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(54) **Electromechanical relay**

(57) The present invention provides an electromechanical relay comprising a carrier (4); a contact body (3); at least one first contact element (2) and at least one coil (1) for moving the contact body (3) with respect to the carrier (4). The contact body (3) is implemented as a membrane (31) in which or on which at least one second contact element (32) is provided. The membrane (31) is adapted so as to be moved as a result of a magnetic field generated by the at least one coil (1) in order to disconnect or establish an electrical contact between the at least one second contact element (32) and the at least one first contact element (2) and the membrane (31) is adapted to elastically deform during such movement.

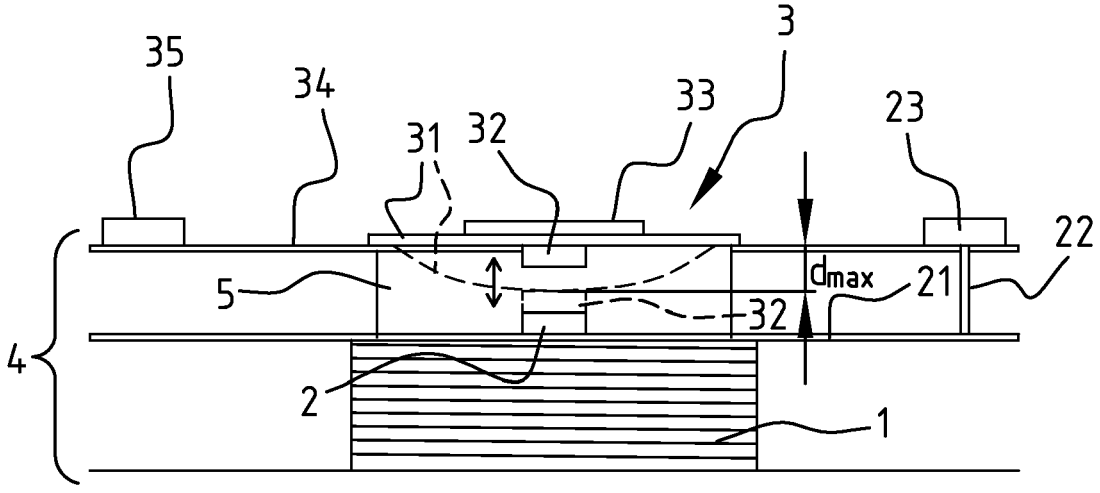

FIG. 1A

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Description

[0001] The present invention relates to an electromechanical relay.

[0002] A known electromechanical relay typically comprises a coil that is mounted on a base made of, for example iron (yoke), an armature of magnetic material which is movable with respect to the base and a first contact element made out of electrically conductive material and connected to the armature. The contact element is intended to establish or disconnect electrical contact with a second contact element, depending on whether the coil has been charged or not. By sending a current through the coil, a magnetic field is generated for moving the armature in such a way that electrical contact between the first contact element and the second contact element is established or disconnected. Such a relay has as a disadvantage that it is not very compact and, therefore, difficult to integrate into small electrical devices of which the space within the device is limited and/or of which the shape is fixed.

[0003] The present invention aims at providing an electromechanical relay which is rather small, and more specifically a compact relay that can form a relatively thin, flat unit.

[0004] For this purpose, an electromechanical relay according to the invention comprises a carrier, a contact body, at least one first contact element and at least one coil for moving the contact body with respect the carrier. The contact body is implemented as a flexible membrane in which or on which at least one second contact element is provided. This flexible membrane is adapted to be moved as a result of a magnetic field generated by the at least one coil in order to disconnect or establish an electrical contact between the at least one second contact element and the at least one first contact element. During this movement the membrane will typically undergo an elastic deformation.

[0005] Embodiments of the invention are based *inter alia* on the inventive insight that implementing the contact body as a flexible membrane allows to obtain a compact movable contact body. In this way no springs or similar elements are necessary in order to movably mount the contact body with respect to the carrier and a compact relay can be obtained that can easily be integrated in an electronic circuit.

[0006] The at least one coil may preferably be provided in the carrier. For this purpose, the carrier may be provided with a recess in which the coil can be placed. It is also possible to form the coil using electrically conductive tracks that are integrated into the carrier, in particular when the carrier is a PCB. The conductive tracks can then be provided in a plurality of layers of the PCB (PCB track coil). In that way, the compact nature of the relay can be further enhanced.

