the fluid active region is split by the branch channels. The

convergence chamber is in communication with the fluid channel for allowing the fluid discharged from the fluid channel to be accumulated therein. The sensor is disposed in the fluid channel for measuring the fluid within the fluid channel. The valves are disposed in the corresponding branch channels. The fluid is discharged out through the branch channels by controlling open/closed states of the valves.

[0006] In an embodiment, the valves are active valves. The fluid system further includes a controller electrically connected to the valves to control the open/closed states of the valves. The controller and the fluid-guiding units are packaged in a system-in-package manner as an integrated structure. The fluid active region includes the fluid-guiding units. The fluid-guiding units are connected to each other in a serial arrangement, in a parallel arrangement or in a serial-and-parallel arrangement. The lengths and widths of the branch channels are preset according to the required amount or the flow rate of the fluid to be transported. The branch channels are connected to each other in a serial arrangement, in a parallel arrangement or in a serial-and-parallel arrangement.

[0007] From the above descriptions, the fluid system of the present disclosure has miniature volume and is capable of acquiring required flow rate, pressure and amount of the fluid to be transported.

[0008] The above contents of the present disclosure will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 schematically illustrates a fluid system according to an embodiment of the present disclosure; FIG. 2A is a schematic cross-sectional view illustrating a fluid-guiding unit of the fluid system according to the embodiment of the present disclosure; FIGS. 2B, 2C and 2D schematically illustrate the actions of the fluid-guiding unit of the fluid system of FIG. 2A;

FIG. 3A schematically illustrates the fluid active region of the fluid system as shown in FIG. 1;

FIG. 3B schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a serial arrangement;

FIG. 3C schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a parallel arrangement;

FIG. 3D schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a serial-and-parallel arrangement;

FIG. 4 schematically illustrates a variant example of

the fluid active region of the fluid system;

FIG. 5 schematically illustrates another variant example of the fluid active region of the fluid system; FIGS. 6A and 6B are schematic cross-sectional views illustrating the actions of a valve used in the fluid system according to a first aspect of the present disclosure; and

FIGS. 7A and 7B are schematic cross-sectional views illustrating the actions of a valve used in the fluid system according to a second aspect of the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] The present disclosure will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this disclosure are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0011] Please refer to FIGS. 1, 2A, 2B, 2C, 2D, 6A, 6B, 7A and 7B. The present disclosure provides a fluid system 100 including at least one fluid active region 10, at least one fluid-guiding unit 10a, at least one outlet aperture 160, at least one fluid channel 20, a plurality of branch channels 20a, 20b, 21a, 21b, 22a, 22b, at least one convergence chamber 30, at least one sensor 40, a plurality of valves 50, 50a, 50b, 50c and 50d, at least one base 51, at least one first passage 511, at least one second passage 512, at least one cavity 513, at least one first outlet 514, at least one second outlet 515, at least one piezoelectric actuator 52, at least one carrier plate 521, at least one piezoelectric ceramic plate 522, at least one linking bar 53 and at least one stopping part 531. The number of the fluid active region 10, the fluid channel 20, the convergence chamber 30, the sensor 40, the base 51, the first passage 511, the second passage 512, the cavity 513, the first outlet 514, the second outlet 515, the piezoelectric actuator 52, the carrier plate 521, the piezoelectric ceramic plate 522, the linking bar 53 and the stopping part 531 is exemplified by one for each in the following embodiments but not limited thereto. It is noted that each of the fluid active region 10, the fluid channel 20, the convergence chamber 30, the sensor 40, the base 51, and the linking bar 53 can also be provided in plural numbers.

[0012] FIG. 1 schematically illustrates a fluid system according to an embodiment of the present disclosure. As shown in FIG. 1, the fluid system 100 includes a fluid active region 10, a fluid channel 20, a convergence chamber 30, a sensor 40, a plurality of valves 50a, 50b, 50c and 50d, and a controller 60. In an embodiment, the above components are packaged in a system-in-package manner on a substrate 11. In other words, the fluid system 100 is produced by an integrated method. The fluid active region 10 includes one or more fluid-guiding

units 10a. The fluid-guiding units 10a may be connected to each other in a serial arrangement, in a parallel arrangement or in a serial-and-parallel arrangement. When each fluid-guiding unit 10a is enabled, a pressure difference within the fluid-guiding unit 10a is formed, by which fluid (e.g., gas) is inhaled into the fluid-guiding unit 10a and pressurized to be discharged out through an outlet aperture 160 of the fluid-guiding unit 10a (see FIG. 3C). Consequently, the fluid is transported through the fluid-guiding unit 10a.

[0013] In this embodiment, the fluid active region 10 includes four fluid-guiding units 10a. The four fluid-guiding units 10a are connected to each other in a serial-and-parallel arrangement. The fluid channel 20 is in communication with the outlet apertures 160 of the fluid-guiding units 10a (see FIG. 3C) to receive the fluid discharged from the fluid-guiding units 10a. The structures, actions and dispositions of the fluid-guiding unit 10a and the fluid channel 20 will be described as follows. The fluid channel 20 includes a plurality of branch channels 20a and 20b for splitting the fluid discharged from the fluid active region 10. Consequently, the required amount of the fluid to be transported is determined. The branch channels 20a and 20b are exemplified in the above embodiment, but the number of the branch channels is not restricted. The convergence chamber 30 is in communication with the branch channels 20a and 20b, and thus the convergence chamber 30 is in communication with the fluid channel 20. The fluid may be transferred to and accumulated and stored in the convergence chamber 30. When the fluid system 100 regulates the discharge of the required amount of the fluid, the fluid accumulated and stored in the convergence chamber 30 is available for the fluid channel 20 so as to increase the amount of the fluid to be transported. In this embodiment, the sensor 40 is disposed in the fluid channel 20 for measuring the fluid within the fluid channel 20.

[0014] As mentioned above, the fluid channel 20 includes a plurality of branch channels 20a and 20b. As shown in FIG. 1, the branch channels 20a and 20b are connected to each other in a parallel arrangement, but not limited thereto. In some other embodiments, the branch channels 20a and 20b are connected to each other in a serial arrangement or in a serial-and-parallel arrangement. The lengths and widths of the branch channels 20a and 20b are preset according to the required amount of the fluid to be transported. In other words, the flow rate and amount of the fluid to be transported are influenced by the lengths and widths of the branch channels 20a and 20b. That is, the lengths and widths of the branch channels 20a and 20b may be calculated in advance according to the required amount of the fluid to be transported.

[0015] In this embodiment, the branch channel 20a further includes two sub-branch channels 21a and 22a (also referred as branch channels), and the branch channel 20b further includes two sub-branch channels 21b and 22b (also referred as branch channels). As shown in FIG.

1, the sub-branch channels 21a and 22a of the branch channel 20a are connected to each other in a serial arrangement, and so are the sub-branch channels 21b and 22b. In some embodiments, the sub-branch channels 21a and 22a of the branch channel 20a may also be connected to each other in a parallel arrangement or in a serial-and-parallel arrangement, and so are the sub-branch channels 21b and 22b. The valves 50a, 50c, 50b and 50d may be active valves or passive valves. In this embodiment, the valves 50a, 50c, 50b and 50d are active valves, and the valves 50a, 50c, 50b and 50d are disposed in the sub-branch channels 21a, 22a, 21b and 22b, respectively. The valves 50a, 50c, 50b and 50d are selectively in an open state or a closed state, so as to control the communication state of the sub-branch channels 21a, 22a, 21b and 22b. When the valve 50a is in the open state, the sub-branch channel 21a is opened to discharge the fluid to an output region A. When the valve 50b is in the open state, the sub-branch channel 21b is opened to discharge the fluid to the output region A. When the valve 50c is in the open state, the sub-branch channel 22a is opened to discharge the fluid to the output region A. When the valve 50d is in the open state, the sub-branch channel 22b is opened to discharge the fluid to the output region A. The controller 60 includes two conductive wires 610 and 620. The conductive wire 610 is electrically connected to the control terminals of the valves 50a and 50d, and the conductive wire 620 is electrically connected to the control terminals of the valves 50b and 50c. Consequently, the open/closed states of the valves 50a, 50c, 50b and 50d can be controlled by the controller 60, so that the communication states of the sub-branch channels 21a, 22a, 21b and 22b corresponding to the valves 50a, 50c, 50b and 50d are controlled by the controller 60 for allowing the fluid to be selectively transported to the output region A.

