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(54) **CONTACT ASSEMBLY CONFIGURED FOR A LOAD BREAK SWITCH, LOAD BREAK SWITCH AND METHOD FOR CLOSING A CIRCUIT PATH OF A CONTACT ASSEMBLY**

(57) A contact assembly (1) configured for a load break switch (7), a load break switch (7) including the contact assembly (1), and a method for closing a circuit path of a contact assembly (1). The contact assembly (1) includes a stationary contact unit (10) and a movable contact unit (20), wherein the movable contact unit (20) is configured to move between an open position and a closed position via an in-

termediate position, and the stationary contact unit (10) is configured, in the intermediate position or closed position, to generate an electromagnetic closing force (50) acting on the movable contact unit (20) with the electromagnetic closing force (50) being directed at least partly in the direction of the closed position.

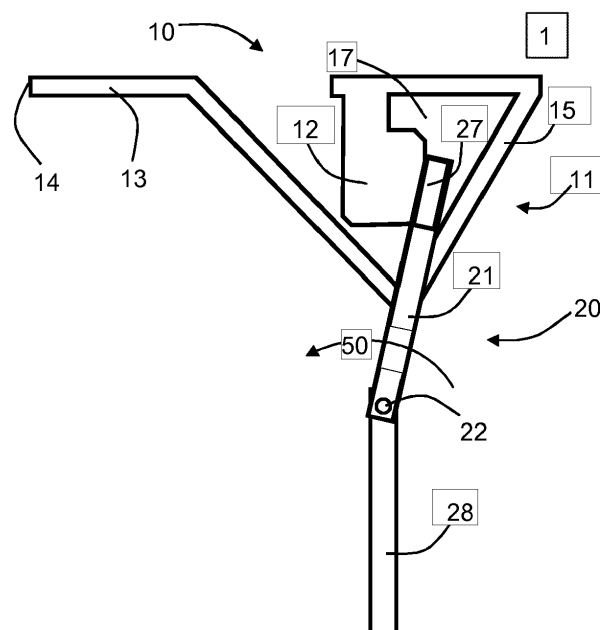


Fig. 2a

Description

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to a contact assembly configured for a load break switch, particularly for closing and/or opening a load break switch, a load break switch, particularly a medium voltage load break switch, including the contact assembly, and a method for closing a circuit path of a contact assembly configured for a load break switch.

BACKGROUND

[0002] A load break switch used in a medium voltage power distribution range circuit generally includes a pair of electrodes, one being stationary and the other being movable to open and close the circuit. When closing the switch, when the magnitude of the gap between the electrodes reaches or falls below a certain value, a current-carrying arc is generated between the electrodes. In such a load break switch, the arc acts on the electrodes due to the consequences of the arc current flowing through the load break switch, increasing the erosion effect on the electrodes, and increasing the mechanical stress on the load break switch when a mechanical force is applied to the movable electrode to close the load break switch.

[0003] Accordingly, it would be beneficial to improve the structure of the switch or switch electrodes in such a way as to facilitate the closing movement, reduce arc damage and, at the same time, arrange the required elements while making efficient use of the space available in a switch and ensuring safe and smooth operation.

SUMMARY

[0004] According to an aspect of the present disclosure, a contact assembly configured for a load break switch is provided. The contact assembly includes a stationary contact unit and a movable contact unit. The movable contact unit is configured to move between an open position and a closed position via an intermediate position. The stationary contact unit is configured, in the intermediate position or closed position, to generate an electromagnetic closing force acting on the movable contact unit with the closing force being directed at least partly in the direction of the closed position.

[0005] According to another aspect of the present disclosure, a load break switch, particularly a medium voltage load break switch, is provided. The load break switch includes the contact assembly that particularly is configured to close and/or to open the load break switch.

[0006] According to another aspect of the present disclosure, a method for closing a circuit path of a contact assembly of a load break switch is provided. The contact assembly includes a stationary contact unit and a movable contact unit adapted to provide a galvanic contact to the stationary contact unit. The method includes:

moving the movable contact unit, in closing movement, from an open position, in which no current flows through the contact assembly, to an intermediate position, in which an arc current flows through the contact assembly;

generating, by means of the arc current flowing through the stationary contact unit, an electromagnetic closing force on the movable contact unit in the direction of the closing movement, to support the closing movement of the movable contact unit; and moving the movable contact unit from the intermediate position to a closed position, in which the stationary contact unit and the movable contact are galvanically connected.

[0007] The contact assembly, the load break switch and the method of the present disclosure provide a concept for facilitating the closing movement, reducing the arc damage and arranging the elements of the load break switch while making efficient use of the space available in the switch and ensuring safe and smooth operation.

[0008] Further aspects, advantages and features of the present disclosure are apparent from the dependent claims, the description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the present disclosure, briefly summarized above, may be had by reference to typical embodiments. The accompanying drawings relate to embodiments of the present disclosure and are described in the following:

Fig. 1 shows a schematic side view of a contact assembly known from prior art;

Fig. 2a shows a schematic side view of a contact assembly configured for a load break switch according to embodiments described herein;

Fig. 2b shows schematically significant positions of the movable contact unit of Fig. 2a during the closing movement, according to embodiments described herein;

Fig. 2c shows a time-dependent diagram of the remaining travel distance of the contact area of the movable contact unit to an end position at the end of the closing movement in the positions of Fig. 2b, according to embodiments described herein;

Fig. 2d shows a perspective 3D view of an electromagnetically active section of the stationary contact unit of Fig. 2a according to embodiments described herein;

Fig. 2e shows a perspective 3D view of the contact assembly of Fig. 2a according to embodiments described herein;

Fig. 2f shows a 3D side view of the contact assembly of Fig. 2a according to embodiments described herein;

Fig. 3 shows a schematic side view of a contact assembly known from prior art;

Fig. 4a shows a schematic side view of a contact assembly configured for a load break switch according to embodiments described herein;

Fig. 4b shows a schematic side view of a contact assembly configured for a load break switch according to embodiments described herein;

Fig. 4c shows a perspective 3D view of the contact assembly of Fig. 4a according to embodiments described herein;

Fig. 4d shows a 3D side view of the contact assembly of Fig. 4a according to embodiments described herein;

Fig. 5 shows a schematic side view of a load break switch according to embodiments described herein;

Fig. 6 shows a flowchart of a method for closing a circuit path of a contact assembly configured to close and/or to open a load break switch according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0010] Reference will now be made in detail to the various embodiments of the present disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to the same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation and is not meant as a limitation of the present disclosure. Features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

[0011] The present invention relates to a contact assembly configured for a load-break switch particularly adapted for use in medium voltage power distribution systems. Correspondingly, the contact assembly as disclosed herein is typically a medium voltage contact assembly. The load-break switch as used herein is typically a medium voltage load-break switch. As used herein, the medium voltage can be understood as the range of be-

tween 1 kilo-voltas (kV) and 72 kV, more specifically as the range of 1 to 52 kV, especially at most to 42 kV for peak currents of up to about 100 kilo-amperes (kA).

[0012] Figs. 1, 3 show schematic side views of contact assemblies 100 known from prior art. Each contact assembly 100 includes a pair of electrodes 110, 120, one electrode 110 being stationary and the other electrode 120 being movable to open and close a circuit. The stationary electrode 110 is attached to a feed line 113. The movable electrode 120 is rotatably attached to a feed line 128 and is configured to move from an open position to a closed position. When the movable electrode 120 has sufficiently approached the stationary electrode 110, a current-carrying arc is generated between the electrodes 110, 120 due to the medium voltage applied.

