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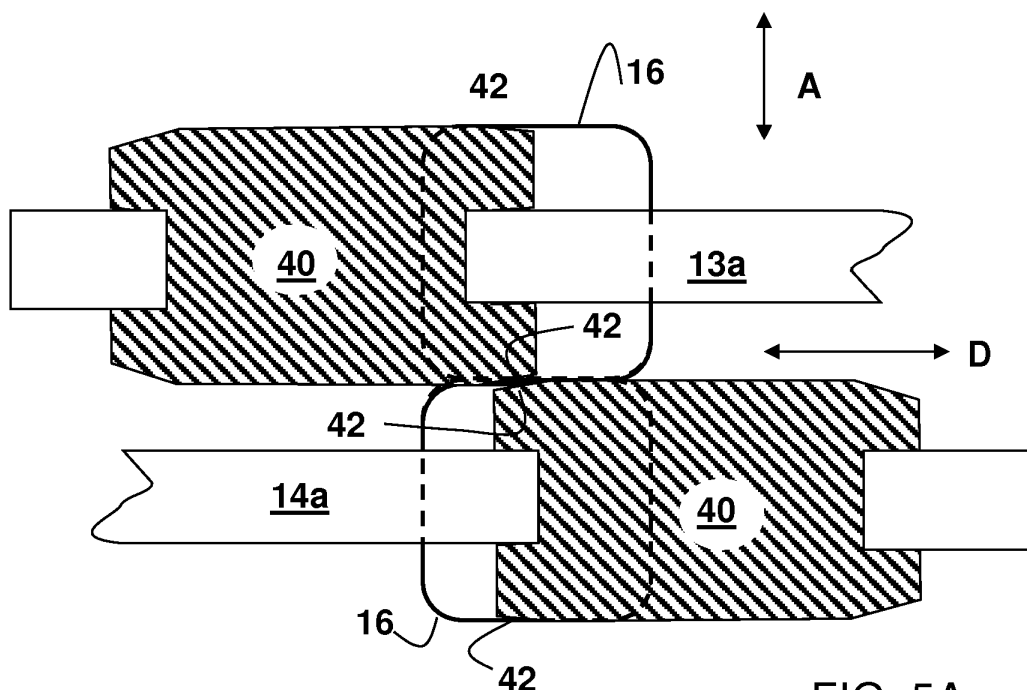
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(54) Switch having two sets of contact elements

(57) A medium or high DC voltage switch has a first set of contact elements (13a, 13b, 13c) and a second set of contact elements (14a, 14b, 14c) with each contact element including an insulating carrier (15) carrying conducting elements (16) aligned to form one or more current paths between terminals (8, 9) along an axial direction (A) in the closed state of the switch. For closing or opening the switch, neighboring contact elements are mutually

displaced along a defined contour-guided path, using for example spacer elements (40) mounted onto the contact elements, along a direction (D) including a small displacement in the axial direction (A) such that the conducting elements can remain separated in axial direction (a) even when already overlapping in the displacement direction (D).

**FIG. 5A**

Description

Technical Field

[0001] The invention relates to a high or medium voltage switch, particularly a DC switch, comprising a first and a second set of contact elements that are mutually displaceable. The invention also relates to a current breaker comprising such a switch.

Background Art

[0002] A switch of this type is disclosed for example in the co-owned United States patents and published patent applications US7235751, US2012/0256711, and US2013/0098874. It has a first and a second set of contact elements and a drive adapted to mutually displace the contact elements along a displacement direction. Each contact element carries at least one conducting element. In a first mutual position of the contact elements, their conducting elements combine to form at least one conducting path between the first and second terminals of the switch in a direction transversally to the displacement direction. In a second position of the contact elements, the conducting elements are mutually displaced into staggered positions and therefore the above conducting path is interrupted.

[0003] The switches described in US2012/0256711, and US2013/0098874 have contact elements with an insulating carrier carrying conducting elements. In the closed state of the switch, the conducting elements align to form one or more current paths between the terminals of the switch along an axial direction. For opening the switch, the contact elements are mutually displaced by means of two drives along a direction perpendicular to the axial direction. The switching arrangement is arranged in a fluid-tight housing in a gas of elevated pressure or in a liquid. The switch has a high voltage withstand capability and fast switching times. The conducting element projects laterally over the two opposite surfaces of the carrier that carries it and is slightly movable in axial direction in respect to the carrier that carries it and/or it is slightly tiltable around a tilt axis, wherein said tilt axis is perpendicular to the axial direction and to the direction of displacement.

[0004] Each terminal forms a contact surface for contacting the conducting elements on the outer contact elements, wherein at least one of the terminals comprises a spring member that elastically urges the contact surface of the terminal against the conducting elements. This ensures a proper contacting force between the conducting elements themselves and between the conducting elements and the contact surfaces on the terminals and, with conducting elements being movable in axial direction the forces between all the conducting elements in a current path are substantially equal.

[0005] While generally satisfactory, it is seen as an object of the present invention to reduce unwanted move-

ment and oscillations of the carriers under high acceleration during the switching process and reduce abrasion and other detrimental impact of the switching process.

Summary of the Invention

[0006] Hence, according to a first aspect of the invention, the switch has at least a first and a second terminal for applying the current to be switched and at least a first set of contact elements and a second set of contact elements and a drive adapted to mutually displace the sets of contact elements relatively to each other along a displacement direction with each contact element including an insulating carrier or carrier frame that carries at least one conducting element with the positions of the conducting elements being such that in a first mutual position of the contact elements the conducting elements form at least one conducting path between the first terminal and the second terminal, i.e., the switch is in the closed, conducting position; and in a second mutual position of the contact elements the conducting elements are mutually displaced such that there is no conducting path formed by the conducting elements between the first terminal and the second terminal, i.e., the switch is in its opened, non-conducting position and wherein each contact element is contour-guided to move along a defined displacement path reducing or increasing the distance in axial direction between the conducting elements of neighboring contact elements during closing and opening, respectively, of the switch.

[0007] Preferably the guiding contours are shaped such that a gap (in the axial direction) between the conducting elements of neighboring contact elements is maintained while the conducting elements overlap partially in displacement direction.

[0008] The contour-guidance can be provided by either external guiding elements such as rails onto which or between which the contact elements are mounted or by insulating lateral spacer elements mounted onto the contact elements or by a combination of such elements. The outer contours of the spacer elements are shaped so as to introduce a small defined displacement path in axial direction, which the conducting elements onto which the spacer elements are mounted follow during closing and opening of the switch.

[0009] The spacer elements, when in full contact, increase slightly the spacing between the neighboring contact elements compared to the same spacing in the first mutual position (when the switch is closed). In other words, the combined maximal lateral extension of spacer elements in axial direction between two neighboring contact elements measured as (perpendicular) elevation out of two reference planes oriented parallel to the displacement direction D (e.g. a plane within or on the juxtaposed faces of the contact elements) is slightly larger than the same combined maximal lateral extension of the conducting elements of the same pair of contact elements.