[0016] FIG. 2A is a schematic cross-sectional view illustrating a fluid-guiding unit of the fluid system according to the embodiment of the present disclosure. In an embodiment, the fluid-guiding unit 10a is a piezoelectric pump. As shown in FIG. 2A, each fluid-guiding unit 10a includes an inlet plate 17, the substrate 11, a resonance plate 13, an actuating plate 14, a piezoelectric element 15 and an outlet plate 16, which are stacked on each other sequentially. The inlet plate 17 has at least one inlet aperture 170. The resonance plate 13 has a central aperture 130 and a movable part 131. The movable part 131 is a flexible structure of the resonance plate 13 that is not attached and fixed on the substrate 11. The central aperture 130 is formed in a middle region adjacent to the movable part 131. A first chamber 12 is formed between the resonance plate 13 and the inlet plate 17. The actuating plate 14 is a suspended structure having a suspension part 141, an outer frame part 142 and a plurality of vacant spaces 143. The suspension part 141 of the actuating plate 14 is connected to the outer frame part 142 through a plurality of connecting parts (not shown), so that the suspension part 141 is suspended and elastically

supported by the outer frame part 142. The vacant spaces 143 are defined between the suspension part 141 and the outer frame part 142 and are disposed for allowing the fluid to flow therethrough. The disposition, the types and the numbers of the suspension part 141, the outer frame part 142 and the vacant spaces 143 may be varied according to the practical requirements, but not limited thereto. Preferably but not exclusively, the actuating plate 14 may be made of a metallic film or a polysilicon film. Moreover, a gap g0 formed between the actuating plate 14 and the resonance plate 13 is defined as a second chamber 18. The outlet plate 16 has an outlet aperture 160. A third chamber 19 is formed between the actuating plate 14 and the outlet plate 16.

[0017] In some embodiments, the substrate 11 of the fluid-guiding unit 10a further includes a driving circuit (not shown) electrically connected to the positive electrode and the negative electrode of the piezoelectric element 15 so as to provide a driving power to the piezoelectric element 15, but not limited thereto. In other embodiments, the driving circuit may be disposed at any position within the fluid-guiding unit 10a. The disposed position of the driving circuit may be varied according to practical requirements.

[0018] FIGS. 2B, 2C and 2D schematically illustrate the actions of the fluid-guiding unit of the fluid system as in FIG. 2A. As shown in FIG. 2A, the fluid-guiding unit 10a is in a non-enabled state (i.e. in an initial state). When the piezoelectric element 15 is driven in response to an applied voltage, the piezoelectric element 15 undergoes a bending deformation to drive the actuating plate 14 to vibrate along a vertical direction in a reciprocating manner. Please refer to FIG. 2B. As the suspension part 141 of the actuating plate 14 vibrates upwardly (i.e. away from the inlet plate 17), the volume of the second chamber 18 is enlarged and the pressure in the second chamber 18 is reduced. The fluid is inhaled into the fluid-guiding unit 10a through the inlet aperture 170 of the inlet plate 17 in accordance with the external pressure, and is then converged into the first chamber 12. Then, the fluid is transported upwardly to flow into the second chamber 18 through the central aperture 130 of the resonance plate 13, which is spatially corresponding to the first chamber 12.

[0019] Please refer to FIG. 2C. The movable part 131 of the resonance plate 13 is driven to vibrate upwardly (i.e. away from the inlet plate 17) in resonance with the vibration of the suspension part 141 of the actuating plate 14, and the suspension part 141 of the actuating plate 14 also vibrates downwardly (i.e. toward the inlet plate 17) at the same time. In such a manner, the movable part 131 of the resonance plate 13 is attached to and abuts against the suspension part 141 of the actuating plate 14. The communication space between the central aperture 130 of the resonance plate 13 and the second chamber 18 is closed. Consequently, the second chamber 18 is compressed to reduce the volume thereof and increase the pressure therein, and the volume of the third

chamber 19 is enlarged and the pressure in the third chamber 19 is reduced. Under this circumstance, the pressure gradient occurs to push the fluid in the second chamber 18 to move toward a peripheral portion of the second chamber 18, and to flow into the third chamber 19 through the vacant spaces 143 of the actuating plate 14. Please refer to FIG. 2D. The suspension part 141 of the actuating plate 14 vibrates downwardly (i.e. toward the inlet plate 17) and drives the movable part 131 of the resonance plate 13 to vibrate downwardly (i.e. toward the inlet plate 17), so as to further compress the first chamber 18. As a result, most of the fluid is transported into the third chamber 19 and is temporarily stored in the third chamber 19.

[0020] Finally, the suspension part 141 of the actuating plate 14 vibrates upwardly (i.e. away from the inlet plate 17) to compress the volume of the third chamber 19, thereby reducing the volume of the third chamber 19 and increasing the pressure in the third chamber 19. Thus, the fluid stored in the third chamber 19 is discharged out to an environment outside the fluid-guiding unit 10a through the outlet aperture 160 of the outlet plate 16 so as to accomplish a fluid transportation process. The above actions and steps of FIGS. 2B, 2C and 2D demonstrate a complete cycle of the reciprocating vibration of the actuating plate 14. When the piezoelectric element 15 is enabled, the suspension part 141 of the actuating plate 14 and the movable part 131 of the resonance plate 13 perform the above actions repeatedly. Consequently, the fluid is continuously inhaled into the inlet aperture 170 and pressurized to be discharged out through the outlet aperture 160. In such way, the purpose of fluid transportation is achieved. In some embodiments, the vibration frequency of the resonance plate 13 along the vertical direction in the reciprocating manner may be identical to the vibration frequency of the actuating plate 14. That is, the resonance plate 13 and the actuating plate 14 can synchronously vibrate along the same direction. It is noted that numerous modifications and alterations of the actions of the fluid-guiding unit 10a may be made while retaining the teachings of the disclosure.

[0021] Consequently, a pressure gradient is formed in the fluid channels of the fluid-guiding unit 10a to facilitate the fluid to flow at a high speed. Moreover, since there is an impedance difference between the inlet direction and the outlet direction, the fluid can be transported from an inhale end to a discharge end of the fluid-guiding unit 10a. Moreover, even if a gas pressure exists at the discharge end, the fluid-guiding unit 10a still has the capability to discharge out the fluid while achieving the silent efficacy.

[0022] FIG. 3A schematically illustrates the fluid active region of the fluid system as shown in FIG. 1. The fluid active region 10 includes a plurality of fluid-guiding units 10a. The amount of the fluid to be discharged from the fluid active region 10 is adjusted according to the arrangement of the fluid-guiding units 10a. In this embodiment, the fluid-guiding units 10a are disposed on the substrate

11 and connected to each other in a serial-and-parallel arrangement.

[0023] Please refer to FIGS. 3B, 3C and 3D. FIG. 3B schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a serial arrangement. FIG. 3C schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a parallel arrangement. FIG. 3D schematically illustrates a portion of the fluid active region of the fluid system, in which the fluid-guiding units are connected to each other in a serial-and-parallel arrangement. As shown in FIG. 3B, the fluid-guiding units 10a of the fluid active region 10 are connected to each other in a serial arrangement. Since the fluid-guiding units 10a are connected to each other in series, the pressure of the fluid at the outlet apertures 160 of the fluid active region 10 is increased. As shown in FIG. 3C, the fluid-guiding units 10a of the fluid active region 10 are connected to each other in a parallel arrangement. Since the fluid-guiding units 10a are connected to each other in parallel, the amount of the fluid to be discharged out from the outlet apertures 160 of the fluid active region 10 is increased. As shown in FIG. 3D, the fluid-guiding units 10a of the fluid active region 10 are connected to each other in a serial-and-parallel arrangement. Consequently, the pressure of the fluid and the amount of the fluid to be discharged out from the fluid active region 10 are both increased.

[0024] FIG. 4 schematically illustrates a variant example of the fluid active region of the fluid system. FIG. 5 schematically illustrates another variant example of the fluid active region of the fluid system. As shown in FIG. 4, in this embodiment, the fluid-guiding units 10a of the fluid active region 10 are connected to each other in a ring-shaped arrangement so as to transport the fluid. As shown in FIG. 5, in this embodiment, the fluid-guiding units 10a of the fluid active region 10 are connected to each other in a honeycomb arrangement.

[0025] In this embodiment, the connections between the fluid-guiding units 10a of the fluid system 100 and the driving circuit may be varied, so that the application flexibility is enhanced. Moreover, the fluid system 100 can be applied to various electronic components, and the fluid-guiding units 10a of fluid system 100 may be enabled to transport gas simultaneously so as to meet the requirement of transporting the gas at a great amount. Moreover, two fluid-guiding units 10a may be independently controlled to be enabled or disabled. For example, one fluid-guiding unit 10a is enabled, and the other fluid-guiding unit 10a is disabled. In another embodiment, the two fluid-guiding units 10a are alternately enabled, but not limited thereto. Consequently, the purpose of transporting various amount of the fluid and the purpose of reducing the power consumption can be achieved.

[0026] FIGS. 6A and 6B are schematic cross-sectional views illustrating the actions of a valve of the fluid system according to a first aspect of the present disclosure. The

valve 50 includes a base 51, a piezoelectric actuator 52 and a linking bar 53. For example, the valve 50 is disposed in the sub-branch channel 21a. The structures and actions of the valves 50 disposed in the sub-branch channels 22a, 21b and 22b are similar to the structure and the actions of the valve 50 disposed in the sub-branch channel 21a, and are not redundantly described herein. The base 51 includes a first passage 511 and a second passage 512, which are in communication with the sub-branch channel 21a and are separated from each other by a partial structure of the base 51. A cavity 513 is concavely formed on the top surface of the base 51. The cavity 513 has a first outlet 514 and a second outlet 515. The first outlet 514 is in communication with the first passage 511, and the second outlet 515 is in communication with the second passage 512. The piezoelectric actuator 52 includes a carrier plate 521 and a piezoelectric ceramic plate 522. The carrier plate 521 may be made of a flexible material. The piezoelectric ceramic plate 522 is attached on a first surface of the carrier plate 521 and electrically connected to the controller 60. The piezoelectric actuator 52 is located over and capped on the cavity 513. A first end of the linking bar 53 is connected to a second surface of the carrier plate 521, and the linking bar 53 is inserted into the second outlet 515 and is movable within the second outlet 515 along a vertical direction. A second end of the linking bar 53 is formed as a stopping part 531 to be used to close the second outlet 515. More specifically, a cross section of the stopping part 531 has a diameter larger than that of the second outlet 515, by which the communication between the second outlet 515 and the second passage 512 may be cut off. Preferably but not exclusively, the stopping part 531 may be a flat plate structure or a mushroom-shaped structure.

