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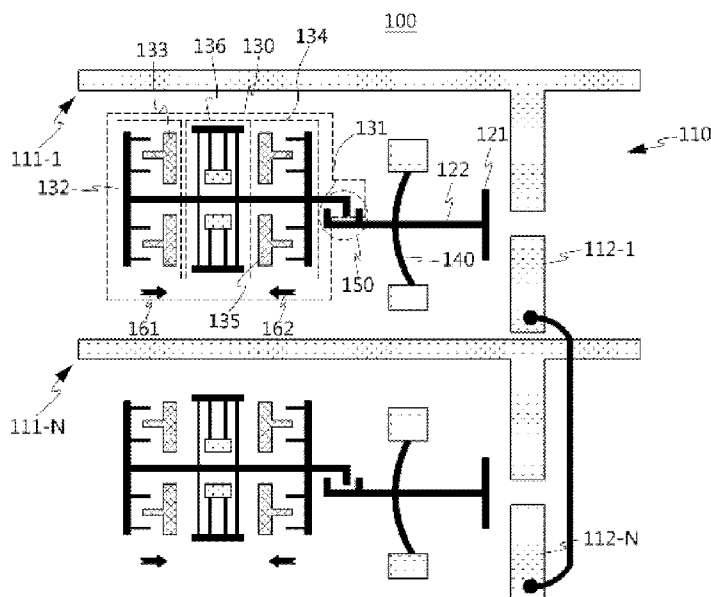
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[Continued on next page]

(54) Title: MICRO MATRIX RELAY SWITCH

[Fig. 1]



(57) Abstract: A matrix relay switch structure that is suitable for micro miniaturization is provided. A matrix switch for electrical signal connection between at least one signal input terminal and at least one signal output terminal is composed of electrical switches, each electrical switch including a signal connection unit opening and closing an electrical connection between a signal input terminal and a signal output terminal corresponding to each other, a first movable driver connected to the signal connection unit and driving the signal connection unit forward or backward, a forward/backward driving unit driving the first movable driver forward or backward and changing an electrical connection state made by the signal connection unit between the signal input terminal and the signal output terminal, and a bistable spring unit connected to the first movable driver and maintaining the electrical connection state while a stability state changes due to the first movable driver. Accordingly, a micro matrix relay switch that is micro miniature yet has excellent stability and expandability can be constituted.



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Description

MICRO MATRIX RELAY SWITCH

Technical Field

- [1] The present invention relates to a matrix switch, and more particularly, to a micro matrix relay switch for electrical signal connection between a plurality of input terminals and a plurality of output terminals that has a relatively simple structure and has excellent stability and expandability in spite of a very small size.

Background Art

- [2] A matrix switch which is an arrangement of switches for electrical signal connection between a plurality of input terminals and a plurality of output terminals is widely employed in an RF switch, etc.
- [3] As a conventional matrix switch, a conventional electrical switch for electrical signal connection is disclosed in Korean Patent Publication No. 1988-7000508. This conventional electrical switch consists of respective input and output lines centered on an insulating substrate, crossing each other perpendicularly, and insulated from either side of the substrate. The respective input and output lines are configured to be electrically connected by a short-circuit plug functioning as a connector.
- [4] Also, Korean Patent Publication No. 1977-7004306 discloses a structure having three matrix substrates having a plurality of input/output lines, in which electrical signal transfer is accomplished by connecting a connector pin driven perpendicular to a substrate with a connection hole in the matrix substrate. These two examples of conventional technology enable electrical signal connection between a plurality of input signal terminals and output signal terminals, however they involve complicated electrical signal line arrangements on a plurality of substrates, and complicated operation of a connector for turning an electrical signal on/off, and overall system size is large, making them difficult to expand when additional input or output signal terminals are required.
- [5] Meanwhile, as the need to perform switching between larger numbers of input signal terminals and output signal terminals is increasing, and the need for micro miniaturization is also steadily increasing, micro electro mechanical systems (MEMS) technology is being gradually employed to manufacture the matrix switch.
- [6] For example, "A Bi-Stable Electro-Thermal RF Switch for High Power Application," by L. Que et al., IEEE MEMS Scientific Journal 2004, pp. 797-800 introduces an RF switch using a thermoelastic driver and a bistable spring. However, a single bistable spring pair design gives rise to movement such as twisting which makes stable change of a stable state difficult, and use of the thermoelastic driver requires a large current in

order to change the stable state of the bistable spring.

- [7] Also, "A Study on the Latch-Up Thermoelastic Microdriver for RF Switches," by Y. S. Shim et al., KMEMS Scientific Journal 2004, pp. 417-422 discloses a matrix switch employing serially connected thermoelastic drivers. However, while large displacement can be achieved by use of serially connected thermoelastic drivers, a bistable spring is formed by only one pair of leaf springs which makes stable change of a stable state difficult.

Disclosure of Invention

Technical Problem

- [8] The present invention is directed to a matrix relay switch that can more stably operate than conventional technology, can be microminiaturized and has excellent expandability, and especially is suitable for employing an MEMS process.

Technical Solution

- [9] One aspect of the present invention provides a matrix switch for electrical signal connection between at least one signal input terminal and at least one signal output terminal. The matrix switch includes a plurality of electrical switches. Each electrical switch includes: a signal connection unit opening and closing an electrical connection between a signal input terminal and a signal output terminal corresponding to each other; a first movable driver connected to the signal connection unit and driving the signal connection unit forward or backward; a forward/backward driving unit driving the first movable driver forward or backward and changing an electrical connection state made by the signal connection unit between the signal input terminal and the signal output terminal; and a bistable spring unit connected to the first movable driver and maintaining the electrical connection state while a stability state changes due to the first movable driver.
- [10] The forward/backward driving unit may include: a second moveable driver; at least one forward driver driving the second moveable driver forward to advance the first moveable driver; and at least one backward driver driving the second moveable driver backward to withdraw the first moveable driver.
- [11] The forward/backward driving unit may include: a second moveable driver; at least one forward driver driving the second moveable driver forward to advance the first moveable driver; a third moveable driver; and at least one backward driver driving the third moveable driver backward to withdraw the first moveable driver.
- [12] Here, a contact surface between the input signal terminal and the signal connection unit may be formed at an angle of less than 90 degrees with respect to a driving direction of the first moveable driver. Likewise, a contact surface between the output signal terminal and the signal connection unit may be formed at an angle of less than

90 degrees with respect to a driving direction of the first moveable driver.