[0010] It is preferred that the spacer elements remain

in contact even during the transitions from the open to the close position and vice versa. It is particularly preferred with regard to the closing operation that the spacers remain in contact even when the neighboring conducting elements already overlap partially (in direction of the displacement) and thus maintain a gap in axial direction between them.

[0011] With the spacer elements arranged on the contact elements it is possible to give the contact elements more freedom for lateral movements and flexing, particularly in axial direction, when compared for example to a solution using guiding rails for the contact elements. Thus each set of contact elements has during closing and opening a slightly larger lateral spread in axial direction than in the first position where the conducting elements are in contact with each other. Thus rather than being pushed across their edges into contact with each other, the conducting elements "fall" or, more accurately, are guided with their flat contact faces against each other at the final stage of the closing of the switch as the guiding spacer elements separate from each other. This is seen as an advantage of the spacer elements.

[0012] The outer contour of each spacer element includes best a slightly sloped face or chamfer edge with a sloping angle away from the displacement direction of less than 10° or even less than 5°. During the closing of the switch, spacer elements on adjacent contact elements first glide along their parallel faces and preferably along a first part of sloping edges and lose contact at some point after their respective sloping edges overlap in displacement direction.

[0013] At this position of the contact elements the conduction elements on the neighboring contact elements overlap already (in displacement direction) such that they come into first contact with an axial motion bringing into contact their mutually parallel oriented flat faces. Thus it can be avoided that the conducting elements make first contact at the closing of the switch with their respective corners or edges. Such an arrangement avoids wear and tear on the edges of the contacting elements and provides when closing almost instantaneously a broad contact area between the conducting elements. This reduces also local heat generation through the contact resistance.

[0014] In principle it is possible to arrange the spacer elements at any position along a contact element. To avoid larger flexing or bending movements of the contact elements in transition, it is however preferred to position the spacer elements close to the conducting elements, best on one or both sides of a conducting element in (direction of line perpendicular to both, the axial direction and the displacement direction, i.e. the tilting axis of the conducting elements. This direction is typically the direction in which the conducting elements have their longest elongation.

[0015] The spacer elements are best fitted to the contact elements by a connection which is free of glue or other materials. The preferred fitting is a form fit with the form fit including fits such as interference fit or a snap fit.

[0016] The spacer elements are best made of an electrically insulating material such as a hard plastic material with a low friction coefficient to avoid larger loads on the drive which closes and separates the contact elements. Suitable materials include PTFE, PEEK or crystalline PET or compositions thereof

[0017] Advantageously, each conducting element is slightly movable in axial direction in respect to the carrier that carries it and/or it is slightly tiltable around the tilting axis as defined above. This allows the conducting element to axially position itself accurately with the contact faces parallel oriented, when the switch is in its first, closed position, thereby improving current conduction.

[0018] In yet a further advantageous embodiment, each terminal extends into a contact plate with a contact surface for contacting the conducting elements, wherein at least one of the terminals comprises a spring member that elastically urges the contact face of the terminal against the conducting elements of the outer contact element. This ensures a proper contacting force between the conducting elements themselves and between the conducting elements and the contact surfaces of the contact plate. This is particularly advantageous when the contact elements themselves are flexible or movable in axial direction since the forces between all the conducting elements in a current path become substantially equal.

[0019] In a particularly preferred embodiment, the spacer elements make contact with a terminal or any extension thereof, such as the contact plate referred to above, at a recess which is less exposed to the electrical fields inside the switch than the contact surface for the conducting elements on the same terminal. In such a manner triple points created at the contacts between the outer spacer elements and the terminals are at least to some extent shielded and electrical field overstress leading to insulation deterioration and breakdown can be avoided.

[0020] The drive (or drives, if there is more than one) are advantageously arranged within the housing, thus obviating the need for mechanical bushings.

[0021] The switch is advantageously used in high DC voltage applications (i.e. for voltages above 72 kV), but it can also be used for medium DC voltage applications (between some kV and 72 kV).

[0022] Other advantageous embodiments are listed in the dependent claims as well as in the description below.

Brief Description of the Drawings

[0023] The invention will be better understood and objects other than those set forth above will become apparent from the following detailed description thereof. Such description makes reference to the annexed drawings, wherein:

FIG. 1 shows a cross-sectional view of a known switch;

FIG. 2 shows an enlarged cross-sectional view of the contact elements of FIG. 1;

FIG. 3A shows a schematic perspective view of a contact element with carrier part and acceleration rod but without dielectric spacer elements and without conducting elements;

FIG. 3B shows an enlarged section of FIG. 3A with a dielectric spacer element inserted into the carrier;

FIGs. 4A and 4B show a perspective cross-section view and a side view, respectively, of a spacer element in accordance with an example of the invention;

FIGs. 5A and 5B show a cross-section of two adjacent contact elements in a closed and open position of a switch, respectively, and

FIG. 6 shows another cross-sectional view with dielectric spacer elements and with conducting elements in accordance with an example of the invention.

Modes of Carrying Out the Invention

[0024] An example of the present invention is now described in further detail using as the switch design as described in the above cited applications US2012/0256711, and US2013/0098874. Accordingly, the switch of Fig. 1 includes a fluid-tight housing 1 enclosing a space 2 filled with an insulating fluid, in particular SF₆ or air at elevated pressure or an oil.

[0025] Housing 1 forms a GIS-type metallic enclosure of manifold type and comprises two tube sections. A first tube section 3 extends along an axial direction A, and a second tube section 4 extends along a direction D, which is called the displacement direction for reasons that will become apparent below. Axial direction A is perpendicular or nearly perpendicular to displacement direction D. The tube sections are formed by a substantially cross-shaped housing section 5.

[0026] First tube section 3 ends in first and second support insulators 6 and 7, respectively. First support insulator 6 carries a first terminal 8 and second support insulator 7 carries a second terminal 9 of the switch. The two terminals 8, 9 extending through the support insulators 6, 7 carry the current through the switch, substantially along axial direction A.

[0027] Second tube section 4 ends in a first and a second cap 10 and 11, respectively.

[0028] First terminal 8 and second terminal 9 extend towards a center of space 2 and end at a distance from each other, with a switching arrangement 12 located between them, at the intersection region of first tube section 3 with second tube section 4.

[0029] As can best be seen from Fig. 2, switching arrangement 12 comprises a first set of contact elements

13a, 13b, 13c and a second set of contact elements 14a, 14b, 14c. In the embodiment shown here, each set comprises three contact elements, but that number may vary, and, for example, be two or more than three. The first and second set may also have different numbers of contact elements, e.g. two and three, respectively. Advantageously, the number is at least two contact elements per set. The contact elements of the two sets are stacked alternately, i.e. each contact element of one set is adjacent to two contact elements of the other set unless it is located at the end of switching arrangement 12, in which case it is located between one contact element of the other set and one of the terminals 8, 9.

[0030] Each contact element comprises a plate-shaped insulating carrier part 15, one or more conducting elements 16 and an actuator rod 17. In the embodiment shown here, each carrier part 15 carries two conducting elements 16.

