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(54) **Multi I/O electromechanical micro switch**

(57) Electrically driven micro switch that is able to actuate galvanic connections between input and output rheophores (here below called "pins") by realizing a complete connection matrix.

The small size micro switch allows to connect a largely definable number of pins and is particularly suited to telephony applications, by featuring for each input and output a double polarity, that can be associated to the poles of a telephone wire pair; the connections are mechanically realized so that they are maintained indefinitely without energy consumption and with a near zero connection attenuation.

Furthermore, the micro switch is realized in order to allow the association between more than one micro switches to define an unlimited size connection matrix.

The invention belongs to the technical area of electro mechanics and to the application area of electromechanical devices manufacture.

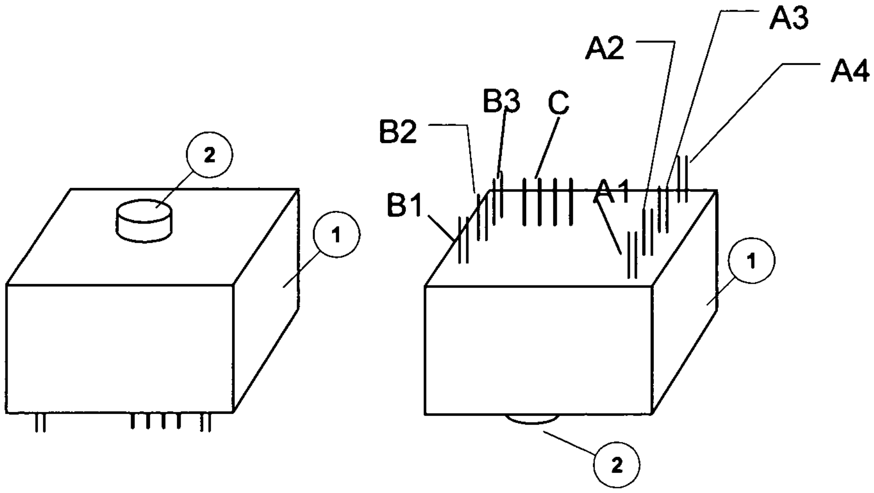

FIG.1

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Description

[0001] The present invention relates to an electromechanical device named "small size micro switch" that features "m" input pins and "n" output pins and is able by means of electrically driven mechanical movements to actuate a galvanic connection between each one of the input pins and each one of the output ones ensuring that the actuated connections remain indefinitely stable until new electrical command change their states by means of new mechanical movements.

[0002] On the market some electronic switches are known, normally using relay technology, that, variously combined, can create multiple I/O switching functionality like the one offered by the micro switch described in this paper. In comparison with those realizations the present invention offers switching functionality in a reduced space with a zero connection attenuation, by realizing the connection electromechanically so that, once it has been actuated, it will indefinitely be maintained in a stable way without any energy consumption. The micro switch that is the present invention is particularly suited for use in telephony application in force of realization details that will be clarified below in the description.

[0003] The input pins and the output pins can by in any number, their limit being determined by the micro switch size. For ease of presentation, in the following description we refer to a number of input pins "m" equal to 3 and to a number of output pins "n" equal to 4: that means we describe a "3 by 4" modularity micro switch. Naturally all the considerations made for such a modularity do apply more generally to a whatever "m by n" modularity.

[0004] The invention is here below described for illustrative and not limitative purpose, by making reference to the following included figures:

- FIG.1: Micro switch in standing position and in upside down position,
- FIG.2: Switching mechanism,
- FIG.3: Section of a connection ring,
- FIG.4: Horizontal section view of the uplifting and rotation mechanism,
- FIG.5: Vertical section view of the uplifting and rotation mechanism,
- FIG.6: Uplifting and rotation elements,
- FIG.7: Equivalent circuit of the micro switch,
- FIG.8: Example of serial/parallel composition,
- FIG.9: Horizontal section of the micro switch,
- FIG.10: Vertical section of the micro switch,
- FIG.11: Schematic representation of the connections to the state memories.

