(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 926 114 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.05.2008 Bulletin 2008/22

(51) Int Cl.:
H01H 13/803 *(2006.01)*

(21) Application number: **06124551.0**

(22) Date of filing: **22.11.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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(54) Keyboard switch

(57) A foil-type switching element with at least three switching states comprises an electrode arrangement comprising at least a first electrode pattern and a second electrode pattern, said first and second electrode patterns being arranged in said active area on first and second carrier foils such that an electrical contact is established between said first and second electrode pattern when said first and second carrier foils are brought together. The electrode arrangement is configured such that, within said active area, at least one primary contact zone and at least one secondary contact zone are formed in which an electrical contact can be established between said first and second electrode pattern, wherein said primary contact zone is centrally located within said active area and wherein said at least one secondary contact zone is located off-centre within said active zone. Moreover at least one first resistive element is associated to one of said first or second electrode pattern in such a way that said at least one first resistive element is connected between the first and second connection terminals if said an electrical contact between said first and second electrode pattern is established only in said primary contact zone and that said first electrical resistance is bypassed if an electrical contact between said first and second electrode pattern is also established in said secondary contact zone.

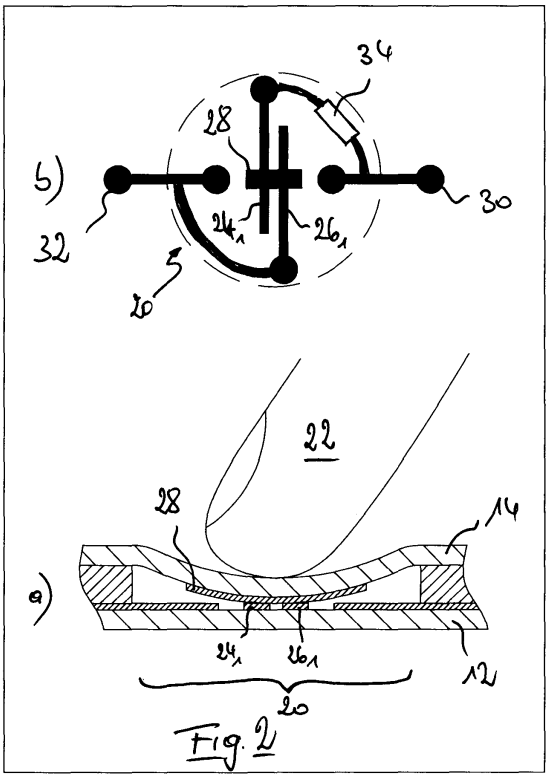

Fig. 2

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Description

Technical field

[0001] The present invention relates to a switching element, in particular to a foil-type switching element, also referred to by some as membrane-type switching elements.

Background Art

[0002] Switching elements, e.g. of foil-type construction are well known in the art. Such switching elements generally comprise a first carrier foil and a second carrier foil arranged at a certain distance by means of a spacer. The spacer is provided with at least one opening, which delimits an active area of the switching element. At least two electrode arrangements are arranged in the active area between the first and second carrier foils in such a way that, in response to a compressive force acting on the active area of the switching element, the first and second carrier foils are pressed together against their reaction force and an electrical contact is established between the at least two electrode arrangements.

[0003] In a first embodiment of such switching elements, a first electrode is arranged on the first carrier foil and a second electrode is arranged on the second carrier foil in facing relationship with the first electrode. When the first and second carrier foils are pressed together in response to a force acting on the switching element, an electrical contact is established between the first and second electrode. Pressure sensors in which the first electrode is carried by the first carrier foil and the second electrode by the second carrier foil are frequently called to operate in a so called "through mode". Accordingly one refers to such switching elements as through-mode switching elements.

[0004] In an alternative embodiment of the switching elements, a first and a second electrode are arranged in spaced relationship on one of the first and second carrier foils. The other carrier foil carries a shunt element, which is arranged in facing relationship to the first and second electrodes in such a way that, when the first and second carrier foils are pressed together in response to a force acting on the active area of the switching element, the shunt elements contacts the first and second electrodes and establishes the electrical contact between them. Switching elements of this type are often said to operate in the so-called "shunt mode", and are, therefore, also simply referred to as shunt-mode switching elements.

[0005] Both through-mode and shunt-mode switching elements can be manufactured cost-effectively and have proven to be extremely robust and reliable in practice.

[0006] The electrical response of such a switching element, i.e. the resistance or the current or voltage across the switching element as a function of the amount of applied force, depends on the type of the electrodes, the design of the electrodes and their arrangement within the active area of the switching element and on the physical contact, which is established between the electrodes in response to the force acting on the active area.

[0007] There is a growing need in industry for foil-type switching elements with more than two discrete states. In this context, it should be noted that one usually distinguishes between switching elements, which switch between discrete states in response to changing force applied thereon, and pressure sensors, whose electrical response continuously varies with the applied force. There is a need, in particular, for solutions that do not rely on pressure sensors with a continuous response which is converted to a stair-like response by an electronic circuit but on switching elements that directly output the stair-like response with at least three well-defined states.

Technical problem

[0008] The object of the present invention is to provide a switching element with improved electrical response. This object is achieved by a switching element as claimed in claim 1.

General Description of the Invention

[0009] To achieve this object, the present invention proposes a switching element which generally comprises a first carrier foil and a second carrier foil and a spacer arranged between said first and second carrier foils, said spacer spacing said first and second carrier foils a certain distance apart from one another. The spacer is provided with an opening extending from said first to said second carrier foil, said opening defining an active area for said switching element in which said first and second carrier foils can be brought together in response to a compressive force exerted on said switching element. The switching element further comprises an electrode arrangement comprising at least a first electrode pattern made of conductive material connected to a first connection terminal and a second electrode pattern made of conductive material connected to a second connection terminal, said first and second electrode patterns being arranged in said active area on said first and second carrier foils such that an electrical contact is established between said first and second electrode pattern when said first and second carrier foils are brought together. In accordance with the invention, the electrode arrangement is configured such that, within said active area, at least one primary contact zone and at least one secondary contact zone are formed in which an electrical contact can be established between said first and second electrode pattern, wherein said primary contact zone is centrally located within said active area and wherein said at least one secondary contact zone is located off-centre within said active zone. Moreover at least one first resistive element is associated to one of said first or second electrode pattern in such a way that said at least one first resistive element is con-

nected between the first and second connection terminals if said an electrical contact between said first and second electrode pattern is established only in said primary contact zone and that said first electrical resistance is bypassed if an electrical contact between said first and second electrode pattern is also established in said secondary contact zone.

[0010] If no compressive force acts on the switching element of the present invention, no electrical contact is established between the first and second electrode pattern and accordingly the resistance between the two connection terminals is extremely high as in conventional membrane switches. If a compressive force is exerted on the switching element as defined, the first and second carrier foils are brought together and an electrical contact is established between the first and second electrode pattern. This electrical contact may be detected as a change in resistance between the first and second connection terminals.

[0011] For small forces above the turn-on point of the switching element, which act centrally on the active area of the switching element, the first and second carrier foils are first brought together in the centrally located region of the active area. Thus for such small forces, an electrical contact is only established in the centrally located primary contact zone. In this case, the at least one resistive element is connected between the first and second connection terminals of the switching element so that the resistance between the first and second connection terminal drops to the resistance of the first resistive element.

[0012] For higher forces acting on the switching element and/or for forces acting on a larger surface, the deflection of the carrier foils and accordingly the area of the mechanical contact surface between the first and second carrier foil increases. If the deflection of the carrier foils is sufficiently large so that the contact surface between the carrier foils extends to or beyond the secondary contact zone formed by the first and second electrode pattern, an electrical contract is established between the first and seconds electrode pattern also in this secondary contact zone. In this case, the first resistive element is bypassed and the resistance between the first and second connection terminal of the switching element drops significantly.

[0013] Depending on the magnitude of the force acting on the switching element, the switching element according to the present invention may thus take one of three well defined and discrete resistance values, which are easily detectable without a complex digital discrimination circuit. Thus the switching element of the present invention exhibits an inherent step-like response function, which may be directly used e.g. in data input applications.

[0014] It will be noted that the bypassing of the first resistive element does not necessarily lead to a resistance value close to zero. In fact, the skilled person will appreciate the expression "bypassing of the first resistive element" also encloses an embodiment, in which a second resistive element, having a resistance smaller than or in the order of the first resistive element, is connected in parallel to the first resistive element if an electrical contact between the first and second electrode pattern is established in the secondary contact zone. In this case, the resulting resistance of the switching element is substantially equal to the parallel value of the first and the second resistive element and thus considerably lower than the resistance of the first resistive element alone. It will further be appreciated, that the electrode arrangement may be configured such that a further tertiary contact zone is formed, which is arranged between the secondary contact zone and the periphery of the active area. The configuration may be such that an electrical contact between said first and second electrode pattern can be established in said tertiary contact zone whereby a third resistive element is connected in parallel to the first and second resistive element. Such a switching element such has a step-like response function showing four discrete steps for different activation forces. In the same way, i.e. by providing further contact zones of higher order, the response of the switching element may be tuned to show even more discrete resistance values.

[0015] The primary contact zone of the switching element in accordance with the invention is located centrally within the active area. The secondary switching zone, which is arranged off-centre of the active area, may be localized in any suitable area between the centrally located region and the periphery of the active area. In a preferred embodiment of the invention however, the secondary contact zone extends on either side of said primary contact zone and is symmetrically arranged with respect to said primary contact zone, so that the switching element shows a symmetrical response to a centrally acting force.

[0016] In a preferred embodiment of the invention said first electrode pattern and said second electrode pattern are arranged on said first carrier foil and said electrode arrangement further comprises at least one shunting element, preferably made of a conductive or semi-conductive material, which is arranged on said second carrier foil in such a way that said electrical contact between said first and second electrode pattern is established via the shunting element if said first and second carrier foils are brought together. This embodiment relates to the so-called "shunt mode" sensor, in which both said first and second electrode patterns and the corresponding connection terminals are arranged on the same carrier foil. This arrangement simplifies the connection of the switching element to an associated evaluation circuit e.g. by a crimp connection.

