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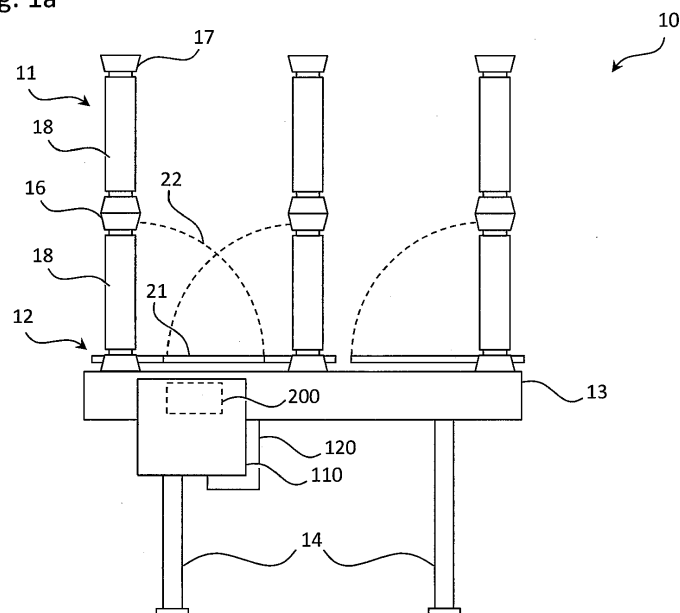
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(54) **ELECTRICAL SWITCHGEAR AND METHOD OF OPERATING AN ELECTRICAL SWITCHGEAR**

(57) The invention relates to an electrical switchgear (10) comprising at least one power switch (11) and a grounding switch (12) associated with said power switch (11) for electrically grounding said power switch (11), wherein a first drive mechanism (110) is provided for driv-

ing said power switch (11), and wherein a second drive mechanism (120) is provided for driving said grounding switch (12), and wherein an interlocking unit (200) is provided which is configured to lock said first drive mechanism (110) and/or said second drive mechanism (120).

Fig. 1a



Description

Field of the invention

[0001] The invention relates to an electrical switchgear comprising at least one power switch and a grounding switch associated with said power switch for electrically grounding said power switch.

[0002] The invention further relates to a method of operating such electrical switchgear.

Background

[0003] An electrical switchgear of the aforementioned type is known from EP 1 786 010 B1.

Summary

[0004] It is an object of the present invention to provide an improved switchgear and method of operating such switchgear which offer an increased operational flexibility and reliability.

[0005] According to the present invention, regarding the electrical switchgear, said object is achieved by providing a first drive mechanism for driving said power switch, providing a second drive mechanism for driving said grounding switch, and by providing an interlocking unit which is configured to lock said first drive mechanism and/or said second drive mechanism. This offers an increased degree of operational flexibility and reliability and helps to avoid undesired combinations of operational states of the power switch(es) and the associated grounding switch(es), which may even lead to destruction of the switchgear.

[0006] According to an embodiment, said interlocking unit is configured to selectively lock either said first drive mechanism or said second drive mechanism.

[0007] According to a further embodiment, at least one locking element, particularly a locking bolt, is provided for locking said first drive mechanism and/or said second drive mechanism. In a preferred variant, one or more locking bolts may be employed that have a basically circular cylindrical shape. However, according to further embodiments, said locking element(s) may also comprise any other suitable shape for effecting a mechanical interlocking (e.g., by form closure) of at least some components of the respective drive mechanism.

[0008] According to a further embodiment, a drive unit is provided to move said at least one locking bolt, wherein said drive unit comprises at least one electromechanical actuator, particularly at least one of a stepper motor, a series-characteristic motor, wherein optionally a reduction gear may be provided. This enables remote control of the interlocking unit and thus increased security for the staff, because manual interaction with components of the drive mechanism is not required any more.

[0009] According to a further embodiment, said drive unit is configured to axially move said locking bolt be-

tween a first axial end position and a second axial end position, wherein preferably a maximum stroke between said first and second axial end positions ranges from about 20 millimeters to about 200 millimeters.

[0010] According to a further embodiment, a control unit is provided for controlling an operation of said interlocking unit, wherein preferably said control unit is arranged at and/or within a housing of said interlocking unit, and wherein preferably said control unit comprises an interface configured to exchange control information and/or data with a further device. This advantageously further supports remote operation of the interlocking unit but also offers the possibility of executing monitoring and/or control functions directly locally in the interlocking unit.

[0011] According to a further embodiment, a thermal control unit is provided within a housing of said interlocking unit, wherein said thermal control unit is configured to influence an internal temperature and/or an internal humidity within said housing.

[0012] According to a further embodiment, one or more sensors (and/or switches) are provided for detecting an operational state of the switchgear and/or of the interlocking unit.

[0013] According to a further embodiment, said second drive mechanism comprises a shaft, preferably a hollow shaft, and a locking disc which is arranged on said shaft in a torque proof manner, wherein said locking disc comprises at least one opening configured to receive an axial end section of said locking bolt.

[0014] According to a further embodiment, a manual drive mechanism (e.g., a crank handle that may be used to drive a shaft of a motor of the drive unit) is provided, which enables to manually influence an operational state of the interlocking unit, especially in emergency situations or faults of a control unit.

[0015] A further solution to the object of the present invention is provided by a method according to claim 14. Further advantageous embodiments are subject of the dependent claims.

Brief description of the figures

[0016] Further features, aspects and advantages of the present invention are given in the following detailed description with reference to the drawings in which:

- | | |
|---------|--|
| Fig. 1a | schematically depicts a front view of an electrical switchgear according to an embodiment, |
| Fig. 1b | schematically depicts a side view of said switchgear according to Fig. 1a, |
| Fig. 2 | schematically depicts a block diagram of a switchgear according to an embodiment, |

- Fig. 3 schematically depicts a perspective view of an interlocking unit according to an embodiment,
- Fig. 4a, 4b, 4c schematically depict a perspective view of an interlocking unit according to a further embodiment in different operational states,
- Fig. 5 schematically depicts a perspective view of a drive unit according to an embodiment,
- Fig. 6 schematically depicts a perspective view of an interlocking unit according to a further embodiment,
- Fig. 7 schematically depicts a perspective view of a drive unit of the interlocking unit according to Fig. 6,
- Fig. 8 schematically depicts a coordinate axis according to an embodiment, and
- Fig. 9 schematically depicts a simplified flow-chart of a method according to the embodiments.

[0017] Figure 1a schematically depicts a front view of an electrical switchgear 10 according to an embodiment.

[0018] According to the present example, the switchgear 10 is configured as three-phase switchgear having three power switches 11 only one of which is denoted with a reference sign. The switchgear 10 also comprises three grounding switches 12 each of which is associated with a respective power switch 11 for electrically grounding said power switch 11. The embodiments are not limited to switchgear having three electrical phases. Rather, the inventive principle may also be applied to single-phase switchgear, i.e. having a single power switch 11 and an associated grounding switch 12, or to systems having two phases or more than three phases. Nevertheless, for the further explanations, reference will be made to the three-phase switchgear 10 exemplarily depicted by Fig. 1a.