[0027] Please refer to FIG. 6A. When the piezoelectric actuator 52 of the valve 50 is not enabled, the linking bar 53 is in an initial position and in a normally open state that the stopping part 531a is separated from the second outlet 515. Meanwhile, a communication space is formed between the stopping part 531 and the second outlet 515 for allowing the second passage 512, the cavity 513 and the first passage 511 to be in fluid communication with each other and in fluid communication with the sub-branch channel 21a and allowing the fluid to flow therethrough. On the contrary, referring to FIG. 6B, when the piezoelectric actuator 52 is enabled, the carrier plate 521 is driven to undergo upward bending deformation by the piezoelectric ceramic plate 522, so that the linking bar 53 is driven by the carrier plate 521 to move upwardly. Consequently, the second outlet 515 is in contact with and entirely covered by the stopping part 531, thereby closing the second outlet 515. Since the second outlet 515 is closed by the stopping part 531, the fluid cannot be transported through the second outlet 515. As mentioned above, the valve 50 is selectively enabled or disabled. When the valve 50 is disabled, the sub-branch channel 21a is maintained in the open state. When the

valve 50 is enabled, the sub-branch channel 21a is in the closed state. In other words, by controlling a communication state of the second passage 512 of valve 50, the discharge of the fluid from the sub-branch channel 21a can be regulated.

[0028] FIGS. 7A and 7B are schematic cross-sectional views illustrating the actions of a valve used in the fluid system of according to a second aspect of the present disclosure. The structure of the valve 50 is similar to that of FIGS. 6A and 6B. In contrast, the valve 50 is in a normally closed state when the valve 50 is not enabled.

[0029] Please refer to FIG. 7A. When the piezoelectric actuator 52 of the valve 50 is not enabled, the linking bar 53 is in an initial position and in a normally closed state. Meanwhile, the second outlet 515 is in contact with and entirely covered by the stopping part 531, thereby closing the second outlet 515. Since the second outlet 515 is closed by the stopping part 531, the fluid cannot be transported through the second outlet 515. Please refer to FIG. 7B. When the piezoelectric actuator 52 is enabled, the carrier plate 521 is driven to undergo downward bending deformation by the piezoelectric ceramic plate 522, so that the linking bar 53 is driven by the carrier plate 521 to move downwardly. Under this circumstance, a communication space is formed between the stopping part 531 and the second outlet 515 for allowing the second passage 512, the cavity 513 and the first passage 511 to be in fluid communication with each other and in fluid communication with the sub-branch channel 21a and allowing the fluid to flow therethrough. As mentioned above, the valve 50 is selectively enabled or disabled. When the valve 50 is disabled, the sub-branch channel 21a is maintained in the closed state. When the valve 50 is enabled, the sub-branch channel 21a is in the open state. In other words, by controlling a communication state of the second passage 512 of the valve 50, the discharge of the fluid from the sub-branch channel 21a can be regulated.

[0030] From the above descriptions, the present disclosure provides the fluid system. The at least one fluid-guiding unit is used for transporting the fluid to the convergence chamber. The valves disposed in the branch channels are used to control and adjust the amount, flow rate and pressure of the fluid to be discharged from the fluid system. The numbers, arrangements and driving methods of the at least one fluid-guiding unit and the branch channels may be flexibly varied according to the practical requirements. In other words, the fluid system of the present disclosure can provide the efficacy of transporting a great amount of fluid in a high performance and high flexible manner according to various applied devices and required amount of fluid to be transported.

[0031] While the disclosure has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the disclosure needs not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included

within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

Claims

1. A fluid system (100), produced by an integrated method, the fluid system (100) comprising:

a fluid active region (10) comprising at least one fluid-guiding unit (10a), wherein the fluid-guiding unit (10a) is enabled under control, so as to transport fluid and discharge the fluid out through at least one outlet aperture (160) thereof;

a fluid channel (20) in communication with the at least one outlet aperture (160) of the fluid active region (10) and having a plurality of branch channels (20a, 20b, 21a, 22a, 21b, 22b), wherein the fluid discharged from the fluid active region (10) is split by the branch channels (20a, 20b, 21a, 22a, 21b, 22b), so that a required amount of the fluid to be transported is determined;

a convergence chamber (30) in communication with the fluid channel (20) and disposed for allowing the fluid to be accumulated therein;

a sensor (40) disposed in the fluid channel (20) for measuring the fluid within the fluid channel (20); and

a plurality of valves (50, 50a, 50b, 50c, 50d) disposed in the branch channels (21a, 22a, 21b, 22b), wherein the fluid is discharged out through the branch channels (21a, 22a, 21b, 22b) correspondingly by controlling open/closed states of the valves (50, 50a, 50b, 50c, 50d), wherein each of the valves (50, 50a, 50b, 50c, 50d) comprises:

a base (51) having a first passage (511) and a second passage (512), wherein the first passage (511) and the second passage (512) are separated from each other and in communication with a corresponding one of the branch channels (21a, 22a, 21b, 22b), a cavity (513) is concavely formed on a surface of the base (51), and the cavity (513) has a first outlet (514) in communication with the first passage (511) and has a second outlet (515) in communication with the second passage (512);

a piezoelectric actuator (52) comprising a carrier plate (521) and a piezoelectric ceramic plate (522) attached on a first surface of the carrier plate (521), wherein the cavity (513) is covered by the piezoelectric actuator (52); and

a linking bar (53) having a first end and a second end, wherein the first end of the linking bar (53) is connected to a second surface of the carrier plate (521), and the linking bar (53) is inserted into the second outlet (515) and movable within the second outlet (515), wherein a stopping part (531) is formed at the second end of the linking bar (53) and has a cross section whose diameter is larger than a diameter of the second outlet (515) for closing the second outlet (515), and

wherein when the piezoelectric actuator (52) is enabled, the carrier plate (521) is driven to move and the stopping part (531) of the linking bar (53) is correspondingly moved to selectively close or open the second outlet (515), so that the fluid is selectively transported through the corresponding one of the branch channels (21a, 22a, 21b, 22b).

2. The fluid system (100) according to claim 1, wherein the at least one fluid-guiding unit (10a) of the fluid active region (10) comprises a plurality of fluid-guiding units (10a), and the fluid-guiding units (10a) are connected to each other in a serial arrangement for transporting the fluid.
3. The fluid system (100) according to claim 1, wherein the at least one fluid-guiding unit (10a) of the fluid active region (10) comprises a plurality of fluid-guiding units (10a), and the fluid-guiding units (10a) are connected to each other in a parallel arrangement for transporting the fluid.
4. The fluid system (100) according to claim 1, wherein the at least one fluid-guiding unit (10a) of the fluid active region (10) comprises a plurality of fluid-guiding units (10a), and the fluid-guiding units (10a) are connected to each other in a serial-and-parallel arrangement for transporting the fluid.
5. The fluid system (100) according to claim 1, wherein the at least one fluid-guiding unit (10a) of the fluid active region (10) comprises a plurality of fluid-guiding units (10a), and the fluid-guiding units (10a) are connected to each other in a ring-shape arrangement for transporting the fluid.
6. The fluid system (100) according to claim 1, wherein the at least one fluid-guiding unit (10a) of the fluid active region (10) comprises a plurality of fluid-guiding units (10a), and the fluid-guiding units (10a) are connected to each other in a honeycomb arrangement for transporting the fluid.
7. The fluid system (100) according to claim 1, wherein

the fluid-guiding unit (10a) is a piezoelectric pump.