[0017] Preferably, said first and second electrode pattern each comprise a first electrode conductor and at least one second electrode conductor, said first and second electrode conductors of said first electrode pattern being electrically connected to said first connection terminal and said first and second electrode conductors of said second electrode pattern being electrically connected to said second connection terminal. The first electrode

conductors of said first and second electrode pattern advantageously extend towards a centrally located region of said active area and are arranged at a certain distance from each other in said centrally located region of said active area, and said second electrode conductors of said first and second electrode pattern extend towards a peripheral region of said active area. Said at least one shunting element is then arranged on said second carrier foil for establishing an electrical contact between the first electrode conductors of said first and second electrode pattern in said centrally located region and for establishing an electrical contact between the second electrode conductors of said first and second electrode pattern in said peripheral region of said active area. The shunting element may e.g. comprise a conductive strip, which is applied onto the second carrier foil and which extends transversely with respect to said first conductors of said first and second electrode pattern in the centrally located region of the active area. The shunting element further preferably extends towards a peripheral region of said active area so as to form the secondary contact zone together with the second conductors of the electrode patterns.

[0018] It should be noted that the second electrode conductors of said first and second electrode pattern may extend substantially parallel to the first electrode conductors and be arranged at a suitable location between the respective first conductor and the periphery of the active area. Alternatively the second electrode conductor may have any other suitable form such as e.g. an arcuate shape and extend along the periphery of the active area. The shunting element may likewise comprise any suitable shape which enables to establish a contact between the first and second electrode pattern in the primary contact zone and the secondary contact zone. The shunting element may e.g. comprise a rectilinear conductive strip or an arcuate strip in the general from of a letter S or the like.

[0019] The at least one first resistive element, e.g. an electrical resistance, may e.g. be associated to one of said first conductors of said first or second electrode pattern. The at least one first resistive element may for instance be integrated into the first electrode conductor and form an integral part of this first electrode conductor. Alternatively, the first at least one first electrical resistance may be connected between the first electrode conductor and the corresponding connection terminal. In a possible variant, a first resistive element is associated to each of said first electrode conductors.

[0020] In a preferred embodiment of the invention, said electrode arrangement comprises a third electrode pattern arranged on said first carrier foil, and said first electrode pattern and said second electrode pattern each comprise an electrode conductor extending from a peripheral region of said active area towards a centrally located region of said active area and are arranged at a certain distance from each other in said centrally located region of said active area. In this embodiment, the third electrode pattern comprises a bypass electrode conductor, which has a first portion arranged in the peripheral region of said active area at a certain distance from said electrode conductor of said first electrode pattern and a second portion arranged in the peripheral region of said active area at a certain distance from said electrode conductor of said second electrode pattern. The shunting element comprises a primary shunting portion associated to the first electrode conductors in the centrally located region of said active area so as to form said first contact zone and at least two secondary shunting portions, each one of said secondary shunting portion being associated in the peripheral portion of said active area to one of the conductors of the first and second electrode pattern and the associated portion of said bypass electrode conductor so as to from said secondary contact zone. This embodiment of the switching element advantageously enables a discrimination between forces acting centrally on the active area and forces which act offset of the central region. In fact, due to the configuration of the third electrode pattern and the shunting element, an electrical contact between the first and second electrode pattern is only established in the secondary contact zone, if both secondary shunting portions of the shunting element are pressed against the respective electrode pattern.

[0021] For small forces acting centrally on the switching element, the primary shunting portion establishes a contact between the first and second electrode pattern in the centrally located region of the active area. For higher forces acting centrally, both secondary shunting portions establish a contact between the one of the conductors of the first and second electrode pattern and the associated portion of said bypass electrode conductor in the peripheral portion of said active area. It follows that a conducting path is established from the peripheral portion of the electrode conductor of the first electrode pattern via the third electrode pattern to the peripheral portion of the electrode conductor of the second electrode pattern, so that any resistive element, which is located between the peripheral portion of one of the electrode conductors of the first and second electrode pattern and the centrally located portion of said electrode conductor is bypassed. If however a force acts off centre so that only one of said secondary shunting portions establishes a contact between the first and second electrode pattern, while the second contact zone remains open, i.e. not closed, then no conductive path is established via the third electrode pattern between the first and second connection terminals, and the first resistive element is not bypassed.

[0022] As already stated above, the first resistive element may be bypassed by connecting a further resistive element in parallel to the first resistive element. In this case, at least one second resistive element may be associated to said bypass electrode conductor, such that said second resistive element is connected between said first and second connection terminals if an electrical contact is established in the secondary contact zone be-

tween said first and second electrode pattern via said secondary shunting portions. In this case, the resulting resistance of the switching element is substantially equal to the parallel value of the first and the second resistive element and thus considerably lower than the resistance of the first resistive element alone. It will be appreciated that by adding further bypass connectors and thus increasing the number of contact zones of higher order, this embodiment enables to adjust the response function of the switching element so as to show a plurality of discrete states associated to different activation forces.

[0023] In a different embodiment of the invention, in which the switching element operates in the so called "through mode", said first electrode pattern is arranged on said first carrier foil and said second electrode pattern is arranged on said second carrier foil in such a way that said first electrode pattern and said second electrode pattern face each other both in said centrally located region of said active area so as to form said primary contact zone and in a peripheral zone located off-centre of said active area so as to form said at least one secondary contact zone. In this embodiment, one of the connection terminals and the associated electrode pattern are arranged on each of said first and second carrier foils and the electrical contact to be established between the first and second electrode pattern is established in a direction transverse to the electrode pattern.

[0024] In a very simple embodiment of the "through mode" type, the first electrode pattern comprises a central electrode portion, a connecting electrode portion, which is connected to the central electrode portion via a resistive portion arranged between the central electrode portion and the connecting electrode portion, and a secondary electrode portion, which is arranged diametrically opposed to the connecting electrode portion at a certain distance from the central electrode portion and which is electrically connected to the central electrode portion. Likewise the second electrode pattern comprises a central electrode portion, a connecting electrode portion, which is connected to the central electrode portion via a resistive portion arranged between the central electrode portion and the connecting electrode portion, and a secondary electrode portion, which is arranged diametrically opposed to the connecting electrode portion at a certain distance from the central electrode portion and which is electrically connected to the central electrode portion. The first and second electrode pattern are arranged on their respective carrier foils in such a way that said central electrode portions face each other and that the secondary electrode portion of the first electrode pattern faces the connecting electrode portion of the second electrode pattern and vice versa. If a small force acts on such a switching element, an electrical contact is established between the central electrode portions of the first and second electrode pattern and the resulting resistance of the switching element equals substantially the sum of the resistances of the resistive portions of the first and second electrode pattern. If however a larger force acts on the switching element, then the secondary electrode portions of the electrode pattern are pressed onto the connecting electrode portions of the opposing electrode pattern and the two resistive portions are bypassed.

[0025] In a different embodiment, both said first and second electrode pattern comprise electrode conductors, which extend in opposing directions from a peripheral region of the active area through the centrally located region and extend beyond the centrally located region. A first resistive element is arranged in the centrally located region as an elevation on the electrode conductors of one of said first and second electrode pattern. If the carrier foils are brought together only in the centrally located region, an electrical contact is established between the first and second electrode pattern via the resistive element. If the activation force increases, the deflection of the carrier foils will increase and bring the electrode conductors of the first and second electrode pattern into contact in an off-centre region, i.e. in a region in which no resistive element is applied on the electrode conductors. It follows that the first and second electrode pattern are directly contacted and that accordingly the resistive element is bypassed in this case. It will be noted that the resistive element may be surrounded by a patch of dielectric material so as to prohibit direct contact between the first and second electrode pattern in the immediate vicinity of the resistive element. In this way, the force threshold, above which a direct contact is established, may be increased so as to adapt the response of the switching element to a specific desired shape. In a variant of this embodiment, a first resistive element is arranged in the centrally located region on each of said electrode conductors of the first and second electrode pattern, so that an electrical contact between the first and second electrode pattern is established in the primary contact zone via the two resistive patches. Furthermore, second resistive patches may be applied on either side of the central region on one of the electrode conductors, so that an electrical contact between the first and second electrode pattern is established in the secondary contact zone via the second resistive patches.

[0026] In a preferred embodiment of a "through mode" switching element, said first electrode pattern comprises a first electrode conductor extending through the centrally located region of said active area towards a first location of a peripheral region and a second electrode conductor extending towards a second location of a peripheral region, said first and second electrode conductors of said first electrode pattern being electrically connected to said first connection terminal, and said second electrode pattern comprises a first electrode conductor extending towards the centrally located region of said active area so as to face said first electrode conductor of said first electrode pattern and a second electrode conductor extending from said first location of said peripheral region to said second location of said peripheral region, such that a first end of said second electrode conductor faces said first electrode conductor of said first electrode pat-

tern in said first location of said peripheral region and that a second end of said second electrode conductor faces said second electrode conductor of said first electrode pattern in said second location of said peripheral region. This embodiment of the switching element advantageously enables a discrimination between forces acting centrally on the active area and forces which act offset of the central region. In fact, due to the configuration of the electrode patterns, a conducting path bypassing the first resistive element is only established in the secondary contact zone, if both the first and second end of the second conductor of the second electrode pattern are pressed against the respective conductor of said first electrode pattern.

[0027] For small forces acting centrally on the switching element, an electrical contact is established between the centrally arranged portion of the first electrode conductor of the first electrode pattern and the first electrode conductor of the second electrode pattern in the centrally located region of the active area. For higher forces acting centrally, an electrical contact is established between the first end of said second electrode conductor of the second electrode pattern and said first electrode conductor of said first electrode pattern in said first location of said peripheral region and between the second end of said second electrode conductor of the second electrode pattern and said second electrode conductor of said first electrode pattern in said second location of said peripheral region. It follows that a conducting path is established from the first connection terminal via the second conductor of the first electrode pattern, via the second electrode conductor of the second electrode pattern, via the portion of the first electrode conductor of the first electrode pattern extending from the first peripheral location to the central location and via the first electrode conductor of the second electrode pattern to the second connection terminal, so that any resistive element, which is located in the first conductor of the first electrode pattern "upstream" of the centre portion is bypassed. If however a force acts off centre so that only one end of said second electrode conductor of the second electrode pattern is brought into contact with the associated conductor of the first electrode pattern while the second contact zone remains open, i.e. not closed, then no conductive path is established via the second electrode conductor of the second electrode pattern between the first and second connection terminals, and the first resistive element is not by-passed.

It will be noted that said first location of said peripheral region and said second location of said peripheral region are preferably arranged symmetrically with respect to said centrally located region of said active area. It will further be appreciated, that said at least one first resistive element is preferably integrated into said first electrode conductor of said first electrode pattern between said first connection terminal and said centrally located region of said active area.

[0028] Finally it will be appreciated that the present invention also relates to an input device for an electrical appliance, such as a keypad or keyboard, comprising one or more switching elements as described hereinabove.