- [13] Here, the bistable spring unit may include: a hinge spring and/or a linear spring; and a spring structure including a spring connector connected to the hinge spring and/or linear spring.
- [14] The bistable spring unit may include: a spring structure composed of linear or curved leaf springs.
- [15] Also, the bistable spring unit may include: at least one pair of spring structures forming a symmetrical structure centered on the first moveable driver.
- [16] Here, each of the electrical switches may include: a structure layer including the signal input terminal, the signal output terminal, the forward/backward driving unit, the signal connection unit, the first movable driver, and the bistable spring unit; an insulating layer located under the structure layer for electrical insulation; and a base supporting the structure layer and the insulating layer.
- [17] Here, the structure layer may be formed by etching a conductive material. Also, the structure layer may be formed by depositing a conductive material on a nonconductive material. Here, a polymer may be used as the nonconductive material.
- [18] Here, the structure layer may be formed by making a mold using a conductive or nonconductive solid material or a polymer and then depositing a metal material including at least one of copper (Cu), aluminum (Al), platinum (Pt), chrome (Cr), and nickel (Ni) by electroplating.
- [19] Here, each electrical switch may include: electrodes formed by depositing at least one of gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) on the signal input terminal and the signal output terminal. Here, each electrode of each electrical switch may be connected by a gold wiring.
- [20] Also, the matrix switch may include a separate electrode substrate wired with electrodes and leads, and the electrode substrate may be configured to connect the signal input terminal and the signal output terminal of each electrical switch with a conductive solder material.
- [21] Here, at least one low-resistance metal material selected from gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) may be deposited on contact surfaces between the input and output signal terminals and the signal connection unit.

Advantageous Effects

- [22] According to the present invention, a matrix relay switch that can be micro-miniaturized and has excellent expandability can be provided. In particular, when a matrix relay switch according to the present invention is fabricated using a MEMS process, it can be microminiaturized more easily than convention technology.
- [23] Also, when a bistable spring unit according to the present invention is formed of a

plurality of spring structures that are symmetrically centered on the first moveable driver, the moveable driver can be advanced and withdrawn without twisting that occurs in the conventional technology, and stable state change can be accomplished.

Brief Description of Drawings

- [24] FIG. 1 is a conceptual diagram illustrating one exemplary embodiment of a matrix switch according to the present invention.
- [25] FIG. 2 is a conceptual diagram illustrating an alternative configuration of the forward/backward driving unit in an exemplary embodiment of a matrix switch according to the present invention.
- [26] FIG. 3 is a conceptual diagram illustrating another exemplary embodiment of a matrix switch according to the present invention.
- [27] FIG. 4 is a conceptual diagram illustrating another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according to the present invention.
- [28] FIG. 5 is a conceptual diagram illustrating still another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according to the present invention.
- [29] FIG. 6 is a conceptual diagram illustrating yet another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according to the present invention.
- [30] FIGS. 7 to 14 are conceptual diagrams illustrating configurations of a bistable spring unit that can be applied to a matrix switch according to the present invention.
- [31] FIG. 15 is a conceptual diagram illustrating one configuration of a contact surface between a signal connection unit and a signal input terminal or signal output terminal of a matrix switch according to the present invention.
- [32] FIG. 16 is a conceptual diagram illustrating another configuration of a contact surface between the signal connection unit and the signal input terminal or signal output terminal of a matrix switch according to the present invention.
- [33] FIG. 17 is a cross-sectional view showing a cross-sectional configuration of a unit electrical switch in the case of a matrix switch according to the present invention being manufactured by MEMS processes.
- [34] FIG. 18 is a cross-sectional view showing another cross-sectional configuration of a unit electrical switch in the case of a matrix switch according to the present invention being manufactured by MEMS processes.
- [35] FIG. 19 is a cross-sectional view showing one exemplary embodiment of electrode formation on a unit electrical switch of a matrix switch according to the present invention.

Mode for the Invention

- [36] Hereinafter, exemplary embodiments of the present invention will be described in detail. However, the present invention is not limited to the exemplary embodiments disclosed below, but can be implemented in various forms. The following exemplary embodiments are described in order to enable those of ordinary skill in the art to embody and practice the invention.
- [37] FIG. 1 is a conceptual diagram illustrating one exemplary embodiment of a matrix switch according to the present invention.
- [38] Referring to FIG. 1, a matrix switch 100 according to the present invention is intended for electrical signal connection between at least one signal input terminal 111-1 to 111-N and at least one signal output terminal 112-1 to 112-N, and may be formed to include at least one unit electrical switch 110.
- [39] Each electrical switch 110 constituting the matrix switch may be formed to include a signal connection unit 121, a first moveable driver 122 connected to the signal connection unit 121, a forward/backward driving unit 130, and a bistable spring unit 140.
- [40] The signal connection unit 121 opens and closes an electrical connection between an input terminal 111-1 and an output terminal 112-1 corresponding to each other.
- [41] The first moveable driver 122 is connected to the signal connection unit 121 and moves the signal connection unit 121 forward and backward, thereby being driven to enable the signal connection unit 121 to open and close the connection between the signal input terminal 111-1 and the signal output terminal 112-1.
- [42] The forward/backward driving unit 130 drives the first moveable driver 122 forward and backward, thereby changing an electrical connection state established by the signal connection unit 121 between the signal input terminal 111-1 and the signal output terminal 112-1.
- [43] In more detail, the forward/backward driving unit 130 may include a second moveable driver 131, at least one forward driver 132 moving the second moveable driver 131 forward, at least one backward driver 134 moving the second moveable driver 131 backward, and a support spring 136 providing elastic force to the second moveable driver 131 and inducing forward or backward movement.
- [44] Here, the second moveable driver 131 contacts the first moveable driver 122 connected to the signal connection unit 121 through a contact unit 150 and indirectly drives the first moveable driver 122 forward and backward.
- [45] Lastly, the bistable spring unit 140 is connected to the first moveable driver 122 and functions to maintain an electrical connection state established by the signal connection unit 121 between the signal input terminal 111-1 and the signal output

terminal 112-1.

[46] Operation of the matrix switch according to the present invention shown in FIG. 1 will now be described.

[47] First, an operation of connecting the corresponding signal input terminal 111-1 and signal output terminal 112-1 using the signal connection unit 121 is accomplished by movement of the second moveable driver 131 in a forward direction 161 due to electrostatic force generated when a voltage is applied to a forward driving electrode 133 of a forward driver 132 of the forward/backward driving unit 130.

[48] That is, the second moveable driver 131 moves in the forward direction 161, contacts the first moveable driver 122 through the contact unit 150, and thereby moves the first moveable driver 122 in the forward direction 161. Accordingly, the signal connection unit 121 connected to the first moveable driver 122 contacts both the signal input terminal 111-1 and the signal output terminal 112-1 to achieve electrical signal connection.

[49] Next, an operation of disconnecting the corresponding signal input terminal 111-1 and signal output terminal 112-1 is accomplished by movement of the second moveable driver 131 in a backward direction 162 due to electrostatic force generated when a voltage is applied to a backward driving electrode 135 of a backward driver 134 of the forward/backward driving unit 130.

[50] That is, the second moveable driver 131 moves in the backward direction 162, contacts the first moveable driver 122 through the contact unit 150, and thereby moves the first moveable driver 122 in the backward direction 162. Accordingly, the signal connection unit 121 connected to the first moveable driver 122 is removed from contact with both the signal input terminal 111-1 and the signal output terminal 112-1 to achieve electrical signal disconnection.