[0013] The feed lines 113, 128 of the contact assembly 100 shown in Fig. 1 are arranged perpendicular to each other. The feed lines 113, 128 of the contact assembly 100 shown in Fig. 3 are parallel to each other.

[0014] The arc current flowing through the electrodes 110, 120 generates a Lorentz force 150 opposing the closing movement of the movable electrode 110, which is a counter-closing force. The force 150 slows down or inhibits the closing movement and causes a higher erosion of the electrodes due to the high temperature of the arc in combination with the slower closing movement and the longer time the arc has an effect on the electrodes.

[0015] The electromagnetic counter-closing force 150 also causes the contact assembly 100 to be subjected to considerable mechanical stress, since a higher mechanical closing force must be applied to overcome the electromagnetic counter-closing force 150 and to allow the closing movement to be performed.

[0016] Figs. 2a, 4a show schematic side views of contact assemblies configured for a load break switch. Details explained with illustrative reference to Figs. 2a, 4a shall not be understood as limited to the elements of Figs. 2a, 4a. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0017] According to embodiments described herein, the contact assembly 1 configured for a load break switch, especially for closing and/or opening the load break switch, may include a stationary contact unit 10 and a movable contact unit 20. The movable contact unit 20 may be configured to move between an open position and a closed position via an intermediate position. The stationary contact unit 10 may be configured, in the intermediate position or closed position, to generate an electromagnetic closing force 50 acting on the movable contact unit 20 with the closing force 50 being directed at least partly in the direction of the closed position.

[0018] Herein, the indication of positions (i.e., open, intermediate or closed) refers to positions of the movable contact unit. The direction towards the closed position is defined by the direction of movement of the movable contact unit 20, in particular of the contact area 27 of the movable contact unit 20, from the open position to the

closed position.

[0019] If the closed position is a single position of the movable contact unit 20, such as in the case of a single contact between the movable contact unit 20 and the stationary contact unit 10, the "direction of the closed position" can be understood as the direction towards the position of the single contact. The movable contact unit is moved in this direction during the closing movement.

[0020] If the closed position includes a range of positions of the movable contact unit 20, such as in the case of a sliding contact 16 between the movable contact unit 20 and the stationary contact unit 10, the "direction of the closed position" can be understood as direction towards an end position of the closing movement of the movable contact unit. The end position may be defined by a stopper or projection in one end portion of the stationary contact unit 10 determining the end of the closing movement of the movable contact unit 20.

[0021] According to embodiments described herein, the contact assembly 1 may include an actuator 72 for exerting a mechanical closing force 50 to the movable contact unit 20.

[0022] The movable contact unit 20 and the stationary contact unit 10 can include or be made of an electrically conductive material, in particular a metal such as copper, copper alloy, aluminum or the like. The closing movement of the movable contact unit 20 may be effected by the action of a mechanical closing force, which in particular may be exerted by means of the actuator 72 connected to the movable contact unit 20 of contact assembly 1.

[0023] As soon as the movable contact unit 20, coming from the open position and moving under the action of the mechanical closing force in the closing direction, reaches the intermediate position so that an arc is created and an arc current begins to flow, the electromagnetic closing force 50 may begin to act, thereby increasing the speed of the closing movement of the movable contact unit 20. In addition, a mechanical closing force may be applied. By applying the mechanical closing force 73 (Fig. 5), which may be constant over time, the movable contact unit 20 moves through the intermediate position faster as compared to the prior embodiment (Fig. 1), thus reducing the time the arc has an effect on the electrodes and the erosive effect of the arc on the contact units 10, 20 and their erosion.

[0024] In contrast to the prior technique (Figs. 1, 3), wherein the electromagnetic force 150 constitutes a closing counterforce, in the present case the electromagnetic force 50 is a closing force which supports the closing movement, reduces the mechanical closing force necessary to execute the closing movement and thus advantageously reduces the mechanical load on the contact assembly 1 and its abrasion.

[0025] In some situations, the problem related to the mechanical load on the contact assembly 1 may be even more critical, for example when a fault current is superimposed. In this case, the current flowing through the contact assembly 1 may increase, particularly in the in-

termediate position and/or the closed position. With high currents also high electromagnetic forces are generated. In the known technology (Figs. 1, 3), the higher electromagnetic forces were directed against the closing movement of the movable contact unit. This caused a slower closing process, and due to this slower closing process, the closing took longer which implied that the arc affected the contacts for a longer time period, leading to damage at the contacts. With the present concept of having the electromagnetic closing force 50, the electromagnetic force is applied in the direction of the closing movement, thus resulting in a shorter closing time. A shorter closing time implies that the arc has less time to affect the contacts of the contact assembly, and so the damage to the contacts can advantageously be considerably reduced as compared to the known technologies.

[0026] According to embodiments described herein, the open position can be characterized by no electrical current flowing through the contact assembly 1 when a voltage is applied between the movable contact unit 20 and the stationary contact unit 10. An electrical current flowing through the contact assembly 1 can be an arc current, if the movable contact unit 20 and the stationary contact unit 10 are spaced from each other, the distance at which the contact units are spaced being small enough to allow an arc to establish between the two contact units. Alternatively, the electrical current flowing through the contact assembly 1 can be a galvanic current, if the movable contact unit 20 and the stationary contact unit 10 are not spaced from each other, particularly if they are galvanically connected to each other.

[0027] The closed position can be characterized by the movable contact unit 20 and the stationary contact unit 10 being galvanically connected. In the closed position, the movable contact unit 20 can be in motion, particularly with a sliding contact 16 (see Figs. 2e, 2f, 4c) between the movable contact unit 20 and the stationary contact unit 10. Particularly, the movable contact unit 20 can be at standstill in the closed position, especially with a non-sliding contact between the contact units, in which an electrical galvanic connection is achieved in a motionless end position of the movable contact unit 20.

[0028] The intermediate position, which can be viewed as a transit position of the movable contact unit 20 from the open position to the closed position, can be characterized by an electrical current flowing through the contact assembly 1, wherein:

- i) the electrical current may be an arc current, which can be a result of an arc between the stationary contact unit 10 and the movable contact unit 20, especially between a contact area 12 of the stationary contact unit 10 and a contact area 27 of the movable contact unit 20, or
- ii) the stationary contact unit 10, especially the contact area 12 of the stationary contact unit 10, may not be galvanically connected to the movable contact unit 20, or is spaced from the movable contact unit

20, especially the contact area 27 of the movable contact unit 20.

[0029] In view of the transitional position in which the movable contact unit 20 is in the closing movement and is separated from the stationary contact unit 10 and from the closed position only by a short distance, the transitional position may be referred to as an almost closed position.

[0030] According to embodiments described herein, the stationary contact unit 10 can be configured to support a closing movement of the movable contact unit 20 enabling the movable contact unit 20 to transit from the intermediate position to the closed position, particularly by means of the electromagnetic closing force 50 acting on the movable contact unit 20. The functional feature of the stationary contact unit 10 of supporting the closing movement of the movable contact unit 20 may be related to several structural features of the stationary contact unit 10 or the contact assembly 1.