Brief Description of the Drawings

[0029] Preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 shows a cross sectional view of one embodiment of a switching element in the non activated state and a plan view of the corresponding electrode arrangement in the plane of the electrode pattern;

Fig. 2 shows the behaviour of the switching element of Fig. 1 for small activation forces;

Fig. 3 shows the behaviour of the switching element of Fig. 1 for higher activation forces;

Fig. 4-6 show different possible electrode pattern configurations for switching elements having three different switching states and operating in "shunt mode";

Fig. 7-8 show different possible electrode pattern configurations for switching elements having more than three different switching states and operating in "shunt mode";

Fig. 9 shows a possible response function of a switching element as shown in Figs. 7 and 8;

Fig. 10 shows an electrode pattern configuration of an embodiment of a "shunt mode" switching element with three different switching states and discrimination of off-centre forces;

Fig. 11 shows an electrode pattern configuration of an embodiment of a "through mode" switching element with three different switching states and discrimination of off-centre forces;

Fig. 12 shows a cross sectional view of the switching element of Fig. 11;

Fig. 13-15 show different possible electrode pattern configurations for switching elements operating in "through mode";

Fig. 16 shows an electrode pattern configuration of an embodiment of a "shunt mode" switching element similar to the switching element of Fig. 10,but with more than three different switching states;

Fig. 17-18 show the equivalent electrical circuit for

a switching element with discrimination of off-centre forces and with three different switching states or more than three different switching states.

Description of Preferred Embodiments

[0030] Figs. 1a to 3b illustrate the behaviour of a foil-type switching element 10 according to the present invention in response to an increasing force applied to the active area. As can be seen, the switching element 10 comprises two carrier foils 12, 14 (made e.g. of PET, PEN, PI, and/or like materials), which are maintained at a certain distance by a spacer 16. The spacer 16 has an opening 18 therein, which defines the active area 20 of the switching element 10. The dimension of the opening 18 is adapted to the actuating element which is supposed to activate the switching element 10 in operation thereof. For instance if the switching element is intended to be activated by a human finger 22, then the diameter of the opening 18 will be in the order of 0,3 to 3 cm.

[0031] Within the active area 20, the switching element 10 is provided with an electrode arrangement, including a first and a second electrode patterns 24 and 26 arranged on the first carrier foil 12 and a shunting element 28 arranged on the second carrier foil 14. The first and second electrode patterns 24, 26 are connected to first and second connection terminals 30 and 32, respectively. They respectively comprise a first conductor 24_1,26_1, which extends into the central region of the active area 20, and a second conductor 24_2, 26_2, which extends less far into the centre of the active area. In the illustrated embodiment, this means that the radial distance between the centre of the active area and the first conductors is substantially lower than the radial distance between the centre of the active area and the second conductors. The second conductor 24_2 of the first electrode pattern 24 is connected to the first terminal 30 via a resistive element 34, e.g. a printed resistor.

[0032] Figs. 1 a and 1b relate to the case when no force is applied on the switching element 10, or when the applied force is not sufficient for causing physical contact between the components on the first and second carrier foils 12 and 14. The current path between the connection terminals 30 and 32 is interrupted because the first and second electrode patterns 24 and 26 are electrically insulated from one another. Consequently, in the situation illustrated in Fig. 1, the resistance between the first and second terminals 30 and 32 is virtually infinite (e.g. in the mega-ohm range or above).

[0033] In Figs. 2a and 2b, the actuating element 22 (here: a user's finger) exerts a compressive force on the active area 20 of the switching element. A physical contact is established in the middle of the active area 20 between the centrally arranged first conductors 24_1, 26_1 of the first and second electrode patterns 24, 26 via the shunting element 28 on the opposite carrier foil. This physical contact is represented in Fig. 2b by the larger line 28. This representation, i.e. the thinner lines representing the electrode conductors of the lower carrier foil and the larger lines representing the contacting electrode conductors of the upper carrier foils, is maintained throughout the different figures, in which electrode pattern configurations are shown.

[0034] It should be noted that for the amount of compressive force applied in Fig. 2, the zone of physical contact is limited to the central region of the active area. Those conductors of the first and second electrode patterns that are located outside that contact zone, i.e. the second conductors 24_2 and 26_2, are not yet in contact with the shunting element 28. Since the contact is limited to the first conductors in the central region of the active area, the electrical resistance that can be measured between the first and second terminals 30 and 32 corresponds to the resistance of the resistor 34.

[0035] Figs. 3a and 3b illustrate the case of higher compressive force exerted on the active area 20 of the switching element 10. The compressive force now is sufficiently strong so that the physical contact zone extends over the peripherally arranged second conductors 24_2, 26_2 of the first and second electrode arrangements. As a consequence, the shunting element 28 provides an electrical contact between the second conductors 24_2, 26_2, which establishes a current path electrically in parallel to the resistor 34. Consequently, the resistance of the switching element in the situation of Fig. 3 is low (e.g. a few ohms).

[0036] The skilled reader will appreciate that the switching element represented in Figs. 1a-3b can switch between three discrete states, i.e. a low-conductivity state, an intermediate-conductivity state and a high-conductivity state.

[0037] Fig. 4 shows an alternative electric circuit layout for a switching element 110 according to the present invention. As will be appreciated, the resistive element 134 interconnecting the first connection terminal 130 and the first conductor 124_1 of the first electrode 124 may be placed outside the active area 120 of the switching element 110.

[0038] Figs. 5 and 6 represent further embodiments of switching elements 160. Both the first conductors 174_1, 176_1 of the first and second electrode patterns 174, 176 are connected to the respective terminal 180 and 182 via a resistive element 184_1 and 184_2. In Fig. 5, the second conductors 174_2, 176_2 of the first and second electrode arrangements are substantially bow-shaped and extend along the border of the active area 170. In Fig. 6, the second conductors 174_2, 176_2 of the first and second electrode arrangements extend substantially parallel to the first conductors 174_1, 176_1.

[0039] Figs. 7 and 8 represent switching elements with multiple (more than three) states. The first and second electrode patterns respectively comprise a first conductor 224_1, 226_1 extending into the central region of the active area 220. For each electrode pattern, a number of further conductors 224_2, ..., 224_x, 226_2, ..., 226_x, extend into the active area. In Fig. 7, these conductors run substantially in parallel to the first conductors, whereas

in Fig. 8, they are partial rings arranged substantially concentrically with respect to the centre of the active area 220. With an increasing compressive force, an electrical contact is established first between the first conductors 224_1, 226_1 of the electrode patterns. With the contact zone progressing further and further to the borders of the active area, more and more of the further conductors 224_2, ..., 224_x, 226_2, ..., 226_x are contacted and further electrical paths are established in parallel with the initial path. Consequently, the impedance of the switching element behaves as illustrated in Fig. 9. As can be seen, the impedance takes quantized values as a function of applied force.

Fig. 10 shows an electrode pattern configuration of an embodiment of a "shunt mode" switching element with three different switching states and discrimination of off-centre forces. In this embodiment the first and second electrode pattern each comprise a first electrode conductor 324_1 and 326_1, which are connected to the respective first and second connection terminals 330 and 332, and which extend towards a central region of said active area 320 where they are arranged at a certain distance from each other. A third electrode pattern comprising a bypass electrode conductor 338, which has a first portion 338_1 arranged in the peripheral region of said active area 320 at a certain distance from said electrode conductor 324_1 and a second portion 338_2 arranged in the peripheral region of said active area at a certain distance from said electrode conductor 326_1. The shunting element comprises a primary shunting portion 328_1 associated to the first electrode conductors 324_1 and 326_1 in the centrally located region of said active area and at least two secondary shunting portions 328_2 and 328_3, each one of said secondary shunting portions 328_2 and 328_3 being associated in the peripheral portion of said active area 320 to one of the conductors 324_1 and 326_1 of the first and second electrode pattern and the associated portion 338_1 and 338_2 of said bypass electrode conductor 338 so as to from said secondary contact zone.

[0040] In this embodiment of the switching element an electrical contact between the first and second electrode pattern is only established in the secondary contact zone, if both secondary shunting portions 328_2 and 328_3 are pressed against the respective electrode pattern. If this is the case, the resistive element 334, which is integrated into the first conductor 324_1 is bypassed by bypass electrode conductor 338. It will be noted that bypass electrode conductor 338 may also comprise a resistive element 340, which will be connected in parallel to resistive element 334 if the contact in the secondary contact zones is closed.

[0041] It will be appreciated that Fig. 16 shows an electrode pattern configuration of an embodiment of a "shunt mode" switching element similar to the switching element of Fig. 10, but with more than three different switching states. In this embodiment, a plurality of bypass electrode conductors 338_1, 338_2 and 338_3, each with a respective resistive element 340_1, 340_2, 340_3 are provided and associated at different locations to the first and second electrode conductors 324_1 and 326_1. Furthermore a plurality of shunting portions 328_1-328_7 are provided for enabling an electrical contact to be established between each one of said bypass electrode conductors 338_1, 338_2 and 338_3 and the associated portion of said first and second electrode conductors 324_1 and 326_1.

An electrode pattern configuration of an embodiment of a "through mode" switching element with three different switching states and discrimination of off-centre forces is shown in Fig. 11 and the cross section of this switching element is shown in Fig. 12. In a "trough mode" switching element the first electrode pattern 424 arranged on said first carrier foil 412 and said second electrode pattern 426 is arranged on said second carrier foil 414 in such a way that said first electrode pattern 424 and said second electrode pattern 426 face each other both in said centrally located region of said active area 420 so as to form said primary contact zone and in a peripheral zone located off-centre of said active area so as to form said at least one secondary contact zone. Similar to the electrode pattern, the first connection terminal 430 is arranged on the said first carrier foil 412 and the second connection terminal 432 is arranged on the said first carrier foil 414.

[0042] In the shown embodiment, said first electrode pattern comprises a first electrode conductor 424_1 extending through the centrally located region of said active area 420 towards a first location 451 of a peripheral region and a second electrode conductor 424_2 extending towards a second location 452 of a peripheral region. Both the first and second electrode conductors 424_1 and 424_2 of said first electrode pattern 424 are electrically connected to the first connection terminal 430. The second electrode pattern 426 comprises a first electrode conductor 426_1 extending towards the centrally located region of said active area 420 so as to face said first electrode conductor 424_1 of said first electrode pattern 424. The second electrode pattern 426 also comprises a second electrode conductor 426_2 extending from said first location 451 of said peripheral region to said second location 452 of said peripheral region, such that a first end of said second electrode conductor 426_2 (at 451) faces said first electrode conductor 424_1 of said first electrode pattern 424 in said first location 451 of said peripheral region and that a second end of said second electrode conductor 426_2 (at 452) faces said second electrode conductor 424_2 of said first electrode pattern 424 in said second location 452 of said peripheral region.