[51] Meanwhile, the bistable spring unit 140 also moves forward or backward due to the forward or backward movement of the first moveable driver 122. Here, when a force in the forward or backward direction exceeding the elastic restoration force of the bistable spring unit 140 is transferred through the first moveable driver 122, the bistable spring unit 140 maintains a state of being bent to one side and maintains the electrical connection state established by the signal connection unit 121 between the signal input terminal 111-1 and the signal output terminal 112-1.

[52] For example, the bistable spring unit 140 illustrated in FIG. 1 is bent in the backward direction 162 of the first moveable driver 122, demonstrating a state in which the signal connection unit 121 does not connect the signal input terminal 111-1 and the signal output terminal 112-1. In contrast, the bistable spring unit 140 may be bent in the forward direction 161 of the first moveable driver 122 to maintain a state in which the signal connection unit 121 connects the signal input terminal 111-1 and the signal

output terminal 112-1.

- [53] Such an electrical switch 110 is one unit forming a matrix switch enabling electrical signal connection between a plurality of signal input terminals and a plurality of signal output terminals.
- [54] Meanwhile, while FIG. 1 illustrates an exemplary embodiment in which the forward driver 132 and the backward driver 134 of the forward/backward driving unit 130 are both located at one side of the bistable spring unit 140, the forward driver 132 and the backward driver 134 may be respectively disposed at opposite sides of the bistable spring unit 140.
- [55] FIG. 2 is a conceptual diagram illustrating an alternative configuration of the forward/backward driving unit in an exemplary embodiment of a matrix switch according to the present invention.
- [56] Referring to FIG. 2, a forward/backward driving unit 230 having a different configuration from the forward/backward driving unit 130 shown in FIG. 1 is illustrated. The forward/backward driving unit 230 shown in FIG. 2 includes a second moveable driver 232 and a third moveable driver 236, and may be configured by separately disposing a forward driver 231 driving the second moveable driver 232 and a backward driver 235 driving the third moveable driver 236. Also, the forward/backward driving unit 230 may include a support spring 234 providing elastic force to the second moveable driver 232 and inducing forward or backward movement, and a support spring 238 providing elastic force to the third moveable driver 236 and inducing forward or backward movement.
- [57] Meanwhile, all other elements besides the forward/backward driving unit 230 are the same as in the exemplary embodiment shown in FIG. 1, are denoted by the same reference numerals as in FIG. 1, and will not be described in detail below.
- [58] That is, in the illustrated structure, the forward driver 231 moving the second moveable driver 232 forward to contact the first moveable driver 122 through a contact unit 151 and cause the first moveable driver 122 to move forward is disposed at a backward direction side of the first moveable driver 122 of the bistable spring unit 140. And, the backward driver 235 moving the third moveable driver 236 backward to contact the first moveable driver 122 through a contact unit 152 and cause the first moveable driver 122 to move backward is disposed at a forward direction side of the first moveable driver 122 of the bistable spring unit 140.
- [59] Accordingly, unlike the forward/backward driving unit 130 shown in FIG. 1, the forward/backward driving unit 230 of the matrix switch illustrated in FIG. 2 includes a moveable driver (the second moveable driver 232) driven by the forward driver 231 included in the forward/backward driving unit 230 and a separate moveable driver (the third moveable driver 236) driven by the backward driver 235 included in the forward/

backward driving unit 230.

[60] Either of the exemplary embodiments shown in FIGS. 1 and 2 may be selected for implementation according to ease of design and operation.

[61] Meanwhile, the forward driver 132 and the backward driver 134 which are included in the forward/backward driving unit 130 illustrated in FIG. 1 generate force to move the second moveable driver 131 forward and backward by electrostatic force between the second moveable driver 131 and the forward driving electrode 133, and between the second moveable driver 131 and the backward driving electrode 135. Likewise, the forward driver 231 included in the forward/backward driving unit 230 illustrated in FIG. 2 generates force to move the second moveable driver 232 forward or backward by electrostatic force between the second moveable driver 232 and the forward driving electrode 233, and the backward driver 235 included in the forward/backward driving unit 230 illustrated in FIG. 2 generates force to move the third moveable driver 236 forward or backward by electrostatic force between the third moveable driver 236 and the backward driving electrode 237.

[62] As the force moving the moveable driver forward or backward, not only electrostatic force as shown in FIGS. 1 and 2, but alternatively thermoelastic force caused by thermal expansion, Lorentz force known as electromagnetic force, etc. may be employed.

[63] FIG. 3 is a conceptual diagram illustrating another exemplary embodiment of a matrix switch according to the present invention.

[64] Referring to FIG. 3, another exemplary embodiment of a matrix switch according to the present invention may be configured to include a forward/backward driving unit 330 employing thermoelastic force or electromagnetic force.

[65] Meanwhile, all other elements besides the forward/backward driving unit 330 are the same as in the exemplary embodiments shown in FIGS. 1 and 2, are denoted by the same reference numerals as in FIGS. 1 and 2, and will not be described in detail below.

[66] The forward/backward driving unit 330 may be configured to include a second moveable driver 332, a forward driver 331 for moving the second moveable driver 332 forward, a third moveable driver 335, and a backward driver 334 for moving the third moveable driver 335 backward.

[67] In the forward driver 331, when a voltage is applied to a forward driving electrode 333, a structure heats up and expands causing the second moveable driver 332 to move in a forward direction 161. Also, in the case of a forward driver employing electromagnetic force, a solenoid or permanent magnet is adhered to the bottom of an element to generate a vertical magnetic field, and the second moveable driver 332 is driven by Lorentz force resulting from application of current to the forward driving electrode 333.

- [68] Likewise, in the backward driver 334, when a voltage is applied to a backward driving electrode 336, a structure heats up and expands causing the third moveable driver 335 to move in a backward direction 162. Also, in the case of a backward driver employing electromagnetic force, a solenoid or permanent magnet is adhered to the bottom of an element to generate a vertical magnetic field, and the third moveable driver 335 is driven by Lorentz force resulting from application of current to the backward driving electrode 336.
- [69] FIG. 4 is a conceptual diagram illustrating another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according to the present invention.
- [70] While FIG. 3 shows an exemplary embodiment in which both the forward driver 331 and the backward driver 334 of the forward/backward driving unit 330 are located on one side of the bistable spring unit 140, FIG. 4 shows a case in which a forward driver 431 and a backward driver 435 are respectively disposed on either side of the bistable spring unit 140.
- [71] The configuration of a forward/backward driving unit 430 illustrated in FIG. 4 is only different from the forward/backward driving unit 230 illustrated in FIG. 2 in whether a force driving second and third moveable drivers 432 and 436 is electrostatic force, thermoelastic force, or electromagnetic force. Otherwise, the configuration is the same and thus will not be described in detail below. Also, all other elements besides the forward/backward driving unit 430 are the same as in the exemplary embodiments shown in FIGS. 1 to 3 and thus will not be described in detail below.
- [72] FIG. 5 is a conceptual diagram illustrating still another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according to the present invention.
- [73] Referring to FIG. 5, in still another configuration 530 of the forward/backward driving unit of a matrix switch according to the present invention, electrodes 533 and 536 included in a forward driver 531 and a backward driver 534 are arranged in series.
- [74] Accordingly, when the configuration 530 of the forward/backward driving unit of a matrix switch according to the present invention illustrated in FIG. 5 is adopted, drive displacement of the second moveable driver 532 and the third moveable driver 535 in the forward direction 161 or the backward direction 162 may be larger than when the configurations of the forward/backward driving units 330 and 430 of a matrix switch according to the present invention illustrated in FIGS. 3 and 4 are adopted. That is, by giving the forward driver 531 and the backward driver 534 greater driving force, drive displacement in the forward direction or backward direction can be increased.
- [75] FIG. 6 is a conceptual diagram illustrating yet another configuration of the forward/backward driving unit in another exemplary embodiment of a matrix switch according

to the present invention.