[0019] As can be seen from Fig. 1a, the switchgear 10 comprises a supporting frame 13 on which said power switches 11 and their associated grounding switches 12 are arranged, said supporting frame 13 having two racks 14 for attachment to a supporting surface (not shown), i.e. a ground surface or a foundation.

[0020] In case of more than one switch 11, i.e. as exemplarily depicted by Fig. 1a, all power switch poles represented by the respective power switches 11 may have the same configuration and may e.g. be configured as per se known high-voltage power switches or high-voltage power switches with disconnecting functionality (particularly according to IEC 62271-108), which may also

be referred to as "disconnecting circuit breaker" (DCB). According to a further embodiment, the power switches 11 may also be configured as high-voltage load break switches. According to a further embodiment, each of said power switch poles comprises a basically cylindrical shape and is arranged on a top surface of supporting frame 13.

[0021] According to an embodiment, each of the three power switches 11 comprises a first terminal 16, which may be displaced relative to the top surface of supporting frame 13 by means of an insulator 18 (insulator 18 may also be denoted as support insulator), and a second terminal 17 arranged at a vertical top section of the power switch pole represented by power switch 11. Between terminals 16, 17, a further insulator 18 may be provided, which may e.g. comprise a switching chamber. Generally, one or more components of the power switch 11 may be arranged in said insulator(s) 18 in a per se known manner.

[0022] Each of the power switches 11 is equipped with a respective grounding switch 12. The grounding switches 12 may be connected to electrical ground e.g. by means of the supporting frame 13 and the racks 14. It is also possible that at least some components, particularly movable components, of said grounding switches 12 are electrically connected to the frame 13 and/or the racks 14 by means of flexible grounding cables or sliding contacts. According to one embodiment, all three grounding switches 12 may comprise a basically identical configuration with pivotable contact arms 21, also cf. the dashed quadrant lines 22 indicating a path of movement from the surface of the supporting frame 13 to the first terminal 16 of the first power switch 11.

[0023] In a first operational state of the grounding switch 12, the "switched-on" state, the contact arm 21 is in a vertically upright position, in electrical contact with the first terminal 16 of the switch 11 thus grounding said switch 11. In a second operational state, the "switched-off" state, the contact arm 21 is in a horizontal position, i.e. basically in parallel with a longitudinal axis of the supporting frame 13, thus not grounding said switch 11. Further details of the grounding switches are provided in EP 1 786 010 B1, cf. e.g. paragraphs [0019] to [0031].

[0024] As can also be seen from Fig. 1a, a first drive mechanism 110 is provided at the supporting frame 13, said first drive mechanism 110 being configured to drive said power switch 11 in a per se known manner. For example, the first drive mechanism 110 may comprise a spring drive mechanism enabling storage of mechanical energy for driving or moving, respectively, one or more components of the switch 11 to effect a change of said switch 11 from a first operational state to a second operational state and vice versa. According to one embodiment, the drive mechanism 110 may comprise a spring drive mechanism, for example of the "FK3" type series of Alstom Grid.

[0025] Further, a second drive mechanism 120 is provided for driving said grounding switch 12, particularly

the movement of the pivotable contact arm(s) 21 as already explained above.

[0026] Generally, both drive mechanisms 110, 120 may comprise one or more movable shafts and/or hollow shafts and/or levers and/or rod linkages and the like to establish a functional chain for transferring movement energy or "switching energy" from an energy source such as a spring energy store and/or a motor drive and/or a manual drive or the like to at least one movable component of the power switch 11 and the grounding switch 12.

[0027] According to the present invention, an interlocking unit 200 is provided, which is configured to lock said first drive mechanism 110 and/or said second drive mechanism 120 thus advantageously enabling to control or even prevent changes in the operational states of the power switch(es) 11 and the grounding switch(es) 12.

[0028] According to an example, as can be seen from Fig. 1a, the interlocking unit 200 is arranged at or within the supporting frame 13, preferably close to the drive mechanisms 110, 120.

[0029] Fig. 1b schematically depicts a side view of said switchgear 10 according to Fig. 1a. As can be seen from Fig. 1b, the interlocking unit 200 is arranged between the drive mechanisms 110, 120.

[0030] Fig. 2 schematically depicts a block diagram of the interlocking unit 200 according to an embodiment. In this embodiment, at least one locking bolt is provided for locking said first drive mechanism 110 and/or said second drive mechanism 120. Presently, without limitation to the generality of the foregoing, two locking bolts 202', 202" are provided, which, according to a further embodiment, may e.g. be individually moved by a drive unit 210 of said interlocking unit 200.

[0031] A control unit 220 is provided for control of said drive unit 210 and thus for controlling the operational states of the locking bolts 202', 202". The control unit 220 may comprise a calculating unit (not shown) such as e.g. a microcontroller and/or microprocessor and/or digital signal processor (DSP) and/or an application specific integrated circuit (ASIC) and/or a field programmable gate array (FPGA) or the like.

[0032] According to an embodiment, said control unit 220 is arranged at and/or within a housing (not shown in Fig. 2) of said interlocking unit 200, wherein preferably said control unit 220 comprises an interface 222 configured to exchange control information 222a and/or data 222a with a further device, e.g. an external control device (not shown) for controlling operation of said switchgear (Fig. 1a).

[0033] According to an embodiment, particularly, the first locking bolt 202' may be moved by said interlocking unit 200 or its drive unit 210, respectively, at least between two different operational states, wherein in a first operational state, the first locking bolt 202' does not lock the drive mechanism 110 for the switch 11 (Fig. 1a) thus not preventing the switch 11 from altering its operational state, and wherein in a second operational state, the first locking bolt 202' does lock the drive mechanism 110 for

the switch 11 thus preventing the switch 11 from altering its operational state.

[0034] In analogy, according to an embodiment, the second locking bolt 202" (Fig. 2) may also be moved by said interlocking unit 200 or its drive unit 210, respectively, at least between two different operational states, wherein in a first operational state, the second locking bolt 202" does not lock the drive mechanism 120 for the grounding switch 12 (Fig. 1a) thus not preventing the grounding switch 12 from altering its operational state, and wherein in a second operational state, the second locking bolt 202" does lock the drive mechanism 120 for the grounding switch 12 thus preventing the grounding switch 12 from altering its operational state.

[0035] Locking a drive mechanism 110, 120 may e.g. be affected by moving a locking bolt into a position where movement of at least one movable component of the drive mechanism 110, 120 to be locked may be prevented, e.g. by means of form closure of the locking bolt with said at least one movable component, also cf. the embodiments explained below with reference to Fig. 3, 4, for example.

[0036] According to a preferred embodiment, as already mentioned above, the drive unit 210 of the interlocking unit 200 may be configured such that individually driving either said first locking bolt 202' and/or said second locking bolt 202" is possible. I.e., in this case, the first and second locking bolts 202', 202" may be driven by the interlocking unit 200 independently from each other.

[0037] According to an embodiment, a drive unit 210 is provided to move said at least one locking bolt 202', 202", wherein said drive unit 210 comprises at least one electromechanical actuator, particularly at least one of a stepper motor, a series-characteristic motor, wherein optionally a reduction gear may be provided.