8. The fluid system (100) according to claim 1, wherein the lengths and widths of the branch channels (20a, 20b) are preset according to the required amount of the fluid to be transported. 5
9. The fluid system (100) according to claim 1, wherein the open/closed states of the valves (50, 50a, 50b, 50c, 50d) are controlled by a controller (60), wherein the controller (60) and the fluid-guiding unit (10a) are packaged in a system-in-package manner as an integrated structure. 10
10. The fluid system (100) according to claim 1, wherein the branch channels (20a, 20b, 21a, 22a, 21b, 22b) are connected to each other in a serial arrangement. 15
11. The fluid system (100) according to claim 1, wherein the branch channels (20a, 20b, 21a, 22a, 21b, 22b) are connected to each other in a parallel arrangement. 20
12. The fluid system (100) according to claim 1, wherein the branch channels (20a, 20b, 21a, 22a, 21b, 22b) are connected to each other in a serial-and-parallel arrangement. 25
13. The fluid system (100) according to claim 1, wherein the stopping part (531) is a flat plate structure. 30
14. The fluid system (100) according to claim 1, wherein the stopping part (531) is a mushroom-shaped structure. 35
15. A fluid system (100), produced by an integrated method, the fluid system comprising:
 - at least one fluid active region (10) comprising at least one fluid-guiding unit (10a), wherein the fluid-guiding unit (10a) is enabled under control, so as to transport fluid and discharge the fluid out through at least one outlet aperture (160) thereof; 40
 - at least one fluid channel (20) in communication with the at least one outlet aperture (160) of the fluid active region (10) and having a plurality of branch channels (20a, 20b, 21a, 22a, 21b, 22b), wherein the fluid discharged from the fluid active region (10) is split by the branch channels (20a, 20b, 21a, 22a, 21b, 22b), so that a required amount of the fluid to be transported is determined; 45
 - at least one convergence chamber (30) in communication with the fluid channel (20) and disposed for allowing the fluid to be accumulated therein; 50
 - at least one sensor (40) disposed in the fluid

channel (20) for measuring the fluid within the fluid channel (20); and

a plurality of valves (50, 50a, 50b, 50c, 50d) disposed in the branch channels (21a, 22a, 21b, 22b), wherein the fluid is discharged out through the branch channels (21a, 22a, 21b, 22b) correspondingly by controlling open/closed states of the valves (50, 50a, 50b, 50c, 50d), wherein each of the valves (50, 50a, 50b, 50c, 50d) comprises:

at least one base (51) having at least one first passage (511) and at least one second passage (512), wherein the first passage (511) and the second passage (512) are separated from each other and in communication with a corresponding one of the branch channels (21a, 22a, 21b, 22b), at least one cavity (513) is concavely formed on a surface of the base (51), and the cavity (513) has at least one first outlet (514) in communication with the first passage (511) and has at least one second outlet (515) in communication with the second passage (512);

at least one piezoelectric actuator (52) comprising at least one carrier plate (521) and at least one piezoelectric ceramic plate (522) attached on a first surface of the carrier plate (521), wherein the cavity (513) is covered by the piezoelectric actuator (52); and

at least one linking bar (53) has a first end and a second end, wherein the first end of the linking bar (53) is connected to a second surface of the carrier plate (521), and the linking bar (53) is inserted into the second outlet (515) and movable within the second outlet (515), wherein at least one stopping part (531) is formed at the second end of the linking bar (53) and has a cross section whose diameter is larger than a diameter of the second outlet (515) for closing the second outlet (515), and

wherein when the piezoelectric actuator (52) is enabled, the carrier plate (521) is driven to move and the stopping part (531) of the linking bar (53) is correspondingly moved to selectively close or open the second outlet (515), so that the fluid is selectively transported through the corresponding one of the branch channels (21a, 22a, 21b, 22b).