- [76] Referring to FIG. 6, in yet another configuration 630 of the forward/backward driving unit of a matrix switch according to the present invention, electrodes 633 and 637 included in a forward driver 631 and a backward driver 635 are arranged in series. This serial arrangement of the electrodes included in the forward driver 631 and the backward driver 635 is the same as in the configuration 530 of the forward/backward driving unit shown in FIG. 5, and disposition of the forward driver 631 and the backward driver 635 respectively on either side of the bistable spring unit 140 is the same as in the configuration of the forward/backward driving unit 430 shown in FIG. 4.
- [77] FIGS. 7 to 14 are conceptual diagrams illustrating configurations of the bistable spring unit that can be applied to a matrix switch according to the present invention.
- [78] Referring to FIG. 7, the bistable spring unit 140 may be configured to include a support member 141 for supporting both ends, a hinge spring 142-1 and a spring connector 143 joined to the support member 141, and a hinge spring 142-2 joining the spring connector 143 to the moveable driver 144.
- [79] Here, the moveable driver 144 means the first moveable driver 122 connected to the signal connection unit 121 illustrated in FIGS. 1 to 6. That is, the bistable spring unit 140 adopting a structure that is symmetrical about the first moveable driver 122 can induce forward or backward driving of the signal connection unit 121 without tilting, and is preferable for stable operation.
- [80] Referring to FIG. 8, the bistable spring unit 140 may be configured to include a support member 141 for supporting both ends, a linear spring 145-1 and a spring connector 143 joined to the support member 141, and a linear spring 145-2 joining the spring connector 143 to the moveable driver 144.
- [81] Referring to FIGS. 9 and 10, unlike the bistable spring units illustrated in FIGS. 7 and 8, cases of the bistable spring unit being configured with an integrated linear spring 146 and an integrated curved spring 147 are respectively shown.
- [82] Any of the configurations of the bistable spring unit shown in FIGS. 7 to 10 may be chosen according to force required to the bistable spring unit to maintain contact between the signal input terminal and signal output terminal through the signal connection unit 121.
- [83] Meanwhile, the bistable spring unit 140 is not necessarily configured with one pair of springs symmetrically centered on the moveable driver 144, but may also be configured with a plurality of pairs of springs in parallel centered on the moveable driver 144.
- [84] Referring to FIGS. 11 to 14, unlike the bistable spring units illustrated in FIGS. 7 to 10, cases of the bistable spring unit configured with two pairs of springs symmetrically

centered on the moveable driver 144 are shown.

- [85] FIG. 11 corresponds to the bistable spring unit shown in FIG. 7 configured to include the hinge spring and the spring connector, and shows the configuration of a bistable spring unit configured with two pairs of hinge springs 142-1-1, 142-1-2, 142-2-1, and 142-2-2, and spring connectors 143-1 and 143-2.
- [86] Likewise, FIG. 12 corresponds to the bistable spring unit shown in FIG. 8 configured to include the linear spring and the spring connector, and shows the configuration of a bistable spring unit configured with two pairs of linear springs 145-1-1, 145-1-2, 145-2-1, and 145-2-2, and spring connectors 143-1 and 143-2.
- [87] FIGS. 13 and 14 show bistable spring units configured with integrated linear springs and integrated curved springs, respectively. That is, FIGS. 13 and 14 correspond to FIGS. 9 and 10 and show bistable spring units symmetrically configured with two pairs of linear springs 146-1 and 146-2 or curved springs 147-1 and 147-2.
- [88] Any of the configurations of the bistable spring unit illustrated in FIGS 11 to 14 may be chosen, for example, when configuring the bistable spring unit with only one pair of springs does not provide sufficient connection maintenance force, or in order to increase safety of repeated operation by distributing mechanical fatigue to several pairs of springs as a precaution against degradation due to repeated opening and closing of the electric switch. Also, by symmetrically arranging a plurality of spring structures about the moveable driver in this way, twisting of the moveable driver can be prevented.
- [89] FIG. 15 is a conceptual diagram illustrating one configuration of a contact surface between the signal connection unit and the signal input terminal or signal output terminal of a matrix switch according to the present invention.
- [90] Referring to FIG. 15, as an example of the contact surface between the signal connection unit 122 and the signal input terminal 111-1 or the signal output terminal 112-1, in its most basic form, the contact surface may be configured at substantially a 90 degree angle with respect to the driving directions 161 and 162 of the first moveable driver 122.
- [91] Meanwhile, the contact surface between the signal connection unit and the signal input terminal, or the contact surface between the signal connection unit and the signal output terminal may be configured to form an angle of less than 90 degrees with respect to the driving directions of the moveable driver.
- [92] FIG. 16 is a conceptual diagram illustrating another configuration of a contact surface between the signal connection unit and the signal input terminal or signal output terminal of a matrix switch according to the present invention.
- [93] Referring to FIG. 16, unlike the contact surface configuration shown in FIG. 15, in which a contact surface 401 or 402 between the signal connection unit 122 and the

signal input terminal 111-1 or signal output terminal 112-1 is configured at substantially a 90 degree angle with respect to the driving directions 161 and 162 of the first moveable driver 122, a contact surface 403 or 404 between the signal connection unit 122 and the signal input terminal 111-1 or signal output terminal 112-1 may be configured to form an angle of less than 90 degrees with respect to the driving directions 161 and 162 of the first moveable driver 122.

[94] Thus, the area of the contact surfaces 403 and 404 shown in FIG. 16 is larger than the area of the contact surfaces 401 and 402 shown in FIG. 15, and accordingly contact resistance between the signal connection unit 122 and the signal input terminal 111-1 or signal output terminal 112-1 can be reduced.

[95] Meanwhile, in order to enhance micro miniaturization, expandability, and ease of manufacture, it may be preferable for the matrix switch according to the present invention to be manufactured by micro electro mechanical systems (MEMS) processes.

[96] FIG. 17 is a cross-sectional view showing a cross-sectional configuration of a unit electrical switch in the case of a matrix switch according to the present invention being manufactured by MEMS processes.

[97] Referring to FIG. 17, a unit electrical switch in the case of a matrix switch according to the present invention being manufactured by MEMS processes may be configured to include a structure layer 410, an insulating layer 420, and a base 430.