[0031] Said structural features may enable the stationary contact unit 10 to generate, when carrying an electrical current, an electromagnetic closing force 50 to assist the closing movement of the movable contact unit 20. The structural features may include, for example, a geometric shape of the stationary contact unit 10, an electrical conductivity of the constituent material, a temperature and/or technical parameters of the medium surrounding the stationary contact unit 10.

[0032] The stationary contact unit 10 may include an electromagnetically active section 11 configured to generate, when carrying an electrical current, the electromagnetic closing force 50. The design of the electromagnetically active section 11 enabling the section to generate, when carrying an electrical current, the electromagnetic closing force 50 may relate to a geometric shape of the section, an electrical conductivity of the constituent material, a temperature and/or technical parameters of the medium surrounding the stationary contact unit 10.

[0033] The stationary contact unit 10, particularly the electromagnetically active section 11, may include a stationary contact area 12 for establishing electrical, particularly galvanic, contact with the movable contact unit 20. Particularly, the movable contact unit 20 may include a movable contact area 27 for establishing electrical, particularly galvanic, contact with the stationary contact unit 10. The contact area 12 of the stationary contact unit (also called "stationary contact area") and the contact area 27 of the movable contact unit (also called "movable contact area") may be operatively coupled to each other at a single position or in a sliding manner.

[0034] A single contact can mean that the operatively coupled elements (stationary contact unit 10, movable contact unit 20) have galvanic contact with each other in a single position of the movable contact unit 20. The closed single contact can be reopened. A sliding contact means that the operatively coupled elements are in galvanic contact with each other in a multitude of positions;

the elements are thus slidably connected to each other galvanically. The closed sliding contact can be reopened.

[0035] A sliding contact 16 as used herein is illustrated in the three-dimensional views of Figs. 2e, 2f, and 4c, therein denoted with reference number 16. The sliding contact 16 may have stationary and movable contact areas 12, 27, as exemplified in Figs. 2a, 4a. In particular, the stationary contact area 12 may have an electrically conductive flat surface; and/or the movable contact area 27 may have either an electrically conductive flat surface or an electrically conductive projection. The facing surfaces of the contact areas 12, 27 can be parallel to each other.

[0036] The contact assembly 1 may include a first feed line 13 for electrically connecting the stationary contact unit 10 to an external power circuit such as a power circuit at a first end 14 of the first feed line 13, wherein the first feed line 13 has a second end connected to the stationary contact unit 10 and opposite the first end 14. The contact assembly 1 may also include a second feed line 28 for electrically connecting the movable contact unit 20 to the external power circuit. The first end 14 of the first feed line 13 may be directed to the external circuit.

[0037] The orientation and the arrangement of the first and/or second feed lines can be designed as a function of the space conditions in the load break switch 7 or circuit to which the feed lines are leading. Accordingly, the first feed line 13 and the second feed line can be perpendicular to each other, as shown in the contact assembly 1 of Fig. 2a, or can be angled with an angle greater than 45° and less than 135°. Alternatively, the first feed line 13 and the second feed line can be arranged parallel to each other, as shown in the contact assembly 1 of Fig. 4a.

[0038] When carrying an electrical current, the electromagnetically active section 11 of the stationary contact unit 10 can be configured to generate the electromagnetic closing force 50 acting on the movable contact unit 20. Especially, the electromagnetically active section 11 can be configured to direct the electromagnetic closing force 50 and/or the closing movement of the movable contact unit 20 towards the first end 14 of the first feed line 13.

[0039] The electromagnetically active section 11 may have a geometric shape of a loop, particularly of an open loop. The loop can be shaped as a circle, ellipse or as a polygon with at least three, especially three or four, corners. For example, the loop of Fig. 2a may have the shape of a triangle (an upside down delta), and the loop of Fig. 4a may have the shape of a square.

[0040] The loop 11 shaped as described allows it, when it is powered by an electric current, to direct the electromagnetic closing force 50, especially the closing movement, to the first end 14 of the first feed line 13.

[0041] The orientation of the electromagnetic closing force 50, especially the closing movement, towards the first end 14 of the first feed line 13, provides the technical effect to allow arranging or placing the actuator 72, which provides a mechanical closing force to the movable con-

tact unit, in a space that is not heavily used, especially in a space in which the first or second feed line is not located, in particular in a space opposite the space occupied by the first feed line 13.

[0042] The present contact assembly 1 can also solve a problem that could arise if, starting from the known devices (Fig. 1, 3), an attempt is made to generate an electromagnetic force in the closing direction by means of structural adaptations. Such a structural adjustment could include, for example, allowing the movable contact unit to move from the other side of the closed position to the stationary contact unit so that the movement is made in the direction of the electromagnetic force.

[0043] However, such an arrangement would be problematic in that a mechanical force would have to act on the movable contact unit, wherein the actuator 72 for generating the mechanical force would have to be located in an area of space already occupied by other elements, for example by at least one feed line. This would create a safety, design and operating problem.

[0044] The orientation of the electromagnetic closing force 50, especially the closing movement, towards the first end 14 of the first feed line 13, solves the above problem.

[0045] According to embodiments, the movable contact unit, at the intermediate position, is located in the inner region 17 of the loop 11. At this position the arcing typically starts, and due to the positioning in the inner region 17 of the loop 11, the electromagnetic force will push the contact towards the closed position.

[0046] In particular embodiments, in the intermediate position, a first line segment 15 of the polygon and the movable contact unit 20 can be arranged parallel or substantially parallel to each other. Substantially as used in this context should include a deviation of ± 20 degrees. Currents flowing opposite to each other can be conducted in the first line segment 15 of the polygon and the movable contact unit 20. According to Ampère's force law, conductors flowed through in this way repel each other. This allows achieving the technical effect of generating an electromagnetic closing force 50 that assists the closing movement of the movable contact unit 20 and/or that is directed towards the first end 14 of the first feed line 13.

[0047] With the loop 11 shown in Fig. 2a having the shape of a triangle (upside down delta), the maximum attracting force 50 applies when the movable contact unit 20 enters the intermediate position. With the loop 11 shown in Fig. 4a having the shape of a square, the maximum attracting force 50 applies when the movable contact unit 20 comes to an end of the closed position. Thus, depending on the desired technical effect, an adequate shape of the loop can be used.

[0048] Particularly, in the intermediate position, the contact area 27 of the movable contact unit 20 can be arranged in an inner region 17 of the loop 11 or between the first line segment 15 of the polygon and the contact area 12 of the stationary contact unit 10, in particular as

seen from a viewing point on an axis perpendicular to a plane of the loop 11 ("side view", as also illustrated in the figures). The magnetic field lines generated by the loop 11 are perpendicular to the plane of the loop 11 and act on the movable contact unit 20 in such a way that a Lorentz force or electromagnetic force 50 is generated which is directed towards the first end 14 of the first feed line 13 and/or assisting the closing movement of the movable contact unit 20, thus acting as an electromagnetic closing force 50.

[0049] The stationary contact unit 10, especially the electromagnetically active section 11, can be configured, in the intermediate or closed position, to generate the electromagnetic closing force 50 by means of an electric current, especially an arc current, flowing through the electromagnetically active section 11. This effect may be enabled by the loop 11 form of the electromagnetically active section 11 and/or by the position of the movable contact unit 20 with regard to the loop 11, particularly to the first line segment 15 of the polygon of the loop 11.