[0007] The flexible membrane may preferably be fixed to the carrier. The flexible membrane may typically be fixed along its circumference to the corresponding circumferential edge of the carrier. It is noted that the membrane does not need to be fastened to the carrier along the full circumference, but can, according to other embodiments, for example also be fastened only at individual points or zones of the carrier. More in general, the membrane may preferably be fastened in such a way that it is held along at least two opposite zones during an elastic deformation of the membrane as a result of the generation of a magnetic field by the at least one coil in order to disconnect or establish an electrical contact between the at least one second contact element and the at least one first contact element. In that way, the membrane can, for example, be fastened in two opposite points or in three points along the circumference. This fastening at three points will also ensure that the membrane is held in two opposite zones, although these zones do not have to coincide with the points of fastening.

[0008] Preferably, the flexible membrane may extend over a recess in the carrier. The at least one second electrical contact element may then preferably be provided at a bottom side of the flexible membrane facing the recess and the at least one first contact element may then preferably be positioned in the recess. The at least one coil may then preferably be in or under the recess in the carrier, such that it can attract the flexible membrane in order to establish contact between the at least one second electrical contact element and the at least one first contact element.

[0009] With the term membrane is meant an elastic layer structure that may contain one or more layers. The membrane may preferably have a thickness of less than 2 mm, and more preferably less than 1 mm. The membrane may typically comprise at least one layer of an elastic synthetic material, such as an elastomer, polyamide, polyester or the like. The membrane could also comprise a very thin layer of a relatively hard material, such as a PCB material. Such a relatively hard membrane should preferably have a thickness of less than 0.5 mm, more preferably less than 0.1 mm. A PCB FR4 material may, for example, be used with a thickness of 0.06 mm; at this thickness this material is flexible and can undergo minor elastic deformation. Except for a layer of elastic synthetic material the membrane may also comprise an electrically conductive layer, such as copper foil, and/or a magnetic conductive layer; see further.

[0010] According to embodiments of the invention, a permanent magnet may be provided on or in the flexible membrane. The permanent magnet and the at least one coil may be provided in such a way that the flexible membrane is movable as a result of charging the at least one coil to disconnect or establish an electrical contact between the at least one second contact element and the at least one first contact element. According to alternative embodiments, at least one electrical winding may be provided on or in the flexible membrane. This at least one electrical winding and the at least one coil may be provided such that an electrical contact is disconnected or established between the at least one second contact el-

ement and the at least first contact element upon charging the electrical windings of the at least one coil.

[0011] According to another embodiment, a magnetic material (e.g. soft steel or an alloy) can be provided into or onto the flexible membrane. The magnetic material may be provided into/onto the membrane in any suitable way known by a person skilled in the art, for example as a solid material, a powder or a coating.

[0012] According to embodiments of the invention, the flexible membrane may comprise at least one electrically conductive part to form the at least one second contact element. This electrically conductive part can, for example, be in the form of solid material (such as copper tracks), as a synthetic material to which microfibers are added, as a coating, etc.

[0013] According to a preferred embodiment, the at least one first contact element may be provided between the at least one coil and the flexible membrane and the at least one second electrical contact element may be provided on a side of the flexible membrane facing the at least one coil. This may typically result in the most compact configuration. It is, however, also possible to provide the first and second contact elements on the other side of the flexible membrane.

[0014] The carrier may preferably be a thin plate, in particular a PCB, so that a thin device can be obtained. These plates may have any shape depending on the electronic device in which the relay is required. Preferably the carrier may have a thickness of less than 3 mm. By implementing the carrier as a PCB an additional function is given to the carrier, i.e. the formation of a mounting surface for electronic components, such as resistors, capacitors, chips, etc. Such measures can further contribute to the compactness of the relay unit and/or a circuit in which the relay is incorporated.

[0015] The at least one first and/or second electrical contact element may, for example, comprise a spring contact or a spheroid contact. More in general, the first and second electrical contact element may have any suitable shape and contact elements of different types or shapes may be combined in one relay.

[0016] The relay may, according to embodiments of the invention, comprise one coil, but may also, according to embodiments of the invention, comprise a plurality of coils. The coils can be provided on top of and/or next to each other. Each coil may preferably have an axis that is oriented substantially perpendicular to the carrier and/or the flexible membrane. This will allow the flexible membrane to easily be attracted or rejected. The distance between the carrier and the flexible membrane, in the condition in which the at least one first contact element is removed from the at least one second contact element, may preferably be less than 5 mm. In this way, the distance to be bridged can be limited.