[0031] Figs. 1 and 2 show the switch in the closed state with the contact elements 13a, 13b, 13c, 14a, 14b, 14c in a first mutual position, where the conducting elements 16 align to form two conducting paths 34 along axial direction A between the first and the second terminals 8, 9. The conducting paths 34 carry the current between the terminals 8, 9. Their number can be greater than one in order to increase continuous current carrying capability.

[0032] For example an arrangement with three conducting elements 16 in each insulating carrier part 15 leads to three conducting paths 34 when the switch is closed. A non-inline arrangement with four contact elements 16 in each insulating carrier part 15 to four conducting paths 34 when the switch is closed and so forth.

[0033] The contact elements 13a, 13b, 13c, 14a, 14b, 14c are moved in operation along the displacement direction D into a second position, where the conducting elements 16 are staggered in respect to each other and do not form a conducting path. In Fig. 2, the position of the conducting elements in this second position is shown in dotted lines under reference number 16'. As can be seen, the conducting elements 16' are now separated from each other along direction D, thereby creating several contact gaps (two times the number of contact elements 13, 14), thereby quickly providing a high dielectric withstand level.

[0034] To achieve such a displacement, and as best can be seen in Fig. 1, the actuator rods 17 are connected to two drives 18, 19. A first drive 18 is connected to the actuator rods 17 of the first set of contact elements 13a, 13b, 13c, and a second drive 19 is connected to the actuator rods 17 of the second set of contact elements 14a, 14b, 14c.

[0035] In the embodiment shown in Figs. 1 and 2, the switch is opened by pulling the actuator rods 17 away from the center of the switch, thereby bringing the conducting elements into their second, staggered position. Alternatively, the rods 17 can be pushed towards the center of the switch, which also allows to bring the con-

ducting elements into a staggered position.

[0036] The drives 18, 19 can e.g. operate on the repulsive Lorentz-force principle and be of the type disclosed in US 7 235 751, and they are therefore not described in detail herein. Each drive is able to displace one set of contact elements along the displacement direction D. They are adapted and controlled to move the first and second sets in opposite directions at the same time in order to increase the travelling length and speed of displacement.

[0037] The drives 18, 19 are arranged in opposite end regions of second tube section 4.

[0038] It should be noted that the full stroke (e.g. 20 mm per drive) of the drives may not be necessary to travel in order for the contact system to provide the dielectric strength required, but a distance much shorter (e.g. 10 mm per drive), which can be reached in an even shorter time, suffices. This also provides certain safety in case of backtravel upon reaching the end-of-stroke position and damping phase of the actuators. A sufficient separation of the conducting elements 16 can be reached within 1 or 2 ms (milliseconds).

[0039] As shown in Fig. 2, each terminal 8, 9 carries a contact plate 32 forming a contact surface 33 contacting the conducting elements 16 when the switch is in its first position. The contact plates 32 are mounted to the terminals 8, 9 in axially displaceable manner, with springs 20 elastically urging the contact surface 33 against the conducting elements, thereby compressing the conducting elements 16 in their aligned state for better conduction. In the embodiment of Fig. 2, helical compression springs 20 are used for this purpose, but other types of spring members can be used as well. Also, even though it is advantageous if there is at least one spring member in each terminal 8, 9, a compression force for the aligned conducting elements 16 can also be generated by means of a spring member(s) in only one of the terminals 8, 9.

[0040] A perspective schematic view of one of the contact elements prior to being full assembled is shown in FIG. 3A. A contact element includes a carrier part 15 forming a frame structure and the solid actuator rod 17. In the example shown both parts are made of a homogeneous material (e.g. a fiber reinforced epoxy material) in one piece. The carrier part 15 has a frame structure with cut-out sections or recesses 151, 152 to mount further elements such as spacer elements 40 to be described below and/or conducting elements 16. The carrier part 15 has further a central opening 153 and further cut-out sections at one end to reduce the mass which has to be accelerated at each operation of the switch without reducing the mechanical stability unduly.

[0041] An enlarged section of the carrier part 15 is shown in FIG. 3B as referred to below. This section includes a recess or slot 151 for the insertion of spacer elements 40 as described in more detail in the following.

[0042] FIG. 4A is a top view of a spacer element 40 for insertion into the carrier part 15 of a contact element. The spacer element 40 has an essentially rectangular cross-

section with slots 41 on two sides. The corners of the spacer element are chamfered providing at least one plane 42 with a sloping angle of about 4° towards the plane of the carrier part 15 or the displacement direction D as indicated by the dashed lines. The other corners are also shown chamfered but at a higher chamfer or sloping angle of about 15°. Both planes are also shown in the side view of the spacer element 40 of FIG. 4B.

[0043] The length of the spacer 40 and the slots 41 are designed such that the spacer is fixed to the carrier part 15 through form fit after being pressed into the recess 151 of the carrier part 15 during assembly of the contact element 13a. FIG. 3B showing an enlarged section of FIG. 3A illustrates the spacer element 40 after assembly within the recess 151 being held in place by interference fit and by a snap fit with the jaws of the undercut sections of the recess 151 locking onto the spacer element.

[0044] The elevation of the spacer element in direction of the axis A (and hence out of the plane of the carrier part 15 or any other reference plane parallel to the direction of the displacement) is at its maximum slightly larger than the maximal elevation of the conducting elements 16 in the same direction. The maximal elevation of both, the spacer element and the conducting element in the example shown is assumed, respectively, at the location of their flat contact surfaces oriented parallel to the plane of the carrier part 15. However, as the contact face of the spacer element can also be contoured as a continuously sloping face, e.g. by extending the slope 42 across the whole length of the spacer element, such a maximum elevation can be assumed at a different point, e.g., at the end of such a continuous sloping surface.

[0045] The length and angle of the sloping plane 42 and the position of the spacer element 40 relative to the conducting element 16 of the same carrier part 15 are chosen such that there is no contact between adjacent spacer elements 40 only at a position where the respective juxtaposed flat sections of the faces of the conducting elements 16 of neighboring contact elements overlap partially. In other words, in this example with spacer elements 40 on neighboring contact elements being essentially identical and only mounted in reverse orientation, the point at which the elevation of the spacer elements and the maximal elevation of the conducting elements are equal is a point on the sloping plane 42. The spacer elements 40 of neighboring contact elements remain in contact and separate their respective conducting elements 16 even when the contact surface of these conducting elements 16 already overlap partially along the displacement direction D.

[0046] The above is illustrated in the following FIGs. 5A and 5B, which show an enlarged section of the switch at the location of two neighboring contact elements 13a, 14a.

[0047] In FIG. 5A the two adjacent contact elements 13a, 14a are shown in a position in which the switch is closed. In this position the plane flat faces of the conducting elements 16 are in contact with each other,

while the chamfer or sloping planes 42 of the spacer elements 40 is just sufficient to separate the spacer elements 40 in this first mutual position of the contact elements 13a, 14a (and of the switch).

