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(54) Latching mechanism for activating a switch

(57) A latching mechanism (10) for activating a switch, a switch comprising a latching mechanism (10) described herein, and a method of unlatching a latching mechanism (10) are described. The latching mechanism (10) comprises a latch element (12), at least one linear actuator (11), and a first clamp element (13), wherein the latching mechanism (10) is configured to change between a latched state and an unlatched state. In the latched state the at least one linear actuator (11) is extended along a longitudinal axis (20) and presses the latch element (12) against the first clamp element (13) to thereby establish a frictional locking between the latch element (12) and the first clamp element (13). In the unlatched state the at least one linear actuator (11) is contracted along the longitudinal axis (20) thereby releasing the frictional locking between the latch element (12) and the first clamp element (13) to thereby allow a movement of the latch element (12) for activating the switch.

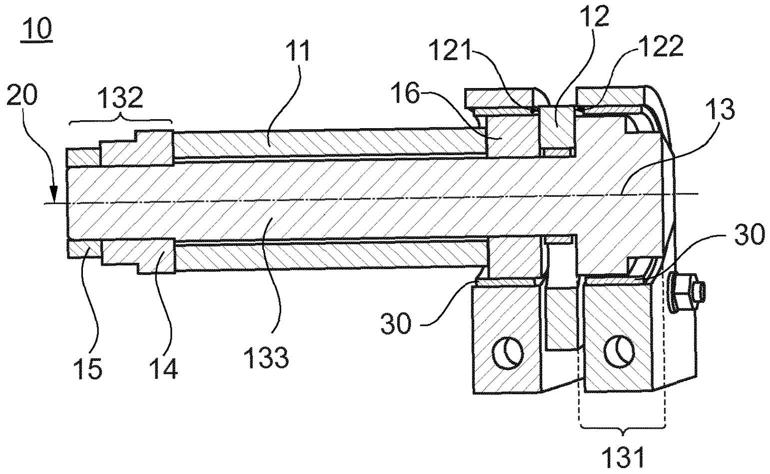

Fig. 1

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Description

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to a latching mechanism for activating a switch. Further, embodiments of the present disclosure relate to a switch comprising a latching mechanism described herein. Additionally, embodiments of a method of unlatching a latching mechanism are disclosed.

TECHNICAL BACKGROUND

[0002] Switches having a short response time are needed for many applications, e.g. circuit breakers for low, medium and high voltage. Typical circuit breakers are driven by a drive unit with stored energy and a latching mechanism used for restraining the drive unit from activating the circuit breaker. Conventional latching mechanisms are robust and safe, but are quite restricted in their release time. Usually they are based on form-fit locking, which means that the part to be latched is geometrically hindered to move until exactly this geometrical barrier is moved away. Normally, such latching mechanisms are based on a complex system of different levers in order to achieve force degradation in several stages, that in a further consequence allow using a small and simple actuator to activate the release. Typically, in conventional latching mechanisms relatively large displacement - low force actuators like solenoids are used.

[0003] However, latching mechanisms having a complex system of different levers for force degradation have disadvantages. In particular, their complexity introduces a lot of inertia that in the end causes longer response times. Hence, conventional latching mechanisms are difficult to adapt for fast response time as needed for ultrafast applications.

[0004] Standard unlatching times are around 3 ms - 10 ms at present. Nevertheless, new products like DC breakers for example necessitate latching mechanisms that are able to operate more than one order of magnitude faster than the existing latches.

[0005] In view of the above, it is an object of the present disclosure to provide a latching mechanism that overcomes at least some of the problems in the prior art. This object is achieved by providing a latching mechanism with reduced complexity based on a friction-locking concept. In particular, this object is achieved at least to some extent by a latching mechanism, a limiting switch comprising a latching mechanism described herein and a method of unlatching a latching mechanism according to the independent claims. Further aspects, advantages, and features of the present disclosure are apparent from the dependent claims, their combinations, the description, and the accompanying drawings.

SUMMARY OF THE DISCLOSURE

[0006] In view of the above, a latching mechanism for activating a switch is provided, wherein the latching mechanism comprises a latch element, at least one linear actuator, and a first clamp element. The latching mechanism is configured to change between a latched state and an unlatched state, wherein in the latched state the at least one linear actuator is extended along a longitudinal axis and presses the latch element against the first clamp element to thereby establish a frictional locking between the latch element and the first clamp element. In an unlatched state the at least one linear actuator is contracted along the longitudinal axis thereby releasing the frictional locking between the latch element and the first clamp element to thereby allow a movement of the latch element for activating the switch.

[0007] According to a further aspect of the present disclosure, a switch comprising a latching mechanism described herein is provided. The switch further comprises a movable mechanical contact element coupled with a contact element of the switch, wherein in the latched state the mechanical contact element is held back by the latch element thereby hindering an opening movement of the electrical contact element, and wherein in the unlatched state the mechanical contact element is released by the latch element thereby enabling the opening movement of the electrical contact element.

[0008] According to another aspect of the present disclosure a method of unlatching a latching mechanism is provided, wherein the method comprises releasing a frictional locking between a latch element and a first clamp element by actuating at least one linear actuator such that the latch element is able to perform a movement for activating a switch.

[0009] The present disclosure is also directed to an apparatus for carrying out the disclosed methods and including apparatus parts for performing each described method steps. These method steps may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two, or in any other manner. Furthermore, the invention is also directed to methods by which the described apparatus operates. It includes method steps for carrying out every function of the apparatus.