[0043] This embodiment of the switching element advantageously enables a discrimination between forces acting centrally on the active area and forces which act offset of the central region. In fact, due to the configuration of the electrode patterns, a conducting path bypassing the first resistive element 434 is only established in the secondary contact zone, if both the first and second end of the second conductor 426_2 of the second electrode pattern are pressed against the respective conductor of

said first electrode pattern.

[0044] Fig. 13-15 show different possible electrode pattern configurations for switching elements operating in "through mode". In the embodiment of Fig. 13, the first electrode pattern 524 comprises a central electrode portion 524_1, a connecting electrode portion 524_2, which is connected to the central electrode portion 524_1 via a resistive portion 524_3 arranged between the central electrode portion 524_1 and the connecting electrode portion 524_2, and a secondary electrode portion 524_4. The secondary electrode portion 524_4 is arranged diametrically opposed to the connecting electrode portion 524_2 at a certain distance from the central electrode portion 524_1 and is electrically connected to the central electrode portion 524_1. Likewise the second electrode pattern 526 comprises a central electrode portion 526_1, a connecting electrode portion 526_2, which is connected to the central electrode portion 526_1 via a resistive portion 526_3 arranged between the central electrode portion 526_1 and the connecting electrode portion 526_2, and a secondary electrode portion 526_4. The secondary electrode portion 526_4 is arranged diametrically opposed to the connecting electrode portion 526_2 at a certain distance from the central electrode portion 526_1 and is electrically connected to the central electrode portion 526_1. The first and second electrode pattern 524 and 526 are arranged on their respective carrier foils 512 and 514 in such a way that said central electrode portions 524_1 and 526_1 face each other and that the secondary electrode portion 524_4 of the first electrode pattern 524 faces the connecting electrode portion 526_2 of the second electrode pattern 526 and vice versa. If a small force acts on such a switching element, an electrical contact is established between the central electrode portions 254_1 and 526_1 of the first and second electrode pattern and the resulting resistance of the switching element equals substantially the sum of the resistances of the resistive portions 524_3 and 526_3 of the first and second electrode pattern. If however a larger force acts on the switching element, then the secondary electrode portions of the electrode pattern are pressed onto the connecting electrode portions of the opposing electrode pattern and the two resistive portions are bypassed.

[0045] In the embodiment shown in Fig. 14, both said first and second electrode pattern comprise electrode conductors 624 and 626, which extend in opposing directions from a peripheral region of the active area through the centrally located region and extend beyond the centrally located region. A first resistive element 634 is arranged in the centrally located region as an elevation on the electrode conductors 624. If the carrier foils 612 and 614 are brought together only in the centrally located region, an electrical contact is established between the first and second electrode pattern 624 and 626 via the resistive element 634. If the activation force increases, the deflection of the carrier foils will increase and bring the electrode conductors 624 and 626 of the first and second electrode pattern into contact in an off-centre region, i.e. in a region in which no resistive element is applied on the electrode conductors. It follows that the first and second electrode pattern are directly contacted and that accordingly the resistive element is bypassed in this case. It will be noted that the resistive element may be surrounded by a patch of dielectric material 660 so as to prohibit direct contact between the first and second electrode pattern in the immediate vicinity of the resistive element. In this way, the force threshold, above which a direct contact is established, may be increased so as to adapt the response of the switching element to a specific desired shape.

[0046] In the variant shown in Fig. 15, a first resistive element 734_1 and 734_2 is arranged in the centrally located region on each of said electrode conductors 724 and 726 of the first and second electrode pattern, so that an electrical contact between the first and second electrode pattern 724 and 726 is established in the primary contact zone via the two resistive patches 734_1 and 734_2. Furthermore, second resistive patches 734_3 and 734_4 may be applied on either side of the central region on the electrode conductor 724, so that an electrical contact between the first and second electrode pattern 724 and 726 is established in the secondary contact zone via the second resistive patches 734_3 and 734_4.

[0047] Fig. 17 shows the equivalent electrical circuit for a switching element with discrimination of off-centre forces and with three different switching states, Fig. 18 shows the corresponding equivalent electrical circuit for a switching element with more than three different switching states. In these equivalent circuits the centrally located primary switching zones are represented as single switch 870 arranged in series with the first resistive element 834 between the connection terminals 830 and 832. The secondary switching zones, which are electrically coupled in order to be able to discriminate an off-centre activation, are represented as a series connection of two individual switches 872 and 874 and a possible second resistive element 836 between the connection terminals 830 and 832.

Claims

1. A switching element comprising:

a first carrier foil and a second carrier foil;
a spacer arranged between said first and second carrier foils, said spacer spacing said first and second carrier foils a certain distance apart from one another; said spacer being provided with an opening, said opening defining an active area for said switching element in which said first and second carrier foils can be brought together in response to a compressive force exerted on said switching element;
an electrode arrangement comprising at least a first electrode pattern made of conductive ma-

terial connected to a first connection terminal and a second electrode pattern made of conductive material connected to a second connection terminal, said first and second electrode patterns being arranged in said active area on said first and second carrier foils such that an electrical contact is established between said first and second electrode pattern when said first and second carrier foils are brought together; **characterised in that**
said electrode arrangement is configured such that, within said active area, at least one primary contact zone and at least one secondary contact zone are formed in which an electrical contact can be established between said first and second electrode pattern, wherein said primary contact zone is centrally located within said active area and wherein said at least one secondary contact zone is located off-centre within said active zone, and **in that** at least one first resistive element is associated to one of said first or second electrode pattern in such a way that said at least one first resistive element is connected between the first and second connection terminals if said electrical contact between said first and second electrode pattern is established only in said primary contact zone and that said first electrical resistance is bypassed if an electrical contact between said first and second electrode pattern is also established in said secondary contact zone.

2. Switching element according to claim 1, wherein said secondary contact zone extends on either side of said primary contact zone and is symmetrically arranged with respect to said primary contact zone.

3. Switching element according to any one of claims 1 or 2, wherein said first electrode pattern and said second electrode pattern are arranged on said first carrier foil and wherein said electrode arrangement further comprises at least one shunting element arranged on said second carrier foil in such a way that said electrical contact between said first and second electrode pattern is established via the shunting element if said first and second carrier foils are brought together.

4. Switching element according to claim 3, wherein said first and second electrode pattern each comprise a first electrode conductor and at least one second electrode conductor, said first and second electrode conductors of said first electrode pattern being electrically connected to said first connection terminal and said first and second electrode conductors of said second electrode pattern being electrically connected to said second connection terminal, wherein said first electrode conductors of said first and second electrode pattern extend towards a centrally located region of said active area and are arranged at a certain distance from each other in said centrally located region of said active area, wherein said second electrode conductors of said first and second electrode pattern extend towards a peripheral region of said active area, and wherein said at least one shunting element is arranged on said second carrier foil for establishing an electrical contact between the first electrode conductors of said first and second electrode pattern in said centrally located region and for establishing an electrical contact between the second electrode conductors of said first and second electrode pattern in said peripheral region of said active area.

5. Switching element according to claim 4, wherein the at least one first resistive element is associated to one of said first conductors of said first or second electrode pattern.

6. Switching element according to claim 3, wherein said electrode arrangement comprises a third electrode pattern arranged on said first carrier foil,
wherein said first electrode pattern and said second electrode pattern each comprise an electrode conductor extending from a peripheral region of said active area towards a centrally located region of said active area and are arranged at a certain distance from each other in said centrally located region of said active area, wherein said third electrode pattern comprises a bypass electrode conductor, said bypass electrode conductor having a first portion, which is arranged in the peripheral region of said active area at a certain distance from said electrode conductor of said first electrode pattern and a second portion, which is arranged in the peripheral region of said active area at a certain distance from said electrode conductor of said second electrode pattern, and wherein said shunting element comprises a primary shunting portion associated to the first electrode conductors in the centrally located region of said active area so as to form said first contact zone and at least two secondary shunting portions, each one of said secondary shunting portion being associated in the peripheral portion of said active area to one of the conductors of the first and second electrode pattern and the associated portion of said bypass electrode conductor so as to from said secondary contact zone.

7. Switching element according to claim 6, wherein at least one second resistive element is associated to said bypass electrode conductor, such that said second resistive element is connected between said first and second connection terminals if an electrical contact is established in the secondary contact zone between said first and second electrode pattern via said

secondary shunting portions.

8. Switching element according to any one of claims 1 or 2, wherein said first electrode pattern is arranged on said first carrier foil and said second electrode pattern is arranged on said second carrier foil in such a way that said first electrode pattern and said second electrode pattern face each other both in said centrally located region of said active area so as to form said primary contact zone and in a peripheral zone located off-centre of said active area so as to form said at least one secondary contact zone.

9. Switching element according to claim 8,
wherein said first electrode pattern comprises a first electrode conductor extending through the centrally located region of said active area towards a first location of a peripheral region and a second electrode conductor extending towards a second location of a peripheral region, said first and second electrode conductors of said first electrode pattern being electrically connected to said first connection terminal, and
wherein said second electrode pattern comprises a first electrode conductor extending towards the centrally located region of said active area so as to face said first electrode conductor of said first electrode pattern and a second electrode conductor extending from said first location of said peripheral region to said second location of said peripheral region, such that a first end of said second electrode conductor faces said first electrode conductor of said first electrode pattern in said first location of said peripheral region and that a second end of said second electrode conductor faces said second electrode conductor of said first electrode pattern in said second location of said peripheral region.

10. Switching element according to claim 9, wherein said first location of said peripheral region and said second location of said peripheral region are arranged symmetrically with respect to said centrally located region of said active area.

11. Switching element according to claims 9 and 10, wherein said at least one resistive element is integrated into said first electrode conductor of said first electrode pattern between said first connection terminal and said centrally located region of said active area.

12. Input device for an electrical appliance comprising one or more switching elements according to any one of the preceding claims.