[0050] As shown in Figs. 2a, 4a, the movable contact unit 20 may include a rotatable or pivotable element 21. The pivotable element 21 can be mounted pivotably or rotatably about a pivot point 22 or rotation point in the closing direction. In embodiments not shown, the pivot point is located somewhere between the ends of the movable contact unit, e.g. substantially in the middle.

[0051] The contact area 27 of the movable contact unit 20 can move when the pivotable element 21 is pivoted in a bow-shaped path. This design allows the movable contact unit 20 to be easily closed and/or closed with low mechanical force that particularly can be exerted by an actuator 72 of the stationary contact unit 10.

[0052] Fig. 4b shows a schematic side view of a contact assembly 1 configured for a load break switch with an alternative design to the contact assemblies of Figs. 2a, 4a. Details explained with illustrative reference to Fig. 4b shall not be understood as limited to the elements of Fig. 4b. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0053] As shown in Fig. 4b, the movable contact unit 20 can be in the form of an L-shaped element 23. The L-shaped element 23 may include a supporting leg 24 which can be electrically connected at one first end 14 of the supporting leg 24 to the second feed line in a sliding manner, in particular via a sliding contact. Particularly, the L-shaped element 23 may include a connecting leg 25 especially having a contact area 27 of the movable contact unit 20 at one first end of the connecting leg 25. The contact area 27 of the movable contact unit 20 can be configured for establishing electrical contact with the contact area 12 of the stationary contact unit 10 in the closed position. The electrical contact of the two contact areas 12, 27 can be established by axially displacing the movable contact unit 20 relative to the second feed line in the closing direction.

[0054] Fig. 2b shows schematically significant posi-

tions of the movable contact unit 20 of Fig. 2a during the closing movement, and Fig. 2c shows a time-dependent diagram of the remaining travel distance 55 of the contact area of the movable contact unit 20 to an end position at the end of the closing movement in the positions of Fig. 2b. Details explained with illustrative reference to Figs. 2b, 2c shall not be understood as limited to the elements of Figs. 2a, 4a. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0055] The significant positions P0-P3 shown in Fig. 2b indicate movement stages of the movable contact unit 20. For the sake of clarity, it is assumed that the closing movement of the movable contact unit 20 is carried out at a constant speed, which can be different depending on the position. The speed can also be variable, which is not illustrated.

[0056] The positions of the movable contact unit 20 (open and closed positions, intermediate position) can each affect a large number of instantaneous positions of the movable contact unit 20 during the closing movement. Therefore, the open position, intermediate position and closed position can each be viewed as position ranges.

[0057] P0 indicates a stage at which the movable contact unit 20 is in an open position.

[0058] P1 indicates a stage at which the movable contact unit 20 enters the intermediate position.

[0059] P2 indicates a stage at which the movable contact unit 20 exits the intermediate position and enters the closed position.

[0060] P3 indicates a stage at which the movable contact unit 20 comes to the end of the closing movement and to the end of the closed position.

[0061] The positions P0 to P3 of Fig. 2b are reached at the times T0 to T3 of Fig. 2c. Depending on the mentioned timing and positions, the movable contact unit 20 goes through three phases of movement.

[0062] In phase 1, in the range T0-T1, P0-P1, the movable contact unit 20 is in an open position, so that no current flows through the contact assembly 1. In this phase, the movable contact unit 20 starts performing the closing movement. The distance between the contact areas 27, 12 of the movable and the stationary contact unit 10, referred to as contact gap, is proportional to the remaining travel distance 55. In this phase, the contact gap or remaining travel distance 55 is large enough so that no arc is generated between movable contact unit 20 and stationary contact unit 10.

[0063] In phase 2, in the range T1-T2, P1-P2, the movable contact unit 20 enters the intermediate position or almost closed position. In this phase, the movable contact unit 20 keeps on performing the closing movement and is close to the stationary contact unit 10. The contact gap is small, but not zero, so that there is no galvanic contact between the movable and the stationary contact unit 10. Due to the small contact gap, an arc is generated between the movable and the stationary contact unit 10

and arc current flows via the arc.

[0064] In phase 3, in the range T2-T3, P2-P3, the movable contact unit 20 enters the closed position. In this phase, the movable contact unit 20 keeps on performing the closing movement (the contact between the contact units can be a sliding contact). The contact gap is zero, so that there is a galvanic contact between the movable and the stationary contact unit 10. No arc exists between the contact units, and an electric galvanic current flows through the contact assembly 1.

[0065] At the end of phase 3, at time T3 and in position P3, the movable contact unit 20 stops performing the closing movement, and the travel distance 55 becomes zero.

[0066] Fig. 2d shows a perspective 3D view of an electromagnetically active section of the stationary contact unit of Fig. 2a, Fig. 2e shows a perspective 3D view of the contact assembly of Fig. 2a, and Fig. 2f shows a 3D side view of the contact assembly of Fig. 2a. Details explained with illustrative reference to Figs. 2d-2f shall not be understood as limited to the elements of Figs. 2d-2f. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0067] As shown in Figs. 2d-2f, the loop 11 of stationary contact unit 10 may be strip-shaped, having a width, thickness, and length, wherein the width is greater than the thickness by a factor of 5, 10, 20, or 50, and the length is greater than the width by a factor of 5, 10, 20, or 50. Alternatively, the loop 11 of stationary contact unit 10 may be designed as a rod with a round, circular, ellipsoid or polygonal cross-section. The rod may have a length and a cross-sectional dimension, such as cross-sectional width or diameter, wherein the length is greater than the cross-sectional dimension by a factor of 5, 10, 20 or 50. The loop 11 may be curved or bent about a loop axis, with a coordinate along the width parallel to the loop axis. The loop 11 can be mechanically and electrically connected to the first feed line 13 and/or the stationary contact unit 10 via a releasable joint, in particular a screwed joint.

[0068] The embodiments shown in Figs. 2d-2f are 3D illustrations of the contact assembly 1 of Fig. 2a. These illustrations are intended to give the viewer a clear idea of the device shown in Fig. 2a. Among others, the sliding contact 16 between the contact units 1, 20 is shown in Fig. 2e, 2f, and in Fig. 2f an outgoing line feed 29 leading to an external circuit is shown.

[0069] Further, Fig. 4c shows a perspective 3D view of the contact assembly of Fig. 4a and Fig. 4d shows a 3D side view of the contact assembly of Fig. 4a. Details explained with illustrative reference to Figs. 4c, 4d shall not be understood as limited to the elements of Figs. 4c, 4d. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0070] The embodiments shown in Figs. 4c, 4d are 3D illustrations of the contact assembly 1 of Fig. 4a. These

illustrations are intended to give the viewer a clear idea of the device shown in Fig. 4a.

[0071] As shown in Figs. 4c, 4d, the loop 11 of stationary contact unit 10 may be designed as a rod with a round, circular or polygonal cross-section. The rod may have a length and a cross-sectional dimension, such as cross-sectional width or diameter, wherein the length is greater than the cross-sectional dimension by a factor of 5, 10, 20 or 50. The loop 11 can be mechanically and electrically connected to the first feed line 13 and/or the stationary contact unit 10 via a releasable joint, in particular a screwed joint.