[0010] Further aspects, advantages, and features of the present disclosure are apparent from the dependent claims, their combinations, the description, and the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

[0011] Thus, for understanding in detail the above recited features of the present disclosure, a more particular description of the disclosure, briefly summarized above, may be obtained by referencing to embodiments. Typical embodiments are depicted in the drawings and are detailed in the description which follows. In the drawings:

Fig. 1 shows a cross-sectional view of a latching mechanism along its longitudinal axis according to embodiments described herein;

Fig. 2 shows a perspective view of a latching mechanism which is cut perpendicularly to its longitudinal axis at a position of the latching element;

Fig. 3 shows a perspective view of a latching mechanism which is cut perpendicularly to its longitudinal axis at a position of the latching element according to an exemplary embodiment described herein;

Fig. 4 shows a perspective view of a latching mechanism which is cut perpendicularly to its longitudinal axis at a position of the latching element according to another exemplary embodiment described herein;

Fig. 5 shows a perspective view of a latching mechanism which is cut perpendicularly to its longitudinal axis at a position of the latching element according to embodiments described herein;

Fig. 6 shows a perspective view of a latching mechanism according to an embodiment as shown in Fig. 5 is cut along its longitudinal axis;

Fig. 7 shows an exemplary embodiment of a method of unlatching a latching mechanism.

DETAILED DESCRIPTION OF EMBODIMENTS

[0012] Reference will now be made in detail to the various embodiments, one or more examples of which are illustrated in each figure. Each embodiment or example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with any other embodiment to yield yet a further embodiment. It is intended that the present disclosure includes such modifications and variations.

[0013] Within the following description of the drawings, the same reference numbers refer to the same or to similar components. Generally, only the differences with respect to the individual embodiments are described. Unless specified otherwise, the description of a part or aspect in one embodiment applies to a corresponding part or aspect in another embodiment, as well.

[0014] Generally, in the present disclosure "activating a switch" includes initiating a switch by means of releasing stored energy from an energy storage device, in particular from a drive unit.

[0015] In the present disclosure the term "latch element" is defined as an element of the latching mechanism which is latched in a latched state of the latching mechanism and is able to perform a movement into an unlatched state of the latching mechanism. In this regard, "latched" is to be understood as holding, fixing or securing a particular position, particularly by static friction.

[0016] In the present disclosure a "movement of the latch element" is to be understood as a movement of the latch element relative to the clamp element. Typically, at least one degree of freedom of the latch element is limited by its arrangement in the latching mechanism such that the latch element preferably performs a guided movement in the unlatched state. In particular, a "movement of the latch element" is to be understood as a rotational movement around a rotational axis, which is substantially parallel to the longitudinal axis of the latching mechanism, and/or as a translational movement, which is substantially perpendicular to the longitudinal axis of the latching mechanism.

[0017] In the present disclosure the longitudinal axis of the latching mechanism is defined as the axis along which a movement of the linear actuator occurs when changing from an extended state to a contracted state of the linear actuator and vice versa.

[0018] Further, in the present disclosure the term "clamp element" is defined as an element of the latching mechanism by means of which the latch element can be latched in a latched state, particularly by static friction.

[0019] In the present disclosure the term "frictional locking" is to be understood as a frictional locking between a latch element and a clamp element for establishing a latched state, in which the movement of the latch element is restricted by means of static friction between the latch element and the clamp element.

[0020] In the present disclosure the term "switch" is to be understood as an electrical switch. The switch may also comprise a drive mechanism for the switch. Typically, the switch comprises at least one movable electrical contact element and a drive for moving the at least one electrical contact element. In the present disclosure the term "electrical contact element" is to be understood as an element of a switch which is used to establish or interrupt an electrical contact.

[0021] In the present disclosure the term "mechanical contact element" is to be understood as an element which is held back by the latch element in the latched state. Typically, the mechanical contact element is operatively coupled to the switch, e.g. such that a movement of the mechanical contact element causes a movement of at least one movable electrical contact element of the switch.

[0022] In the present disclosure the term "latched state" is defined as the state of the latching mechanism in which the latch element is latched in a particular position by frictional locking with at least one clamp element.

[0023] In the present disclosure the term "unlatched state" is defined as the state of the latching mechanism in which the latch element is unlatched and able to perform a movement.

[0024] In the present disclosure the term "extended state" is defined as the state of a linear actuator which is extended along its longitudinal axis compared to the contracted state of the linear actuator.

[0025] In the present disclosure the term "contracted state" is defined as the state of a linear actuator which is contracted along its longitudinal axis with respect to its extended state.

[0026] As shown in Fig. 1, a latching mechanism 10 for activating a switch according to embodiments described herein comprises a latch element 12, at least one linear actuator 11, and a first clamp element 13. According to embodiments, the latching mechanism 10 is configured to change between a latched state and an unlatched state. In the latched state, the at least one linear actuator 11 is extended along a longitudinal axis 20 and presses the latch element 12 against the first clamp element 13 to thereby establish a frictional locking between the latch element 12 and the first clamp element 13. In the unlatched state, the at least one linear actuator 11 is contracted along the longitudinal axis 20 thereby releasing the frictional locking between the latch element 12 and the first clamp element 13 to thereby allow a movement of the latch element 12 for activating the switch. A typical movement of the latch element will be explained in more detail in the following e.g. with respect to Fig. 2

[0027] Thereby, according to embodiments a latching mechanism having reduced complexity is provided. In particular, by employing a linear actuator, particularly a high force - low displacement actuator, the use of levers required for force degradation needed in conventional latching mechanisms for using small and simple actuators to activate the release can be avoided. Accordingly, the inertia of the latching mechanism according to the embodiments described herein is reduced resulting in a decreased response time compared to known latching mechanisms. Further, since the latching mechanism is based on frictional locking compared to conventional latching mechanisms only small displacements of the at least one linear actuator are required to unlatch the latching mechanism. Therefore, these small displacements can be performed very quickly. Hence, the latching mechanism is based on a radically different principle (frictional locking) compared to previous mechanisms and is thereby capable of realizing high speed latch release times from 0.1 ms to5 ms.