[0005] In FIG.1 the micro switch is schematized in its package 1 with highlighted input pins **B1,B2,**etc. and output pins **A1,A2,**etc. In the same figure more command pins have been highlighted and indicated by the letter **C :** they can be used to read the states of the micro switch connections.

[0006] The micro switch, **FIG:2,** is made of more planes. The number of planes defines the input modularity - also referred as "vertical modularity" - of the micro switch. To each plane **P** all the output pin connections - also referred as "horizontal" - are routed, therefore the plane size defines the micro switch horizontal modularity. Hence an " m by n" micro switch - i.e. with "m" input pins and "n" output pins - is made of "m" planes: to each plane the "n" output pins are routed.

[0007] For ease of presentation, as mentioned above, we consider m=3 - hence 3 input pins, that is three planes - and n=4 - hence four pins are routed onto the three planes -. All the considerations that will be made for such a modularity do apply naturally for any modularity.

[0008] Every input pin and every output pin is made of a pole pair with galvanic isolation even though, for ease of presentation, we will refer to them simply as input pin or output pin, meaning by that an input pole pair or an output pole pair.

[0009] As shown in **FIG:2,** in every plane **P1,P2,P3** there are two concentric rings: the inner **3** called "piston" and the outer **4** called "ring nut". Piston **3 ,** that is a properly shaped ring described below, brings the vertical connections **B ,** one for each plane; in other words to each piston **3** of a given plane **P** a different input pin **B** is connected. Every ring nut **4** brings the "m" horizontal connections **A1,A2,etc.,** in other words to every ring nut of every plane are connected all the output pins. In the case we are describing, reported in **FIG:2,** we have on the first plane **P1** the piston **3** to which is connected the pin **B1** and the ring nut **4 ,** divided in four sectors **S1,S2,etc.,** with galvanic isolation, each one being connected to a pin A - hence **A1,A2,etc** - each one to a sector. In the same way we have on the second plane **P2** the piston **3,** to which the pin **B2** is connected, and the ring nut **4** divided in four sectors **S1,S2,etc.,** with galvanic isolation, each one being connected to a pin A - hence **A1,A2,A3,A4** - each one to a sector; analogously we will have on the third plane **P3.** Two brush elements **5,** defined as connection brushes **5a, 5b** allow to maintain the galvanic connection between the two rings. More precisely, the brush **5a** between the outer and the inner ring and the brush **5b** between the inner ring and a sector of the outer ring. By means of a rotation of the piston **3** with respect to the ring nut **4 ,** the connection can be modified moving the brush **5** up to the interesting ring nut sector. As illustrated in **FIG:2** , the connection brushes **5** are two: the first **5a** integral with the ring nut **4** scrapes on the piston **3** during the latter's rotation, the second **5b** integral with piston **3** scrapes on the ring nut **4** up to the desired sector. In **FIG:2** are realized the connections between the pins B1-A3, B2-A1 and B3-A2. Then it is clear how the micro switch can provide for wider modularity than the one described, just simply increasing the number of planes **P ,** that must be as many as the input pins **B,** and increasing the number of sectors **S** that partition the ring nuts **4 ,** the number of sectors must be equal to the number of output pins **A.** It is evident at this point that by increasing the modularity the size of the micro switch increases because the number of planes **P** grows and the ring nut circumference, hence the plane size, grows too in order to hold a bigger number of sectors.