[0017] According to a possible embodiment, each coil may be provided with a core of magnetic material. Furthermore, each coil may be surrounded by at least one element of magnetic material in order to form a magnetic circuit. If the core and the 'surroundings' (zone outside the core) comprise magnetic material, the magnetic flux obtained will be better and thus a higher level of attraction can be achieved.

[0018] According to further embodiments, the relay may comprise an additional carrier, at least one additional coil for moving the flexible membrane with respect to the additional carrier and at least one additional first contact element. The flexible membrane may extend between the at least one first contact element and the at least one additional first contact element. Furthermore, the flexible membrane may be provided with a second contact element on both sides. The flexible membrane may be provided between the at least one coil and the at least one additional coil in such a way that the flexible membrane can be moved as a result of a magnetic field that is generated by the at least one coil and the at least one additional coil in order to alternately establish an electrical contact of the second contact element with the first contact element or with the additional first contact element. Such a stacked version will allow more complex relay switches to be obtained in which second contact elements are provided on both sides of the flexible membrane.

[0019] According to another embodiment of the invention, a so-called bi-stable electromechanical relay may be formed, in which a flexible membrane is movable between a first and second position as a result of generating a first and second magnetic field, respectively, by the at least one coil. In this case at least one permanent magnet may be mounted on the carrier in such a way that the flexible membrane is held in the first position after removal of the first magnetic field.

[0020] According to another embodiment of the invention, at least two first contact elements and at least two coils may be provided, in which the at least two coils are provided such that, as a consequence of selectively charging one or more coils, the at least two first contact elements can selectively make contact with the at least one second contact element on the flexible membrane. In this way, an alternate switching relay can be obtained.

[0021] According to another possible embodiment, the at least one coil may be provided onto the membrane and the at least one permanent magnet may be mounted onto the carrier. The direction of the current in the coil determines whether the membrane with the contact element is attracted or not. It is also possible to charge the coil with a current in the opposite direction in order to achieve a rejecting power. Preferably, the at least one permanent magnet may be located in or under the recess in the carrier. A permanent magnet can be surrounded by at least one element of magnetic material in order to form a magnetic circuit. According to such embodiment the at least one coil may, for example, be formed as a number of electrical windings that are provided in a layer on or in the membrane.

[0022] The present invention shall be described in detail by means of a number of in no way limiting exemplary

embodiments of an electromechanical relay in accordance with the invention with reference to the drawings.

Figure 1A schematically shows a side view of a first embodiment of a relay according to the invention;
Figure 1B schematically shows a top view of the embodiment of figure 1A;
Figure 2A schematically shows a side view of a second embodiment of a relay according to the invention;
Figure 2B schematically shows a top view of the embodiment of figure 2A;
Figure 3 schematically shows a cross-section of a third embodiment of a relay according to the invention;
Figure 4 schematically shows a cross-section of a fourth embodiment of a relay according to the invention; and
Figure 5 schematically shows a cross-section of a fifth embodiment of a relay according to the invention;

[0023] A first embodiment of an electromechanical relay according to the invention is shown in figures 1A - 1B. The electromechanical relay comprises a carrier 4 in the form of a multi-layer PCB structure, a contact body 3 in the form of a flexible membrane 31, a first contact element 2 and a coil 1 for moving the contact body 3 with respect to the carrier 4. The contact body 3 is implemented as a flexible membrane 31 on which a second contact element 32 is provided. Furthermore, the flexible membrane 31 is adapted to be moved as a result of a magnetic field generated by the coil 1, by providing a permanent magnet 33 on the flexible membrane 31. According to embodiment of the invention, the permanent magnet 33 may be an electrical winding; see also to the embodiment illustrated in figures 2A and 2B.

[0024] In the example given, the coil 1 is inserted in a recess 5 in the carrier 4. The flexible membrane 31 is provided such that above the coil 1 an open space 5 is present in which the flexible membrane 31 can move.

[0025] The second contact element 32 is connected to a contact path 35 by means of a conductive track 34. The contact path 35 can then be connected with, for example an electronic switch, into which the relay function must be integrated. The first contact element 2 is connected via a conductive track 21 and via 22 to a contact path 23. The contact path 23 can in turn be connected with, for example, the electronic switch into which the relay must be integrated. Figure 1A illustrates the open position of the relay in a solid line and the closed position in a dotted line. In the closed position, the permanent magnet 33 is attracted as a result of the generation of a magnetic field by coil 1, as a result of which the flexible membrane 31 is elastically deformed and a contact is established between the first and second contact elements 2, 32. It has to be noted that this elastic deformation can be minimal and that the membrane is typically displaced to a maximum distance d_{max} (see figure 1A) that is smaller than 2 mm and may typically be between 0.3 mm and 1 mm. As can be best seen in figure 1B the first contact element 2 may, for example, be connected to an intermediate plane of the carrier 4 via four conductive tracks 21, 24, 25, 26. In the embodiment illustrated in figures 1A and 1B the flexible membrane is implemented as having a circular shape. Any other suitable shape may, however, be possible.