[0028] According to embodiments, the latch element 12 and the first clamp element 13 are designed to be stiff to ensure that the at least one actuator can provide the required clamping force with a minimal displacement for establishing the frictional locking. In particular, the latch element 12 and the first clamp element 13 comprise a material which is capable of withstanding a load caused by the clamping force such that no significant deformation of the latch element 12 and the first clamp element 13 occurs. Therefore, typically the latch element 12 and the first clamp element 13 are made of metal and/or metal alloys (e.g. steel) and/or ceramics.

[0029] As illustrated in Fig. 1, according to embodiments the latch element 12 is configured as a plate. Typically, the latch element 12 comprises a substantially flat first surface 121 and a substantially flat second surface 122, which are substantially parallel to each other. Further, the first surface 121 and the second surface 122 are perpendicular to the longitudinal axis 20 of the linear actuator 11 and are arranged on opposing sides of the latch element 12. Thereby, the latch element 12 is particularly adapted for establishing a frictional locking with corresponding flat surfaces, e.g. of the first clamp element 13.

[0030] According to embodiments, the at least one linear actuator 11 is at least one of a piezo-actuator 11, a magnetostrictive actuator 11 and a hydraulic actuator 11. Hence, the at least one linear actuator 11 of the latching mechanism 10 is typically a "low displacement - high force" actuator 11. Thereby, according to embodiments a latching mechanism 10 is provided with which levers for force degradation can be avoided. Particularly, piezo-actuators, magnetostrictive actuators and hydraulic actuators are suitable for providing very high forces and small displacements. Further, in a latched state of the latching mechanism 10 said actuators 11 require only little energy. Therefore, according to embodiments a low energy consuming latching mechanism 10 is provided. Typically, dependent on the specific design of the latching mechanism 10, the at least one linear actuator 11 may, for example, be capable of providing a clamping force of at least 10 kN, particularly at least 15 kN, more particularly at least 20 kN. There is no particular upper limit on the clamping force. By selecting an appropriate kind of actuator 11 (e.g. piezo actuator 11 or hydraulic actuator 11) and by providing several linear actuators 11 in parallel, the clamping force can in principle be made arbitrarily large.

[0031] According to embodiments, the at least one linear actuator 11 is adapted to change between a latched state and an unlatched state of the latching mechanism 10. Typically, the at least one linear actuator 11 is used to generate a clamping force acting on the latch element 12 by pressing the latch element 12 against the first clamp element 13 to thereby establish a frictional locking between the latch element 12 and the first clamp element 13 to thereby lock a position of the latch element 12. In particular, the frictional locking can be established by performing an extensional movement of the at least one linear actuator 11 along its longitudinal axis 20. Thereby the at least one linear actuator 11 presses against the substantially flat first surface 121 of the latch element 12 thereby pressing the substantially flat second surface 122 of the latch element 12 against the first clamp element 13. Thus, in a latched state of the latching mechanism 10 a friction force between the latch element 12 and the clamp element 13 is generated by the clamping force.

[0032] As shown in Fig. 1, according to embodiments the linear actuator 11 is arranged such that a change in length of the linear actuator 11 due to an extensional movement of the linear actuator 11 results in a pressure build-up between the latch element 12 and the clamp element 13. In particular, typically the latching mechanism 10 is configured such that in the unlatched state a clearance along the longitudinal axis of the latching mechanism 10 is less than the possible length change of the linear actuator 11.

[0033] According to embodiments, the at least one linear actuator 11 is configured for contracting in a range from a lower limit of 10 μm, particularly 5 μm, more particularly 1 μm, to an upper limit of 250 μm, particularly 150 μm, more particularly 100 μm, for changing from a latched state to an unlatched state of the latching mechanism 10.

[0034] According to embodiments, the latching mechanism 10 is configured for releasing the frictional locking within a period from a lower limit of 0.5 ms, particularly 0.1 ms, more particularly 0.05 ms, to an upper limit of 5 ms, particularly 2.5 ms, more particularly 1.0 ms, when changing from the latched state to the unlatched state. Accordingly, the linear actuator 11 is configured to perform the contraction movement for changing from a latched state to an unlatched state of the latching mechanism 10 within a period from a lower limit of 0.5 ms, particularly 0.1 ms, more particularly 0.05 ms, to an upper limit of 5 ms, particularly 2.5 ms, more particularly 1.0 ms.

[0035] According to embodiments using an electrically actuated linear actuator 11 such as a piezo actuator, the latched state, in which the at least one linear actuator 11 is extended, can be a power-off state or a power-on state of the linear actuator 11. According to a first example, the latched state is obtained in the power-on state of the linear actuator 11. Accordingly, a contraction of the piezo-actuator 11, and thereby the unlatched state, can be realized by changing the state of the piezo-actuator 11 to its power-off state or by reversing a voltage applied to the linear actuator 11 (negative power-on state, negative being defined as inverse voltage relative to the voltage of the extended/latched state). The power-off state can be obtained, e.g., by applying a short circuit to the linear actuator 11 so that the voltage applied to the piezo-actuator 11 drops to zero. In a second example, the latched state is realized when the piezo-actuator 11 is extended in a power-off state; and the unlatched state is realized by changing the state of the piezo-actuator 11 to its power-on state (negative power-on state), i.e. by applying a (negative) voltage to the piezo-actuator 11, so that the piezo-actuator 11 is contracted.

[0036] Independently of the specific linear actuator 11 and of the specific manner in which the linear actuator 11 is caused to contract, the contraction of the linear actuator 11 causes the frictional locking to be released by reducing the frictional force acting on the latch element 12. More particularly, the frictional force acting on the latch element 12 is reduced below a critical frictional force below which the latch element 12 is no longer held in a latched state by static friction, and a motion of the latch element 12 is allowed.