[0010] As already mentioned, all the ring nuts **4** are divided in sectors **S** with reciprocal galvanic isolation, each one being connected to an output pin **A.** All the ring nuts **4** are fixed and reciprocally integral even though they are separated. More precisely, the ring nut **4, FIG. 3**, is formed by two overlapped surfaces , reciprocally isolated, each one being connected to one of the poles of the output pin **A.** The upper surface will be connected to the positive pole **A+** of the pin, while the lower surface will be connected to the negative pole **A- .** Hence every ring nut sector is connected at the same time to the two poles, positive and negative, with a galvanic separation, of an output pin **A .** Actually every ring nut sector provides for a further connection layer, that for ease of description we call neutral pole **Ao,** that, as will appear evident in the following, allows to read the states of the connections. The **FIG.3** shows the section of a ring nut **4** where are evident the connection surfaces to the poles **A+** e **A-** of the output pins with the interposition of the neutral surface **Ao.**

[0011] The pistons **3** of the various **P** planes can rotate in a mutually independent way and each one allows the connection to a different sector of the ring nut **4 .** Even the pistons **3** are actually formed by two overlapped surfaces, mutually isolated, each one being connected to one of the poles of the input pin **B .** The upper surface will be connected to the positive pole of the pin, while the lower surface will be connected to the negative pole. Between the two surfaces, analogously to what has been seen for the ring nut **4 ,** there is a further neutral surface, necessary for reading the states of the micro switch connections as will appear clear in the description that follows below. The piston **3** is actually a ring, properly inside shaped, **FIG.4,** in such a way that can be hooked by an uplifting and rotation mechanism **7 -** called "jack" - that, moving vertically, once it reaches the interesting pistion **3 ,** it imparts it the rotation to displace the brush **5**, **FIG. 2,** up to the sector of the ring nut **4** to be connected. Actually, as shown in **FIG.5** e **FIG.6**, the jack **7** is screwed on a worm screw **8** that is put into rotation by a small electric engine **2** driven by one of the command pins **C .** The rotation of the worm screw **8** moves up and down the jack 7 between the **P** planes of the micro switch up to the desired plane. At this point the jack 7 is blocked integrally with the worm screw **8** and therefore the successive rotation generated by the electric engine 2 imparts the rotation to the jack **7** itself that in turn rotates the piston **3** of the plane **P** where it arrived. Differently stated, the jack **7** on the worm screw **8** can have two states: free or blocked. In the free state **7a** the rotation of the worm screw 8 shifts up vertically the jack to the desired **P** plane, hooked to the piston 3 of that plane; in the blocked state **7b** the jack rotates integrally with the worm screw **8** imparting the rotation to piston 3 to which it is now hooked up. The **FIG.6** highlights the two states of the jack **6a, 6b** and the relevant movement to coincide with the rotation of the worm screw **8 :** in the first case, i.e. free state, to the rotation of the screw corresponds a vertical movement of the jack; in the second case, i.e. blocked state, to the rotation of the screw corresponds the integral rotation of the jack.

[0012] The present invention is advantageous because, being arbitrarily defined the m by n modularity of the micro switch, by choosing the values m and n according to the desired device maximum size, it constitutes an atomic element that, associated to other elements, creates in a modular way a bigger element, whose output and input modularity sum up. More precisely by connecting more elements in parallel the input are summed up while connecting them in serially the outputs are summed up. In order to better understand how this can happen let's consider the equivalent circuit of the 3 by 4 micro switch above describe and illustrated in **FIG.7.** In this equivalent circuit, the micro switches **10** have been considered that, open or closed create the desired connections between the input pins **B** and the output pins **A;** in the case represented in **FIG.7** the active connections are between the pins B1-A3, B2-A1 and B3-A2 as those actuated in the previously described micro switch.

[0013] Now, using the graphical representation of the equivalent circuit, it is easily understandable how the serial or parallel connection of more components provides a higher modularity device. In **FIG.8,** for instance, it is illustrated how to obtain a 12 by 12 modularity device by connecting more 3 by 4 modularity devices as the one formerly described.

[0014] The micro switch physically appears as an electronic device provided with pins , **FIG.1,** so, naturally, it is very simple to combine serially or in parallel more micro switches soldered on a normal electronic printed circuit board. In this way the board itself constitutes the desired composed modularity device: the presented invention allows to realize connection matrices of whatever size.

[0015] At this point all the elements that constitute the micro switch and the way they interact have been illustrated and for clarity purpose are reported in **FIG.9** and in **FIG.10** where the various elements can be seen in a horizontal section relative to a generic plane, and a vertical section a-a.