[0048] To close or open the switch, the contact elements 13a, 14a are pushed together or pulled apart, respectively, along the general direction D. At the point of the travel of the two contact elements 13a, 14a where the combined maximal lateral elevation of the conducting elements 16 is exceeded by the combined lateral extension of the sloping surfaces 42 of the spacer elements 40 the conducting elements 16 are separated. (The elevations are elevations in axial direction A shown as perpendicular to the direction D and in the paper plane.) This point of equal elevation is at a mutual position of the two neighboring contact elements 13a, 14a, at which at least the opposite edges of the conducting elements 16 already overlap (when projected onto a line parallel to the displacement direction D). At this point the adjacent spacer elements 40 either lose contact or come into contact at some upper part of the sloping plane 42. Depending on the operation of the switch they are either separated (when closing the switch) and the conducting elements 16 slip into contact along their flat faces or the spacer elements 40 continue to glide along the slopes 42 until a final (open) position, in which the two adjacent flat sides of the spacer elements 40 form the only contact between the two contact elements 13a, 14a, is reached. This position representing the open position of the switch is shown in FIG. 5B, where the spacer elements 40 are in contact with the mutual flat faces while the conducting elements 16' are separated.

[0049] While some of the above described aspects apply strictly only when the spacer elements on neighboring contact elements are essentially identical and change accordingly when not identical, it is important to note that due to the larger combined lateral elevation, however achieved, of the spacer elements the conducting elements are separated in axial direction while already or still partially overlapping in displacement direction D.

[0050] It will be appreciated that the two adjacent contact elements 13a, 14a are in contact throughout the complete travel between open and closed positions. In the closed state the contact is provided by the conducting elements 16. In the open state and during most of the transition or travel between open and closed position the contact is provided by the spacer elements 40. The sloping planes 42 on the spacer elements 40 ensure that the transition between open and closed state happens rapidly with either a late contact or an early separation through a movement in axial direction in combination with the displacement in displacement direction D such that the conducting elements 16 make either or lose contact along the flat faces and not after their respective edges have passed each other.

[0051] As each contact element has freedom to bend or flex axially, the slope or chamfer angle of the sloping face 42 is very acute (typically below 5°) so as to keep

the accelerating force in axial direction A on the contact elements and contact plates 33 of the terminals 8,9 as small as possible.

[0052] By keeping the difference between the combined maximal lateral extension of the conducting elements 16 and the combined maximal lateral extension of the spacers between two contact elements in the axial direction A small, a flexing movement of the contact elements in axial direction A can be minimized, even at the large acceleration in direction D (of about 3000g) prevalent at the switching of the mechanical switches for high voltage DC circuit breakers.

[0053] A full cross-section of a switch in the region of the contact elements in accordance with an example of the invention is shown in FIG. 6. There are shown six contact elements 13a, 13b, 13c, 14a, 14b, 14c between the two terminals 8, 9 of the switch. The conducting elements 16 and spacer elements 40 are mounted onto the contact elements. As already shown in Fig. 2, each terminal 8, 9 carries at its end a contact plate 32 forming a contact surface 33 contacting the conducting elements 16 of the adjacent contact elements 14a, 13c when the switch is in its first position. The contact plates 32 are mounted to the terminals 8,9 in axially displaceable manner, with springs 20 (not shown in FIG. 6) elastically urging the contact surface 33 against the conducting elements 16, thereby compressing the conducting elements 16 in their aligned state for better conduction.

[0054] When the switch changes from an open to a closed or from a closed position to an open position as described above referring to FIGs. 5, the conducting elements 16 of neighboring contact elements come into or lose contact with each other, as soon as the spacer elements 40 lose contact or come into contact, respectively, with each other.

[0055] The spacer elements 40 mounted on the contact elements 14a, 13c closest to the respective contact plates 32 of the terminals 8, 9 come into contact with the contact plate at a second recessed cam contact surface 33' of the contact plate 32. The angle at which the side of spacer elements engage with cam contact surface 33' is again acute (about 5°). In the open position and during most of the transition the pressure exerted by the contact plates 32 acts on the spacer elements 40. The spacer elements form an electrically insulating but force-transmitting path between the two contact plates 32 much like the conducting elements 16 provide an electrically conducting but force-transmitting path 34 as shown in FIG. 2 above.

[0056] With the spacer elements 40 taking the load from the conducting elements 16 during the transition between the first and second mutual position and in the second mutual position, any acceleration or flexing in axial direction A of the contact elements by the contact plates 32 and the springs 20 is minimized.

[0057] The point or line T at which a spacer elements 40 contacts the metal contact plate 32 is a triple point where a solid insulating material meets a metal material

and a gas or fluid. This triple point/line T is protected by locating the recessed cam contact surface 33' between the adjacent spacer element 40 and the contact plate 32 in a recess (compared with the more elevated contact surface 33 for the conducting elements 16). Thus the triple point T is less exposed to the electric field in the switch than the contact surface 33.

[0058] As shown in FIG. 6, in the example with the recessed contact point 33' the spacer elements 40 of the contact elements 14a, 13c have a larger lateral extension on the side facing a terminal 8, 9 than on the side facing the adjacent contact element 14a, 13c.

[0059] It is further to be noted that the location of the spacer elements can be in principle chosen freely along the length of the contact elements, even including the activation rods. However a position close to the conducting elements 16 as shown in the examples above is preferred as it reduces the lever over which the springloaded terminals 8, 9 can exert a bending force on the contact elements. For the same reason it is advantageous to use the spacer elements as pairs located on opposite sides of a conducting element and best with at least a part of the spacer element overlapping the conducting element on the contact element along the direction D as shown in the figures. However, spacer elements of adjacent contact elements need not be identical and in an extreme example one spacer element can bridge the entire gap between two contact elements and glide along a shaped contour on the carrier's surface.

[0060] To reduce the number of materials, the spacer elements are best not glued, welded, or screwed into the contact element but held solely by form fit which includes an interference fit and a snap fit provided by the undercuts with the resulting jaws locking the spacer element in place (see for example FIGs. 3A and 3B).

[0061] The spacer elements can be made of any robust insulating material, for example PEEK.

[0062] However with a suitable machinable or accurately cast material as base material for the contact elements, it can be also envisaged that the spacer elements are an integral, homogeneous part of the contact elements and appear just as locally thickened sections of the contact element, particularly of the carrier.

[0063] A switch with spacer elements as described above has applications for example in a high voltage circuit breaker as illustrated in the FIG. 5 and described in the accompanying text of US 2013/0098874. In such arrangement the switch is connected in series with solid state breakers and in parallel with a second set of solid state breakers.

[0064] While in the present description preferred embodiments of the invention are described, it should be noted that the invention is not limited to those and can be implemented in other ways within the scope of the following claims.