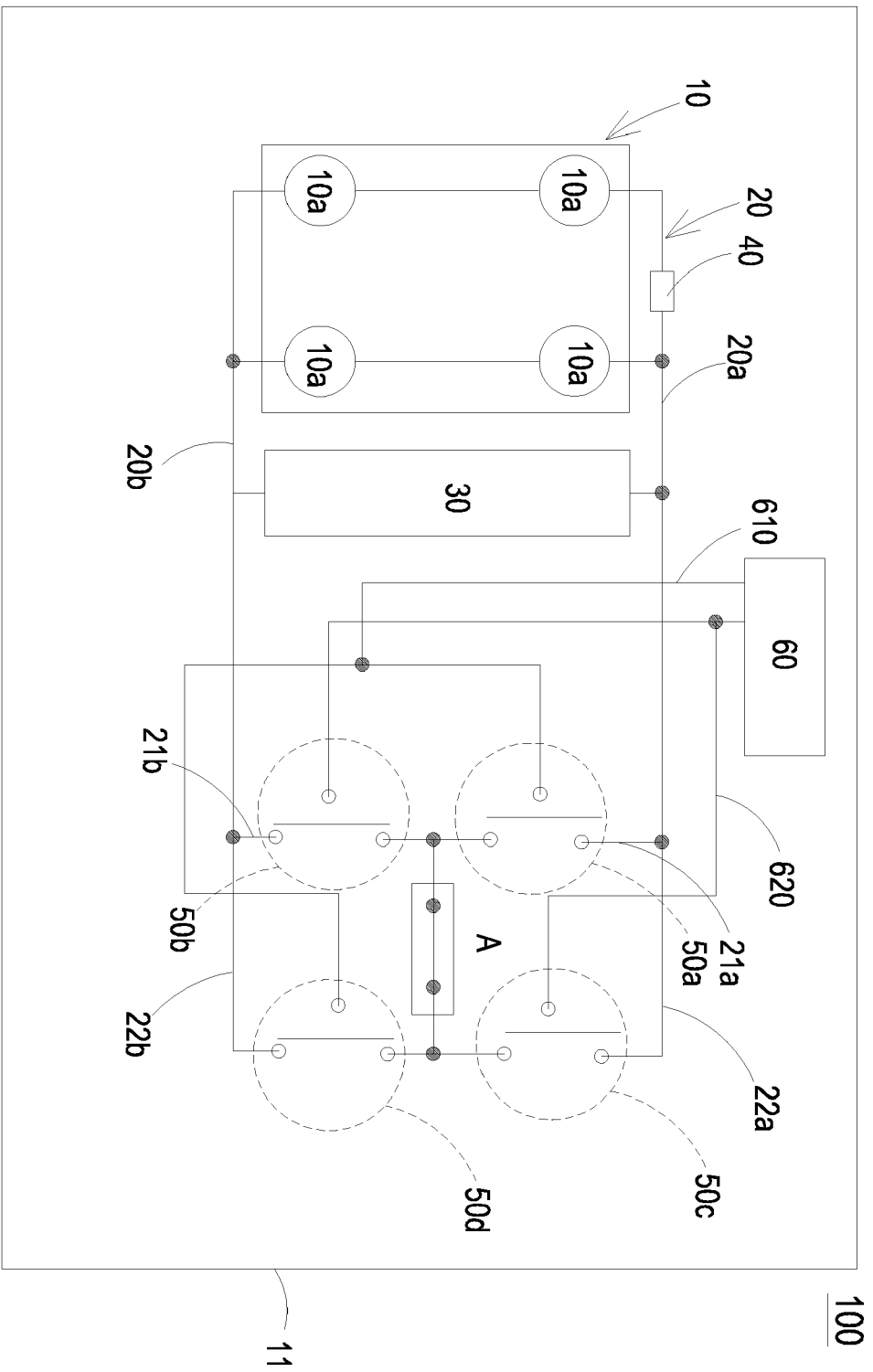


FIG. 1

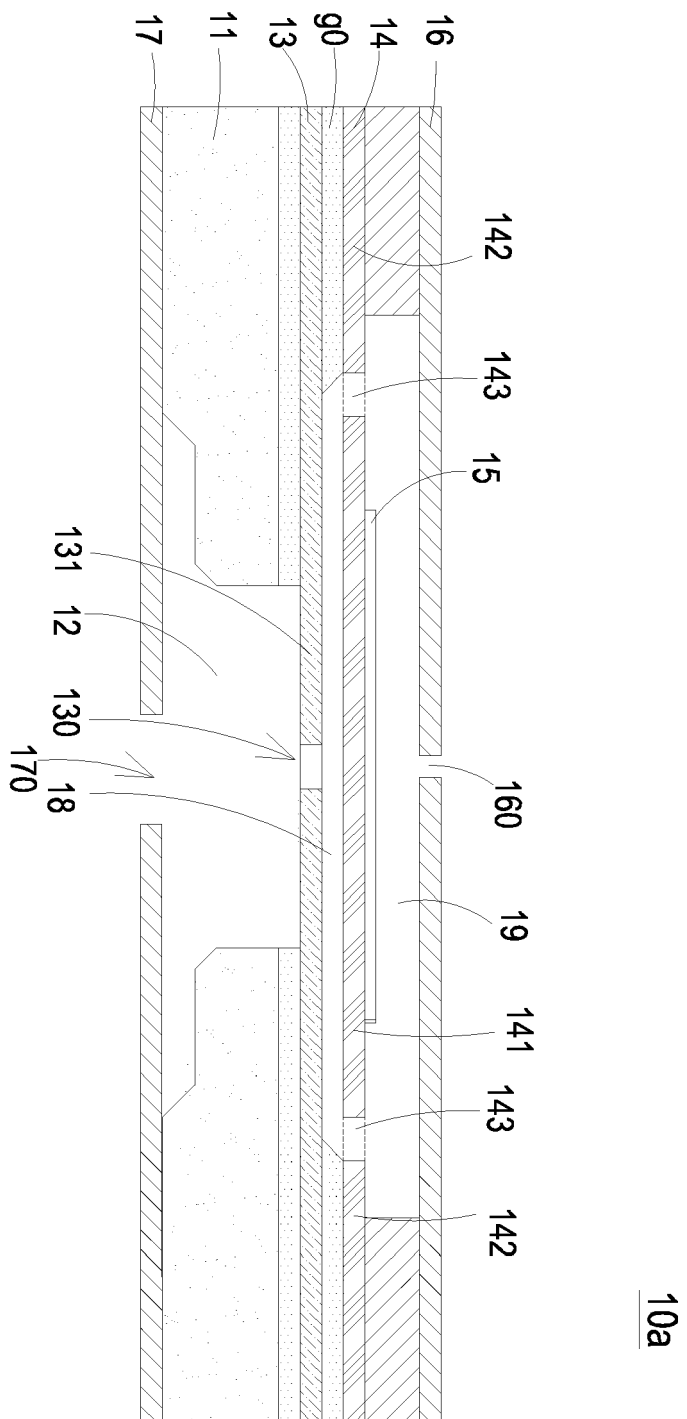


FIG. 2A

10a

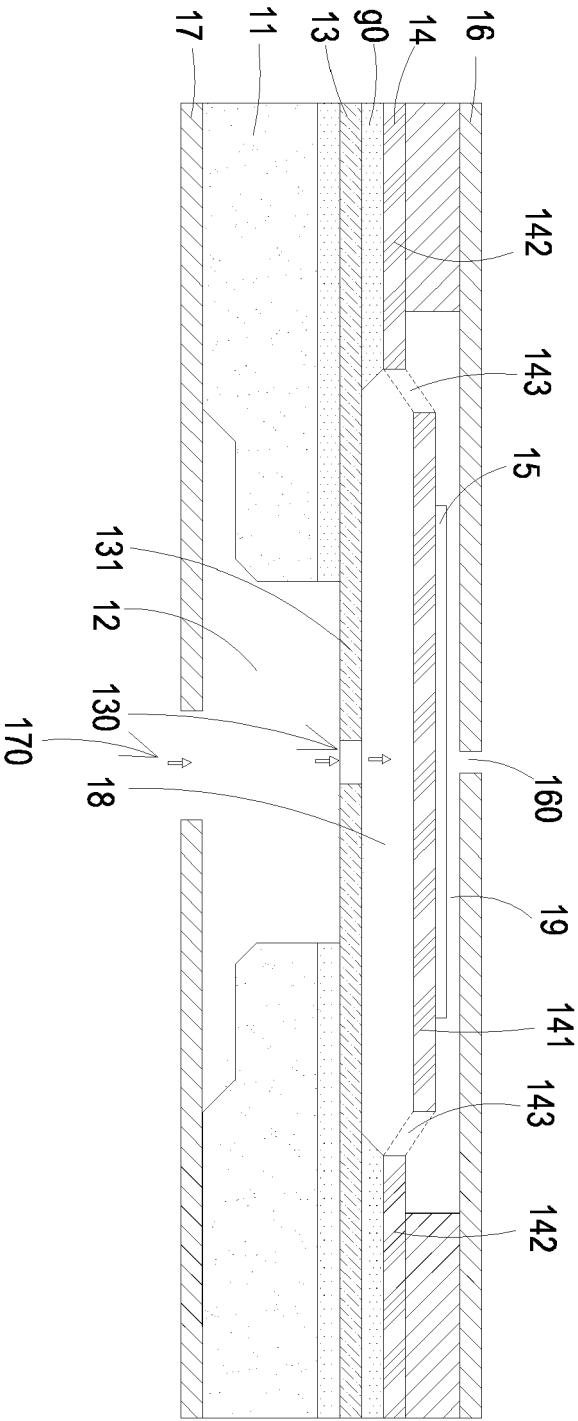


FIG. 2B

10a

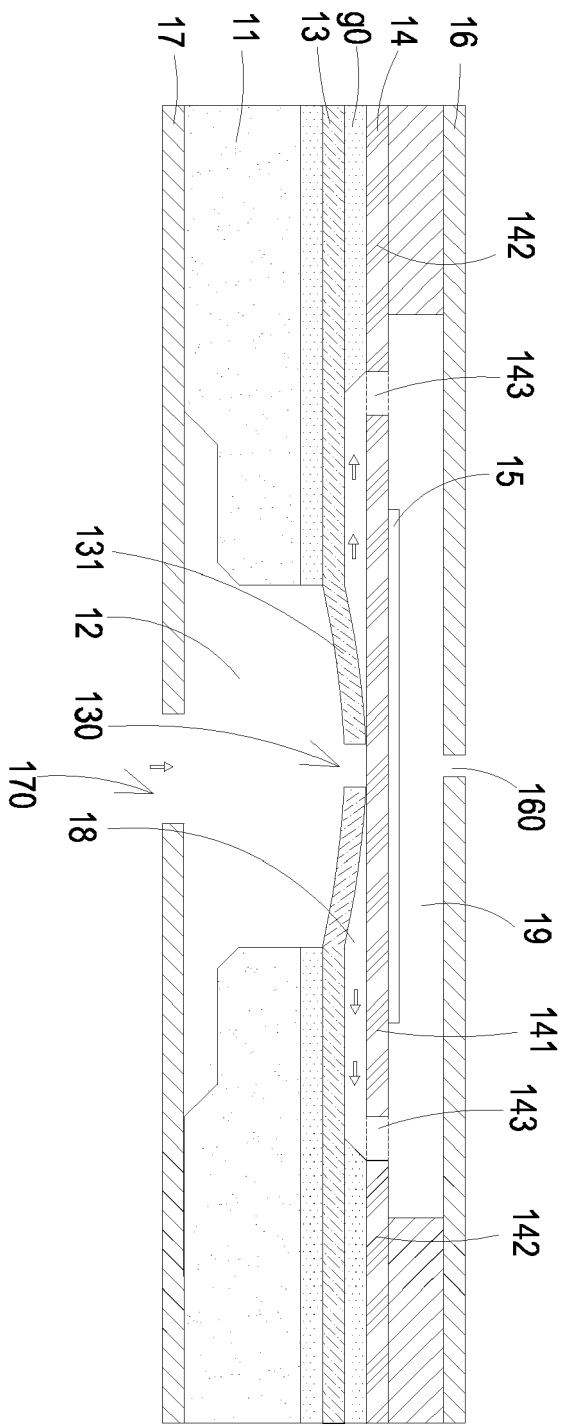