[0037] Next, the clamp element 13 is described in more detail. According to embodiments, as illustrated in Fig. 1 the first clamp element 13 comprises a first end portion 131 and a second end portion 132 which are rigidly connected to each other by a connecting portion 133. In this regard, it is to be understood that a rigid connection may be established by various joining techniques, such as a screwing or clamping etc. Typically, the at least one linear actuator 11 and the latch element 12 are arranged axially between the first end portion 131 and the second end portion 132 of the clamp element 13, so that in the latched state the at least one linear actuator 11 and the latch element 12 are clamped between the first end portion 131 and the second end portion 132. This allows an effective static friction to be established by the actuator 11.

[0038] According to embodiments, the first clamp element 13 has a T-shaped anchor-like configuration. Typically, the longitudinal axis of the first clamp element 13 is parallel to the longitudinal axis of the linear actuator 11. Hence, typically a longer portion of the T-shaped anchor-like clamp element 13 extends parallel to the longitudinal axis of the linear actuator 11, wherein a shorter portion of the T-shaped anchor-like clamp element 13 is typically arranged substantially perpendicular to the longitudinal axis of the linear actuator 11. Particularly, the longitudinal axis of the first clamp element 13 is substantially identical with the longitudinal axis of the linear actuator 11. As shown in Fig. 1, typically the dimensions perpendicular to the longitudinal axis 20 of the first end portion 131 of the first clamp element 13 are increased compared to the corresponding dimensions of the connecting portion 133. Particularly, the first end portion 131 is configured such that a substantially flat surface opposing the second surface 122 of the latch element 12 is provided for frictional locking. Typically, the first clamp element 13 is rotational symmetrical around its longitudinal axis.

[0039] According to embodiments, the connecting portion 133 of the first clamp element 13 extends through a hole in the latch element 12 and through an axial hole of one of the at least one linear actuator 11. Thereby, a compact design of the latching mechanism 10 can be realized. Further, a design of the latching mechanism 10 in which the first clamp element 13 extends through the actuator is beneficial for generating a homogeneous clamping force acting on the latch element 12 to thereby establish a homogenous frictional locking.

[0040] Further, typically the dimensions perpendicular to the longitudinal axis 20 of the second end portion 132 of the first clamp element 13 are increased compared to the corresponding dimensions of the connecting portion 133 for providing a substantially flat surface opposing the substantially flat surface 122 of the latch element 12.

[0041] According to embodiments at least one of the first end portion 131 and the second end portion 132 of the first clamp element 13 form an integral part with the connecting portion 133. Fig. 1 shows an example of a typical embodiment in which the first end portion 131 having increased dimensions forms an integral part with the connecting portion 133 while the second end portion 132 having increased dimensions is designed as a separate part. Thereby, the number of components of the latching mechanism 10 can be reduced leading to a reduction in complexity and in particular to an increased stiffness of the first clamp element 13.

[0042] According to embodiments, the second end portion 132 of the first clamp element 13 comprises an adjusting element 14 for adjusting an axial length between the first end portion 131 and the second end portion 132. In embodiments the adjusting element 14 is used to apply a pre-stress to the linear actuator 11. In this regard, pre-stress is to be understood as a stress applied to the at least one linear actuator 11 along its longitudinal axis before the at least one linear actuator 11 is changed into its extended state for latching the latch element 12. An application of a pre-stress to a linear actuator 11 is particularly used for a reduction of the load acting on the actuator 11 when the latching mechanism 10 is unlatched in a very short period of time of less than 5 ms. Typically, the adjusting element 14 is a pre-stress screw 14 mounted on an outer screw thread on the second end of the first clamp element 13. Further, typically as shown in Fig.1 the second end portion 132 of the first clamp element 13 comprises a counter screw 15 for securing the adjusting element 14.

[0043] According to embodiments, as exemplarily shown in Fig. 1, a second clamp element 16 can be arranged between the at least one linear actuator 11 and the latch element 12, such that in the latched state the at least one linear actuator 11 presses the second clamp element 16 onto the first surface 121 of the latch element 12 to thereby establish a frictional locking between the first surface 121 of the latch element 12 and the second clamp element 16. In particular, the at least one linear actuator 11 further presses the first clamp element 13 onto the second surface 122 of the latch element 12. Thereby a frictional locking between a substantially flat surface of the first clamp element 13 and the second surface 122 of the latch element 12 can be established. Hence, according to embodiments in a latched state of the latching mechanism 10 the latch element 12 is clamped between the first clamp element 13 and the second clamp element 16.

[0044] According to embodiments, as exemplarily shown in Fig. 1, the second clamp element 16 is configured as a plate element 16, particularly as a ring-shaped element 16, which is arranged on an outer circumference of the connecting portion of the first clamp element 13. Typically the second clamp element 16 is movable in an axial direction of the first clamp element 13. For example, the second clamp element 16 can be guided on the outer circumference of its connecting portion 133.

[0045] According to embodiments, an outer circumference of the first end portion 131 of the clamping element 13 and an outer circumference of the second clamp element 16 are supported by bearings 30, particularly needle bearings. Thereby, axial stability of the latching mechanism 10 is provided and wear during the movement is reduced. Particularly, by supporting the latching mechanism 10 with bearings 30 torsional stiffness of the latching mechanism 10 can be improved. Thereby an effective and homogenous frictional locking can be established between the latch element 12 and the clamp element(s) 13, 16.