[0038] According to a further embodiment, two motor drives may be provided which may be controlled by control unit to selectively move the locking bolts 202', 202" thus individually locking the switches 11 and/or 12.

[0039] In case of switchgear 10 (Fig. 1a) having more than one electrical phase, as is well known, all power switches 11 may be controlled by the first drive unit 110 collectively. Likewise, all grounding switches 12 may be controlled by the second drive unit 120 collectively. In this configuration, for the inventive locking unit 200 to work properly, it may be sufficient to configure the locking bolts 201', 202" such that each locking bolt 202', 202" may lock a component of the respective drive unit 110, 120 which collectively drives further components of the drive units 110, 120 that may be provided for distributing the driving force of the respective unit 110, 120 to individual ones of said switches 11 and grounding switches 12. In other words, according to an embodiment, said locking unit 200 may be arranged and configured to centrally exert its locking effect to the respective driving mechanism.

[0040] According to an embodiment, the interlocking

unit 200 is configured to selectively lock either said first drive mechanism 110 or said second drive mechanism 120, preferably independently of each other.

[0041] According to an embodiment, the interlocking unit 200 is configured to selectively lock either said first drive mechanism 110 or said second drive mechanism 120 in a mutually exclusive fashion. I.e., while locking the first drive unit 110, the interlocking unit 200 may not simultaneously lock the second drive unit 120, and vice versa.

[0042] According to a further embodiment, the interlocking unit 200 is configured such that exactly one of said drive units 110, 120 is locked at a time, and the other one is not locked. With this variant, e.g., in a first state, the first drive unit 110 may be locked, and the second drive unit 120 cannot be locked simultaneously by the interlocking unit 200. In a second state, inversely, the second drive unit 120 is locked, and the first drive unit 110 cannot be locked simultaneously by the interlocking unit 200.

[0043] Figure 3 schematically depicts a perspective view of an interlocking unit 200 according to an embodiment. The interlocking unit 200 is arranged between components 112, 112a of the first drive mechanism 110 (Fig. 1b), which is for driving the power switch 11 as explained above, and components 122, 124 of the second drive mechanism 120 which is for driving the grounding switch 12 as explained above.

[0044] More specifically, element 112 is a rotatable (cf. double arrow 112a) hollow shaft 112 to which a lever 113 is attached for driving a rod linkage (not shown in Fig. 3, also cf. 113a of Fig. 6) that effects movement of movable components of the power switches 11 of Fig. 1a. The hollow shaft 112 may e.g. be connected to a driving shaft (not shown) of a spring force drive (not shown) or any other type of drive, which may e.g. be included in the first drive mechanism 110 (Fig. 1b). The present rotational position of the hollow shaft 112 and the lever 113 which is arranged on said hollow shaft 112 in a torque proof manner exemplarily corresponds to an "open state" of the switches 11. According to a particularly preferred embodiment, the lever 113 and the hollow shaft 112 form part of the same monolithic component, which may e.g. be obtained by forging.

[0045] Element 122 is a rotatable (cf. double arrow 122a) shaft 122, preferably a hollow shaft, to which a locking disc 124 is attached in a torque proof manner. Said locking disc 124 comprises at least one opening 126 configured to receive an axial end section 202b of a locking bolt 202 the main body of which is covered by the housing 204 of the interlocking unit 202 in Fig. 3.

[0046] In contrast to the Figure 2 embodiment explained above, one single locking bolt is provided for the embodiment according to Figure 3.

[0047] The housing 204 is arranged on a ground plate 206 which also carries two bearings 208a, 208b having respective openings for opposing axial end sections 202a (cf. Fig. 4a), 202b for the locking bolt 202 which is mov-

able therein in an axially slideable fashion as indicated by the double block arrow of Fig. 3. A portion of the bearing 208a which comprises an opening for guiding the first axial end section 202a of the locking bolt 202 is denoted with reference sign 208a'.

[0048] According to a further embodiment, at least one of said bearings 208a, 208b may be arranged at a further component of said switchgear 10, preferably arranged at the supporting frame 13 (Fig. 1a). For example, the embodiment explained below with reference to Fig. 6 depicts a bearing 208a being arranged at the supporting frame 13.

[0049] Reference sign 222a' denotes a communication cable which serves to exchange control information 222a (Fig. 2) and/or data 222a between control unit 220 and a further device, e.g. an external control device (not shown), for controlling operation of said switchgear 10 (Fig. 1a) and/or said interlocking unit 200.

[0050] Fig. 4a, 4b, 4c schematically depict a perspective view of an interlocking unit 200, preferably the unit 200 as explained above with reference to Fig. 3, in different operational states.

[0051] As can be seen from Fig. 4a, the housing 204 (Fig. 3) of the interlocking unit 200 is not depicted by Fig. 4a, so that the main body of the locking bolt 202 is visible.

[0052] As can also be seen from Fig. 4a, the first axial end portion 202a of the - presently single - locking bolt 202 is in a position where it does not lock or prevent the movement of the lever 113 and thus of hollow shaft 112. Hence, in this state, the lever 113 may e.g. rotate in the direction of arrow a1 when driven by the hollow shaft 112, e.g. for moving the switch 11 from its "open state" to a "closed state", cf. Fig. 4c.

[0053] However, presently, the second axial end portion 202b of said locking bolt 202 is arranged within opening 126 of the locking disc 124 establishing a form closure between bolt 202 and the locking disc 124 thus preventing rotational movement of hollow shaft 122. This is indicated by a dashed double arrow 122a within Fig. 3. As a consequence, in the present state depicted by Fig. 4a (and also by Fig. 3), the grounding switch 12 (Fig. 1a) or its drive unit 120, respectively, is locked by the interlocking unit 200, because locking bolt 202 prevents movement of the hollow shaft 122, which may be provided to drive the pivotable contact arms 21 (Fig. 1a) of the grounding switches 12.

[0054] As a result, in the operational state of the interlocking unit 200 according to Fig. 4a, the power switch 11 is not locked, but the grounding switch 12 is locked. More specifically, the power switch 11 is not locked, and currently is in the "open state", and the grounding switch 12 is locked in its "open state".

[0055] According to a further embodiment, the locking bolt 202 may comprise a double bolt portion 202a' the purpose of which will be explained below with reference to Fig. 4c.

[0056] Figure 4b depicts the interlocking unit 200 of Fig. 4a in a further operational state. In contrast to Fig.

4a, the locking bolt 202 is placed such that its first axial end section 202a locks movement of the lever 113 in direction of the dashed arrow a1', however, since its second axial end portion 202b is not arranged within the opening 126 of the locking disc 124 anymore, the locking bolt 202 does not effect locking of the hollow shaft 122 of the grounding switch drive unit 120 anymore. For example, starting from the Fig. 4a scenario, the interlocking unit 200 may have moved the locking bolt 202 in Fig. 4a to the left thus obtaining the scenario according to Fig. 4b. Also, the second drive mechanism 120 may have turned the hollow shaft 122 to its rotational state depicted by Fig. 4b after the locking state of the second drive mechanism 120 has been left.