[0016] It is clear also, at this point, how the invention is particularly suited for use in telephony application because all the connection mechanism in based upon two-way paths so that every pin has a double polarity and can be consequently associated to the two wires of a telephone pair.

[0017] Optionally the micro switch can be supplied with a memory element 11 directly connected to the output pins A, one memory cell for each pin. Hence, bi soliciting with a test signal the input pins B, the memory is automatically loaded with the values 1 or 0 that represent the state of the active connections. It must be made clear that the memory **11** is connected to the neutral pole **Ao**

of the ring nut sector. The **FIG.11** graphically illustrates the previously described method so that it appears evident, in the case of the considered micro switch, that the memory values correspond to the active connections; precisely, in the above mentioned example, the memory values, using the hexadecimal notation, will be "412" that correspond to the active connections B1-A3, B2-A1, B3-A2. The method of realization of the connection to the memory cells, that in a simple way can be read on some pins C of the micro switch, **FIG.1,** allows to control in any moment in a simple and sure way the state of the input-output connections actuated by the micro switch.

Claims

1. Multio I/O micro switch, electrically driven, featuring, **FIG.1**, input pins **B,** output pins **A** and command/control pins **C,** being constituted by more planes **P**, each one containing two concentric rings, called respectively piston **3** and ring nut **4,** capable to mutually rotate maintaining their connection by means of the connection brushes **5**, and being constituted by a worm screw **8,** a small electric engine **2** capable to rotate the worm screw **8** and a jack **7** capable of a double motion of uplifting and rotation , and being provided with memory cells **11,** available on the market, that report the connection state between the pins.

2. Electromechanical micro switch according to **Claim#1** having the feature that the number of input pins **B** and the number output pins **A** are big at will and mutually independent.

3. Electromechanical micro switch according to **Claim#1** having the feature that the pins are constituted by more poles with galvanic mutual separation.

4. Electromechanical micro switch according to **Claim#1** having the feature that the input pins **B** are each one connected to a different piston **3** and the output pins **A** are all connected to each ring nut **4.**

5. Electromechanical micro switch according to **Claim#1** having the feature that the piston **3,** the ring nut **4** and the brushes **5** are all constituted by more overlapped surfaces with mutual galvanic separation.

6. Electromechanical micro switch according to **Claim#1** having the feature that the piston **3,** is an inside shaped ring in order to be put into rotation by the jack **7** which is in turn constituted by a toothed ring capable to be engaged with the shape of the piston **3.**