[0072] Fig. 5 shows a schematic side view of a load break switch. Details explained with illustrative reference to Fig. 5 shall not be understood as limited to the elements of Fig. 5. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0073] The load break switch 7 of Fig. 5 may include a contact assembly 1 configured for closing and/or opening the load break switch 7. The contact assembly 1 and other components of the load break switch 7 may be arranged in a space 71 dedicated to or occupied by the load break switch 7. This space 71 is symbolically marked in Fig. 5, but can also practically be implemented as a housing.

[0074] The load break switch 7 may include an actuator 72, such as an electric or hydraulic actuator. The actuator may also be designed as a handle rigidly connected to the movable contact unit 20. When the actuator 72 causes a rotation by exerting a mechanical force 73, the movable contact unit 20 can be moved from the open position to the closed position or vice versa.

[0075] Fig. 6 shows a flowchart of a method for closing a circuit path of a contact assembly configured to close and/or to open a load break switch. Details explained with illustrative reference to Fig. 6 shall not be understood as limited to the steps or elements of Fig. 6. Rather, those details may also be combined with further embodiments explained with illustrative reference to the other figures.

[0076] The load break switch 7 used to carry out the method may include a stationary contact unit 10 and a movable contact unit 20 adapted to provide a galvanic contact to the stationary contact unit 10. As shown in Fig. 6, the method for closing the circuit path of the contact assembly 1 configured to close and/or to open the load break switch 7 may include the following steps s1 to s4.

[0077] Step s1 may include moving the movable contact unit 20, in closing movement, from an open position, in which no current flows through the contact assembly 1, to an intermediate position, in which an arc current flows through the contact assembly 1.

[0078] Step s2 may include generating, by means of the arc current flowing through the stationary contact unit 10, an electromagnetic closing force 50.

[0079] Step s3 may include applying the electromagnetic closing force 50 on the movable contact unit 20 in the direction of the closing movement, to support the closing

movement of the movable contact unit 20.

[0080] Step s4 may include transiting the movable contact unit 20 from the intermediate position to a closed position, in which the stationary contact unit 10 and the movable contact are galvanically connected, by continuing the closing movement.

[0081] This written description uses examples to disclose the disclosure, including the best mode, and also to enable any person skilled in the art to practice the described subject-matter, including making and using any apparatus or system and performing any incorporated methods. Embodiments described herein provide an improved contact assembly, load break switch and method for closing a circuit path of a contact assembly, wherein closing movement is facilitated, arc damage is reduced and arranging the elements of the load break switch is improved while making efficient use of the space available in the switch and ensuring safe and smooth operation. While various specific embodiments have been disclosed in the foregoing, mutually non-exclusive features of the embodiments described above may be combined with each other. The patentable scope is defined by the claims, and other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

Claims

1. A contact assembly (1) configured for a load break switch (7), the contact assembly (1) including a stationary contact unit (10) and a movable contact unit (20), wherein the movable contact unit (20) is configured to move between an open position and a closed position via an intermediate position, and the stationary contact unit (10) is configured, in the intermediate position or closed position, to generate an electromagnetic closing force (50) acting on the movable contact unit (20) with the electromagnetic closing force (50) being directed at least partly in direction of the closed position.
2. The contact assembly (1) according to claim 1, wherein the contact assembly (1) is configured for closing and/or opening the load break switch (7).
3. The contact assembly (1) according to any of claims 1 or 2, wherein the stationary contact unit (10) is configured to support a closing movement of the movable contact unit (20) enabling the movable contact unit (20) to transit from the intermediate position to the closed position, particularly by means of the electromagnetic closing force (50) acting on the movable contact unit (20).

4. The contact assembly (1) according to any of claims 1 to 3, wherein
the contact assembly (1) includes a first feed line (13) for electrically connecting the stationary contact unit (10) to an external power circuit at a first end (14) of the first feed line (13), wherein the first feed line (13) has a second end connected to the stationary contact unit (10) and opposite the first end (14), and a second feed line (28) for electrically connecting the movable contact unit (20) to the external power circuit, wherein
the stationary contact unit (10) includes an electromagnetically active section (11) configured for generating the electromagnetic closing force (50) when carrying an electrical current, the electromagnetically active section (11) being configured i) to generate the electromagnetic closing force (50) acting on the movable contact unit (20), and/or ii) to direct the electromagnetic closing force (50) and/or the closing movement of the movable contact unit (20) towards the first feed line (13) or the first end (14) of the first feed line (13).
5. The contact assembly (1) according to any of claims 1 to 4, wherein
the electromagnetically active section (11) has a geometric shape of a loop, especially an open loop, which particularly is shaped as a circle, ellipse or as a polygon with at least three, especially three or four, corners.
6. The contact assembly (1) according to any of claims 1 to 5, wherein
the loop (11), when carrying an electrical current, and/or the arrangement of the loop (11) relative to the movable contact unit (20), are configured to direct the electromagnetic closing force (50) and/or the closing movement to the first feed line (13) or to the first end (14) of the first feed line (13).
7. The contact assembly (1) according to any of claims 1 to 6, further comprising an actuator (72) for exerting a mechanical closing force (50) to the movable contact unit (20).
8. The contact assembly (1) according to any of claims 1 to 7, wherein
the open position is **characterized by** no electrical current flowing through the contact assembly (1) when a voltage is applied between the movable contact unit (20) and the stationary contact unit (10).
9. The contact assembly (1) according to any of claims 1 to 8, wherein
the closed position is **characterized by** the movable contact unit (20) and the stationary contact unit (10) being galvanically connected.
10. The contact assembly (1) according to any of claims 1 to 9, wherein
the intermediate position is **characterized by** an electrical current flowing through the contact assembly (1), wherein i) the electrical current is an arc current between a contact area (12) of the stationary contact unit (10) and a contact area (27) of the movable contact unit (20), or ii) the stationary contact unit (10) is not galvanically connected to, or is spaced from, the movable contact unit (20).
11. The contact assembly (1) according to any of claims 1 to 10, wherein
in the intermediate position, i) a first line segment (15) of the polygon and the movable contact unit (20) are arranged parallel or substantially parallel or at an angle of less than 30° and more than -30° to each other, particularly where currents flowing opposite to each other are conducted, and/or ii) the contact area (27) of the movable contact unit (20) is arranged in an inner region (17) of the loop (11) or between the first line segment (15) of the polygon and the contact area (12) of the stationary contact unit (10).
12. The contact assembly (1) according to any of claims 1 to 11, wherein
the movable contact unit (20) includes a pivotable element (21), wherein particularly the pivotable element (21) is mounted pivotably about a pivot point (22) in the closing direction and and/or the contact area (27) of the movable contact unit (20) moves when the pivotable element is pivoted.
13. A load break switch (7) including a contact assembly (1) according to any one of the preceding claims.
14. Method for closing a circuit path of a contact assembly (1) of a load break switch (7), the contact assembly (1) including a stationary contact unit (10) and a movable contact unit (20) adapted to provide a galvanic contact to the stationary contact unit (10), the method comprising:

moving the movable contact unit (20), in closing movement, from an open position, in which no current flows through the contact assembly (1), to an intermediate position, in which an arc current flows through the contact assembly (1);
generating, by means of the arc current flowing through the stationary contact unit (10), an electromagnetic closing force (50) on the movable contact unit (20) in direction of the closing movement, to support the closing movement of the movable contact unit (20); and
moving the movable contact unit (20) from the intermediate position to a closed position, in which the stationary contact unit (10) and the movable contact are galvanically connected.