[0057] As a result, in the operational state of the interlocking unit 200 according to Fig. 4b, the power switch 11 is locked, but the grounding switch 12 is not locked any more. More specifically, the power switch 11 is locked in its "open state", and the grounding switch 12 is not locked and currently has assumed its "closed state". To close the power switch 11, first the grounding switch 12 must be opened so that the locking bolt 202 may be shifted to the right into the opening 126. Only then the currently depicted locking of the power switch 11 in its open state may be released.

[0058] Figure 4c depicts the interlocking unit 200 of Fig. 4a, 4b in a further operational state, which is similar to the state depicted by Fig. 4a in that the locking bolt 202 is positioned within its right axial end position. Consequently, as with Fig. 4a, the hollow shaft 122 of the second drive mechanism 120 is locked again, and the hollow shaft of the first drive mechanism 110 is not locked.

[0059] As a result, in the operational state of the interlocking unit 200 according to Fig. 4c, the power switch 11 is not locked, but the grounding switch 12 is locked. More specifically, the power switch 11 is not locked and has assumed its "closed state", and the grounding switch 12 is locked and currently has assumed its "open state". Additionally, due to the double bolt portion 202a', the locking bolt 202 is prevented from being moved to its left axial end portion due to form closure with lever 113, whereby it is prevented that the currently applied locking of the grounding switch 12 in its open state is released, while the power switch 11 is in its closed state.

[0060] As already mentioned above, a drive unit 210 (Fig. 2) is provided to move said at least one locking bolt 202, 202', 202'', wherein said drive unit 210 comprises at least one electromechanical actuator, particularly at least one of a stepper motor, a series-characteristic motor, wherein optionally a reduction gear may be provided.

[0061] Fig. 5 schematically depicts a perspective view of a drive unit 210 according to an embodiment, wherein the locking bolt 202 is similar to the one explained above with reference to Fig. 4a to 4c. A stepper motor 212 is provided for moving said locking bolt 202, which is effected by a toothed wheel 213 being applied to a shaft of the stepper motor 212, said toothed wheel 213 working

together with a toothed rack section 202c applied to the locking bolt 202.

[0062] According to an embodiment, one or more sensors are provided for detecting an operational state of the switchgear 10 and/or of the interlocking unit 200 or its drive unit 210, respectively. Presently, Fig. 5 depicts micro switch 215, which is configured to detect a proximity of the double bolt portion 202a' (Fig. 4c) in relation to the micro switch 215. Thus, a signal of the micro switch 215 may e.g. be employed to indicate whether the locking bolt 202 has assumed its right axial position. According to further embodiments, more than one micro switch 215 may be provided, e.g. for indicating a "left" axial end position of the locking bolt 202 or the like. Also, according to further embodiments, a linear position transducer (not shown) may be provided to determine an exact position of the locking bolt 202.

[0063] According to an embodiment, the data provided by the sensor(s) 215 may be evaluated by the control unit 220 and/or may be forwarded to an external unit. Advantageously, an operation of the interlocking unit 200 and/or the switchgear and/or the drive unit 210 may be performed depending on said sensor data.

[0064] According to a further embodiment, a thermal control unit 214 may be provided within a housing 204 (Fig. 3) of said interlocking unit 200, wherein said thermal control unit 214 is configured to influence an internal temperature and/or an internal humidity within said housing 204. In one embodiment, the thermal control unit 214 may comprise a PTC (positive temperature coefficient) element to control an internal temperature of the interlocking unit 200 in a per se known manner to avoid humidity and thus increase an operational flexibility (extended operating temperature/humidity ranges) and reliability.

[0065] Fig. 6 schematically depicts a perspective view of an interlocking unit 200a according to a further embodiment. Depicted is the hollow shaft 112 of the first drive mechanism 110, the lever 113 and a rod linkage 113a which effects movement of movable components of the power switches 11 by conveying kinetic energy from the first drive mechanism 110 or its energy source (e.g., spring energy store) to the switches 11.

[0066] In difference to the embodiments according to Fig. 4a to 4c, 5, the locking bolt 202 of Fig. 6 does not comprise a double bolt portion 202a'.

[0067] Generally, the locking bolt 202 may comprise different axial sections with different outer diameters, as shown by Fig. 6.

[0068] Fig. 7 schematically depicts a perspective view of a drive unit of the interlocking unit 200a according to Fig. 6. An electric motor 212, preferably of the series-characteristic type, is provided together with a reduction gear 2120 attached to a first shaft portion (not shown) of the motor 212. A second shaft portion 2122 of the motor, which is part of the same shaft driving the reduction gear 2120, extends through a housing of the motor and is accessible for applying a driving torque, e.g. manually, e.g.

by means of a crank handle (not shown), whereby the motor 212 and thus the drive unit may also be manually driven, for example in emergency situations.

[0069] A control electronic for driving the motor 212 is arranged in the housing 2140 which is directly attached to the motor housing. The control electronic for driving the motor 212 may e.g. be controlled by the control unit 220 (Fig. 2), preferably depending under control of an external device or a local control panel arranged close to the unit 200 or the switchgear 10.

[0070] An output shaft of the reduction gear is coupled to gear lever 2124 at its radially inner section 2124a to effect rotational movement a_2 of the gear lever 2124. At its radially outer section 2124b, the gear lever 2124 may be connected to the locking bolt 202. For this purpose, the gear lever 2124 may comprise an oblong hole which may be engaged by a driving bolt (not shown) fixedly arranged at the locking bolt 202.

[0071] Fig. 8 schematically depicts a coordinate axis x according to an embodiment, which illustrates the axial movement of the locking bolt 202 according to the embodiments of Fig. 3 to Fig. 7 as explained above.

[0072] A first or "left" axial end position of the locking bolt 202 is denoted with a first coordinate position x_0 . This first axial end position x_0 e.g. corresponds with the scenario of Fig. 4b, also cf. the block arrow of Fig. 8.

[0073] A second or "right" axial end position of the locking bolt 202 is denoted with a coordinate position $x_3 > x_0$. This second axial end position x_3 e.g. corresponds with the scenario of Fig. 4a, also cf. the dashed block arrow of Fig. 8.

[0074] According to an embodiment, a range (x_0, x_1) with $x_1 > x_0$ indicates a first region along the axis x in which - if an end portion 202a of the locking bolt 202 is present within said first range - already a locking of the first drive mechanism 110 will be effected. I.e., if the first axial end section 202a of the locking bolt enters the first range (x_0, x_1), a locking effect will occur.

[0075] According to a further embodiment, a range (x_2, x_3) with $x_2 > x_0, x_2 < x_3$ indicates a second region along the axis x in which - if an end portion 202b of the locking bolt 202 is present within said second range - already a locking of the second drive mechanism 120 will be effected. I.e., if the second axial end section 202a of the locking bolt 202 enters the second range (x_2, x_3), a locking effect will occur.