[0046] In Fig. 2 a perspective view of a latching mechanism 10 which is cut perpendicularly to its longitudinal axis at a position of the latching element 12 is depicted. As shown in Fig. 2, according to embodiments the latch element 12 comprises a protrusion 12a from which in a latched state a movable mechanical contact element 40 of a switch is held back. Thereby, an opening movement of the mechanical contact element 40 is hindered. In particular, the movable mechanical contact element 40 is biased such that the mechanical contact element 40 exerts a torque on the latch element 12. In an unlatched state when the latch element 12 is able to perform a movement the mechanical contact element 40 of the switch is released by the latch element 12 thereby enabling an opening movement of an electrical contact element of a switch which is coupled to the mechanical contact element 40. Thereby, the torque caused by the mechanical contact element 40 translates into a turning movement of the latch element 12, after which the protrusion 12a no longer holds back the mechanical contact element 40.

[0047] In embodiments, prior to the turning movement of the latch element 12, the latch element 12 performs a sliding movement, in particular in cases in which a guidance element 17 is provided, which will be described in the following in more detail. Although not explicitly shown in Fig. 2 due the cut view, an embodiment as illustrated in Fig. 2 typically comprises a clamp element having a first end portion 131 (not shown). It is to be understood that generally the embodiments as illustrated in Fig.2 may comprise the same elements as described with respect to the embodiment as shown in Fig. 1.

[0048] As exemplarily shown in Fig. 2, embodiments of latching mechanism 10 described herein may comprise a guidance element 17 for guiding the movement of the latch element 12, at least in the beginning of the movement of the latch element 12 directly after unlatching. Further, the guidance element 17 can be arranged and configured such that the latch element 12 presses against the guidance element 17 for at least partially compensating a force originating from the torque acting on the latch element 12 by the mechanical contact element 40. As exemplarily shown in Fig. 2, the guidance element 17 can engage with the latch element 12. For example, the engagement is realized by a recess in the latch element 12 into which the guidance element 17 engages.

[0049] According to embodiments, as exemplarily shown in Fig. 2, the engagement is configured such that in an unlatched state of the latching mechanism 10 a sliding movement of the latch plate 12 along an essentially plane surface of the guidance element 17 is possible. Hence, when the clamping force is released and the latching mechanism 10 changes from the latched state in an unlatched state, the latch element 12 slides along a contact surface between the guidance element 17 and the latch element 12 before the latch plate 12 performs a rotational movement for completely releasing the mechanical contact element 40. This movement is, according to an example, driven by a biasing force acting on the mechanical contact element 40, e.g. due to a biasing element such as a spring acting on the mechanical contact element 40. After having been released, i.e. no longer being held back by the latch element 12, the mechanical contact element 40 is free to perform a movement (the movement for which it is biased) for actuating the switch. Typically, the mechanical contact element 40 is operationally coupled to an electrical contact element of the switch such that the switch is actuated (opened or closed) by the movement of the mechanical contact element 40. According to a particular example, the mechanical contact element 40 is connected to the movable electrical contact element of the switch rigidly or via a motion-transmitting element, such as a gear.

[0050] As shown in Fig. 2, according to embodiments of the latching mechanism 10 a bearing 35, preferably a needle bearing, is provided between the latch element 12 and the first clamp element 13. Thereby, the sliding of the latch plate 12 for releasing the mechanical contact element 40 is sustained such that wear of the latch element 12 and/or first clamp element 13 can substantially be avoided.

[0051] According to embodiments of the latching mechanism 10, as exemplarily shown in Fig. 2, typically the latching mechanism 10 comprises a stop element 18. Typically, the latch mechanism 10 is configured such that from the instant at which the latch plate 12 looses contact with the guidance element 17, the latch element 12 and /or the first clamp element 13 and/ or the second clamp element 16 and/ or the at least one linear actuator 11 start to rotate due to the loss of resistance hindering a rotational movement of said elements. Therefore, the stop element 18 is arranged and configured to stop said rotational movements, after sufficient rotation. After said rotational movement has been stopped, the latch plate 12 and /or the first clamp element 13 and/ or the second clamp element 16 and/ or the at least one linear actuator 11 are turned back to their initial position. This initial position can be latched again by simply actuating the linear actuator 11, such that the at least one linear actuator 11 presses the latch element 12 against the first clamp element 12 to thereby re-establish a frictional locking between the latch element 12 and the first clamp element 13.

[0052] According to a further aspect of the present disclosure, a switch (not shown) comprising a latching mechanism 10 described herein is provided. Further, according to embodiments the switch comprises a movable mechanical contact element 40. As explained in more detail above with respect to Fig. 2, in the latched state the mechanical contact element 40 is held back by the latch element 12 thereby hindering a movement of the mechanical contact element 40, and in the unlatched state the mechanical contact element 40 is released by the latch element 12 thereby enabling the movement of the mechanical contact element 40 due to which the switch is opened (or closed) as described in connection with Fig. 2.

[0053] In Fig. 3 and Fig. 4 embodiments of the latching mechanism 10 are shown in a cut view similar to Fig. 2, wherein the latch element 12 is arranged having a fixed pivot axis 19 around which the latch element 12 can perform a rotational movement into an unlatched state.

[0054] The arrow F in Fig. 3 and 4 indicates the force acting on the latch element 12 due to a biased mechanical contact element 40, as explained in more detail with respect to the embodiment shown in Fig. 2. Generally, the embodiments of the latching mechanism shown in Fig. 3 and Fig. 4 essentially differ from the embodiment as shown in Fig. 2 in the particular shape of the latch element 12. In detail, in dependence of the particular shape of the latch element 12 in the region where the mechanical contact element 40 presses against the latch element 12 a latching force degradation can be adjusted depending on the contact angle between the force direction and the orientation of the contact surface between the mechanical contact element 40 and the latch element 12. Thereby, a latching mechanism 10 is provided with which a certain force degradation can be achieved. Consequently, the linear actuators 11 used in embodiments comprising a latch element 12 with which force degradation is achievable can be configured smaller, or the latching force can be correspondingly higher. Otherwise, description of Fig.2 applies also to Figs. 3 and 4.