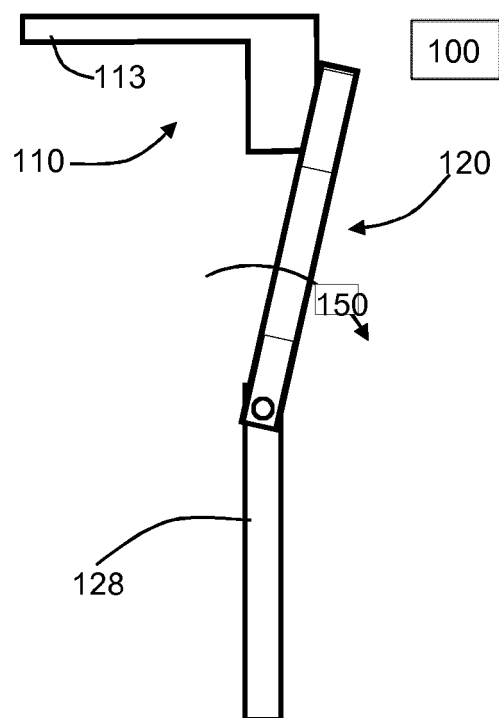


Fig. 1

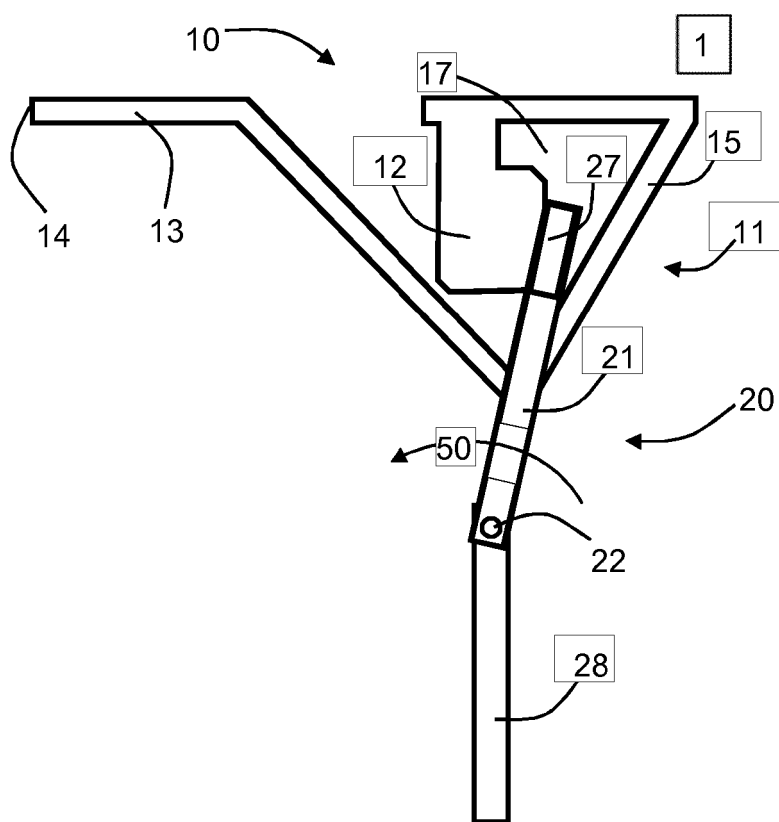


Fig. 2a

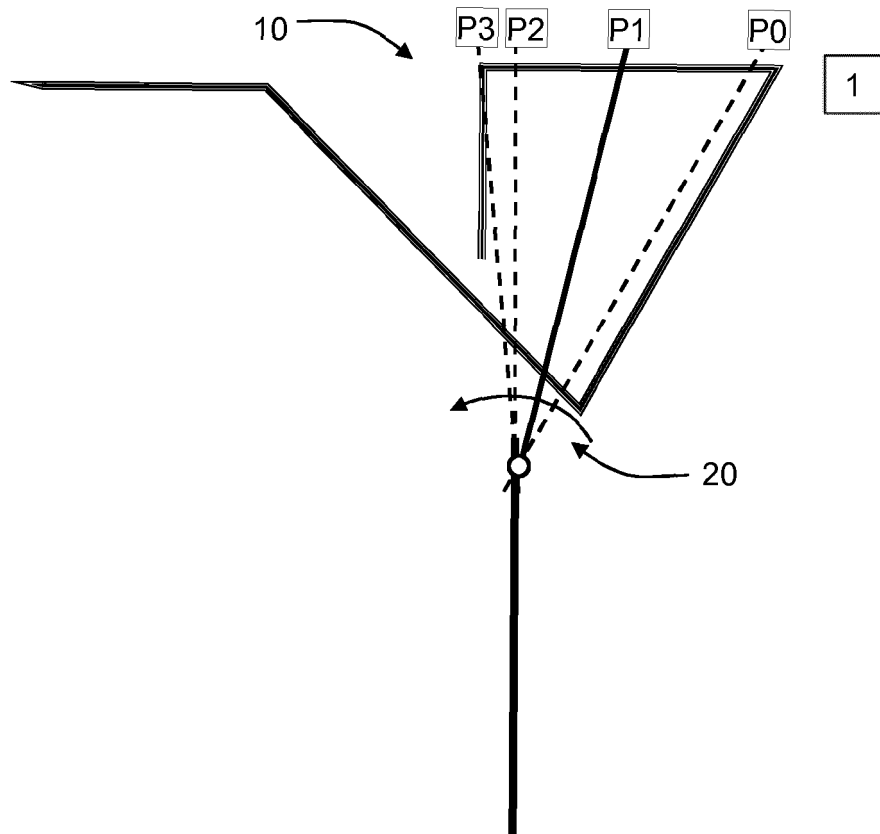


Fig. 2b

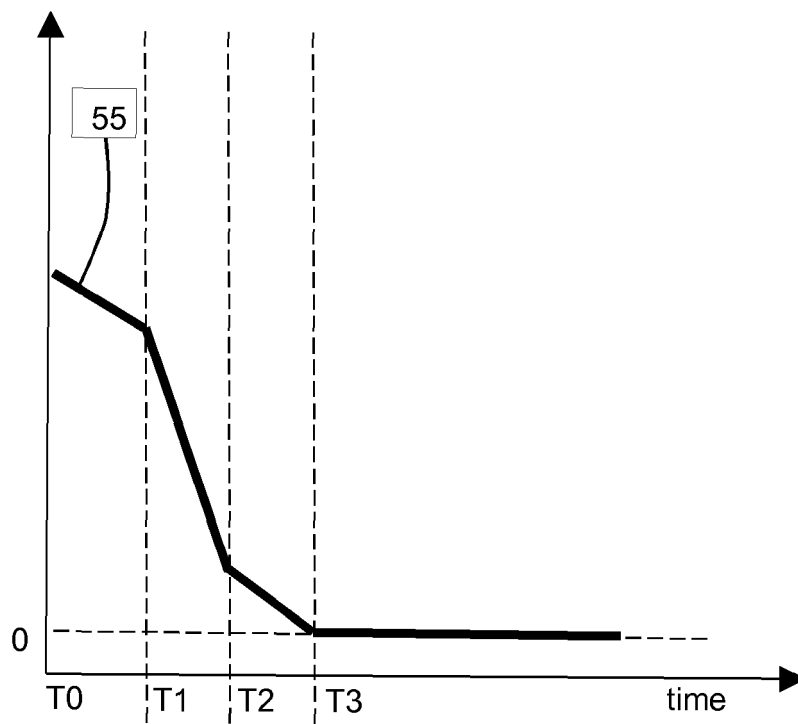


Fig. 2c

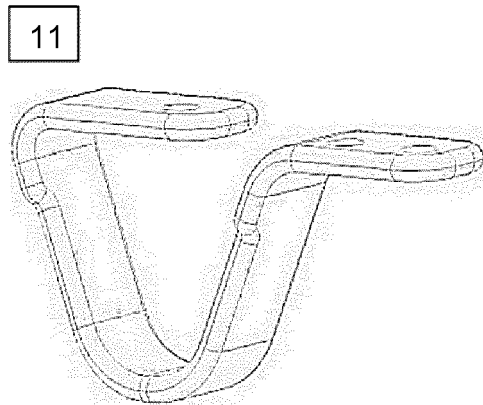


Fig. 2d

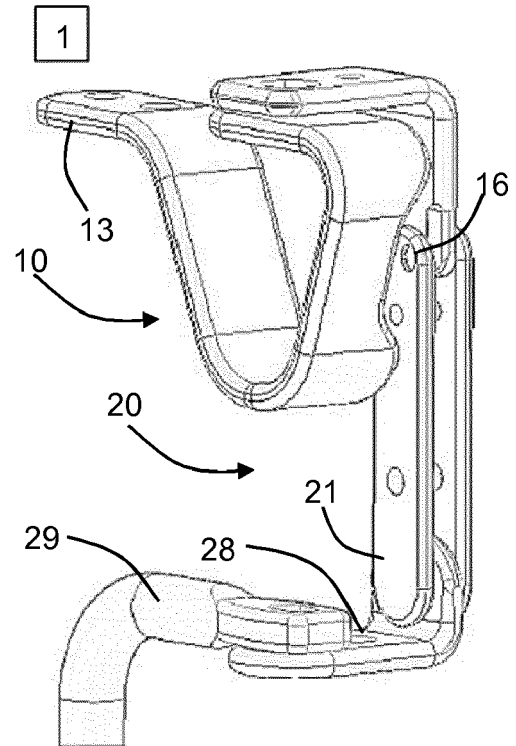


Fig. 2e

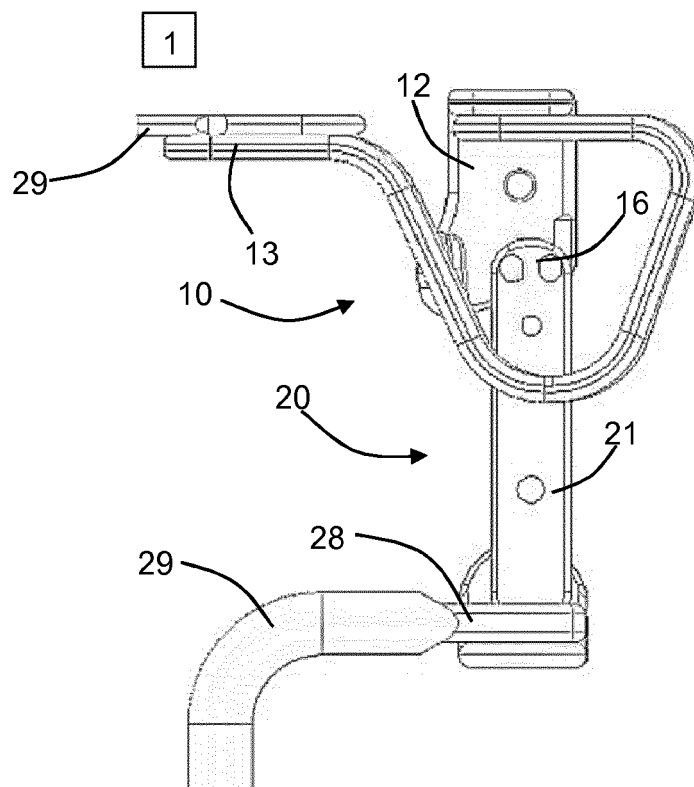


Fig. 2f