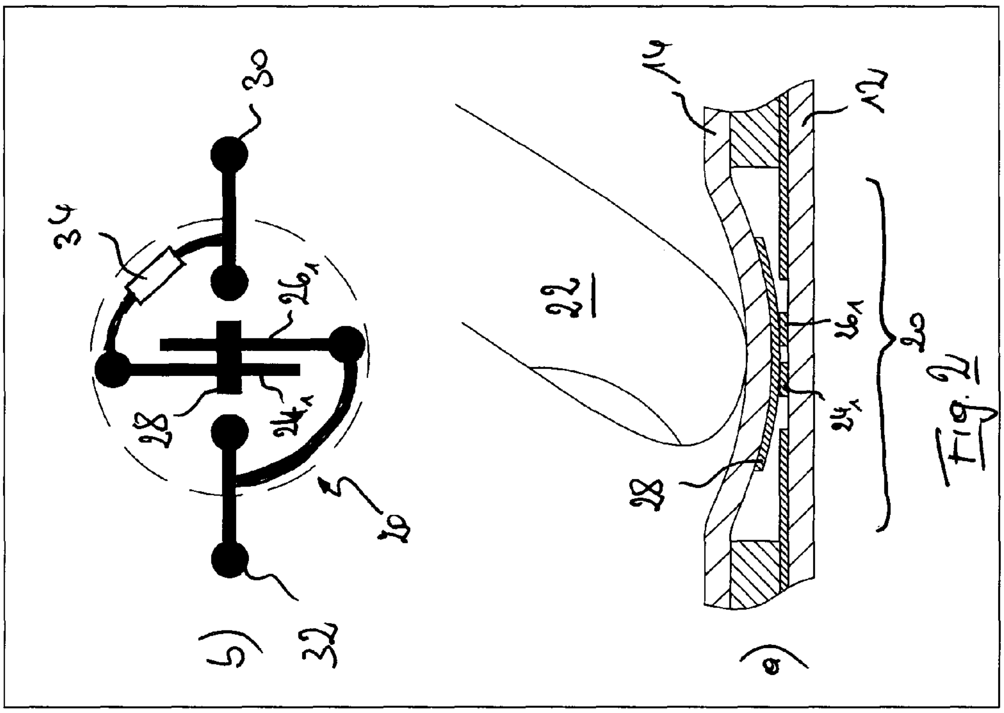
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Fig. 2

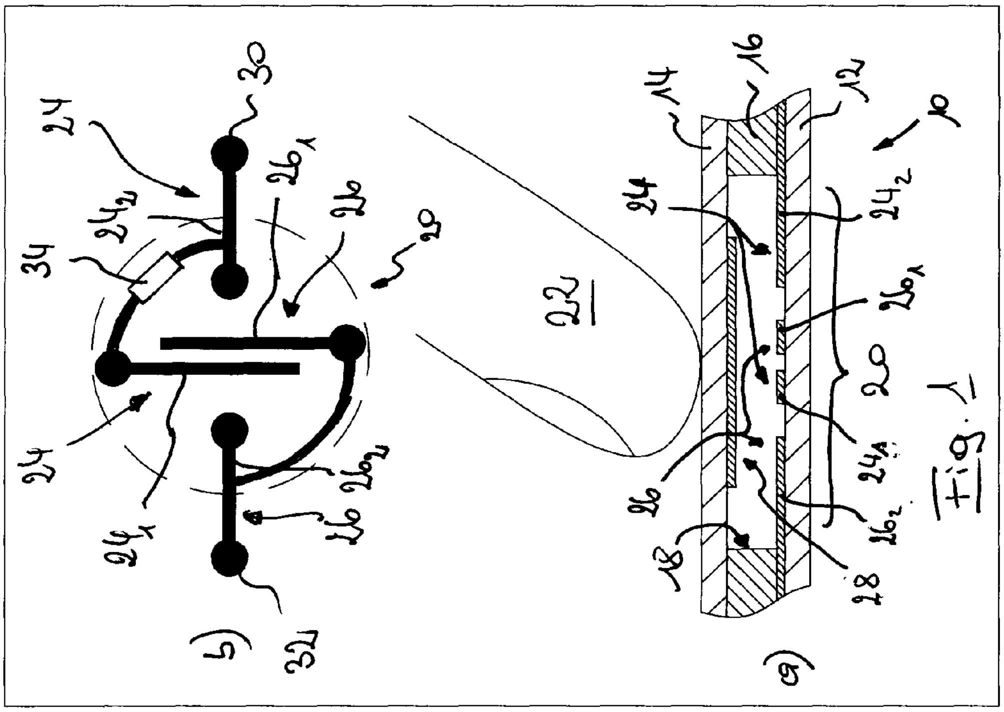
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Fig. 1

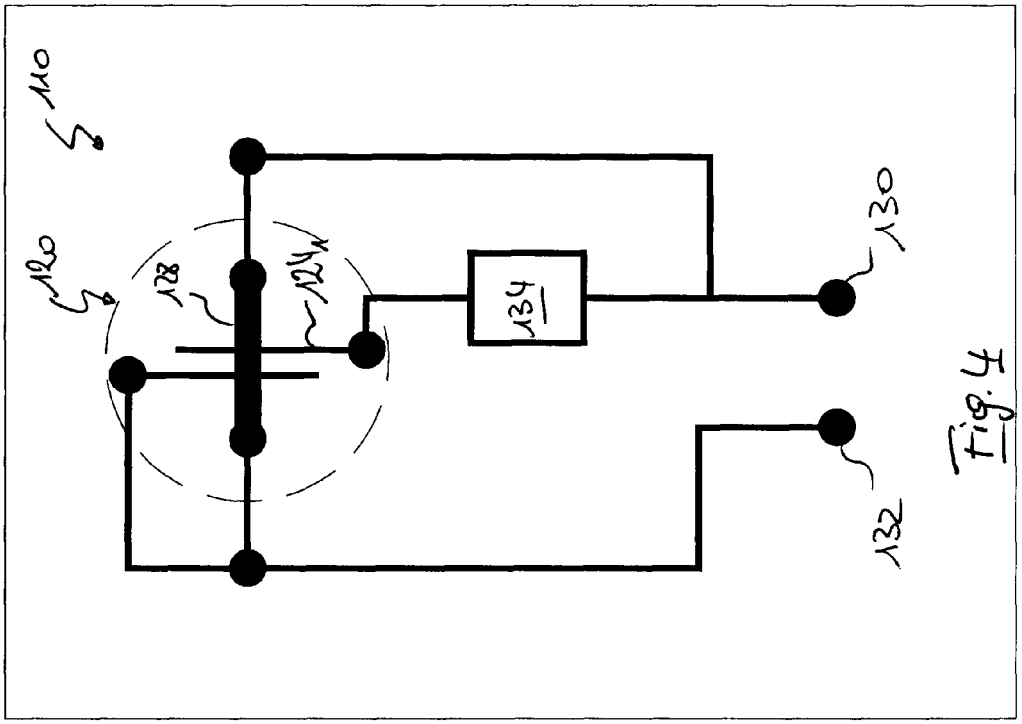

Fig. 4

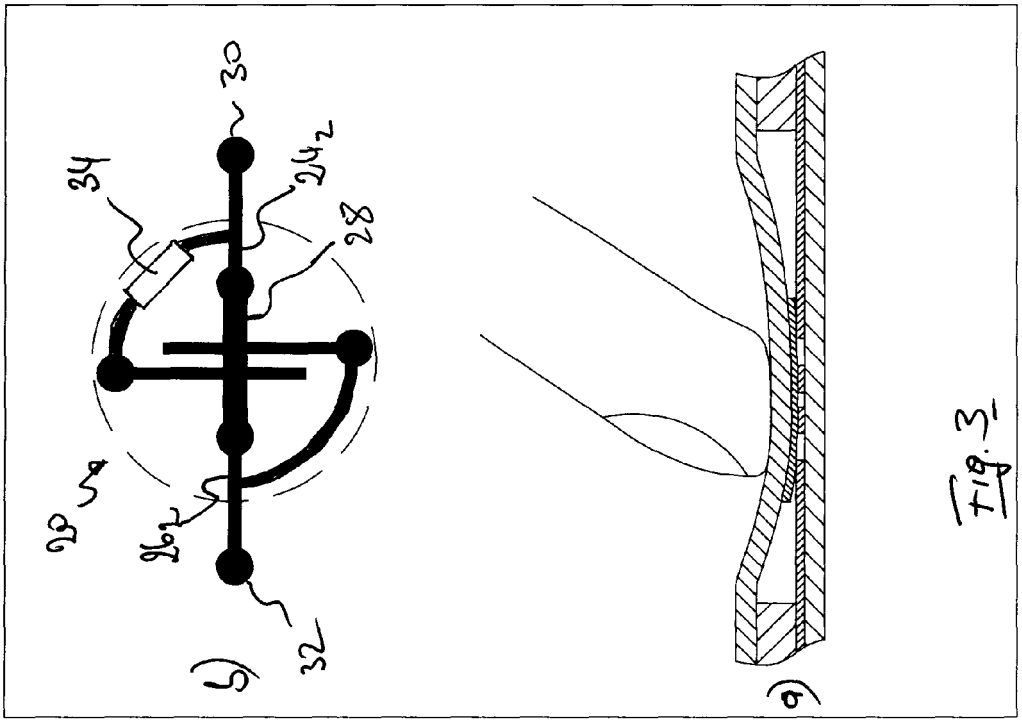

Fig. 3

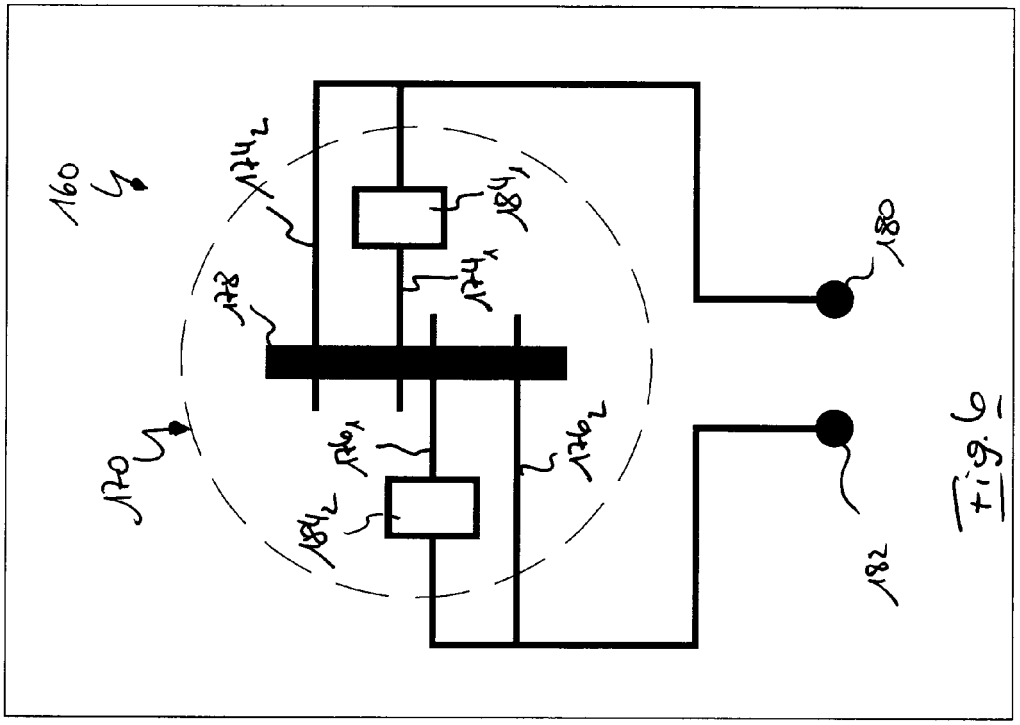
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Fig. 6