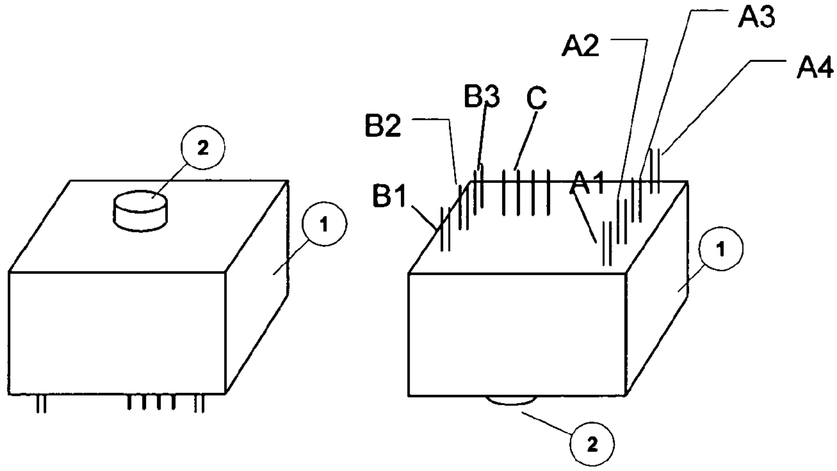
A3
A2
A4
B3
C
B2
A1
B1
2
1
1
2

FIG.1

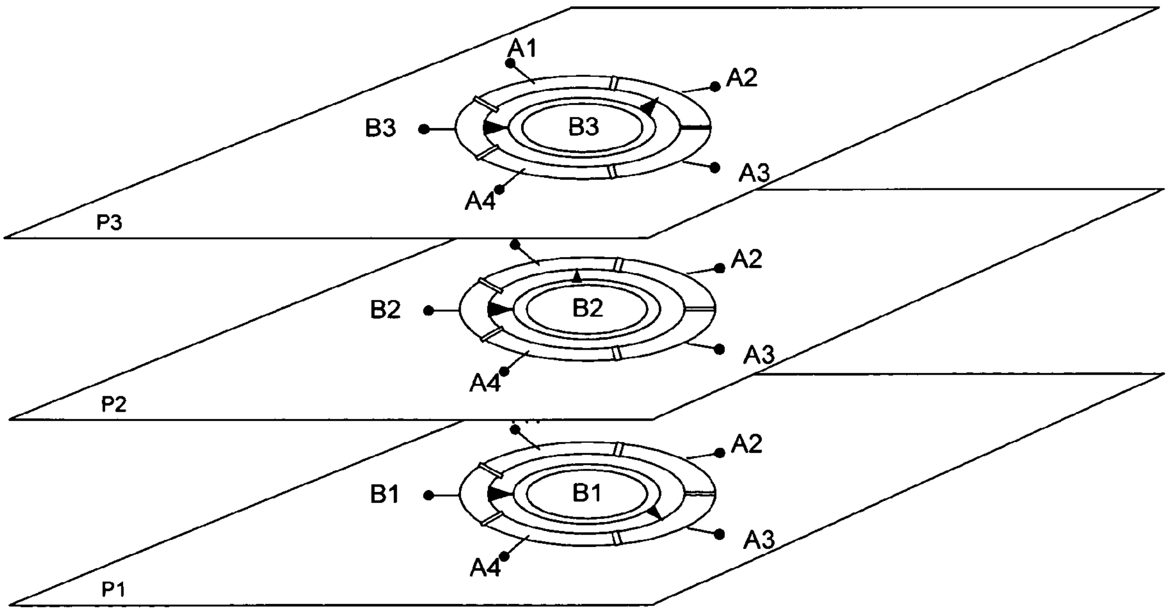
A1
A2
B3
B3
A3
A4
P3
A2
B2
B2
A3
A4
P2
A2
B1
B1
A3
A4
P1