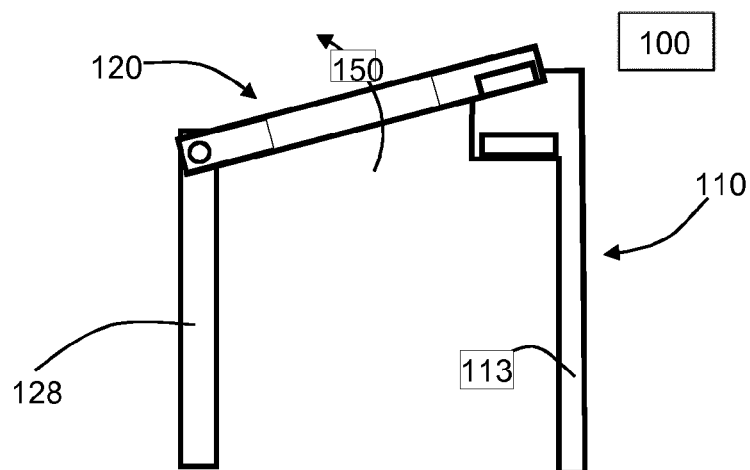


Fig. 3

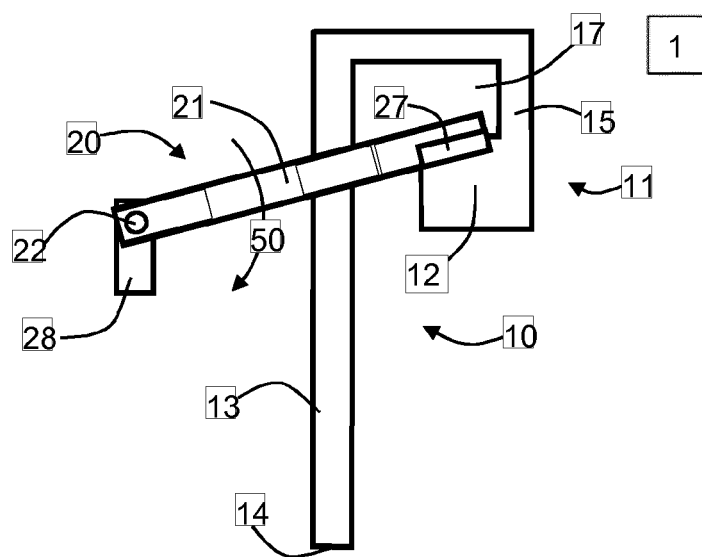


Fig. 4a

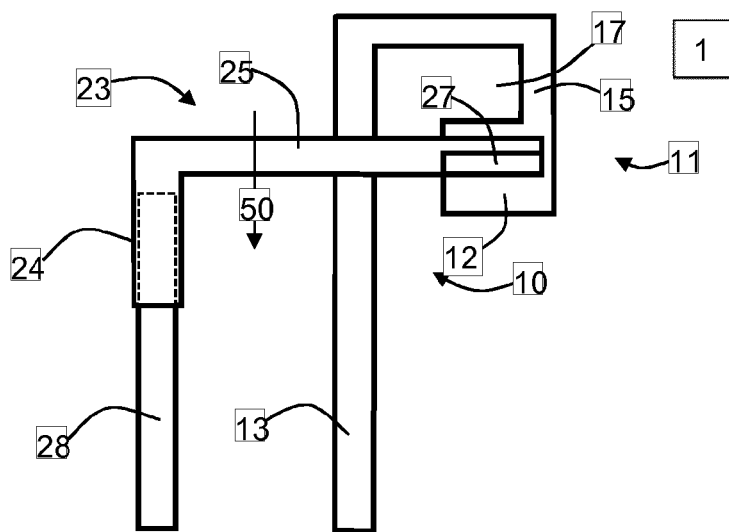


Fig. 4b

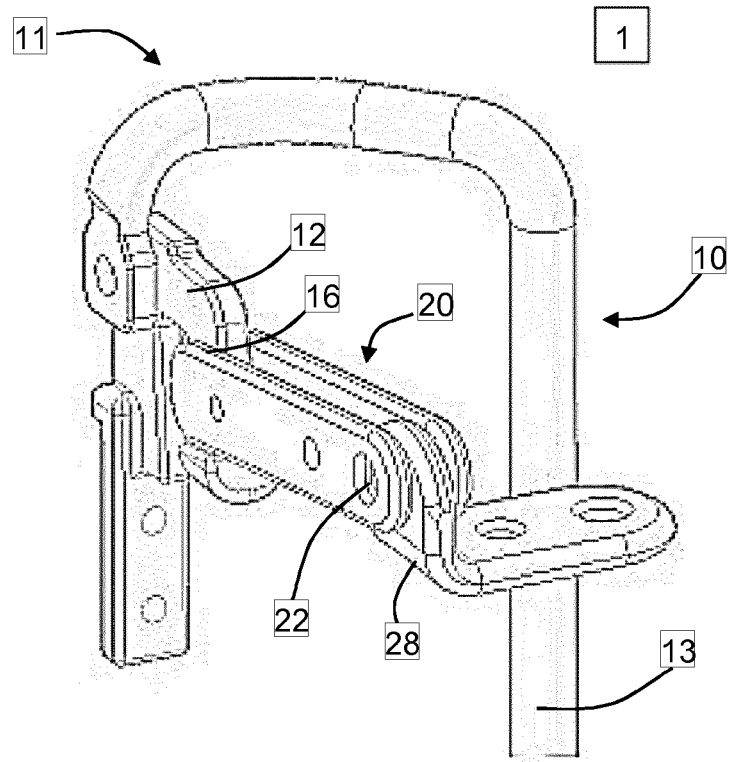


Fig. 4c

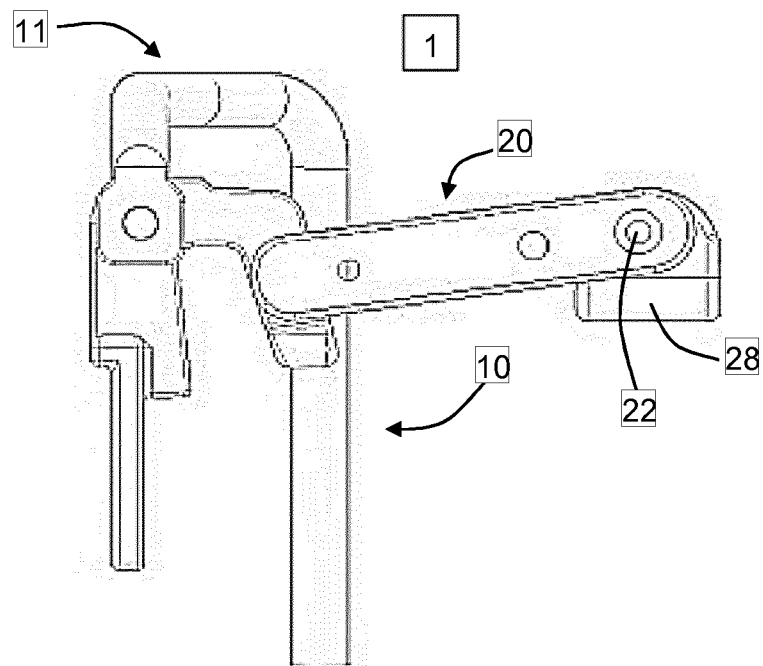


Fig. 4d

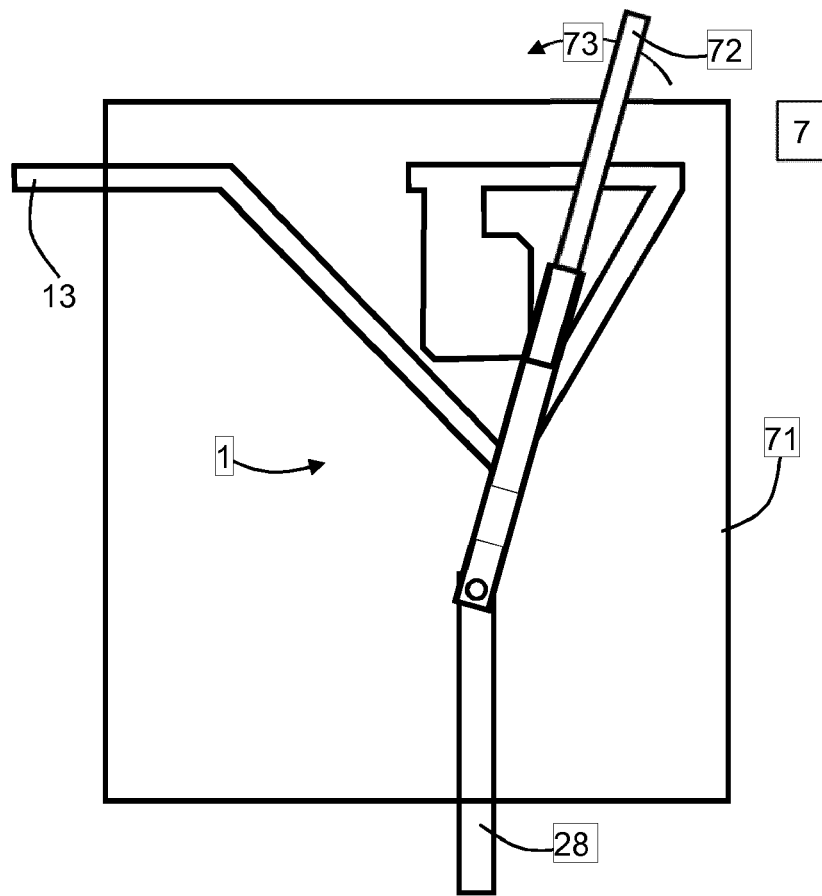


Fig. 5

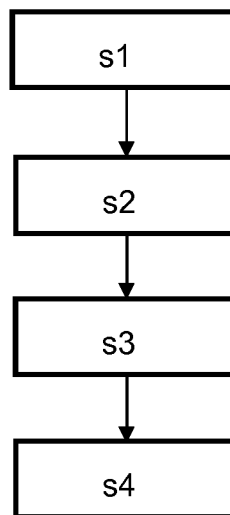


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
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			TECHNICAL FIELDS SEARCHED (IPC)
			H01H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 June 2019	Examiner Simonini, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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11-06-2019

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