[98] The structure layer 410 is a layer on which elements configuring the matrix switch according to the present invention, such as a signal input terminal, a signal output terminal, a forward/backward driving unit including a forward driver and a backward driver, and a bistable spring unit connected to a signal connection unit, are formed.

[99] Meanwhile, the structure layer 410 may be formed by etching a conductive material, and the conductive material is preferably a material containing silicon.

[100] Also, the structure layer 410 may be formed by depositing a conductive material on a nonconductive material. Here, the nonconductive material may be a polymer, and a metal material containing at least one of copper (Cu), aluminum (Al), platinum (Pt), chrome (Cr) and nickel (Ni) may be selected as the conductive material.

[101] Also, the structure layer 410 may be formed by making a mold using a conductive or nonconductive solid material or a polymer and then depositing a metal material containing at least one of copper (Cu), aluminum (Al), platinum (Pt), chrome (Cr), and nickel (Ni) by electroplating.

[102] The insulating layer 420 is formed under the structure layer 410 for electrical insulation, and the base 430 is a layer for supporting the structure layer 410 and the insulating layer 420.

[103] Meanwhile, by depositing at least one metal material having low electrical resistance selected from gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) on contact

surfaces between the signal input terminal, the signal output terminal, the signal connection unit, and other elements, electrical signal distortion caused by resistance can be minimized.

[104] FIG. 18 is a cross-sectional view showing another cross-sectional configuration of a unit electrical switch in the case of a matrix switch according to the present invention being manufactured by MEMS processes.

[105] As described above, depending on the need to minimize electrical signal distortion caused by resistance, by depositing at least one metal material 411 having low electrical resistance selected from gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) on contact surfaces between the signal input terminal, the signal output terminal, the signal connection unit, and other elements formed in the structure layer 410, electrical signal distortion caused by resistance can be minimized.

[106] Meanwhile, in the unit electrical switch of a matrix switch according to the present invention described with reference to FIG. 17, it may be necessary to form electrodes for connection between the plurality of signal input terminals and signal output terminals.

[107] Ordinarily, in connecting electrodes for transferring electrical signals to signal input terminals and/or signal output terminals, a method of forming electrodes by depositing metal such as gold (Au), aluminum (Al), platinum (Pt), etc. on the signal input terminals and signal output terminals, and then connecting the electrodes with gold wiring may be employed.

[108] FIG. 19 is a cross-sectional view showing one exemplary embodiment of electrode formation on a unit electrical switch of a matrix switch according to the present invention.

[109] FIG. 19 illustrates a method of forming electrodes for transferring electrical signals of signal input terminals and/or signal output terminals using a separate electrode substrate, instead of forming electrodes by depositing metal and connecting the electrodes with gold wiring.

[110] Referring to FIG. 19, in one example of electrode formation on a unit electrical switch of a matrix switch according to the present invention, the matrix switch includes a separate electrode substrate 440 wired with electrodes 441 and 442 and leads 443. The electrode substrate 440 may be configured to connect the signal input terminal and the signal output terminal of each electrical switch with a conductive solder material 450. Meanwhile, outward signal transmission may be connected by a gold wiring 460.

[111] When such a configuration is adopted, when an electrical signal is connected from the signal input terminal to the signal output terminal, since there is only electrical resistance at one contact surface, a uniform electrical signal can be expected at all signal output terminals.

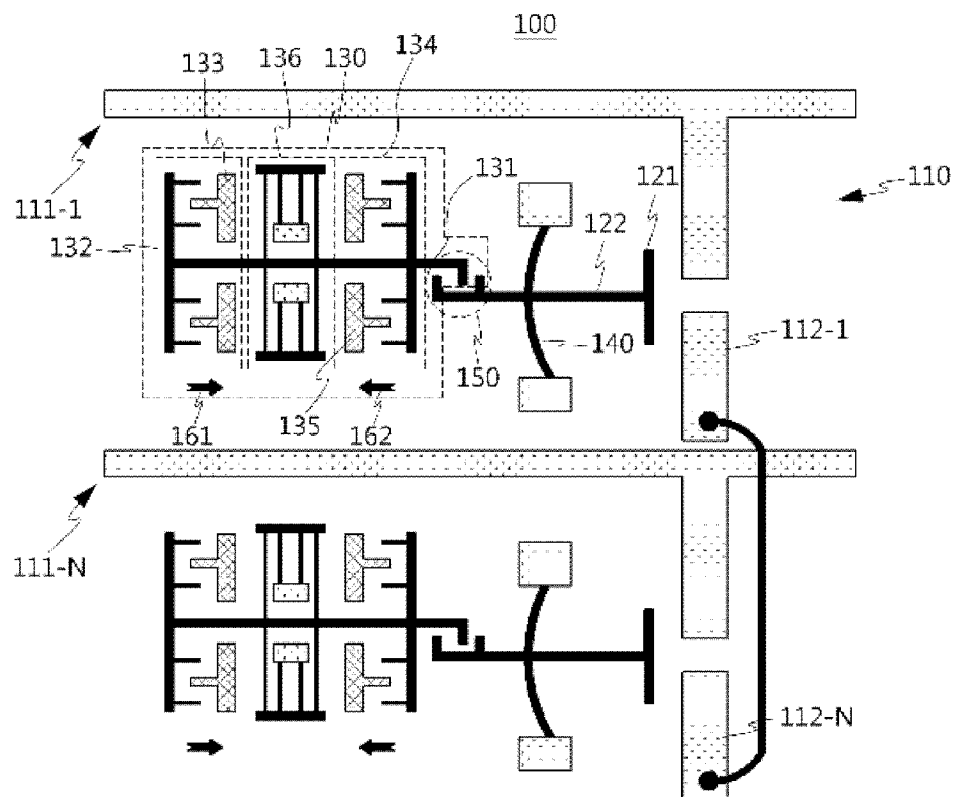
- [112] While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