FIG.2

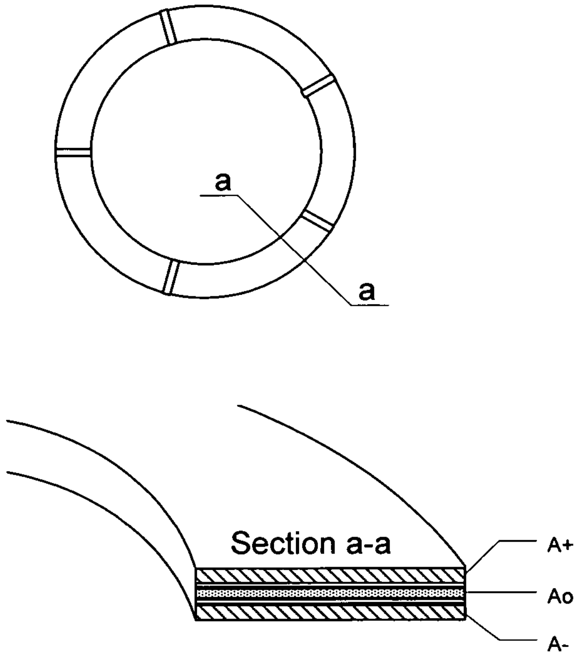

Fig.3

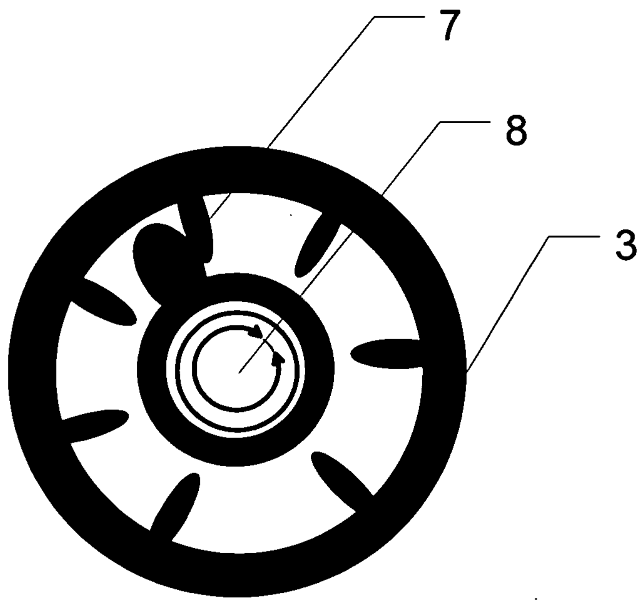

FIG.4

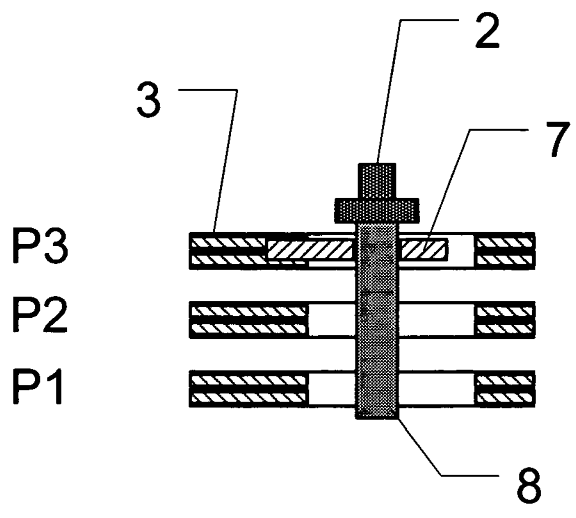

FIG.5

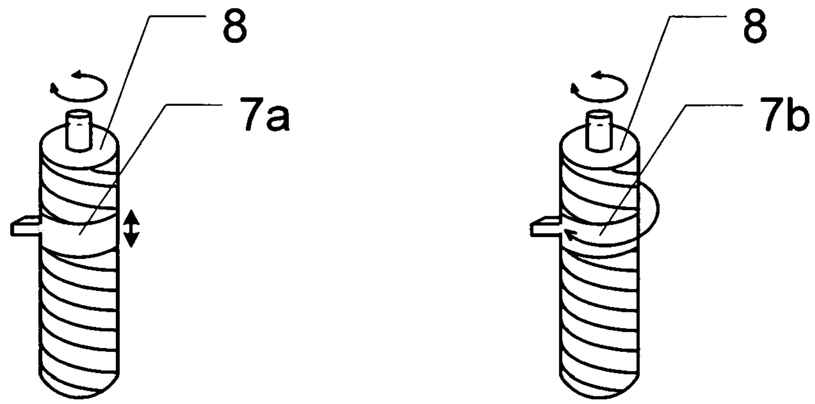