[0026] According to a possible embodiment, each coil 1 may be provided with a core of magnetic material. Furthermore, each coil may be surrounded by at least one element of magnetic material (not illustrated) in order to form a magnetic circuit. This element may, for example, be formed by a hollow tube which is installed around the coil 1. In that way, the attractive force can be further enhanced.

[0027] Figures 2A and 2B illustrate a second embodiment of a relay according to the invention, in which similar components are indicated with the same reference numbers as in figures 1A and 1B. In the embodiment of figures 2A and 2B, instead of a permanent magnet as in figures 1A and 1B, an electrical winding 36 is provided on the flexible membrane 31. When the electrical winding 36 and the coil 1 are charged in an appropriate way, the flexible membrane 31 together with the second contact element 32 will move in the direction of the first contact element 2. According to the embodiment of figures 2A and 2B the first contact element 2 may be a spring contact that is inserted in the recess of the coil 1. This spring contact is connected to a contact path 23 via a conductive track 21 at the bottom side of the carrier 4. The electrical winding 36 may, for example, be connected via conductive tracks 37, 38 on the top side or bottom side of the flexible membrane 31, respectively.

[0028] Figure 3 illustrates a third embodiment of a relay according to the invention in which a carrier 4 and an additional carrier 4' are mounted above each other. The carrier 4 is provided with a recess 5 in which a coil 1 and a first contact element 2 are provided. In a similar way the additional carrier 4' is provided with a recess 5' in which a coil 1' and a first contact element 2' are provided. According to another embodiment of the invention, the coil 1' can be omitted and coil 1 is able to attract or reject the flexible membrane 31 depending on the direction of the current. The carriers 4, 4' are provided above each other whereby the recesses 5, 5' are facing each other and whereby a flexible membrane 31 is provided between the recesses 5 and 5'. The flexible membrane 31 is at both its sides provided with a second contact element 32,32'. These second contact elements 32, 32' are intended to respectively make contact with the first contact elements 2, 2'. Furthermore, an electrical winding 36 is provided in the flexible membrane 31. According to an alternative embodiment, a permanent magnet 33 may be provided in the flexible membrane 31. Electrically conductive tracks 34, 34', 37 are provided for connecting respectively the second contact elements 32, 32' and the

electrical winding 36. The first contact elements 2, 2' are respectively connected via conductive tracks 21, 21', conductive passages 22, 22' and contact paths 23, 23' on respectively the top side and bottom side of the combined carrier 4, 4'. In that way, two relay functions may be provided by means of one flexible membrane 31. A person skilled in the art will understand that more complex relay functions can be built in which the invention is implemented by, for example, providing a plurality of second contact elements 32 on the top side and/or bottom side of the flexible membrane 31 and by providing a plurality of first contact elements 2. Furthermore, a plurality of coils 1 can be provided next to each other below/above the flexible membrane 31.

[0029] Figure 4 illustrates a fourth embodiment in which similar components are indicated with the same reference numbers as in figures 1A, 1B and 2A, 2B. In the embodiment illustrated in figure 4 the flexible membrane 31 may be provided directly above two coils 1. The coils 1 are provided next to each other in the carrier 4. At the bottom side of the flexible membrane 31, two permanent magnets 33 are provided which are intended to work together with the two coils 1. At the top side of the flexible membrane, a second contact element 32 is provided which is intended to work together with the first contact element 2. The first contact element 2 is connected to a contact path 23 at the top side of the carrier 4 via a conductive track 21. The second contact element 32 is connected to a contact path 35 at the top side of the carrier 4 via a conductive track 34 in an intermediate plane of the carrier 4 and a passage 39.

[0030] A person skilled in the art will understand that different embodiments can be combined with one another. For example, the embodiments of figures 1A - 1B, 2A - 2B and 3 can be implemented with a plurality of coils 1 next to each other in a plane parallel to the carrier 4 instead of with one coil 1. Further, in all embodiments a plurality of first and/or second contact elements 2, 32 can be provided. Furthermore, it is also possible to, for example, provide the coils 1 onto a carrier and to provide the flexible membranes at a distance from the carrier via portal structures.