[0076] According to a particularly preferred embodiment, a total length L_1 of said locking bolt 202 is chosen such that $L_1 > (x_2 - x_1)$, i.e. the length L_1 exceeds a "free" moving range $L_2 = x_2 - x_1$, wherein moving completely within said "free" moving range L_2 does not effect any locking of either drive mechanism 110, 120. In this case, $L_1 > L_2$, the locking bolt 202 in any case locks at least one drive mechanism 110, 120. Presently, for the example of Fig. 8, L_1 is chosen to be larger than L_2 .

[0077] However, according to a further embodiment, L_1 may also be chosen to be smaller than L_2 , whereby an "intermediate" position of said locking bolt 202 may

be assumed in which the locking bolt 202 is not placed within any of the first and second ranges. In this state, neither the power switch 11 nor the grounding switch is locked (mechanically).

[0078] However, if "mutually exclusive" open and closed states are desired to be attained with a high degree of inherent security (e.g., in the case of a fault of the control unit 220), the locking bolt length L_1 may be chosen such that it exceeds L_2 . Thereby it is guaranteed that for many possible positions of the locking bolt 202 both switches 11, 12 are locked, and that in no case, both switches 11, 12 are simultaneously not locked. This e.g. ensures that the grounding switch 12 can never be closed when the power switch 11 is currently closed. Likewise, it will be impossible to close the power switch 11 if the grounding switch 12 is closed.

[0079] According to a further embodiment, additional manual locking means such as a padlock (not shown) may be provided to secure the locking bolt 202 or any component of the drive mechanisms 110, 120 in a pre-determined position.

[0080] Fig. 9 schematically depicts a simplified flow-chart of a method according to the embodiments. In a first step 300, the control unit 220 (Fig. 2) receives a command from an external device, e.g. a computer of a remote operator, to control an operation of the interlocking unit 200. Such command may e.g. comprise an instruction to ensure that the grounding switch 12 is locked in its open state, cf. e.g.

[0081] Fig. 4a. Subsequently, in step 310 (Fig. 9), the control unit 220 may check sensor data (e.g., from micro switch 215, cf. Fig. 5) or other information (e.g., a log file of preceding commands that have been executed and the like) to determine whether the locking of the grounding switch 12 is already established. If so, the procedure terminates and the control unit 220 may e.g. wait for further commands. If not, the control unit 220 may control drive unit 210 to drive the motor 212 for moving the locking bolt 202 in a position which ensures locking of the grounding switch 12 in its open state.

[0082] According to a further embodiment, the locking bolt 202 may comprise a plurality of axial sections having different outer diameters, cf. Fig. 6, wherein a first axial end section 202a comprises an outer diameter ranging between 20 millimeters and 40 millimeters, wherein said outer diameter more preferably equals about 35 millimeters. In contrast, a second axial end section 202b comprises an outer diameter ranging between 15 millimeters and 30 millimeters, wherein said outer diameter more preferably equals about 25 millimeters.

[0083] According to a further embodiment, the locking bolt 202 may be made of steel or stainless steel.

[0084] According to a further embodiment, the locking bolt 202 may comprise a plurality of axial sections 202a, 202b which are tiltably and/or rotatably connected to each other, for example by means of a hinge 2020, cf. Fig. 6. Presently, the two axial sections 202a, 202b are connected by a hinge 2020 having a hinge bolt 2022 that

enables a tilt movement of said two axial sections 202a, 202b around a tilt axis defined by said hinge bolt 2022 thus enabling to compensate mechanical tolerances of the components 200, 110, 112, 113, 120, 122, 124 and their arrangement relative to each other (e.g., deviations in (angular) alignment, and the like).

[0085] According to a further embodiment, the locking bolt 202 may comprise an annular groove 2024 which may e.g. serve to receive mechanical locking means such as a shackle of a padlock (not shown), whereby the locking bolt 202 may be locked in place, e.g. to ensure that no movement of said locking bolt 202 is possible thus also preventing a change of an operational state of the interlocking unit 200. For example, a padlock may be placed with its shackle around the annular groove 202, whereby upon axial movement of said locking bolt 202 the padlock may be driven against a side surface of the bearing 208b (Fig. 3) and/or a housing of the second drive mechanism 120 (Fig. 1a) thus effecting a form closure-type of locking the locking bolt 202 against further axial movement.

[0086] According to a further embodiment, a further locking element 2026 may be provided, which is arranged at a component of the first drive mechanism 110 (Fig. 1a). As exemplarily depicted by Fig. 6, said further locking element 2026 may be attached to a rod linkage 113a which is driven by the lever 113, and may comprise a bent sheet material element. Said further locking element 2026 may be arranged at the rod linkage 113a such that - preferably depending on an axial position of the rod linkage 113a - it prevents an axial movement of the locking bolt 202 in the direction of its first axial end section 202a (i.e., to the left in Fig. 6). Thus, by appropriately arranging said further locking element 2026 at the rod linkage 113a (and or by choosing a width of the locking surface 2026a), the locking bolt 202 can be locked by said further locking element 2026 thus preventing a movement of the locking bolt 202 to its first axial end position x0 (cf. Fig. 8), if the rod linkage 113a and thus also the first drive mechanism 110 as a whole comprises a first operational state, which is depicted by Fig. 6, and which e.g. corresponds to a "closed state" of the switch 11, also cf. Fig. 4c. If, however, the rod linkage 113a and thus also the first drive mechanism 110 as a whole comprises a second operational state, which corresponds to an "open state" of the switch 11, also cf. Fig. 4b, the further locking element 2026 does not prevent an axial movement of the locking bolt 202 in the direction of its first axial end section 202a anymore. Insofar, the further blocking element 2026 comprises a functionality similar to the one of the embodiment with the double bolt portion 202a', cf. Fig. 4c.

[0087] Although the explanations above primarily refer to embodiments with one or more locking bolts (that may, but not necessarily do, comprise a basically circular cylindrical shape) as locking elements, according to further embodiments, said locking elements may also comprise any other suitable shape for effecting a mechanical in-

terlocking (e.g., by form closure) of at least some components of the respective drive mechanism 110, 120.

[0088] The principle according to the embodiments advantageously enables to efficiently, and particularly also to remotely, control an operational state of the interlocking unit 200, whereby an increased operational flexibility and reliability is attained while at the same time offering more safety for technicians and staff operating said switchgear. Also, the use of sensor elements and/or switches to determined information on an operational state of the interlocking unit further increases operational flexibility and reliability and security for the staff. Alternatively or in addition to (micro) switches, an analysis of the motor driving current for the motor 212 (Fig. 5, 7) of the drive unit 210 may be employed to derive information on a position of the locking element.

[0089] According to a further embodiment, visually recognizable position indicating means may also be provided at the interlocking unit 200 or a remote unit being in data connection with said interlocking unit 200, said position indicating means indicating a current operational state of the interlocking unit and/or of a locking element.