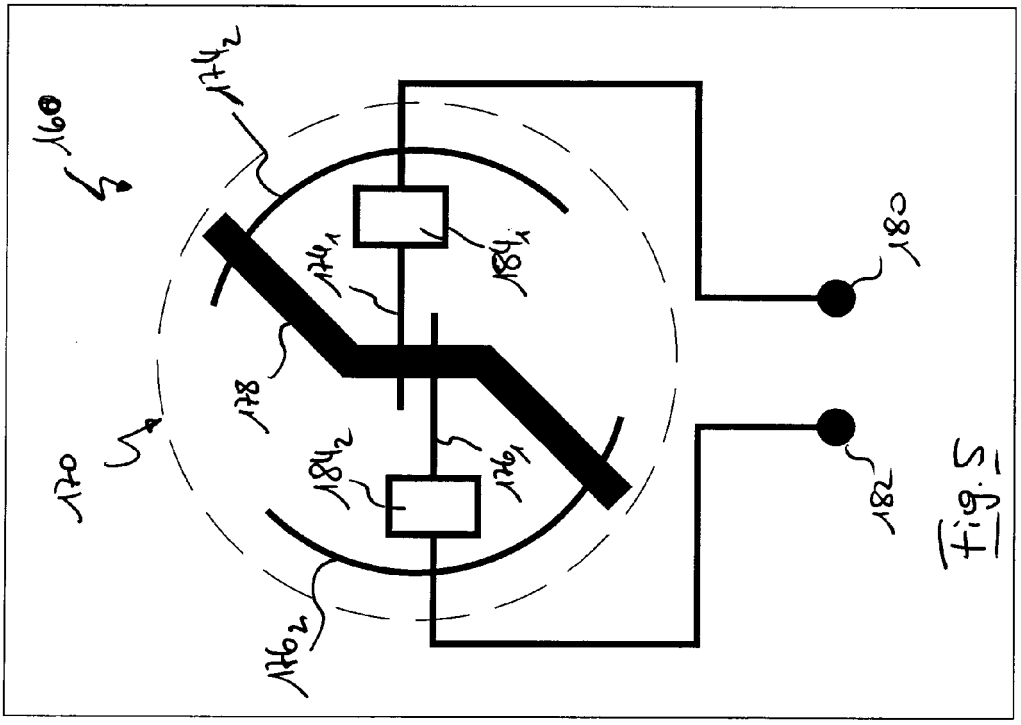
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Fig. 5

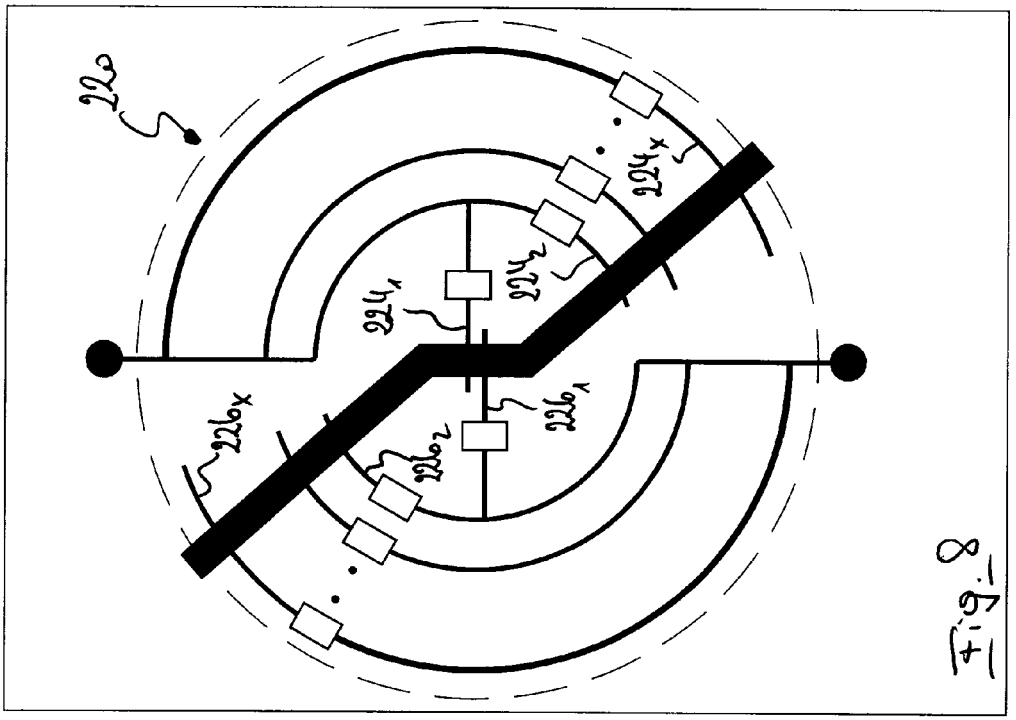


Fig.8

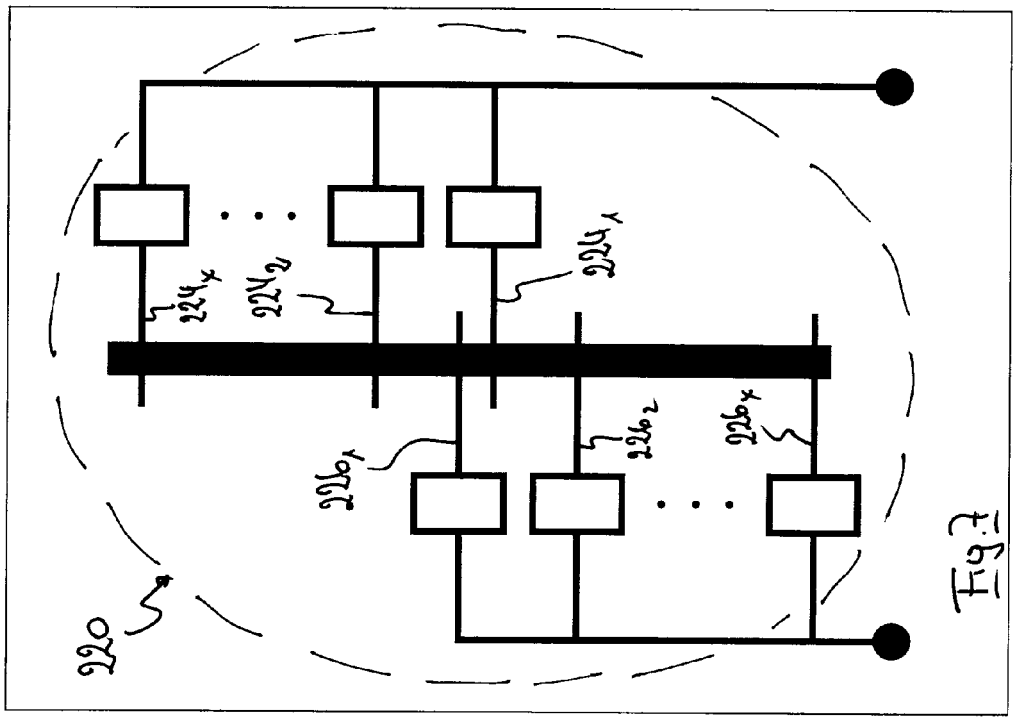
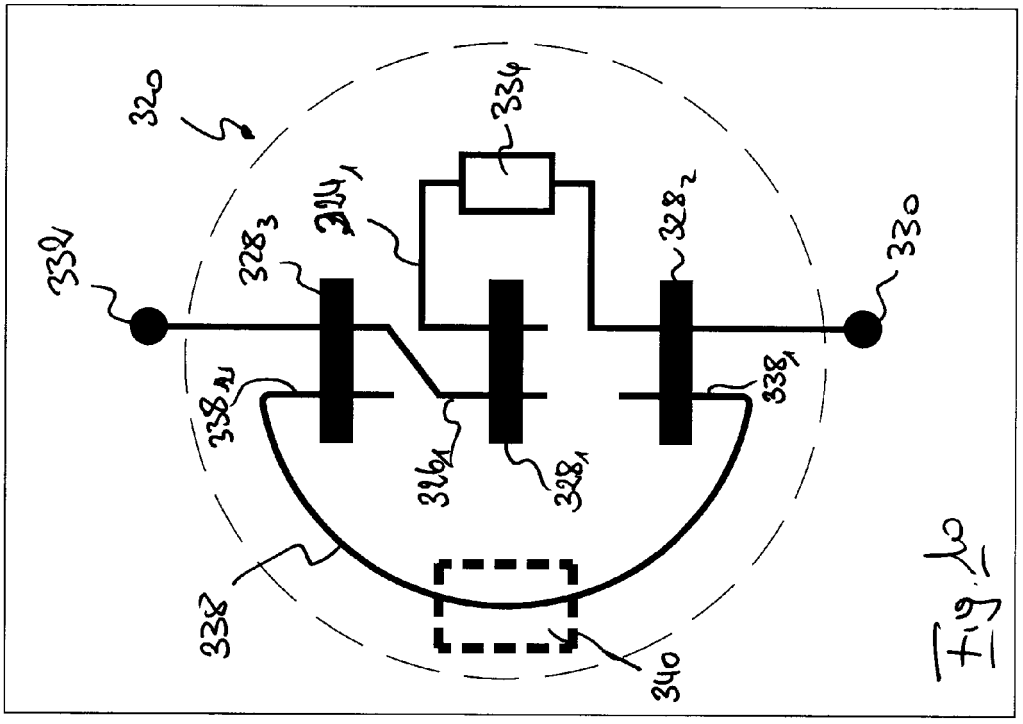