FIG.6

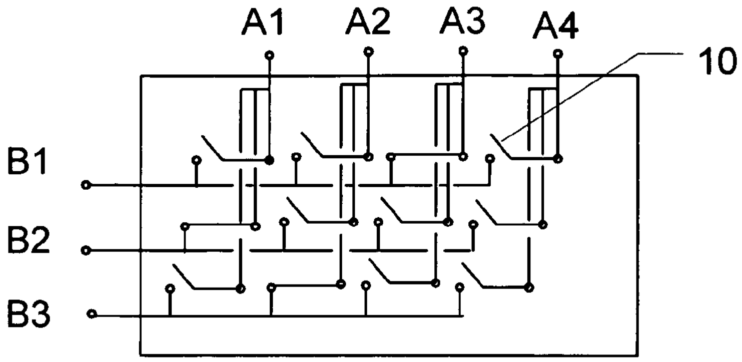
A1
A2
A3
A4
10
B1
B2
B3

FIG.7

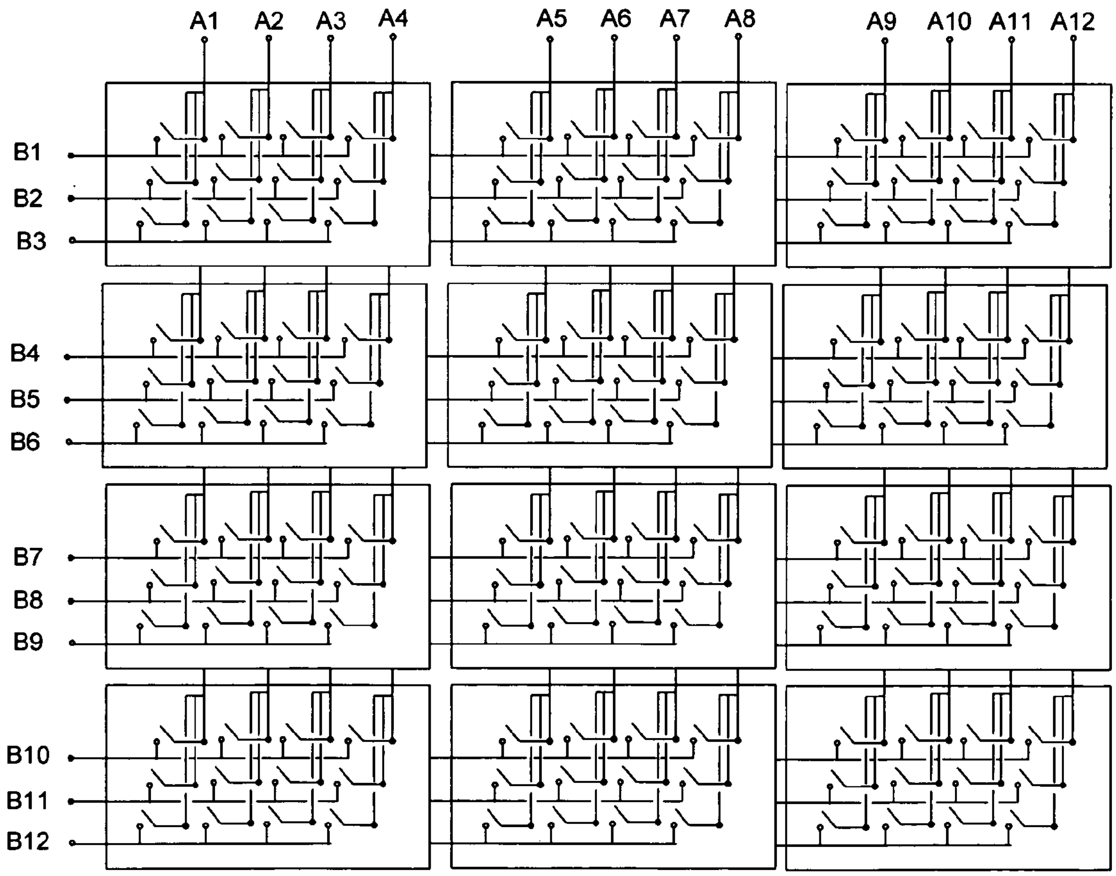
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12