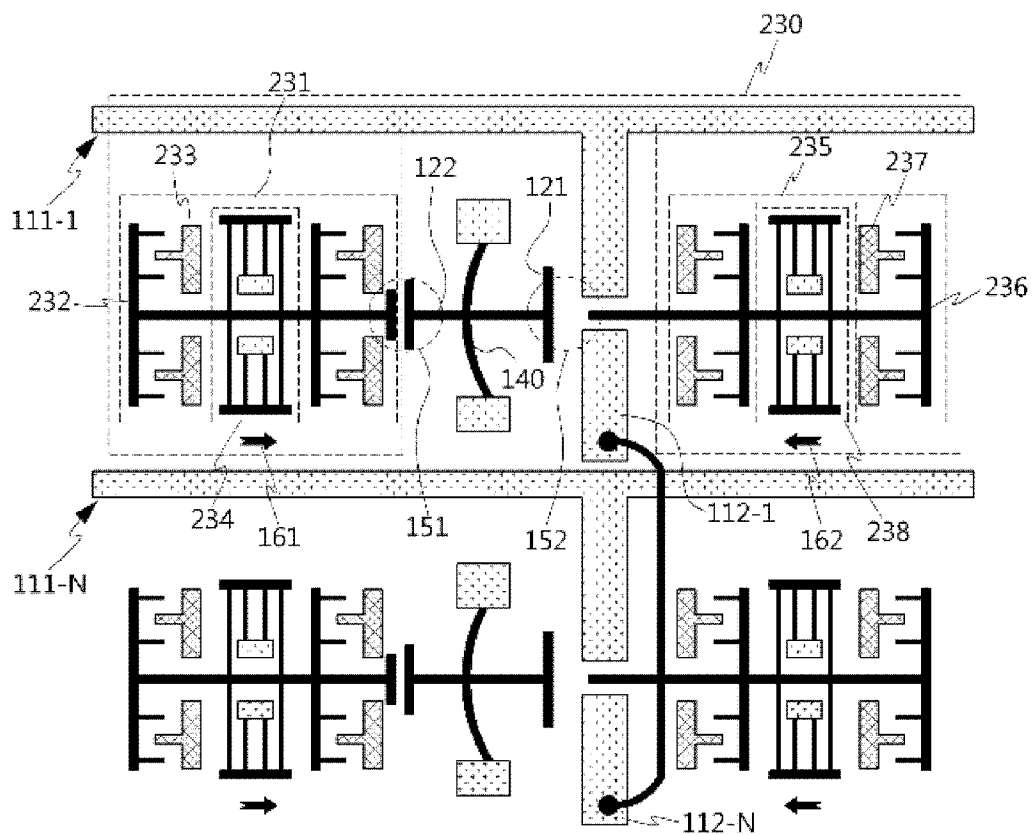
- [1] A matrix switch for electrical signal connection between at least one signal input terminal and at least one signal output terminal, the matrix switch comprising a plurality of electrical switches, each electrical switch comprising:
a signal connection unit opening and closing an electrical connection between a signal input terminal and a signal output terminal corresponding to each other;
a first movable driver connected to the signal connection unit and driving the signal connection unit forward or backward;
a forward/backward driving unit driving the first movable driver forward or backward and changing an electrical connection state made by the signal connection unit between the signal input terminal and the signal output terminal;
and
a bistable spring unit connected to the first movable driver and maintaining the electrical connection state while a stability state changes due to the first movable driver.
- [2] The matrix switch of claim 1, wherein the forward/backward driving unit comprises:
a second moveable driver;
at least one forward driver driving the second moveable driver forward to advance the first moveable driver; and
at least one backward driver driving the second moveable driver backward to withdraw the first moveable driver.
- [3] The matrix switch of claim 1, wherein the forward/backward driving unit comprises:
a second moveable driver;
at least one forward driver driving the second moveable driver forward to advance the first moveable driver;
a third moveable driver; and
at least one backward driver driving the third moveable driver backward to withdraw the first moveable driver.
- [4] The matrix switch of claim 1, wherein a contact surface between the input signal terminal and the signal connection unit is formed at an angle of less than 90 degrees with respect to a driving direction of the first moveable driver.
- [5] The matrix switch of claim 1, wherein a contact surface between the output signal terminal and the signal connection unit is formed at an angle of less than 90 degrees with respect to a driving direction of the first moveable driver.
- [6] The matrix switch of claim 1, wherein the bistable spring unit comprises:

- a hinge spring and/or a linear spring; and
a spring structure including a spring connector connected to the hinge spring and/or linear spring.
- [7] The matrix switch of claim 1, wherein the bistable spring unit comprises:
a spring structure composed of linear or curved leaf springs.
- [8] The matrix switch of claim 6 or 7, wherein the bistable spring unit comprises at least one pair of spring structures forming a symmetrical structure centered on the first moveable driver.
- [9] The matrix switch of claim 1, wherein each of the electrical switches comprises:
a structure layer including the signal input terminal, the signal output terminal, the forward/backward driving unit, the signal connection unit, the first movable driver, and the bistable spring unit;
an insulating layer located under the structure layer for electrical insulation; and
a base supporting the structure layer and the insulating layer.
- [10] The matrix switch of claim 9, wherein the structure layer is formed by etching a conductive material.
- [11] The matrix switch of claim 9, wherein the structure layer is formed by depositing a conductive material on a nonconductive material.
- [12] The matrix switch of claim 11, wherein the nonconductive material is a polymer.
- [13] The matrix switch of claim 9, wherein the structure layer is formed by making a mold using a conductive or nonconductive solid material or a polymer and then depositing a metal material containing at least one of copper (Cu), aluminum (Al), platinum (Pt), chrome (Cr), and nickel (Ni) by electroplating.
- [14] The matrix switch of claim 9, wherein each electrical switch comprises:
electrodes formed by depositing at least one of gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) on the signal input terminal and the signal output terminal.
- [15] The matrix switch of claim 14, wherein each electrode of each electrical switch is connected by a gold wiring.
- [16] The matrix switch of claim 9, further comprising:
a separate electrode substrate wired with electrodes and leads, the electrode substrate being configured to connect the signal input terminal and the signal output terminal of each electrical switch with a conductive solder material.
- [17] The matrix switch of claim 1, wherein at least one low-resistance metal material selected from gold (Au), copper (Cu), aluminum (Al), and platinum (Pt) is deposited on contact surfaces between the input and output signal terminals and the signal connection unit.

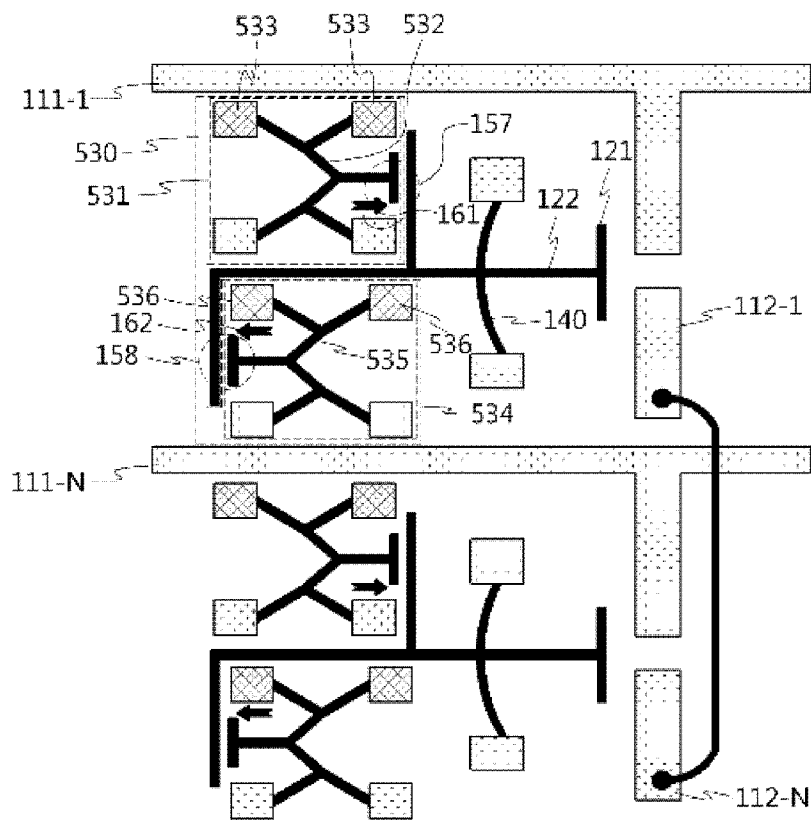
[Fig. 1]