Claims

1. Electrical switchgear (10) comprising at least one power switch (11) and a grounding switch (12) associated with said power switch (11) for electrically grounding said power switch (11), wherein a first drive mechanism (110) is provided for driving said power switch (11), and wherein a second drive mechanism (120) is provided for driving said grounding switch (12), and wherein an interlocking unit (200) is provided which is configured to lock said first drive mechanism (110) and/or said second drive mechanism (120).
2. Switchgear (10) according to claim 1, wherein said interlocking unit (200) is configured to selectively lock either said first drive mechanism (110) or said second drive mechanism (120).
3. Switchgear (10) according to one of the preceding claims, wherein at least one locking element, particularly a locking bolt (202; 202', 202''), is provided for locking said first drive mechanism (110) and/or said second drive mechanism (120).
4. Switchgear (10) according to claim 3, wherein a drive unit (210) is provided to move said at least one locking bolt (202; 202', 202''), wherein said drive unit (210) comprises at least one electromechanical actuator, particularly at least one of a stepper motor (212), a series-characteristic motor (212), wherein optionally a reduction gear (2120) may be provided.
5. Switchgear (10) according to claim 4, wherein said

drive unit (210) is configured to axially move said locking bolt (202) between a first axial end position and a second axial end position, wherein preferably a maximum stroke between said first and second axial end positions ranges from about 20 millimeter to about 200 millimeters.

6. Switchgear (10) according to one of the preceding claims, wherein a control unit (220) is provided for controlling an operation of said interlocking unit (200), wherein preferably said control unit (220) is arranged at and/or within a housing (204) of said interlocking unit (200), and wherein preferably said control unit (220) comprises an interface (222) configured to exchange control information (222a) and/or data (222a) with a further device.
7. Switchgear (10) according to one of the preceding claims, wherein a thermal control unit (214) is provided within a housing (204) of said interlocking unit (200), wherein said thermal control unit (214) is configured to influence an internal temperature and/or an internal humidity within said housing (204).
8. Switchgear (10) according to one of the preceding claims, wherein one or more sensors (215) are provided for detecting an operational state of the switchgear (10) and/or of the interlocking unit (200).
9. Switchgear (10) according to one of the claims 3 to 8, wherein said second drive mechanism (120) comprises a shaft (122), preferably a hollow shaft, and a locking disc (124) which is arranged on said shaft (122) in a torque proof manner, wherein said locking disc (124) comprises at least one opening (126) configured to receive an axial end section (202b) of said locking bolt (202).
10. Switchgear (10) according to one of the preceding claims, wherein a motor (212) is provided which is connected to a reduction gear (2120), and wherein a gear lever (2124) is coupled to an output shaft of the reduction gear.
11. Switchgear (10) according to one of the preceding claims, wherein a manual drive mechanism is provided, which enables to manually influence an operational state of the interlocking unit (200).
12. Switchgear (10) according to one of the claims 3 to 11, wherein the locking bolt (202) comprises a plurality of axial end sections (202a, 202b) having different outer diameters, wherein preferably a first axial end section (202a) comprises a first outer diameter ranging between about 20 millimeters and about 40 millimeters, wherein said first outer diameter more preferably equals about 35 millimeters, wherein preferably a second axial end section (202b) comprises

a second outer diameter ranging between about 15 millimeters and about 30 millimeters, wherein said second outer diameter more preferably equals about 25 millimeters.

13. Switchgear (10) according to one of the claims 3 to 12, wherein the locking bolt (202) comprises a plurality of axial sections (202a, 202b) which are tiltably and/or rotatably connected to each other.
14. Method of operating an electrical switchgear (10) comprising at least one power switch (11) and a grounding switch (12) associated with said power switch (11) for electrically grounding said power switch (11), wherein a first drive mechanism (110) is provided for driving said power switch (11), and wherein a second drive mechanism (120) is provided for driving said grounding switch (12), and wherein an interlocking unit (200) is provided which locks said first drive mechanism (110) and/or said second drive mechanism (120).
15. Method according to claim 14, wherein said interlocking unit (200) moves a locking element (202; 202', 202''), particularly a locking bolt, by means of a drive unit (210).

Amended claims in accordance with Rule 137(2) EPC.

1. Electrical switchgear (10) comprising at least one power switch (11) and a grounding switch (12) associated with said power switch (11) for electrically grounding said power switch (11), wherein a first drive mechanism (110) is provided for driving said power switch (11), and wherein a second drive mechanism (120) is provided for driving said grounding switch (12), and wherein an interlocking unit (200) is provided which is configured to lock said first drive mechanism (110) and/or said second drive mechanism (120), wherein at least one locking element, particularly a locking bolt (202; 202', 202''), is provided for locking said first drive mechanism (110) and/or said second drive mechanism (120), and wherein a drive unit (210) is provided to move said at least one locking bolt (202; 202', 202''), wherein said drive unit (210) comprises at least one electro-mechanical actuator, particularly at least one of a stepper motor (212), a series-characteristic motor (212), wherein optionally a reduction gear (2120) may be provided.
2. Switchgear (10) according to claim 1, wherein said interlocking unit (200) is configured to selectively lock either said first drive mechanism (110) or said second drive mechanism (120).

3. Switchgear (10) according to claim 1, wherein said drive unit (210) is configured to axially move said locking bolt (202) between a first axial end position and a second axial end position, wherein preferably a maximum stroke between said first and second axial end positions ranges from about 20 millimeter to about 200 millimeters. 5
4. Switchgear (10) according to one of the preceding claims, wherein a control unit (220) is provided for controlling an operation of said interlocking unit (200), wherein preferably said control unit (220) is arranged at and/or within a housing (204) of said interlocking unit (200), and wherein preferably said control unit (220) comprises an interface (222) configured to exchange control information (222a) and/or data (222a) with a further device. 10
5. Switchgear (10) according to one of the preceding claims, wherein a thermal control unit (214) is provided within a housing (204) of said interlocking unit (200), wherein said thermal control unit (214) is configured to influence an internal temperature and/or an internal humidity within said housing (204). 15
6. Switchgear (10) according to one of the preceding claims, wherein one or more sensors (215) are provided for detecting an operational state of the switchgear (10) and/or of the interlocking unit (200). 20
7. Switchgear (10) according to one of the claims 1 to 6, wherein said second drive mechanism (120) comprises a shaft (122), preferably a hollow shaft, and a locking disc (124) which is arranged on said shaft (122) in a torque proof manner, wherein said locking disc (124) comprises at least one opening (126) configured to receive an axial end section (202b) of said locking bolt (202). 25
8. Switchgear (10) according to one of the preceding claims, wherein a motor (212) is provided which is connected to a reduction gear (2120), and wherein a gear lever (2124) is coupled to an output shaft of the reduction gear. 30
9. Switchgear (10) according to one of the preceding claims, wherein a manual drive mechanism is provided, which enables to manually influence an operational state of the interlocking unit (200). 35
10. Switchgear (10) according to one of the claims 1 to 9, wherein the locking bolt (202) comprises a plurality of axial end sections (202a, 202b) having different outer diameters, wherein preferably a first axial end section (202a) comprises a first outer diameter ranging between about 20 millimeters and about 40 millimeters, wherein said first outer diameter more preferably equals about 35 millimeters, wherein preferably a second axial end section (202b) comprises a second outer diameter ranging between about 15 millimeters and about 30 millimeters, wherein said second outer diameter more preferably equals about 25 millimeters. 40
11. Switchgear (10) according to one of the claims 1 to 10, wherein the locking bolt (202) comprises a plurality of axial sections (202a, 202b) which are tiltably and/or rotatably connected to each other. 45
12. Method of operating an electrical switchgear (10) comprising at least one power switch (11) and a grounding switch (12) associated with said power switch (11) for electrically grounding said power switch (11), wherein a first drive mechanism (110) is provided for driving said power switch (11), and wherein a second drive mechanism (120) is provided for driving said grounding switch (12), and wherein an interlocking unit (200) is provided which locks said first drive mechanism (110) and/or said second drive mechanism (120), wherein at least one locking element, particularly a locking bolt (202; 202', 202''), is provided for locking said first drive mechanism (110) and/or said second drive mechanism (120), and wherein a drive unit (210) is provided which moves said at least one locking bolt (202; 202', 202''), wherein said drive unit (210) comprises at least one electromechanical actuator, particularly at least one of a stepper motor (212), a series-characteristic motor (212), wherein optionally a reduction gear (2120) may be provided. 50
13. Method according to claim 14, wherein said interlocking unit (200) moves a locking element (202; 202', 202''), particularly a locking bolt, by means of a drive unit (210). 55