FIG. 2C

10a

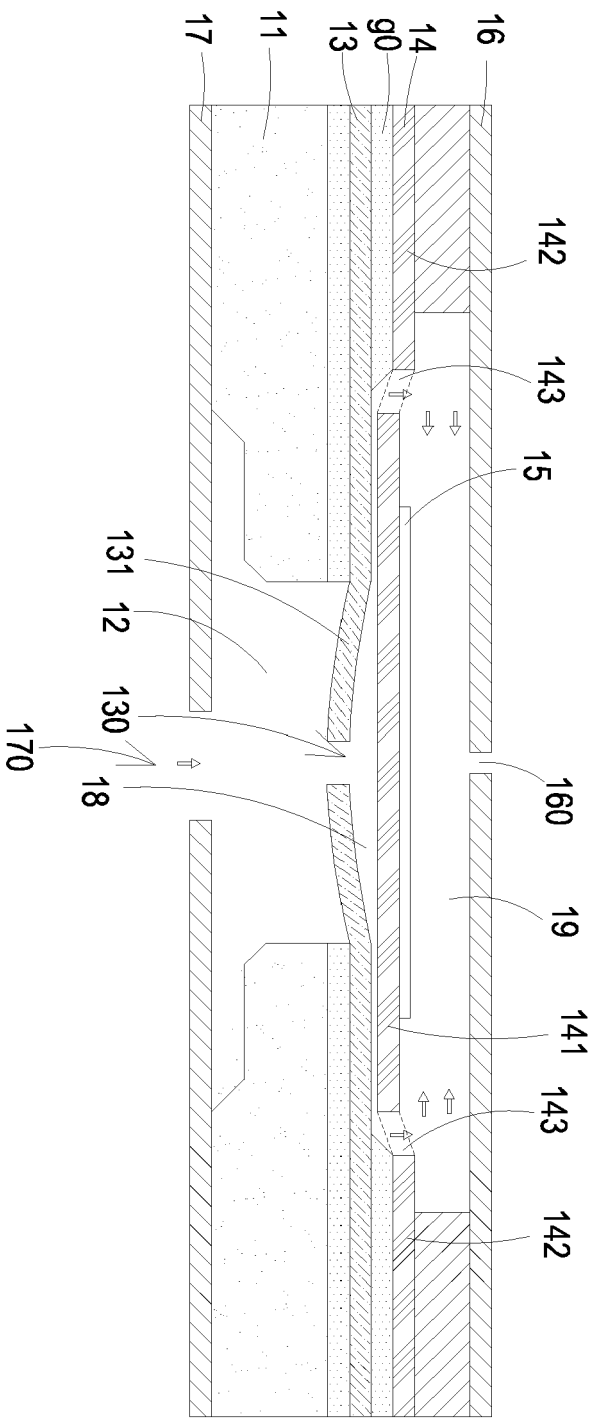


FIG. 2D

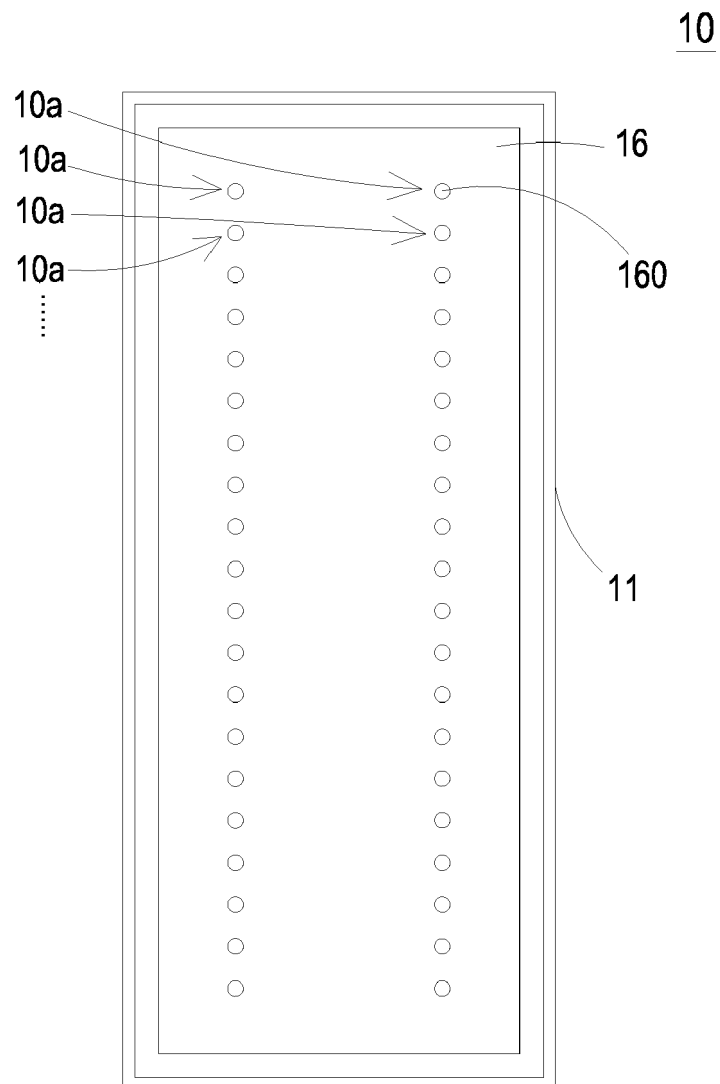


FIG. 3A

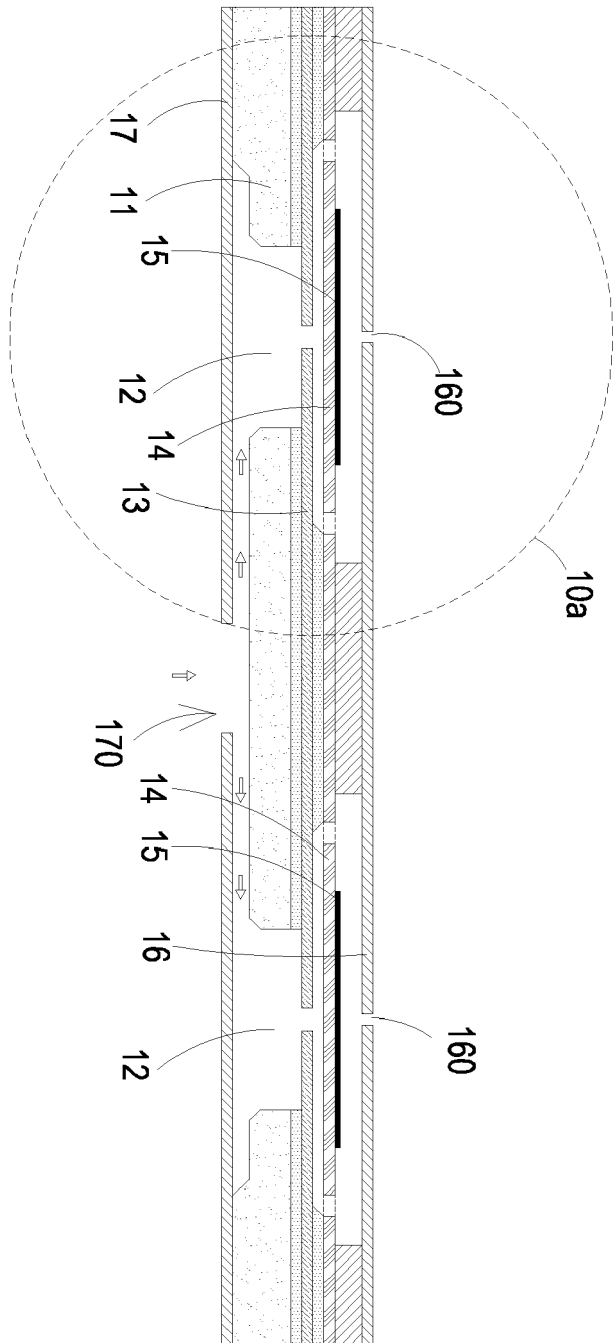
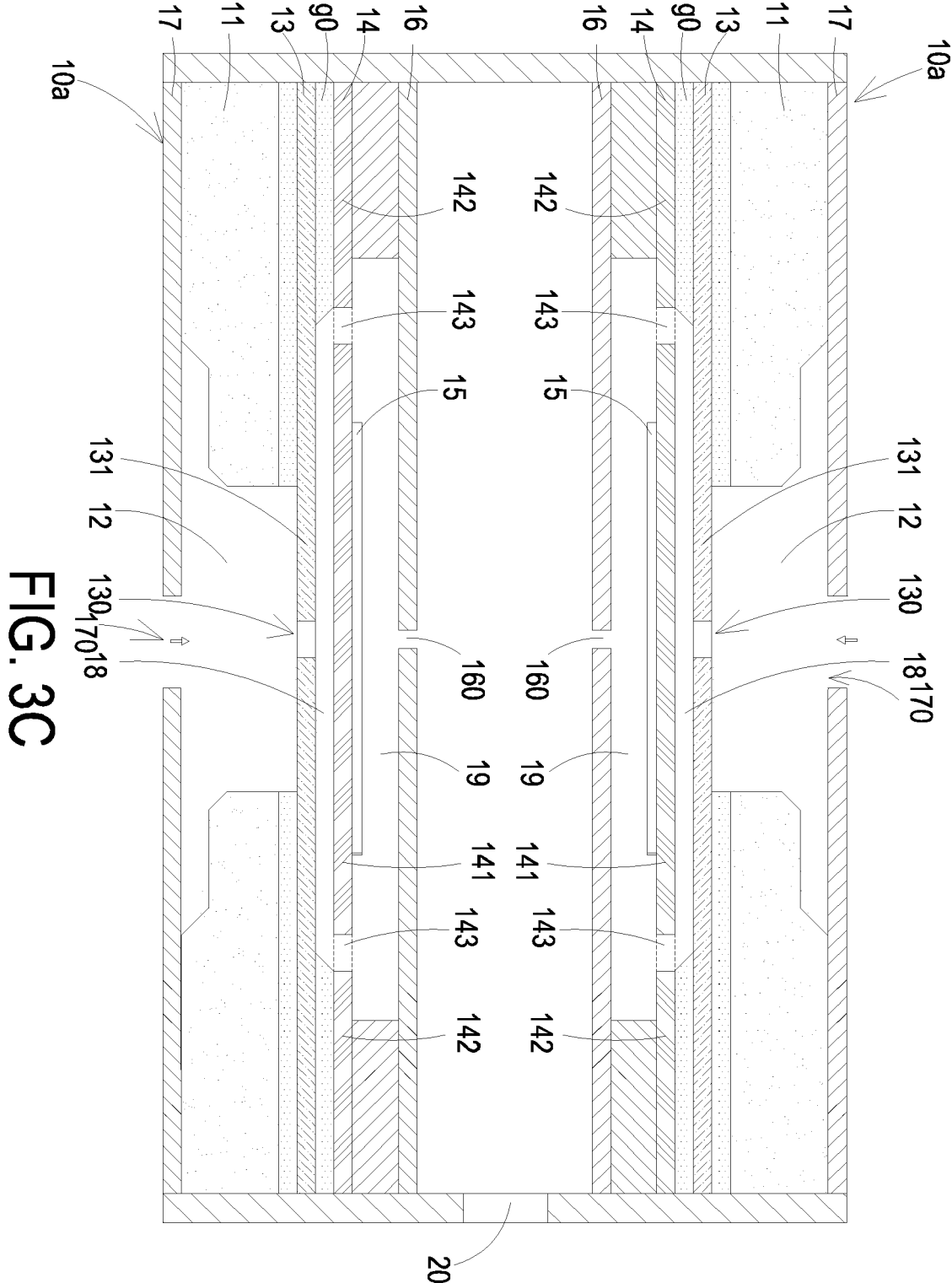