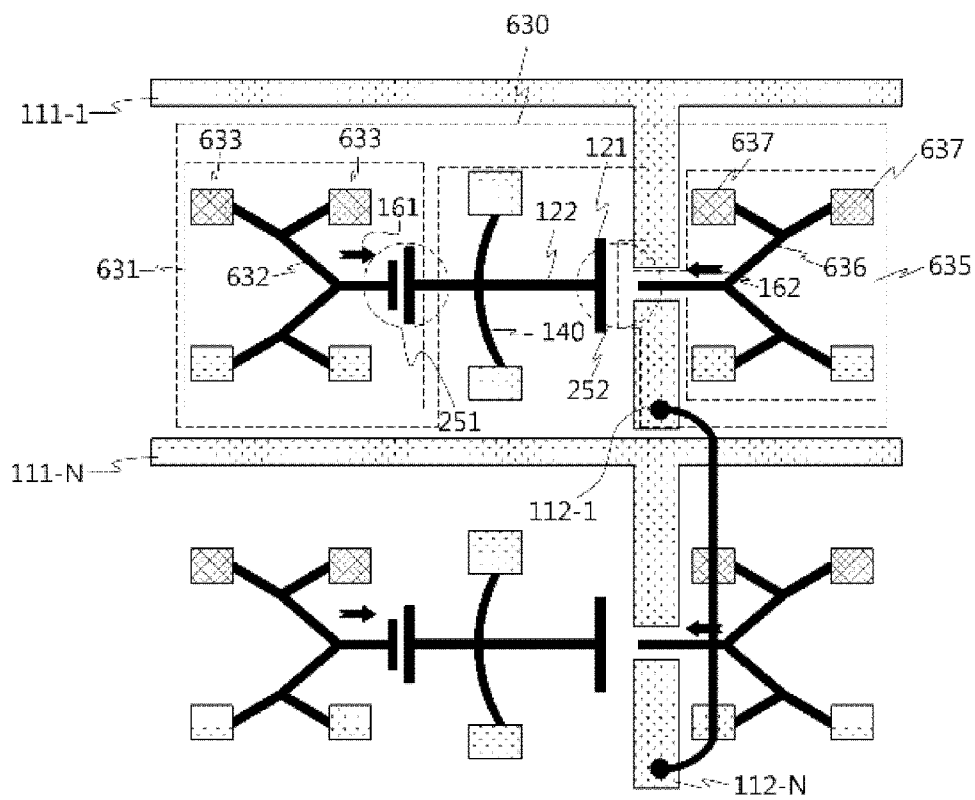
[Fig. 2]



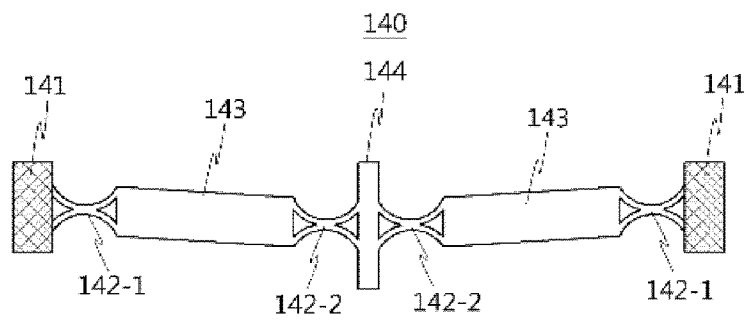
[Fig. 5]



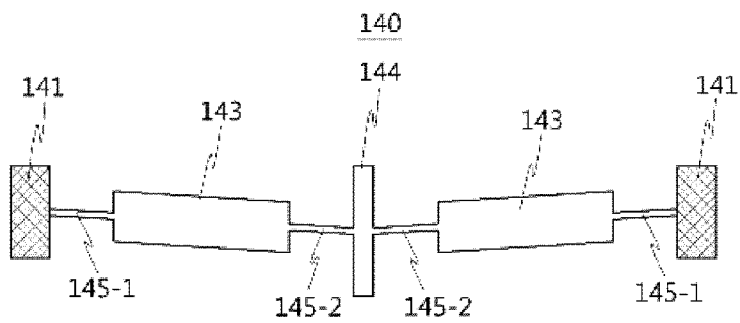
[Fig. 6]



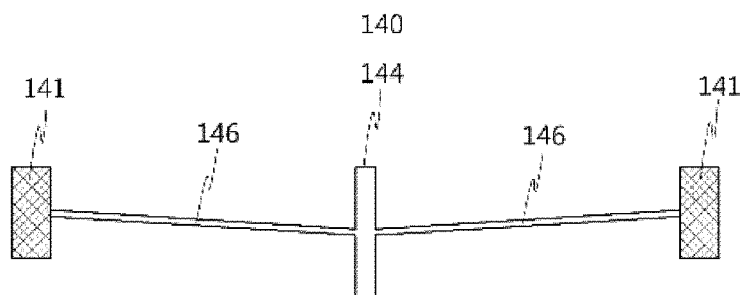
[Fig. 7]



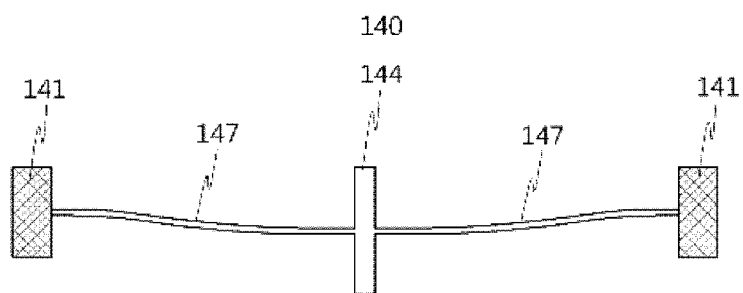
[Fig. 8]



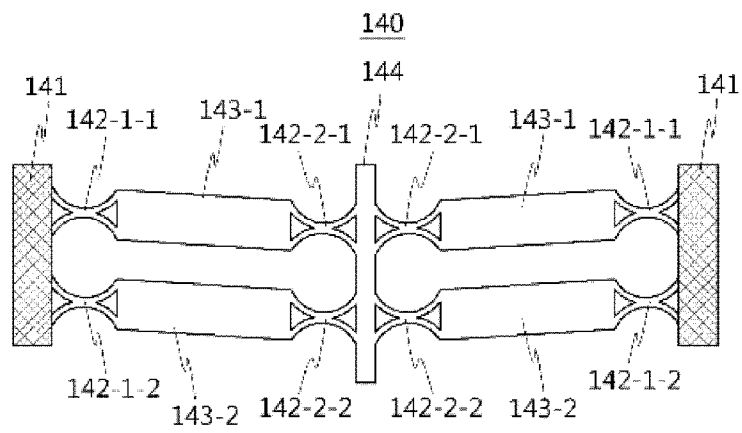
[Fig. 9]