Fig.7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338_{n-1}
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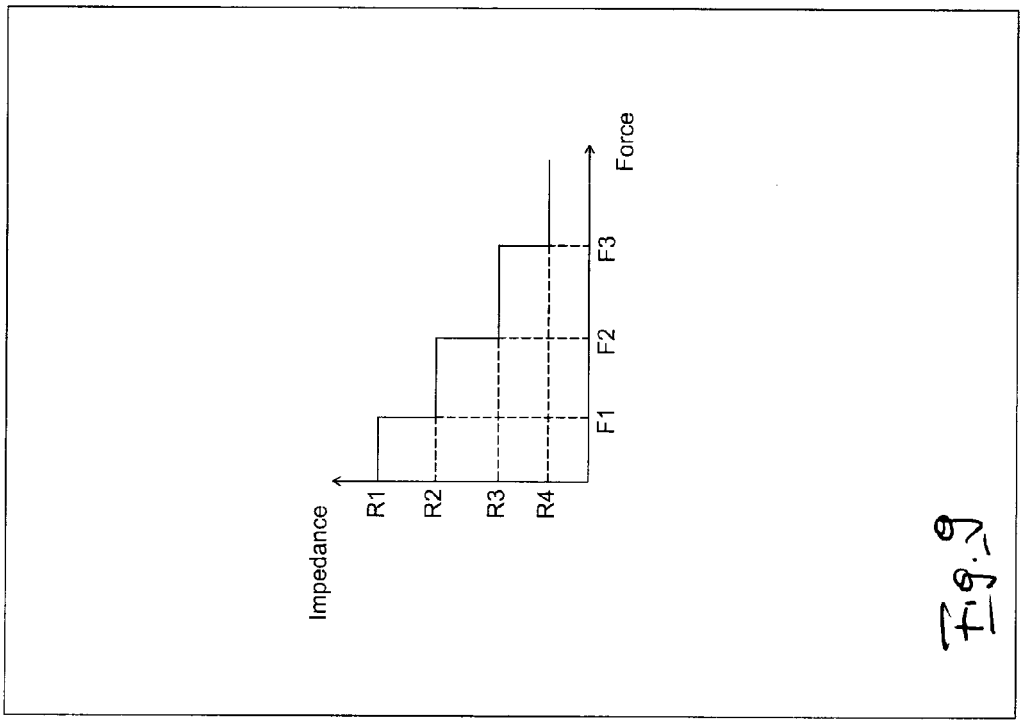
Fig.10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R3
R4

Fig.9

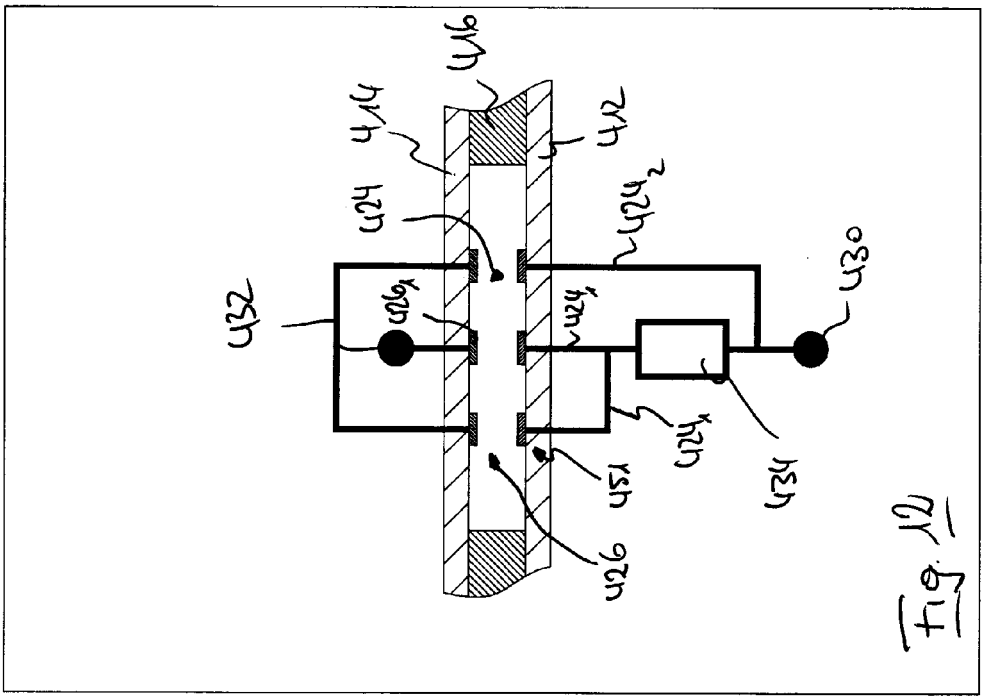
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Fig. 10

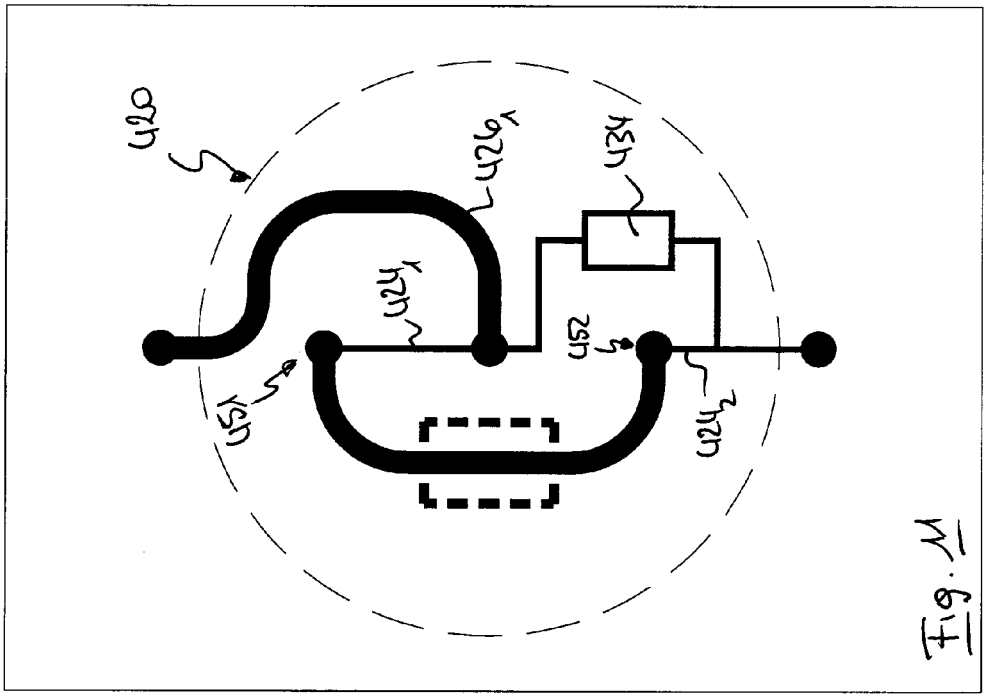
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Fig. 11

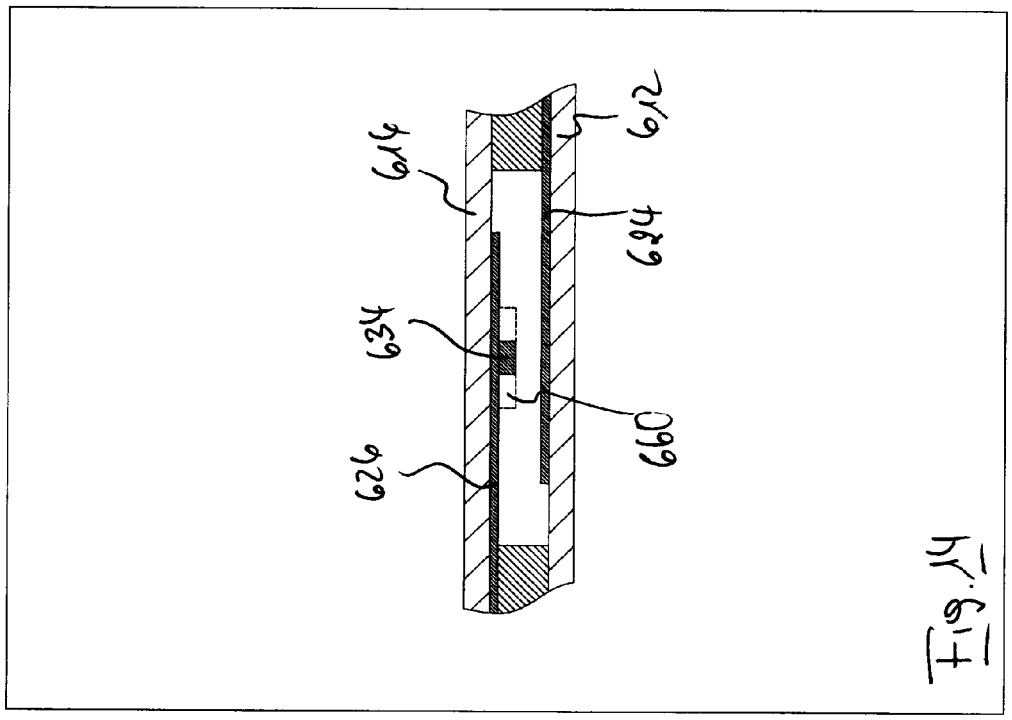
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Fig. 14

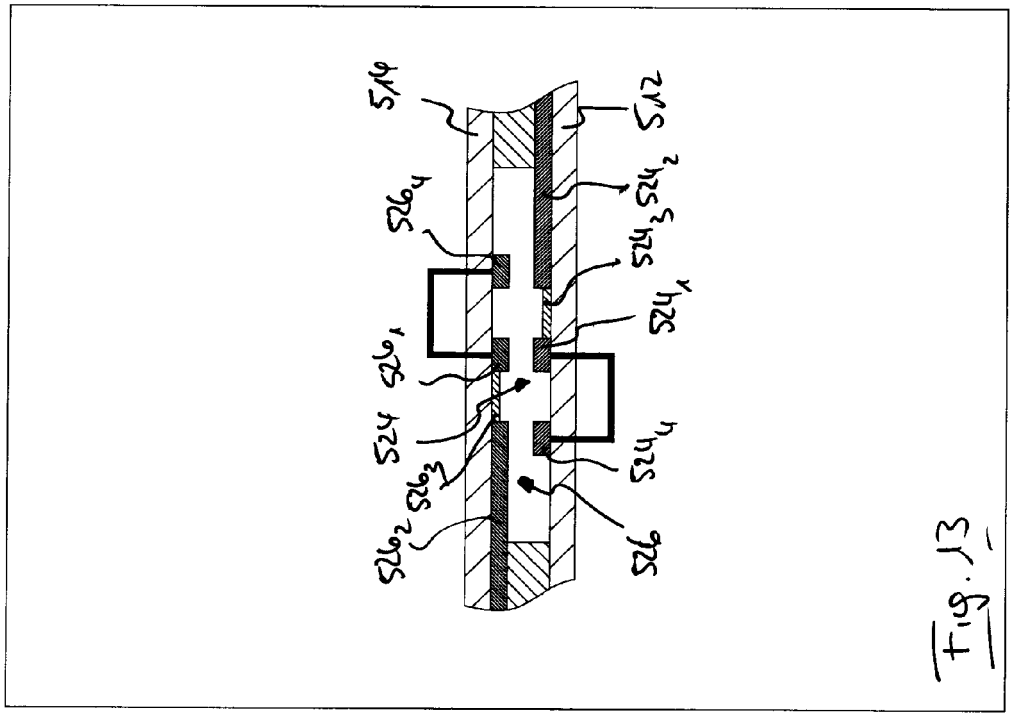
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Fig. 13