[0031] Figure 5 illustrates a fifth embodiment of a relay according to the invention in which similar components are indicated with the same reference numbers as in figure 1A. In the embodiment illustrated in figure 5, the coil 1 is provided on the membrane 31 instead of in the carrier 4. According to another embodiment, the coil 1 may be formed as a plurality of flat electrical windings provided as a single layer in, on or under the membrane 31. A permanent magnet 33 may be provided in the carrier 4. If the coil 1 is charged in an appropriate manner, the flexible membrane 31 together with the second contact element 32 will move in the direction of the first contact element 2 in order to establish an electrical contact between the first and second contact element 2, 32.

[0032] A person skilled in the art will understand that many modifications and additions can be thought of in the framework of the present invention which by no means is limited by the embodiments provided above. The scope of protection is determined only by the following conclusions.

Claims

1. Electromechanical relay comprising:

- a carrier (4);
- a contact body (3);
- at least one first contact element (2);
- at least one coil (1) for moving the contact body (3) with respect to the carrier (4);

characterized in that the contact body (3) is implemented as a membrane (31) in which or on which at least one second contact element (32) is provided; which membrane (31) is adapted to be moved as a result of a magnetic field generated by the at least one coil (1) in order to disconnect or establish an electrical contact between the at least one second contact element (32) and the at least one first contact element (2), and that the membrane (31) is adapted to elastically deform during such movement.

2. Electromechanical relay according to claim 1, wherein the at least one coil (1) is provided in the carrier (4)

3. Electromechanical relay according to claim 1 or 2, wherein the membrane (31) is fixed to the carrier (4).

4. Electromechanical relay according to any of the previous claims, wherein the membrane (31) extends over or into a recess (5) in the carrier (4).

5. Electromechanical relay according to claim 3, wherein the at least one second electrical contact element (32) is provided onto a bottom side of the membrane (31) facing the recess (5), and wherein the at least one first contact element (2) is positioned in the recess (5).

6. Electromechanical relay according to claim 4 or 5, wherein the at least one coil (1) is located in or under the recess (5) in the carrier (4).

7. Electromechanical relay according to any of the previous claims, wherein the membrane (31) is fixed in such a way that it is kept along at least two opposing circumferential zones during the elastic deformation of the membrane (31).

8. Electromechanical relay according to any of the previous claims, wherein at least one permanent magnet (33) is provided on or in the membrane (31), such

that at least one permanent magnet (31) is movable as the result of charging the at least one coil (1) in order to disconnect or establish an electrical contact between the at least one second contact element (32) and the at least one first contact element (2).

9. Electromechanical relay according to any of the previous claims, wherein at least one electrical winding (36) is provided on or in the membrane (31), such that the membrane (31) is movable as a result of charging the at least one coil (1) and the electrical winding (36) in order to disconnect or establish an electrical contact between the at least one second contact element (32) and the at least one first contact element (2).

10. Electromechanical relay according to any of the previous claims, wherein at least one electronic component (6, 6') is provided on a top side and/or a bottom side of the carrier (4).

11. Electromechanical relay according to any of the previous claims, furthermore comprising an additional carrier (4') and at least one additional first contact element (2); wherein the membrane (31) extends between the at least a first contact element (2) and the at least one additional first contact element (2); the membrane (31) being provided on both sides with a second contact element (32) and is provided in order to be moved so as to disconnect or establish an electrical contact between at least one second contact element (32) and the at least one additional first contact element (2).

12. Electromechanical relay according to any of the previous claims, wherein the membrane (31) is movable between a first and a second position as a as a result of generating respectively a first and second magnetic field by means of the at least one coil (1) and that at least one permanent magnet (33) is mounted on the carrier (4) in such a way that the membrane (31) is kept in the first position once the first magnetic field is removed.

13. Electromechanical relay according to any of the previous claims, wherein at least two first contact elements (2) and at least two coils (1) are provided and that the at least two coils (1) are provided in such a way that, as a result of selective charging of one or more coils (1), the at least two first contact elements can selectively make contact with the at least one second contact element (32) on the membrane (31).