Reference numerals

[0065]

5	1: housing
	2: space
	3, 4: tube sections
	5: housing section
	6, 7: support insulators
10	8, 9: terminals
	10, 11: caps
	12: switching arrangement
	13a, 13b, 13c: first set of contact elements
	14a, 14b, 14c: second set of contact elements
15	15: insulating carrier part
	151, 152, 153: recesses, openings of the carrier
	16: conducting elements
	16': conducting elements in open position
	17: actuator rods
20	18: drive
	19: drive
	20: springs
	32: contact plate
	33: (elevated) contact surface
25	33': (recessed) cam surface
	34: conducting path
	40: spacer element
	41: slots on spacer element
	42: sloping plane on spacer element
30	

Claims

1. A high or medium voltage switch comprising
 - 35 a first terminal (8) and a second terminal (9),
 - a first set of contact elements (13a, 13b, 13c) and a second set of contact elements (14a, 14b, 14c) arranged between the first terminal (8) and the second terminal (9),
 - 40 at least one drive (18, 19) adapted to mutually displace the sets of contact elements (13a, 13b, 13c; 14a, 14b, 14c) along a displacement direction (D), wherein each contact element (13a, 13b, 13c; 14a, 14b, 14c) comprises an insulating carrier part (15)
 - 45 carrying at least one conducting element (16), and wherein in a first mutual position of said contact elements (13a, 13b, 13c; 14a, 14b, 14c) the conducting elements (16) of said contact elements (13a, 13b, 13c; 14a, 14b, 14c) form at least one conducting path
 - 50 (34) in an axial direction (A) between said first terminal (8) and said second terminal (9) in a direction transversally to said displacement direction (D), and wherein in a second mutual position of said contact elements (13a, 13b, 13c; 14a, 14b, 14c) the conducting elements (16) are mutually displaced and do not form said conducting path,
 - 55 **characterized in that** the contact elements (13a, 13b, 13c; 14a, 14b, 14c) are contour-guided to move

along a defined displacement path reducing or increasing the distance in axial direction between the conducting elements (16) of neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) during closing and opening of the switch.

2. The switch of claim 1, wherein the guiding contours are shaped such that a gap in the axial direction (A) between the conducting elements (16) of neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) is maintained while said conducting elements (16) of said neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) overlap partially in the displacement direction (D).
3. The switch of claim 1 or claim 2, wherein said first contact elements (13a, 13b, 13c) comprise first spacer elements (40) and second contact elements 14a, 14b, 14c) comprise second spacer elements (40) with the contours of the spacer elements (40) of neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) providing the contour guidance.
4. The switch of claim 3, wherein the spacer elements of neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) remain in contact with each other when the contact elements (13a, 13b, 13c; 14a, 14b, 14c) are in the second mutual position.
5. The switch of claim 3 or 4, wherein the spacer elements (40) of neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) are in contact while the conducting elements (16) of said neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) partially overlap along the displacement direction (D).
6. The switch of any of claims 3 to 5, wherein the combined maximum lateral extension of the spacer elements (40) between two neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c) in the axial direction (A) exceeds slightly the combined maximum lateral extension in the axial direction (A) of the conducting elements (16) between the same two neighboring contact elements (13a, 13b, 13c; 14a, 14b, 14c).
7. The switch of any of claims 3 to 6, wherein the spacer elements (40) are made of an insulating material.
8. The switch of any of claims 3 to 7, wherein the spacer elements (40) are made of a material different from the surrounding material of the contact elements (13a, 13b, 13c; 14a, 14b, 14c) and connected to the contact elements by a form fit.
9. The switch of claim 8, wherein the spacer element (40) has two aligned slots (41) on opposite sides and the contact element (13a, 13b, 13c; 14a, 14b, 14c)

has recesses (151) into which said spacer element (40) is mounted with a width of the slots (41) matching the thickness of the contact element.

10. The switch of any of claims 3 to 9, wherein in the second mutual position the spacer elements (40) form a force-transferring bridge between the first terminal (8) and the second terminal (9) maintaining a distance between the first terminal (8) and the second terminal (9) exceeding by a small amount the distance between the first terminal (8) and the second terminal (9) in the first mutual position.
11. The switch of any of claims 3 to 10, wherein each contact element (13a, 13b, 13c; 14a, 14b, 14c) comprises an elongated actuator rod (17) providing the connection between the drive (18, 19) and a carrier part (15) onto which the conducting elements (16) and the spacer elements (40) are mounted.
12. The switch of any of claims 3 to 11, wherein the spacer elements (40) on the contact element (13a, 13b, 13c; 14a, 14b, 14c) are located within the vicinity of the conducting element (16) on the same contact element (13a, 13b, 13c; 14a, 14b, 14c).
13. The switch of any of claims 3 to 12, wherein each conducting element (16) is arranged in a direction perpendicular to the axial direction (A) and perpendicular to the displacement direction (D) between two spacer elements (40) on the same contact element (13a, 13b, 13c; 14a, 14b, 14c).
14. The switch of any of claims 3 to 13, wherein in a transition between the first mutual position and the second mutual position and vice versa two neighboring spacer elements (40) on two neighboring contact element (13a, 13b, 13c; 14a, 14b, 14c) contact each other first at respective surfaces (42) each having an acute sloping angle of less than 10° with respect to the displacement direction (D).
15. The switch of any of claims 3 to 14, wherein the contact elements (13a, 14c) juxtaposed to the first terminal (8) and to the second terminal (9) carry spacer elements (40) having a larger lateral extension in the axial direction (A) towards the first terminal (8) and to the second terminal (9) than the conducting elements (16) on the same contact elements (13a, 14c) and contact a cam surface (33') of the first terminal (8) and the second terminal (9), respectively, with said cam surface (33') being recessed in the axial direction (A) compared to a contact surface (33) for contacting the conducting elements (16) on the same terminal (8, 9).
16. The switch of claim 15, wherein each terminal (8, 9) extends in axial direction (A) into the contact surface

(33) for contacting the conducting elements (16) and the recessed cam surface (33') for the spacer elements (40) on juxtaposed contact elements (13a, 14c), and wherein at least one terminal (8, 9) comprises a spring member (20) elastically urging the contact surface (33) of the terminal (8, 9) against the conducting elements (16) with the contact surface part (33) in the first mutual position and against the spacer elements (40) with the recessed cam surface (33') during transitions between the first and the second mutual position and/or in the second mutual position.

17. A current breaker comprising the switch of any of the preceding claims, said current breaker further comprising
- a primary branch and a secondary branch in parallel, at least one solid state breaker arranged in the primary branch,
 - a plurality of solid state breakers (arranged in series in the secondary branch,
 - wherein a number of solid state breakers in the secondary branch is larger than a number of solid state breakers in the primary branch, and wherein said switch is arranged in said primary branch in series to said solid state breaker of said primary branch.