FIG. 3B



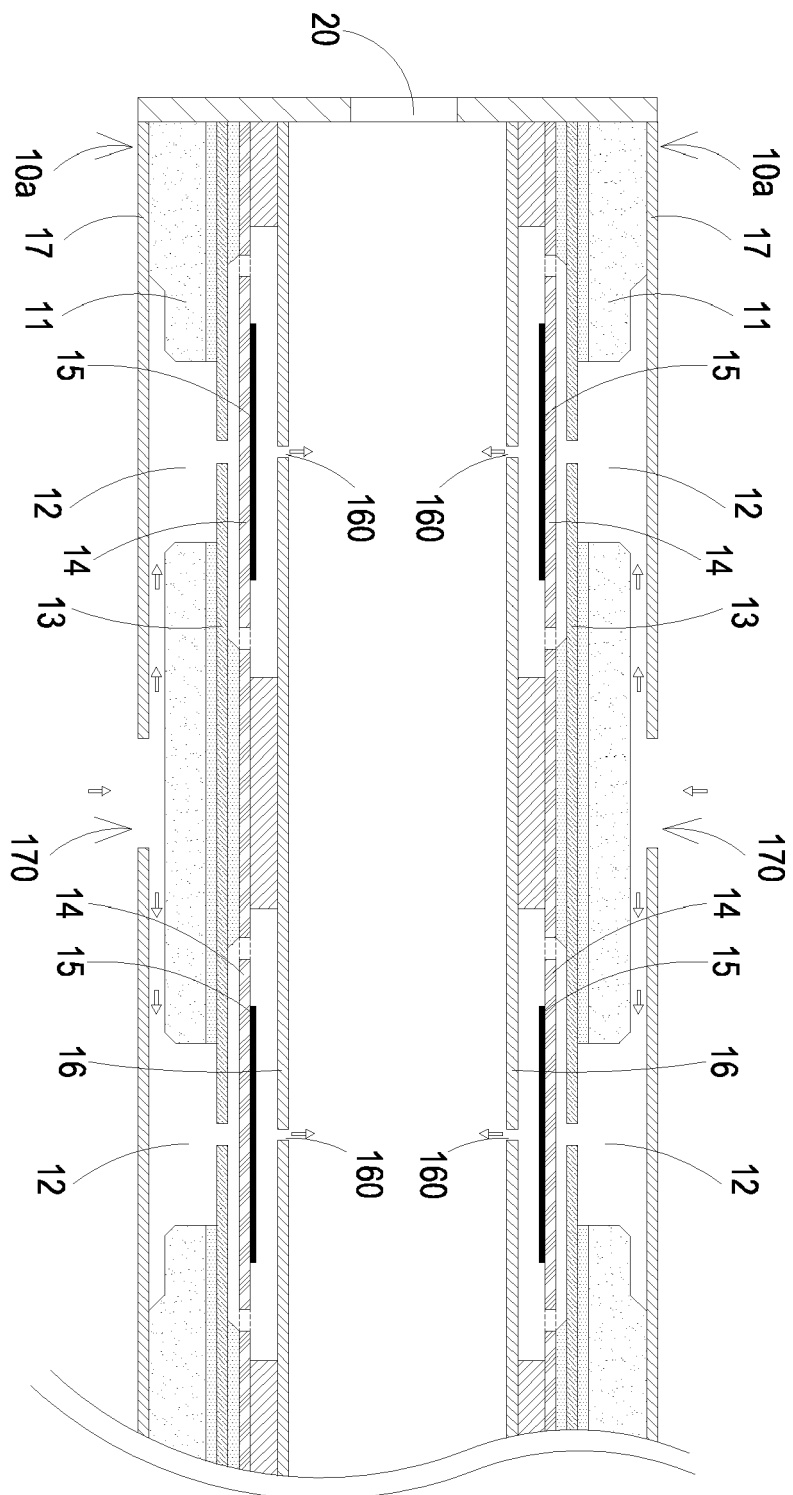


FIG. 3D

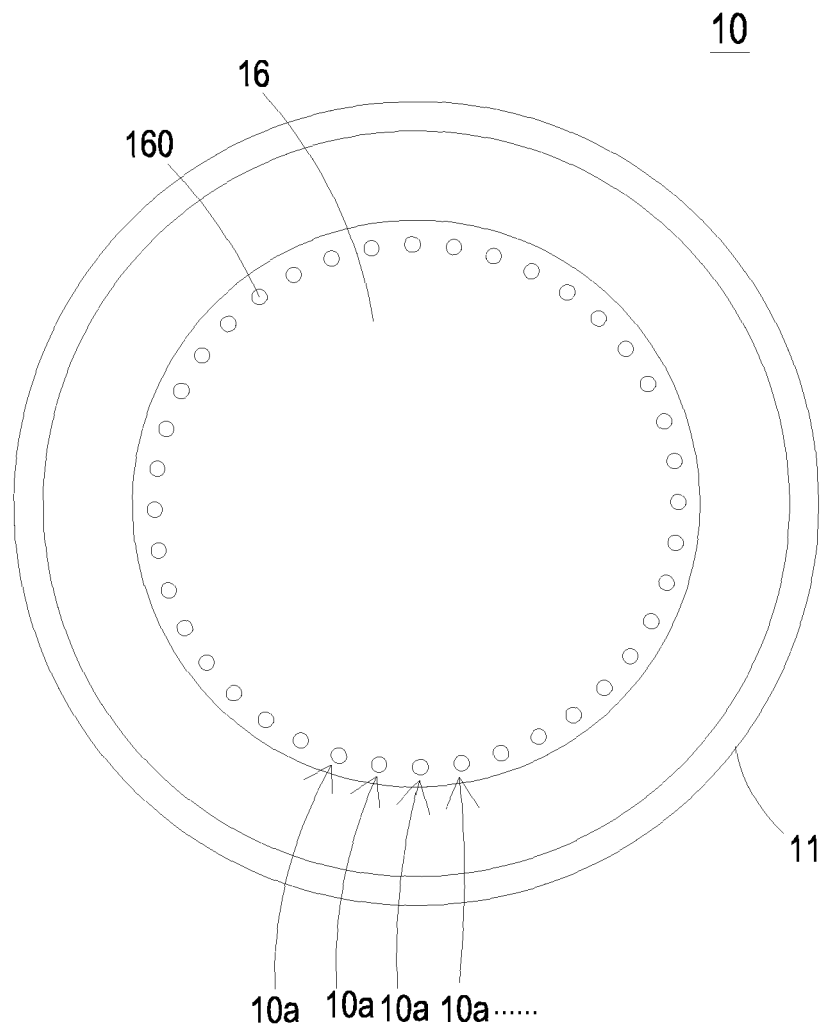


FIG. 4

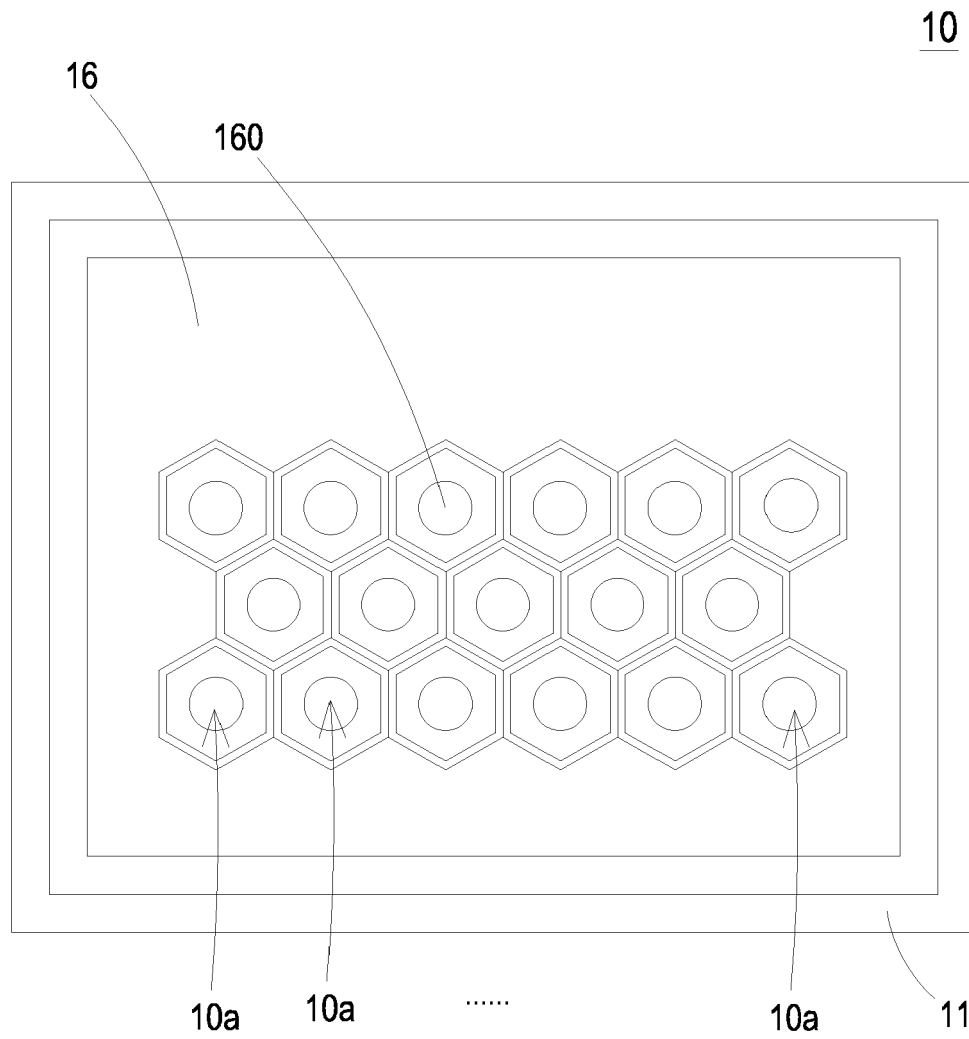


FIG. 5

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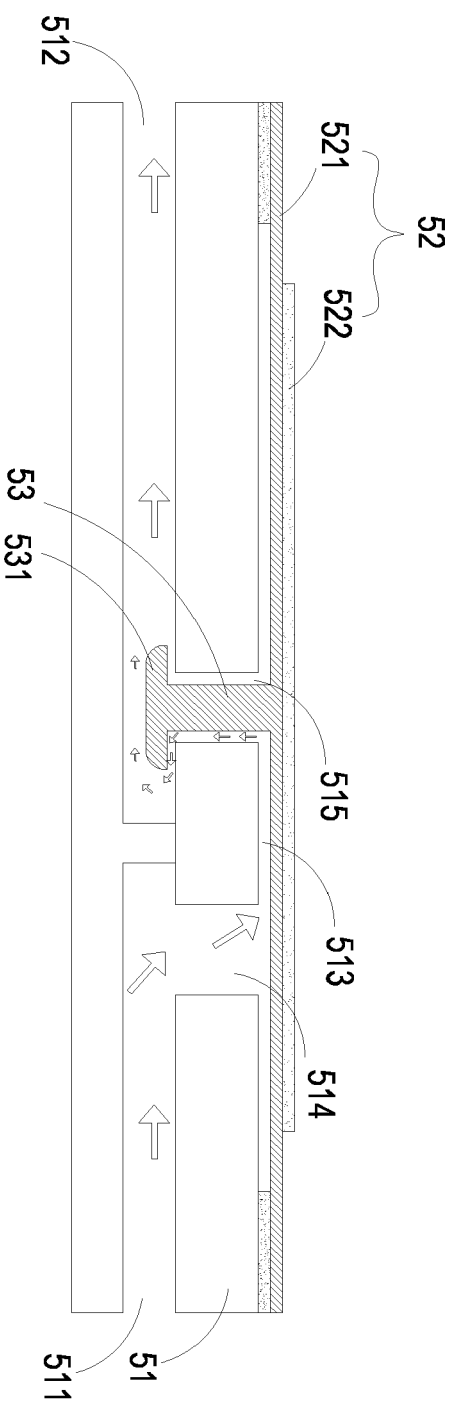


FIG. 6A

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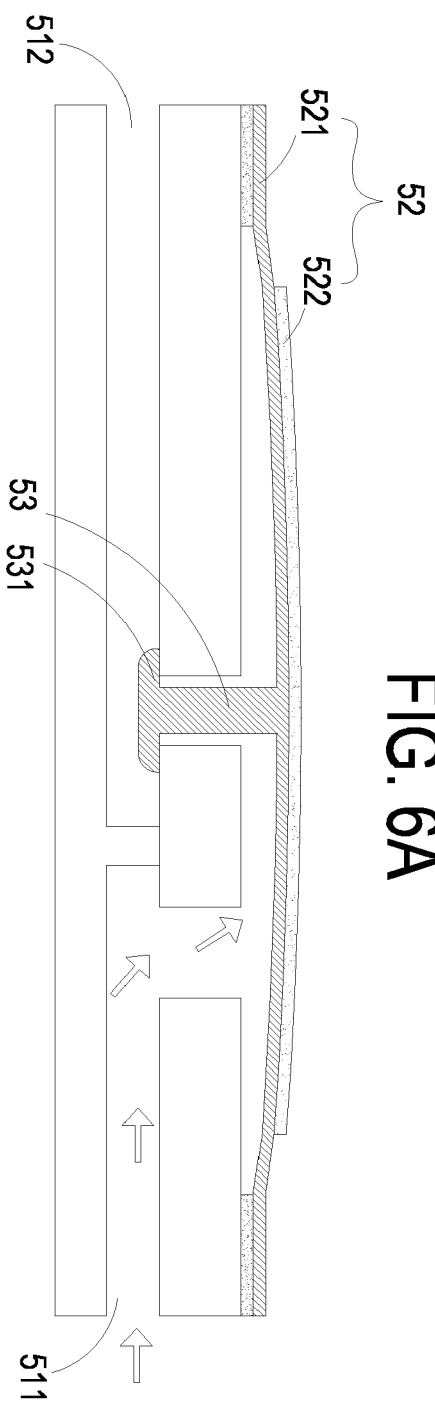


FIG. 6B

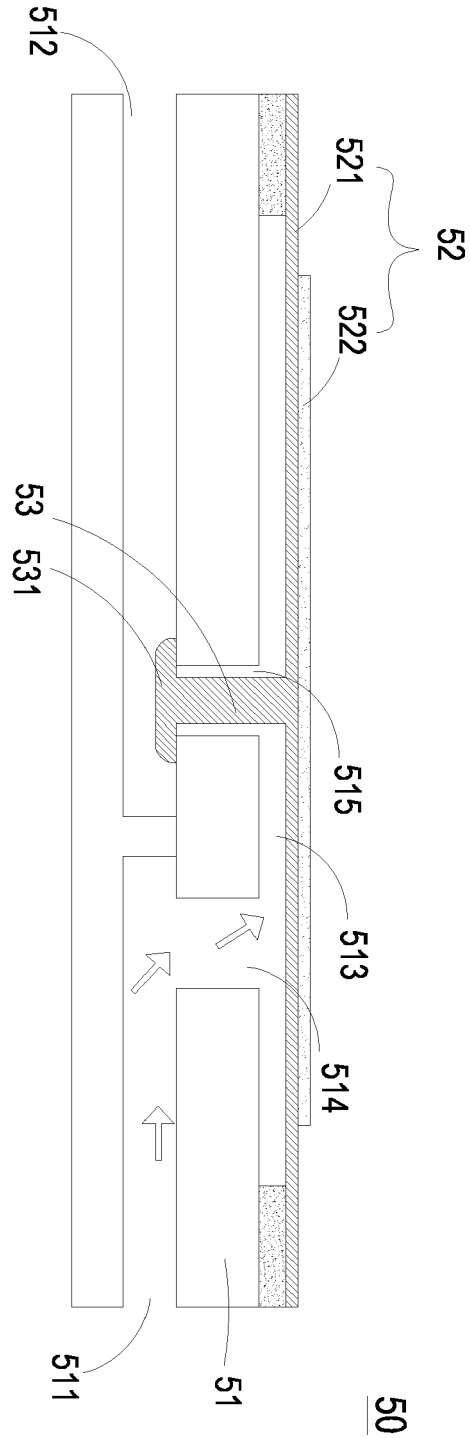


FIG. 7A

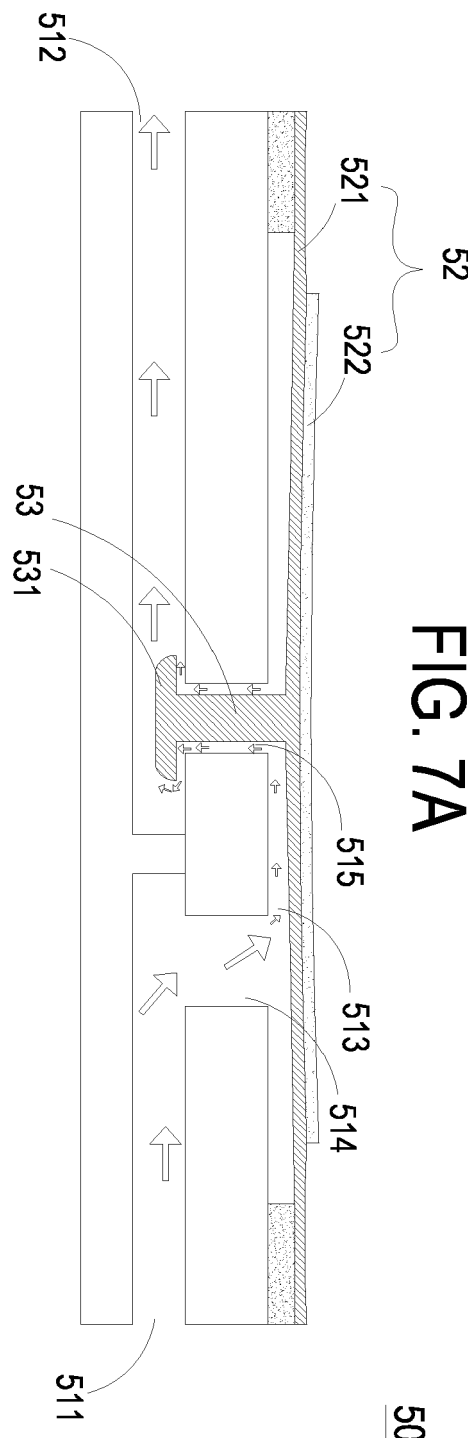


FIG. 7B

**PARTIAL EUROPEAN SEARCH REPORT**

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

EP 18 19 0437

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			TECHNICAL FIELDS SEARCHED (IPC)
			F04B

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

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EPO FORM 1503 03.82 (P04E07)

Place of search	Date of completion of the search	Examiner
Munich	12 February 2019	Pinna, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document		



**INCOMPLETE SEARCH
SHEET C**

Application Number

EP 18 19 0437

5

Claim(s) completely searchable:
1-14

10

Claim(s) not searched:
15

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Reason for the limitation of the search:

R62a

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 19 0437

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82