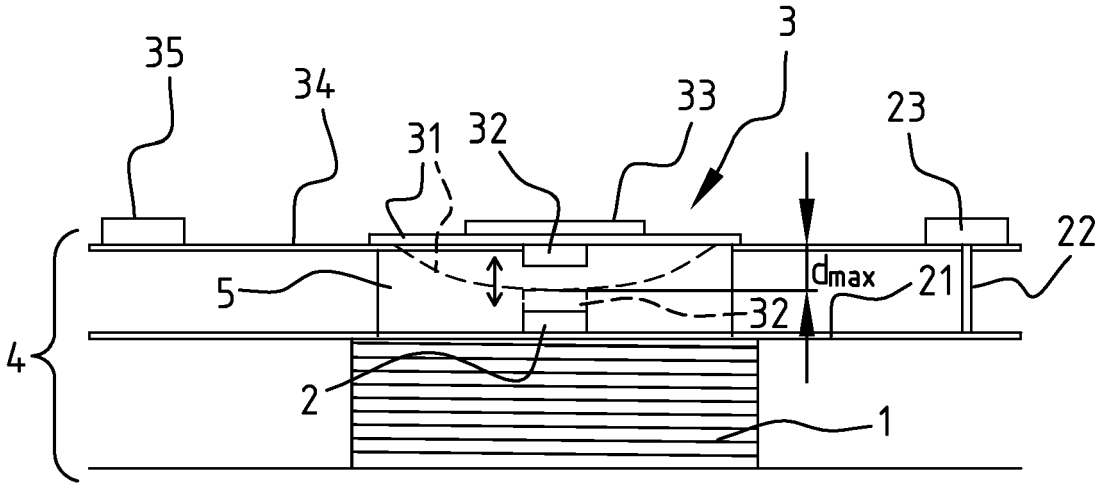
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FIG. 1A

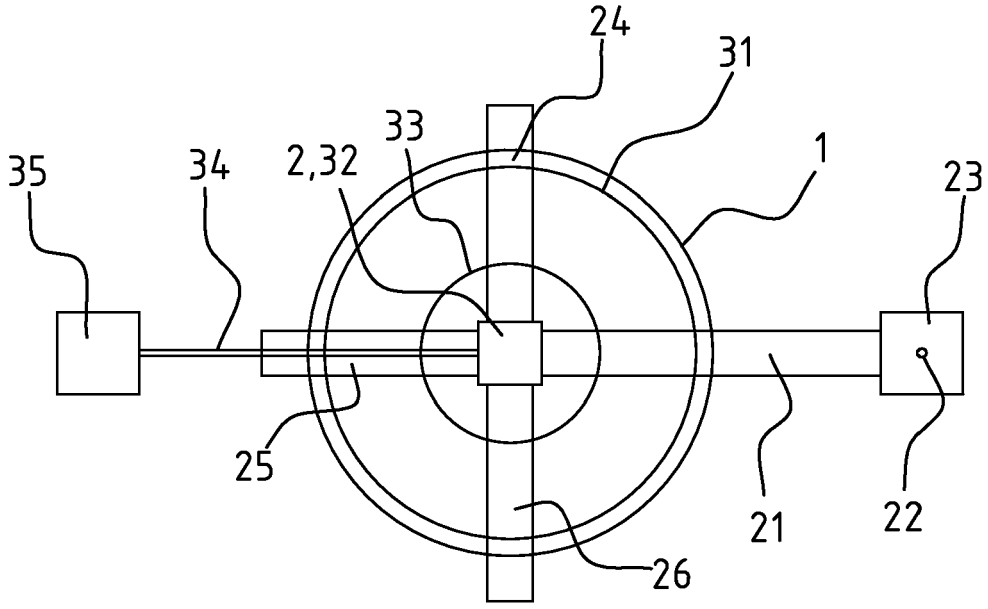
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FIG. 1B