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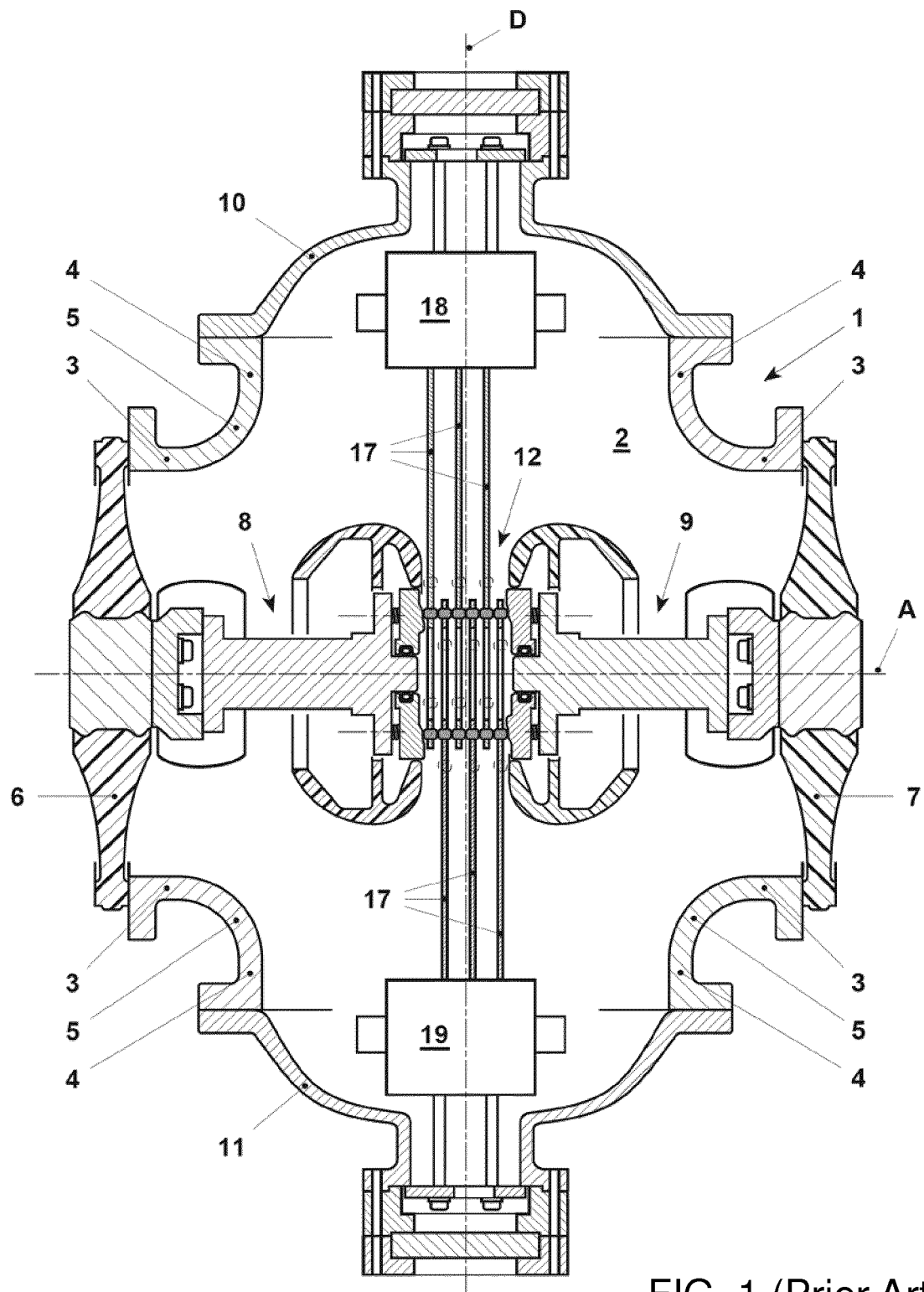
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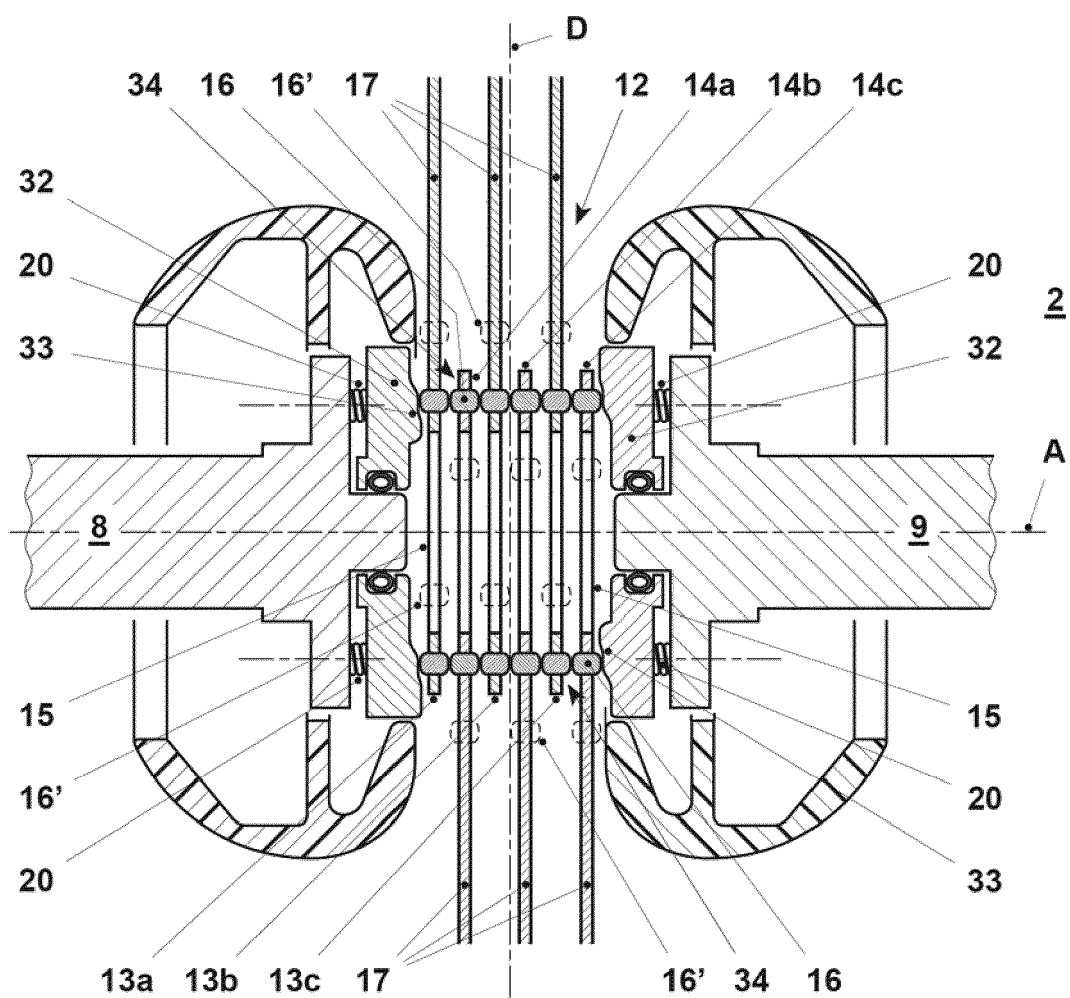
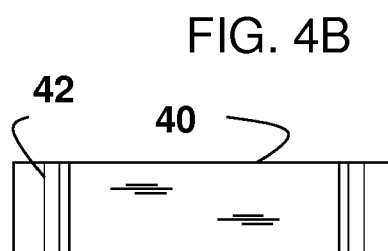
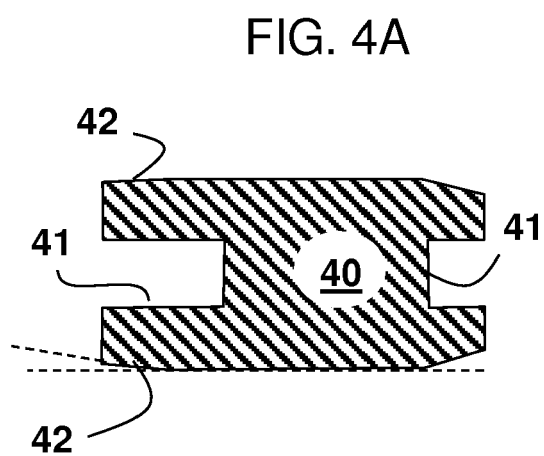
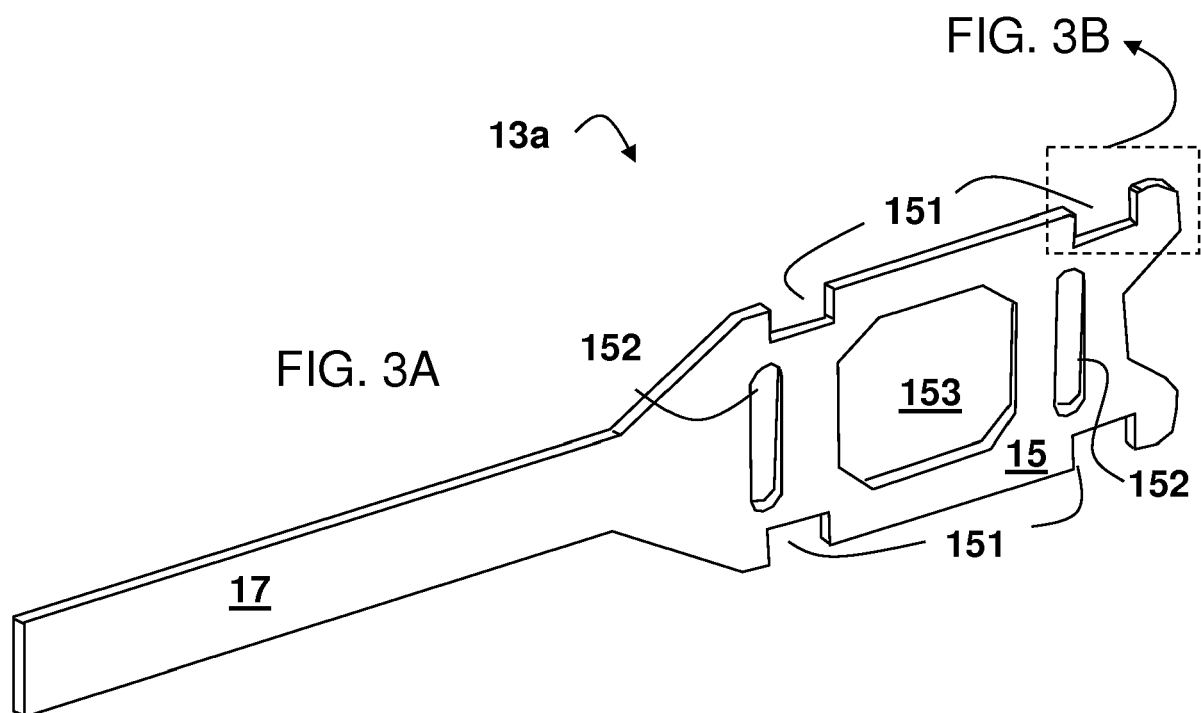