[0055] According to embodiments of the latching mechanism 10 described herein, at least two linear actuators 11 are arranged in parallel, as exemplarily shown in Figs. 5 and 6. Essentially, the configuration of an embodiment comprising two parallel arranged linear actuators 11 is substantially the same as for embodiments in which only one linear actuator 11 is employed (see Fig. 1), with the difference that typically the latch element 12 is configured differently. In particular, as illustrated in Figs. 5 and 6, the latch element 12 can comprise an elongated hole configured such that the latch element 12 can only perform a linear movement in an unlatched state of the latching mechanism 10. Typically, said linear movement of the latch element 12 in an unlatched state is substantially perpendicular to the longitudinal axis of the at least two linear actuators 11. It is to be understood that the latch element 12 as shown in Figs. 5 and 6 may also comprise a protrusion (not shown) from which in a latched state a movable mechanical contact element 40 of a switch is held back, as explained in more detail with respect to the embodiments as illustrated in Figs. 2 to 4.

[0056] By providing a latching mechanism 10 having at least two linear actuators 11 a clamping force of the latching mechanism 10 can be increased. For example, a latching mechanism 10 having two actuators 11 typically has the capability of generating a clamping force which is twice the amount of the clamping force which can be generated by a latching mechanism 10 having only one linear actuator 11.

[0057] According to a further aspect of the present disclosure, a method of unlatching a latching mechanism 10 as exemplarily shown in Fig. 7 is provided. Typically, the method of unlatching the latching mechanism 10 comprises releasing 201 a frictional locking between a latch element 12 and a first clamp element 13 by actuating at least one linear actuator 11 such that the latch element 12 is able to perform a movement for activating 202 a switch.

[0058] According to embodiments of a method of unlatching a latching mechanism 10, a latching mechanism 10 as described herein is employed for the method of unlatching the latching mechanism 10. According to embodiments of the method of unlatching a latching mechanism 10 actuating the at least one linear actuator 11 includes a contraction of the at least one linear actuator 11 along its longitudinal axis 20. According to embodiments of the method of unlatching a latching mechanism 10 releasing the frictional locking between the latch element 12 and the first clamp element 13 occurs within 0.05 ms to 5 ms.

Claims

1. A latching mechanism (10) for activating a switch, wherein the latching mechanism (10) comprises:

    a latch element (12),
    at least one linear actuator (11), and
    a first clamp element (13),
    wherein the latching mechanism (10) is configured to change between a latched state and an unlatched state,
    wherein in the latched state the at least one linear actuator (11) is extended along longitudinal axis (20) and presses the latch element (12) against the first clamp element (13) to thereby establish a frictional locking between the latch element (12) and the first clamp element (13), and
    wherein in the unlatched state the at least one linear actuator (11) is contracted along the longitudinal axis (20) thereby releasing the frictional locking between the latch element (12) and the first clamp element (13) to thereby allow a movement of the latch element (12) for activating the switch.

2. The latching mechanism (10) according to claim 1, wherein the at least one linear actuator (11) is at least one of a piezo-actuator, a magnetostrictive actuator and a hydraulic actuator.

3. The latching mechanism (10) according to claim 1 or 2, wherein the at least one linear actuator (11) is configured for contracting by 1 μm to 100 μm along the longitudinal axis (20) of the at least one linear actuator (11) when changing from the latched state to the unlatched state.

4. The latching mechanism (10) according to any one of the claims 1 to 3, wherein the latching mechanism (10) is configured for releasing the frictional locking within 0.1 ms to 5 ms when changing from the latched state to the unlatched state.

5. The latching mechanism (10) according to any one of the claims 1 to 4, wherein in the latched state the frictional locking between the latch element (12) and the first clamp element (13) is established by the at least one linear actuator (11) pressing against a substantially flat first surface (121) of the latch element (12) thereby pressing a substantially flat second surface (122) of the latch element (12) against the first clamp element (13), wherein the first surface (121) and the second surface (122) of the latch element (12) are substantially parallel to each other and substantially perpendicular to the longitudinal axis (20) and are arranged on opposing sides of the latch element (12).

6. The latching mechanism (10) according to any one of the claims 1 to 5, wherein a second clamp element (16) is arranged between the at least one linear actuator (11) and the latch element (12), such that in the latched state the at least one linear actuator (11) presses the second clamp element (16) onto the first surface (121) of the latch element (12) to thereby establish a frictional locking between the first surface (121) of the latch element (12) and the second clamp element (16), and wherein the at least one linear actuator (11) further presses the first clamp element (13) onto the second surface (122) of the latch element (12) to thereby establish a frictional locking between a substantially flat surface of the first clamp element (13) and the second surface (122) of the latch element (12).

7. The latching mechanism (10) according to any one of the claims 1 to 6, wherein an outer circumference of a or the first end portion (131) of the clamping element (13) and an outer circumference of a or the second clamp element (16) are supported by bearings (30).

8. The latching mechanism (10) according to any one of the claims 1 to 7, wherein the first clamp element (13) comprises a first end portion (131) and a second end portion (132) which are rigidly connected to each other by a connecting portion (133), wherein the at least one linear actuator (11) and the latch element

(12) are arranged axially between the first end portion (131) and the second end portion (132), so that in the latched state the at least one linear actuator (11) and the latch element (12) are clamped between the first end portion (131) and the second end portion (132).

9. The latching mechanism (10) according to any one of the claims 1 to 8, wherein a or the connecting portion (133) of the first clamp element (13) extends through a hole in the latch element (12) and through an axial hole of the at least one linear actuator (11).

10. The latching mechanism (10) according to any one of the claims 1 to 9, wherein a or the second end portion (132) of the first clamp element (13) comprises an adjusting element (14) for adjusting an axial length between a or the first end portion (131) and the second end portion (132).