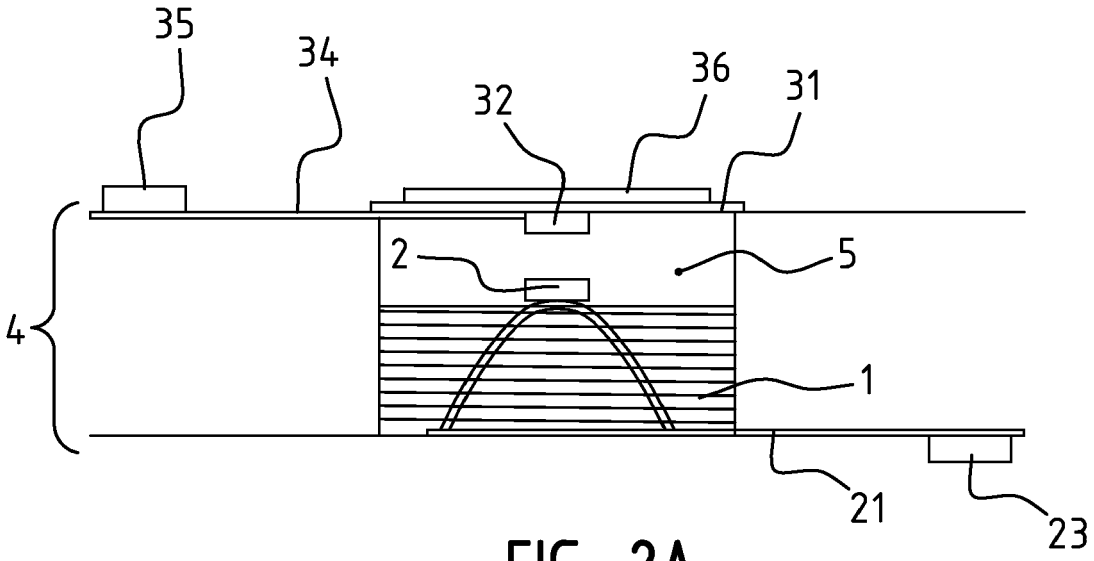

FIG. 2A

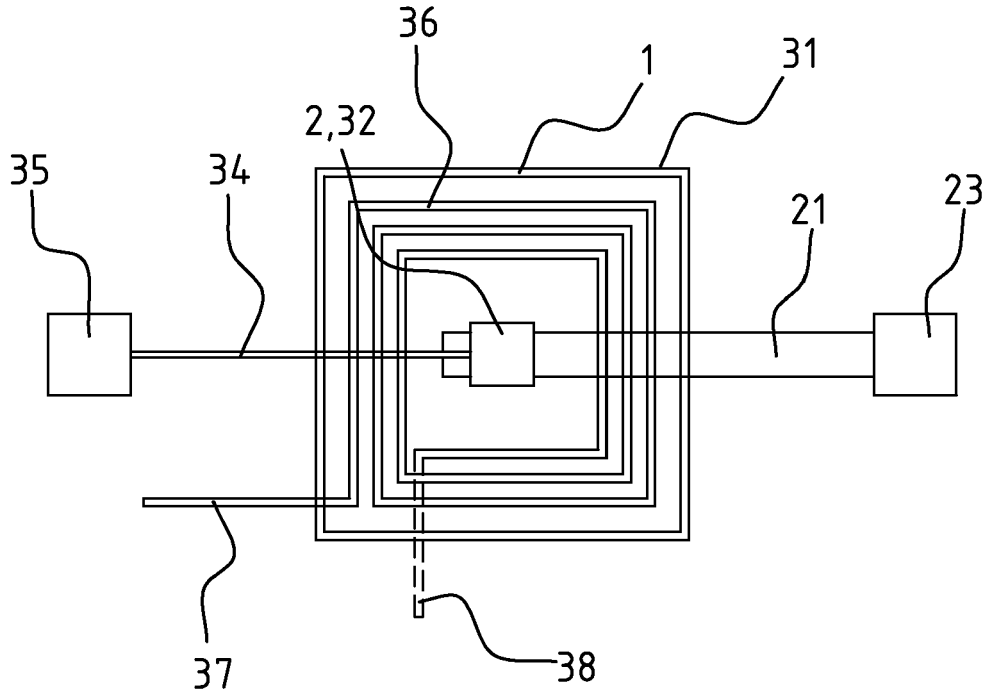

FIG. 2B

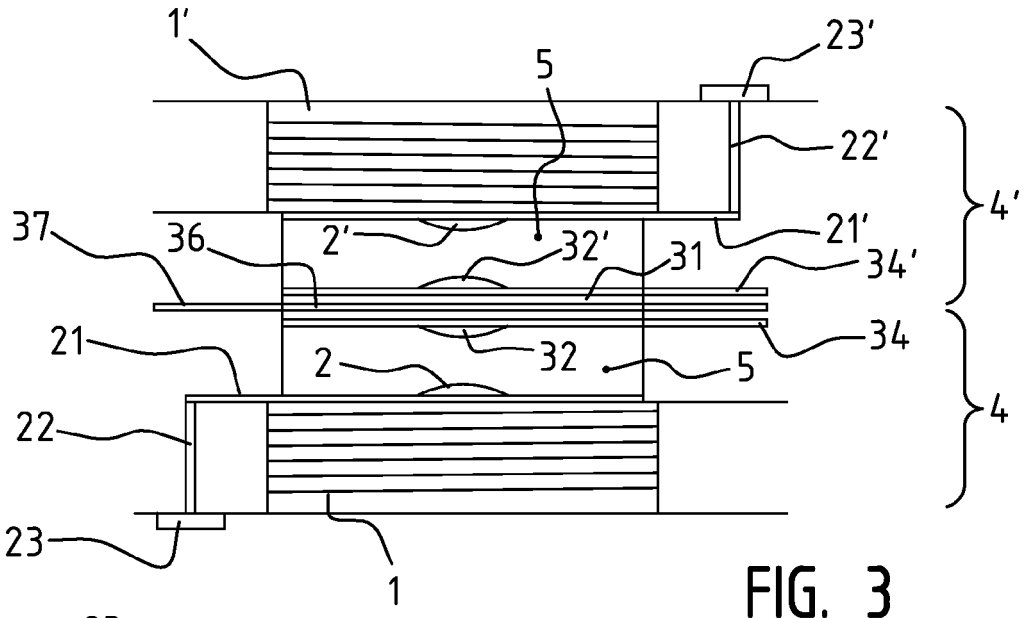

FIG. 3

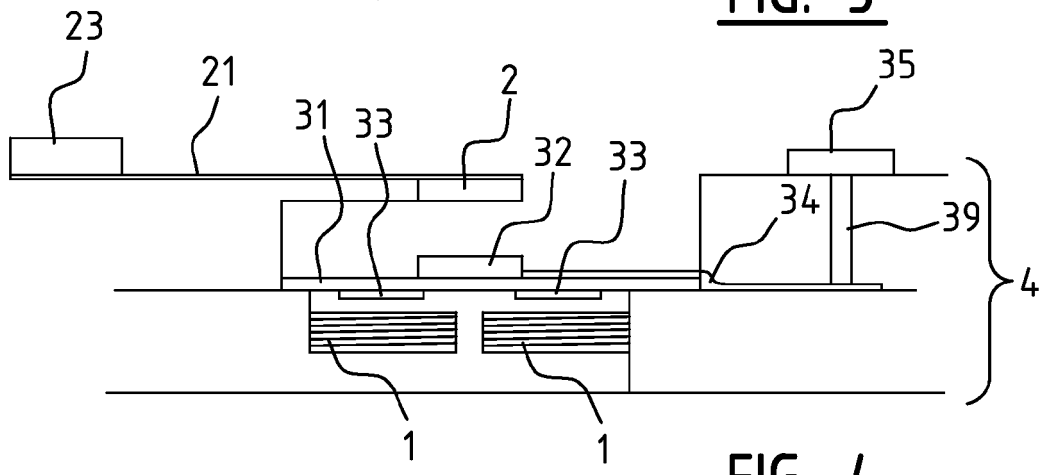

FIG. 4

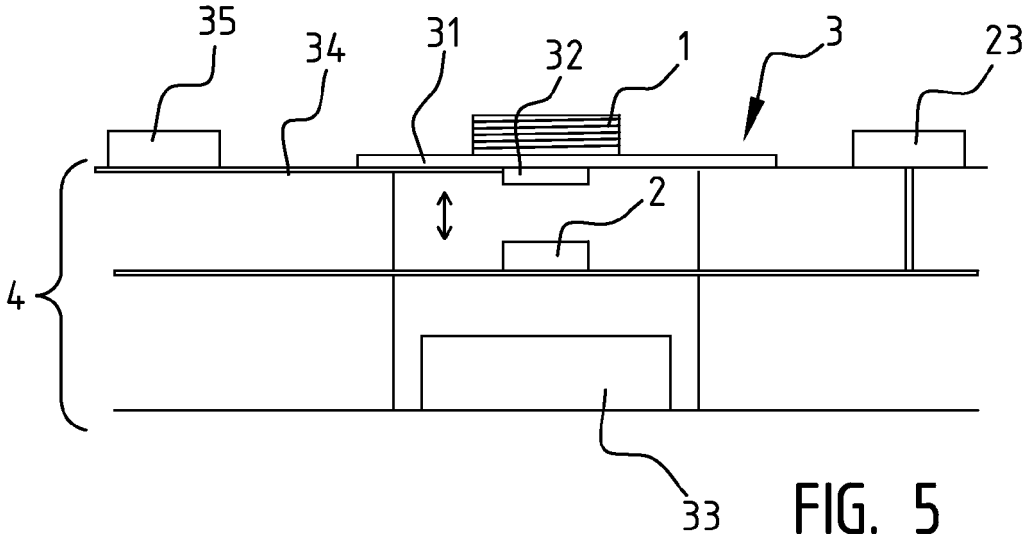

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 6545

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 November 2014	Ramírez Fueyo, M

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28-11-2014

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