FIG. 2 (Prior Art)



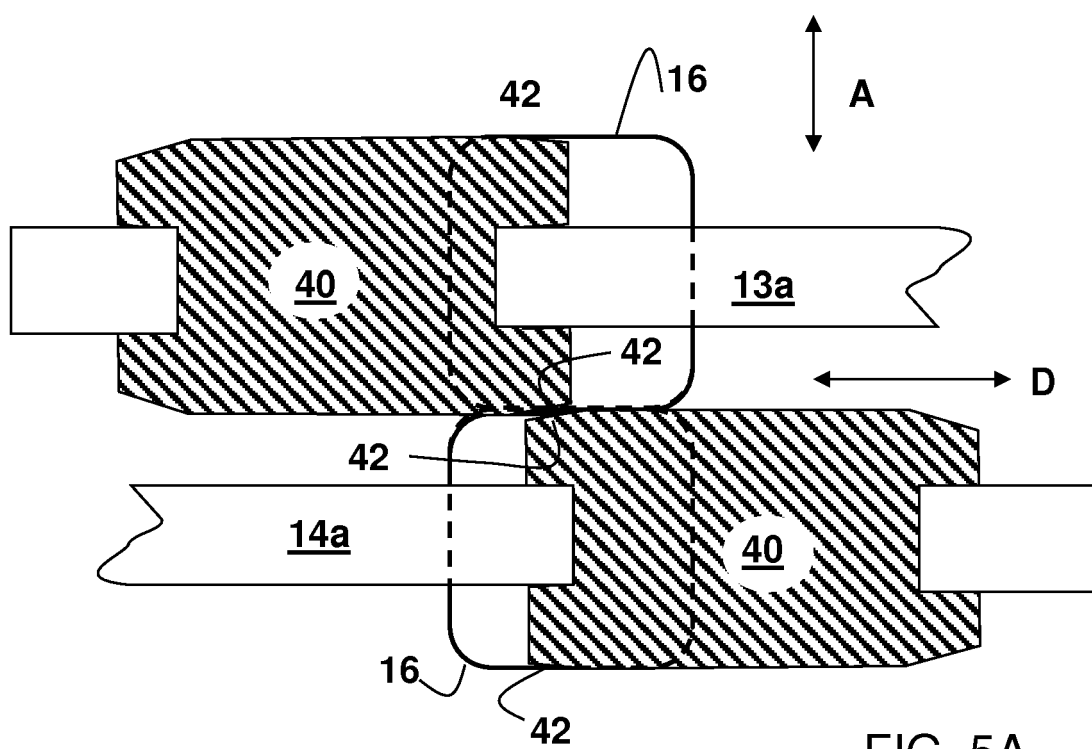
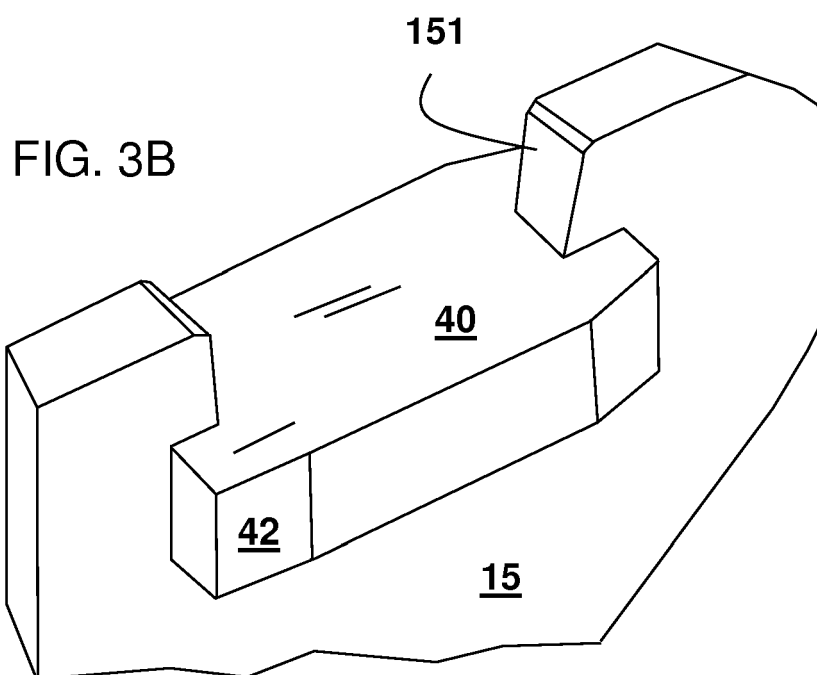