11. A switch comprising a latching mechanism (10) according to any one of the claims 1 to 10 and a movable mechanical contact element (40), wherein in the latched state of the latching mechanism (10) the mechanical contact element (40) is held back by the latch element (12) thereby hindering a movement of the mechanical contact element (40), and wherein in the unlatched state of the latching mechanism (10) the mechanical contact element (40) is released by the latch element (12) thereby enabling a movement of the mechanical contact element (40) causing the switch to open.

12. A method of unlatching a latching mechanism (10), wherein the method comprises releasing (201) a frictional locking between a latch element (12) and a first clamp element (13) by actuating at least one linear actuator (11) such that the latch element (12) is able to perform a movement for activating (202) a switch.

13. The method of unlatching a latching mechanism (10) according to claim 12, the method using a latching mechanism (10) according to any of claims 1 to 10.

14. The method of unlatching a latching mechanism (10) according to claim 13, wherein actuating the at least one linear actuator (11) includes a contraction of the at least one linear actuator (11) along the longitudinal axis (20) of the at least one linear actuator (11).

15. The method of unlatching a latching mechanism (10) according to any one of the claims 12 to 14, wherein releasing the frictional locking between the latch element (12) and the first clamp element (13) occurs within 0.05 ms to 5 ms.

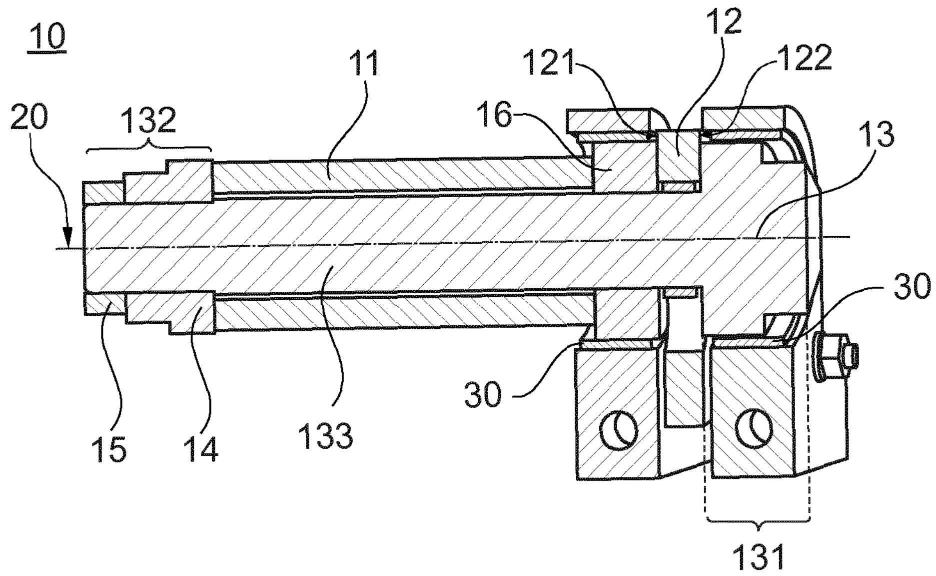
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Fig. 1

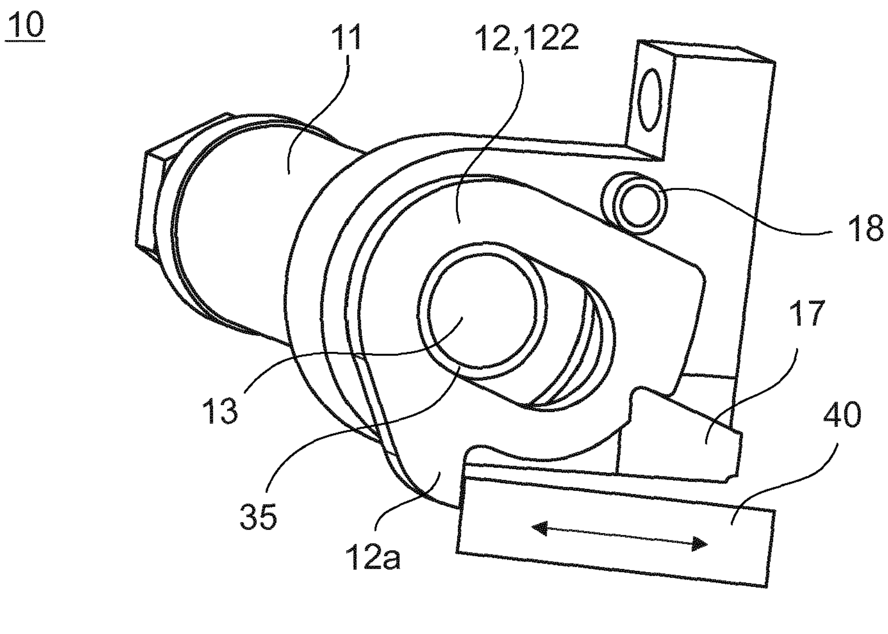
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Fig. 2