FIG.8

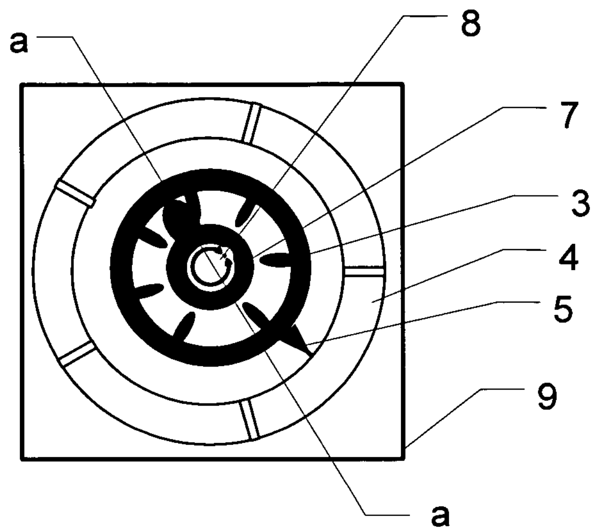

FIG.9

Section a-a

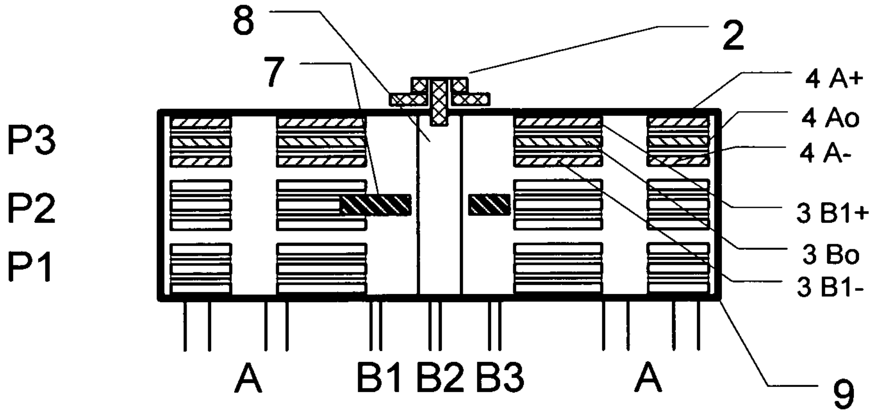

FIG.10

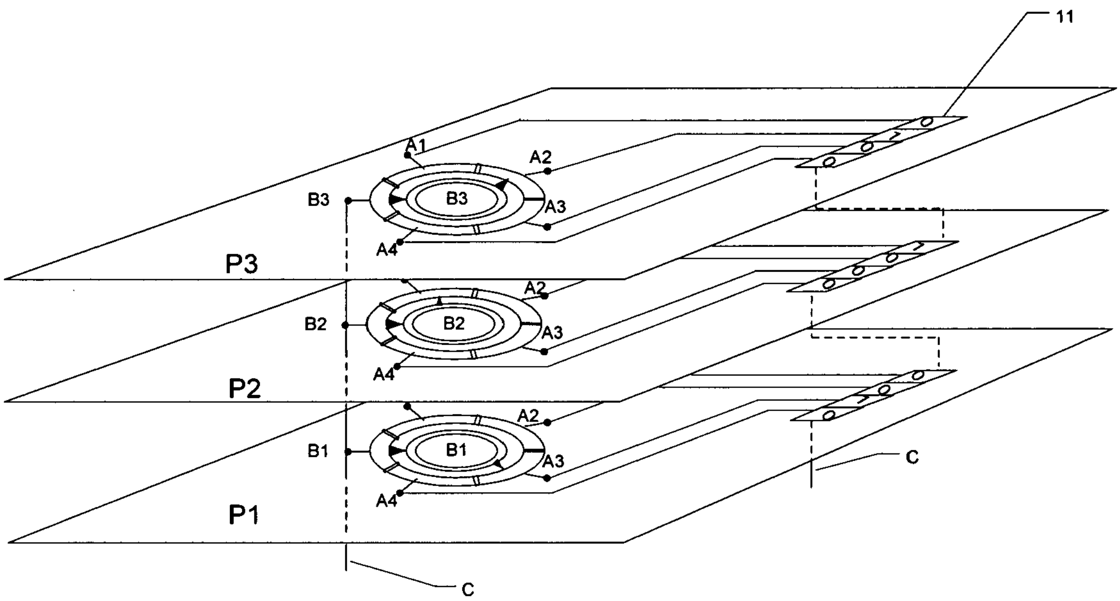

FIG.11