FIG. 5A

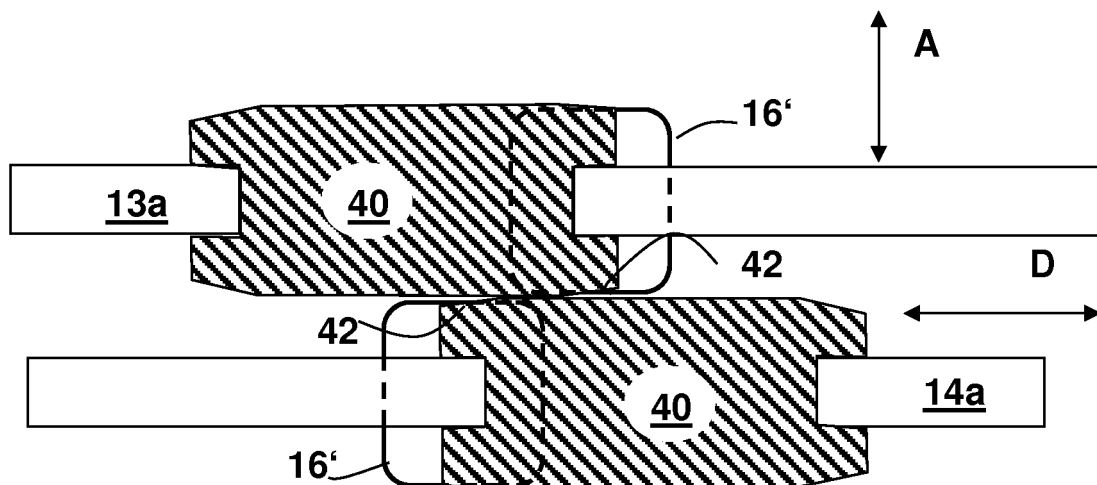


FIG. 5B

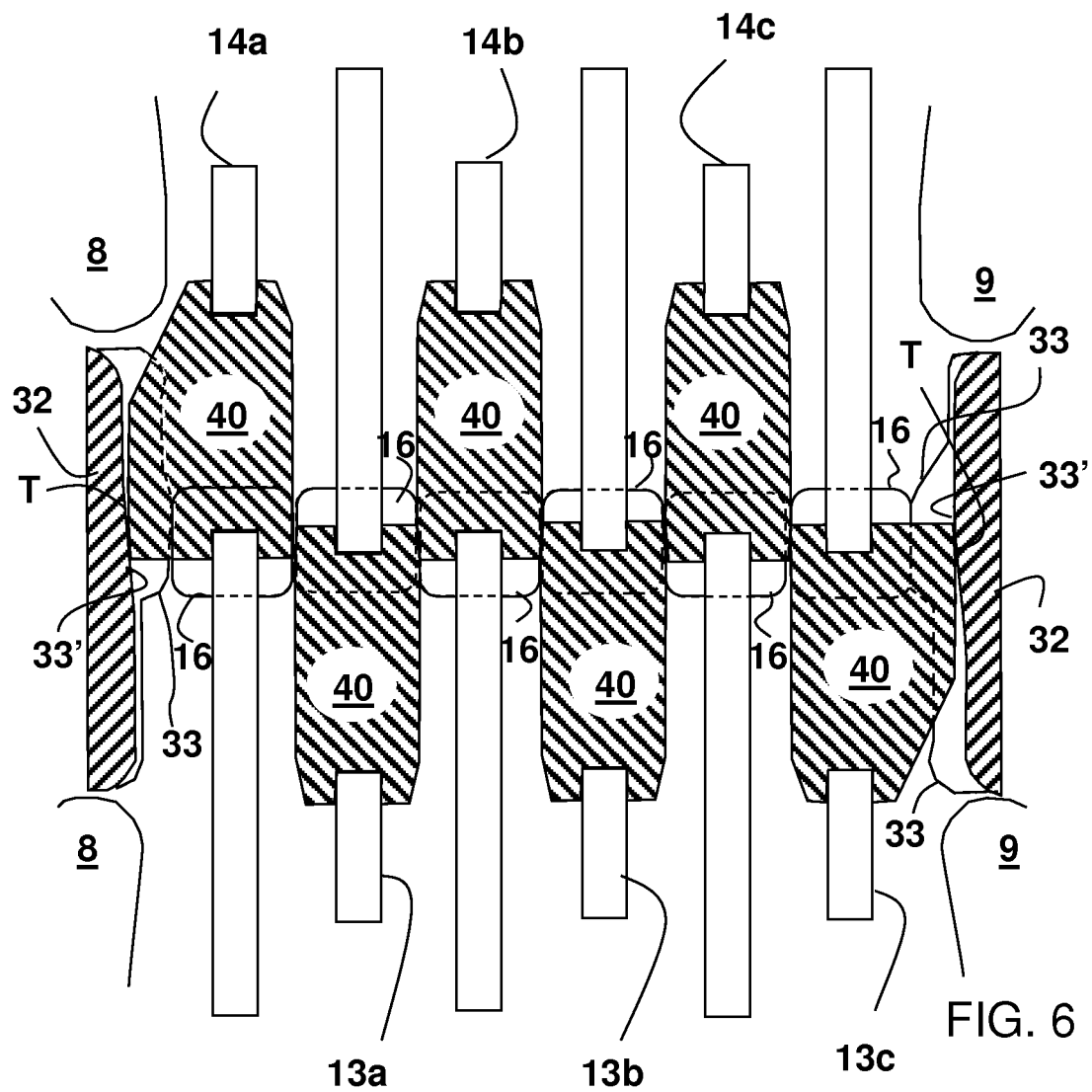


FIG. 6



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Place of search Munich		Date of completion of the search 4 April 2014	Examiner Glamann, C
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