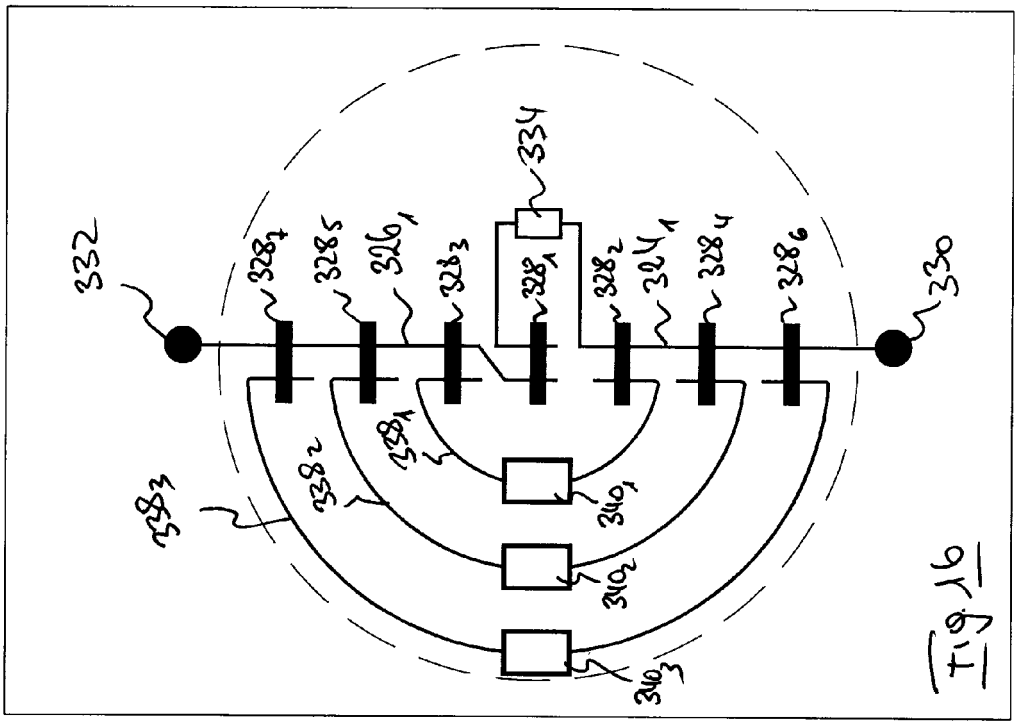
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Fig.16

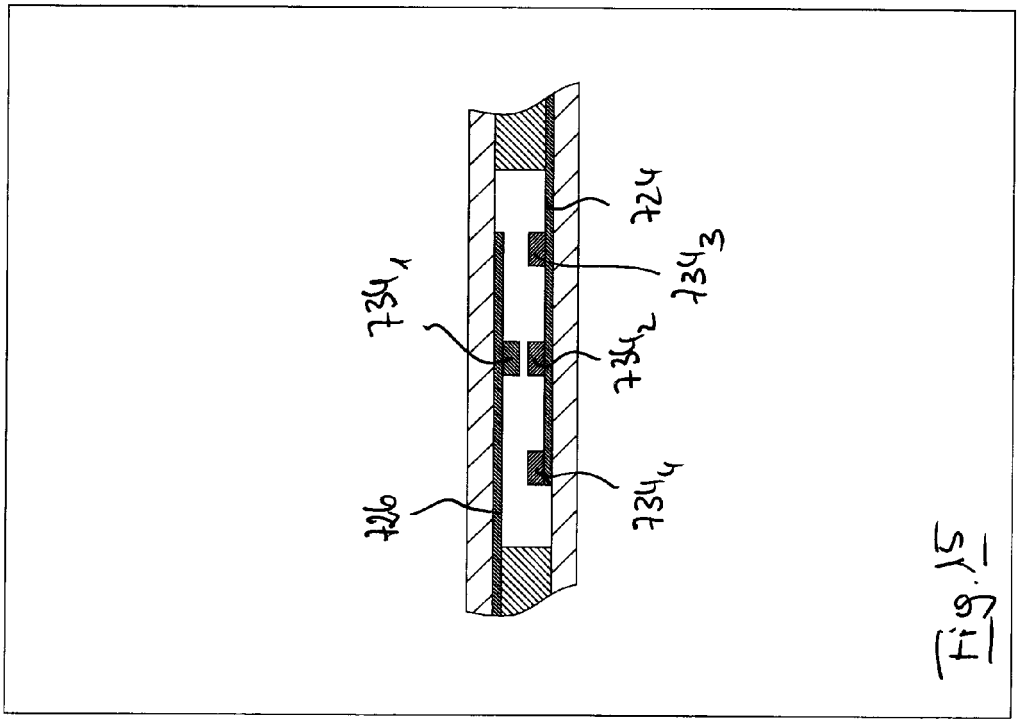
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Fig.15

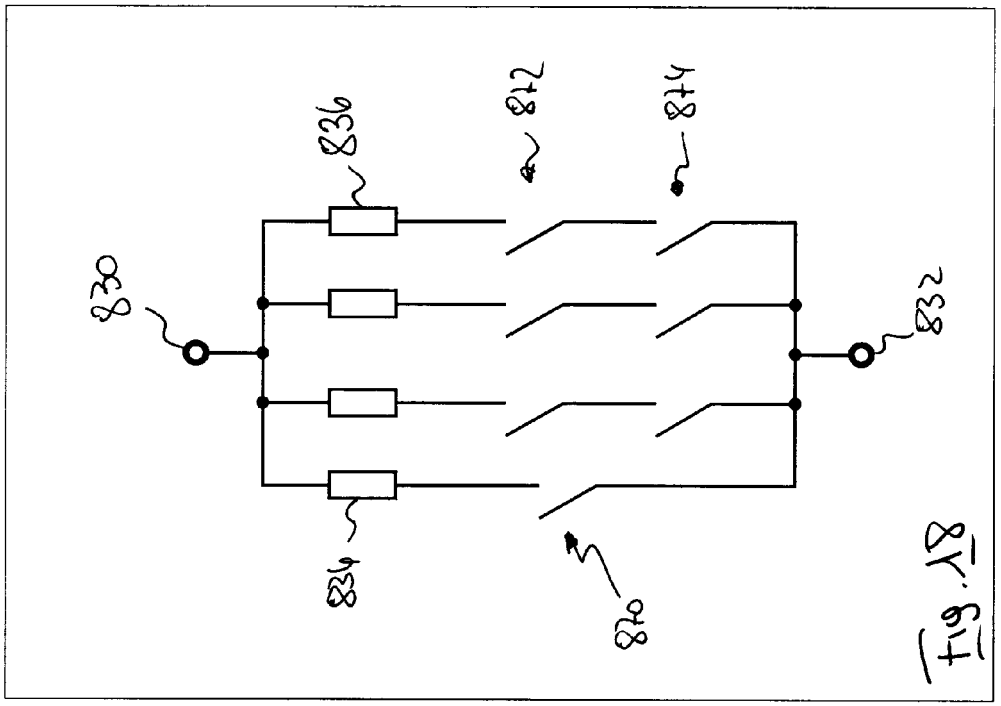

Fig. 18

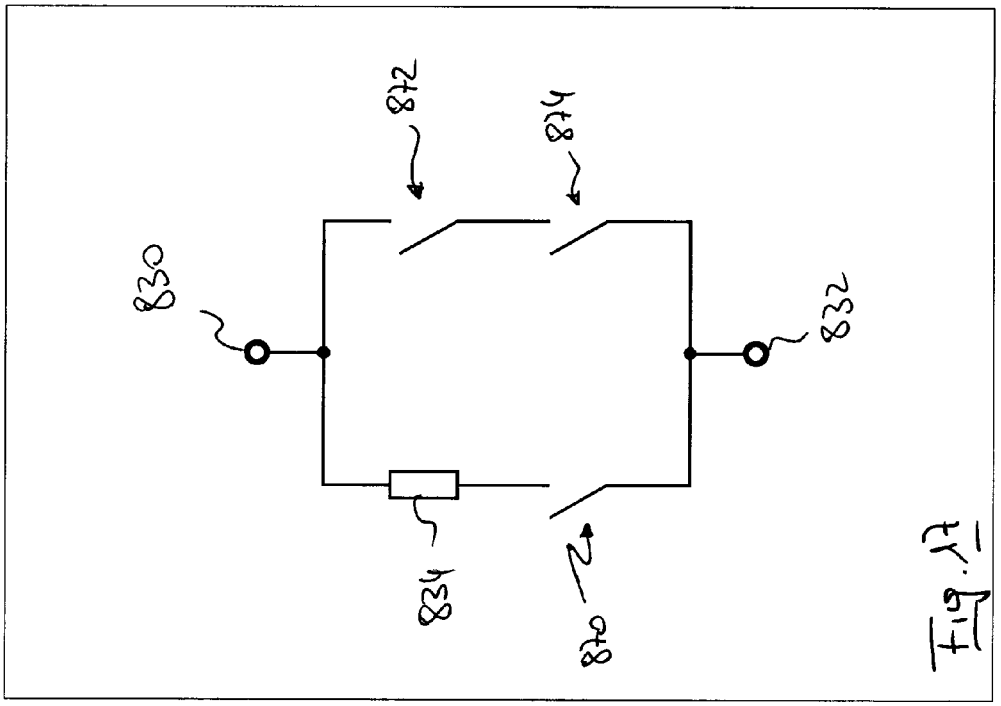

Fig. 17

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 12 4551

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 99/09572 A (HIGH END SYSTEMS INC [US]) 25 February 1999 (1999-02-25) * figures 2-4 *	1	
A	US 5 952 629 A (YOSHINAGA KENICHI [JP] ET AL) 14 September 1999 (1999-09-14) * figure 5B *	1	
A	JP 09 017277 A (JAPAN AVIATION ELECTRON) 17 January 1997 (1997-01-17) * figures 1,2,4 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 April 2007	Overdijk, Jaco

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 12 4551

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20-04-2007

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