Fig. 1a

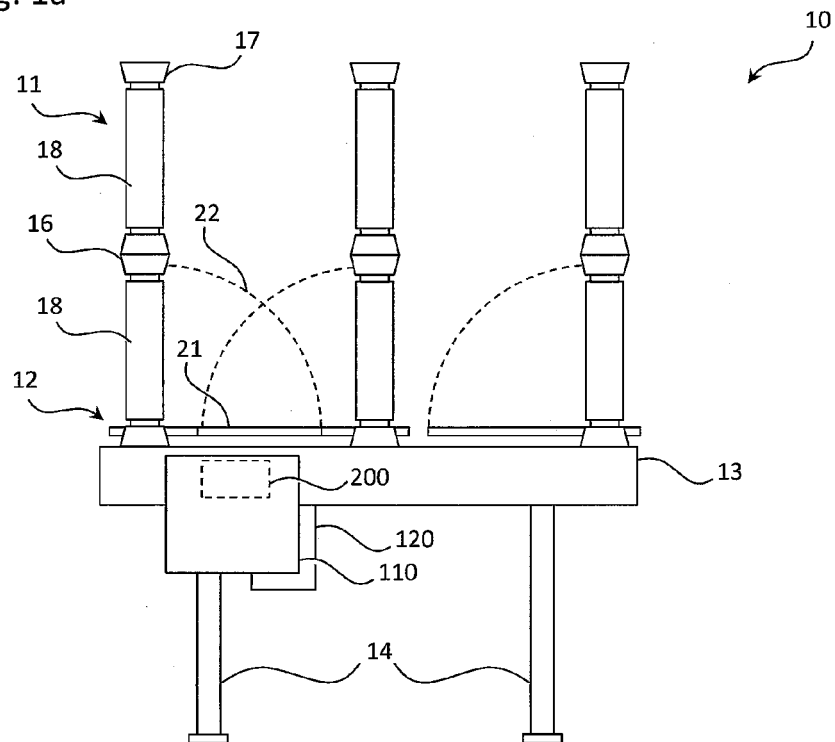


Fig. 1b

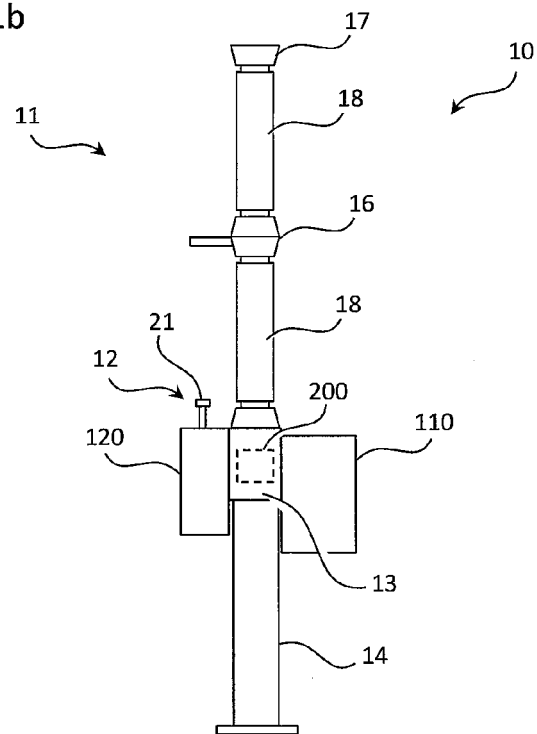


Fig. 2

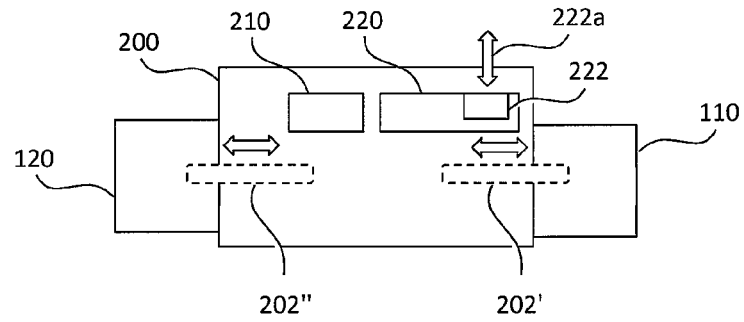


Fig. 3