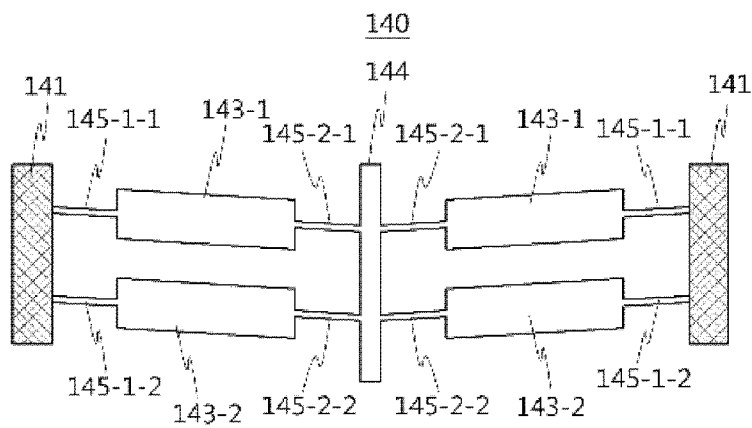
[Fig. 10]



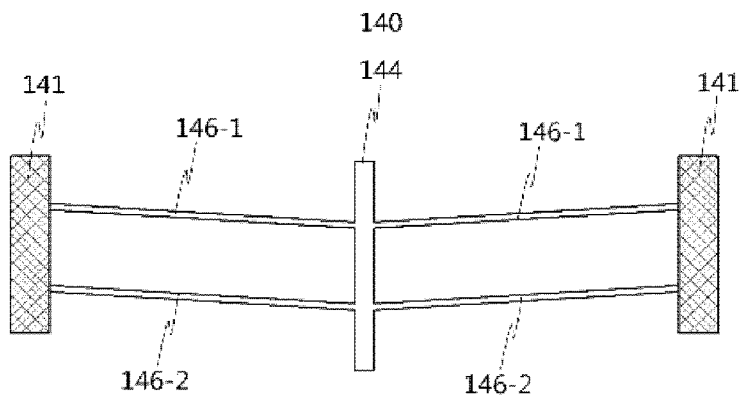
[Fig. 11]



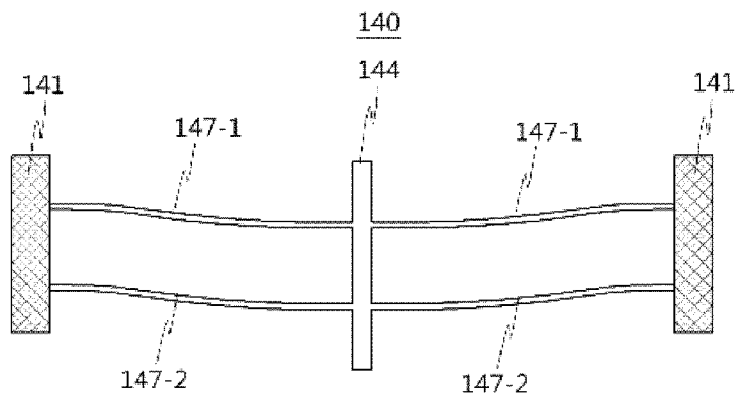
[Fig. 12]



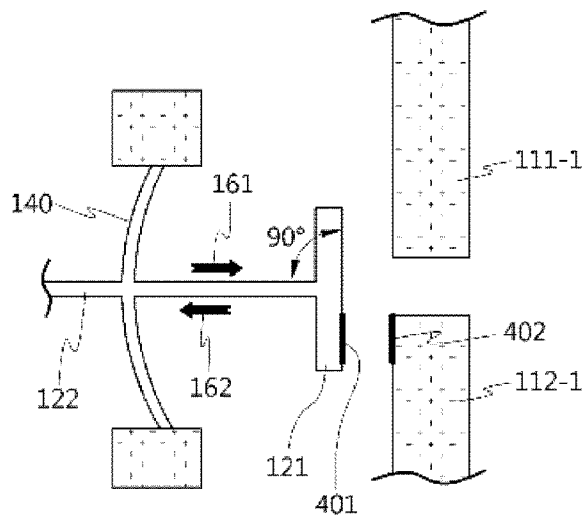
[Fig. 13]



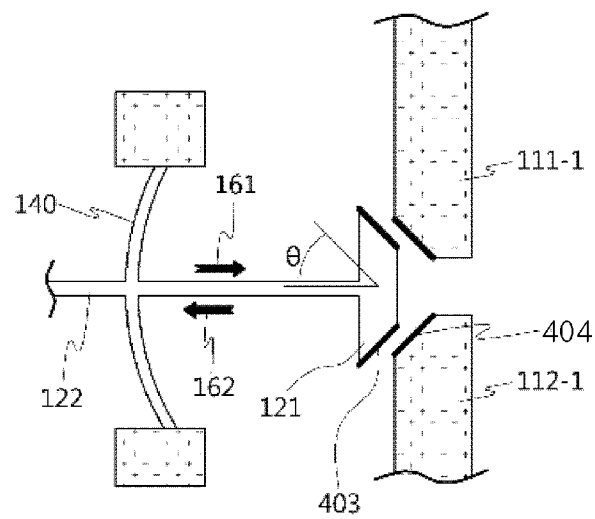
[Fig. 14]



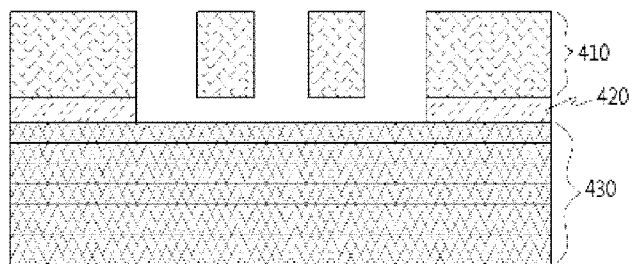
[Fig. 15]



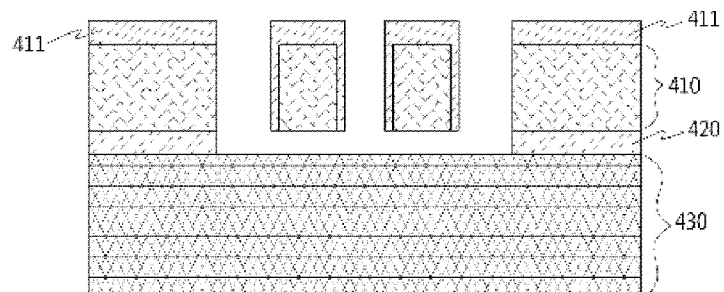
[Fig. 16]



[Fig. 17]



[Fig. 18]



[Fig. 19]