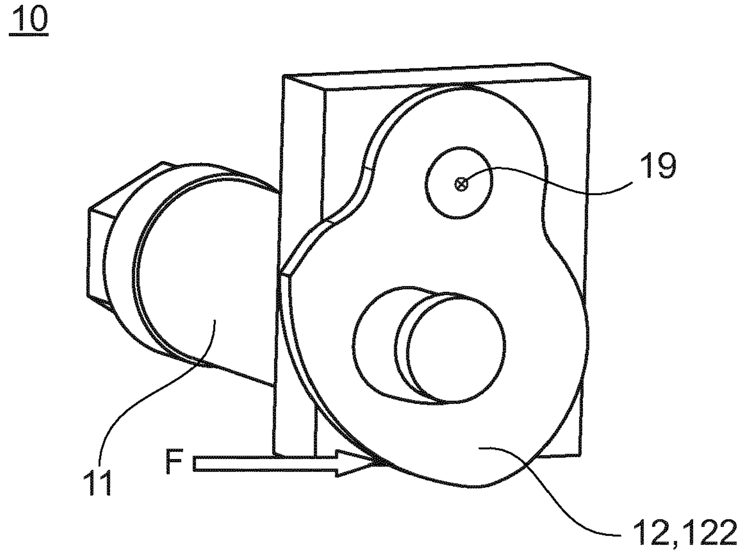

Fig. 3

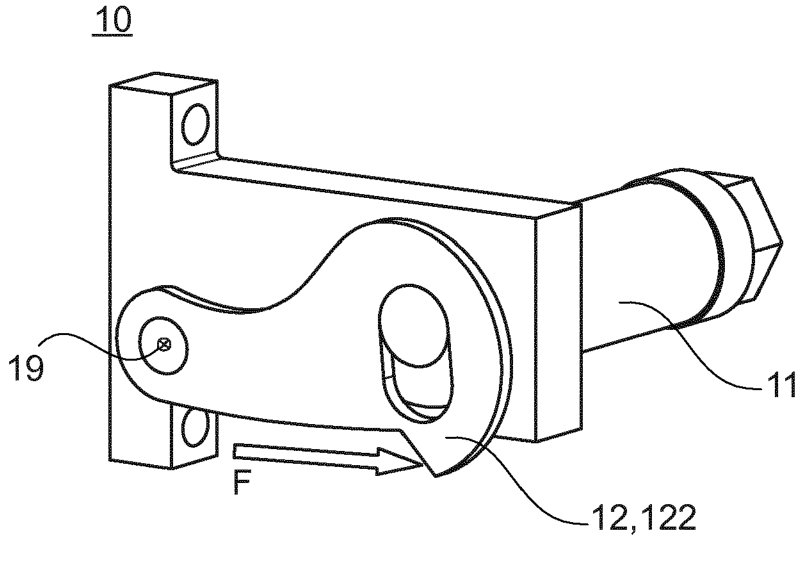

Fig. 4

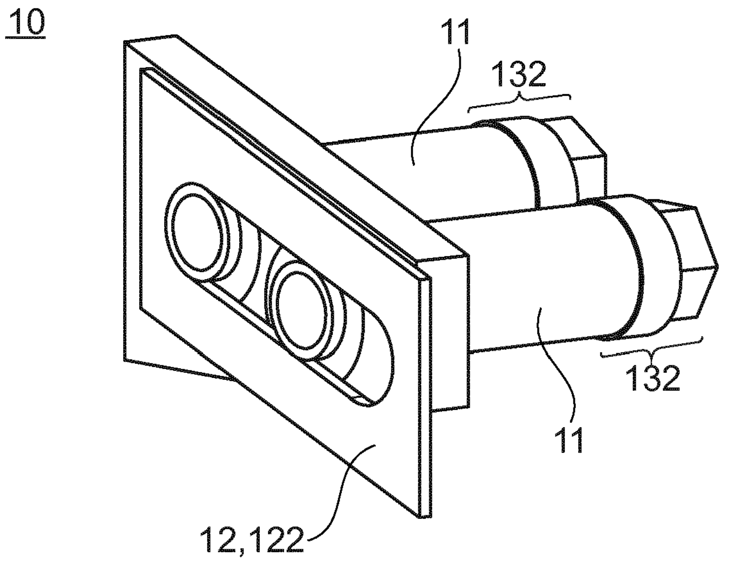

Fig. 5

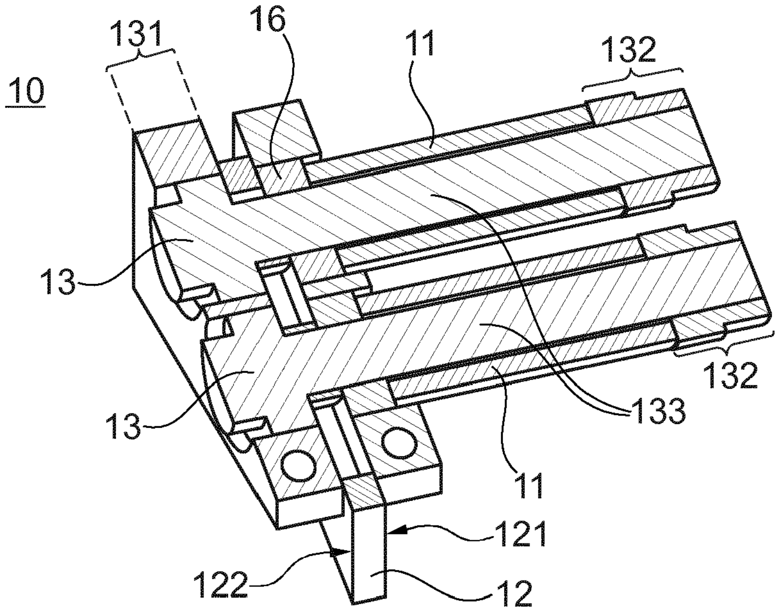

Fig. 6

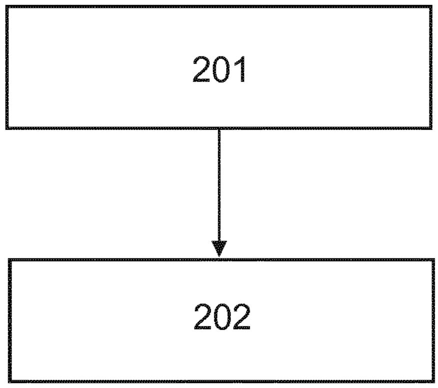

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
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