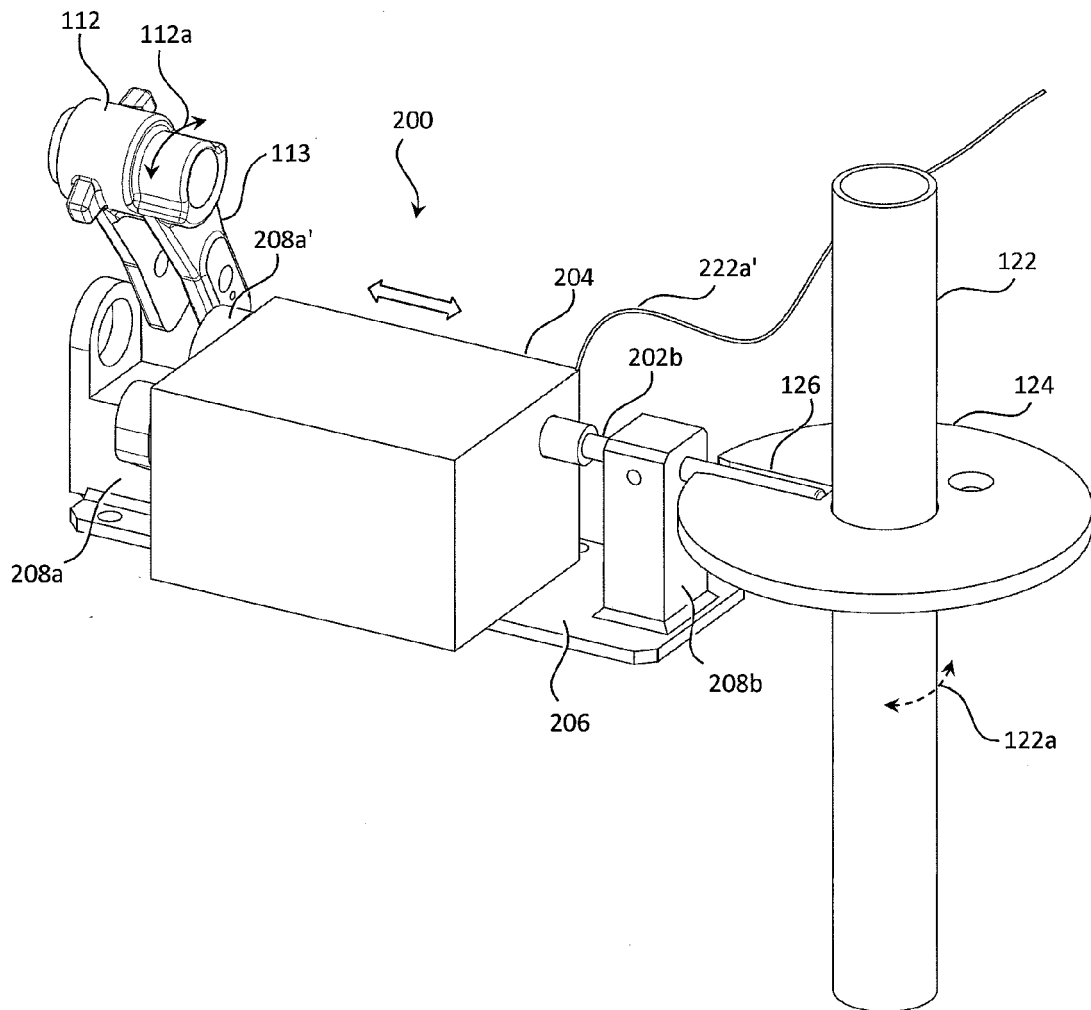


Fig. 4a

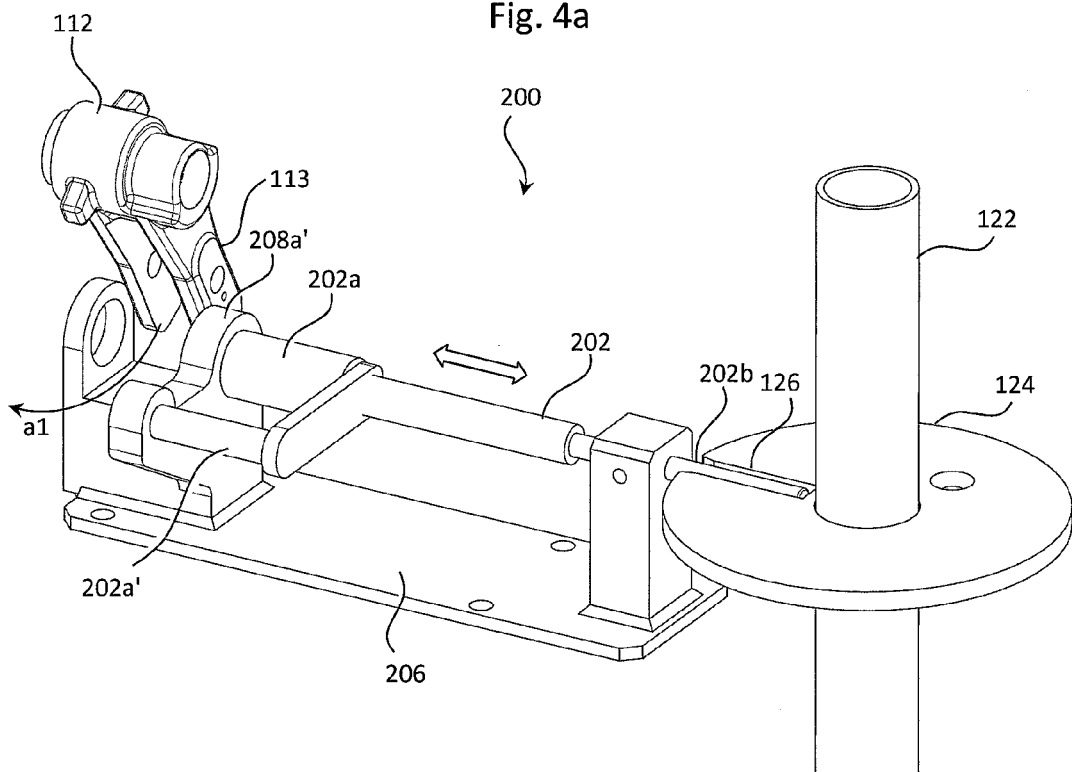


Fig. 4b

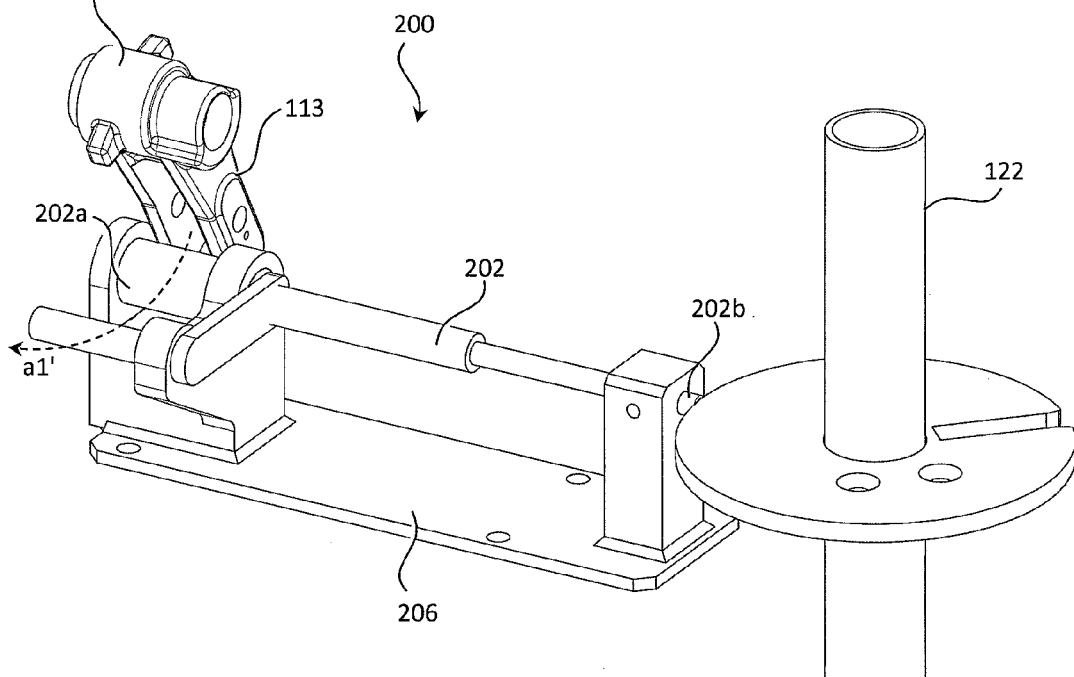


Fig. 4c

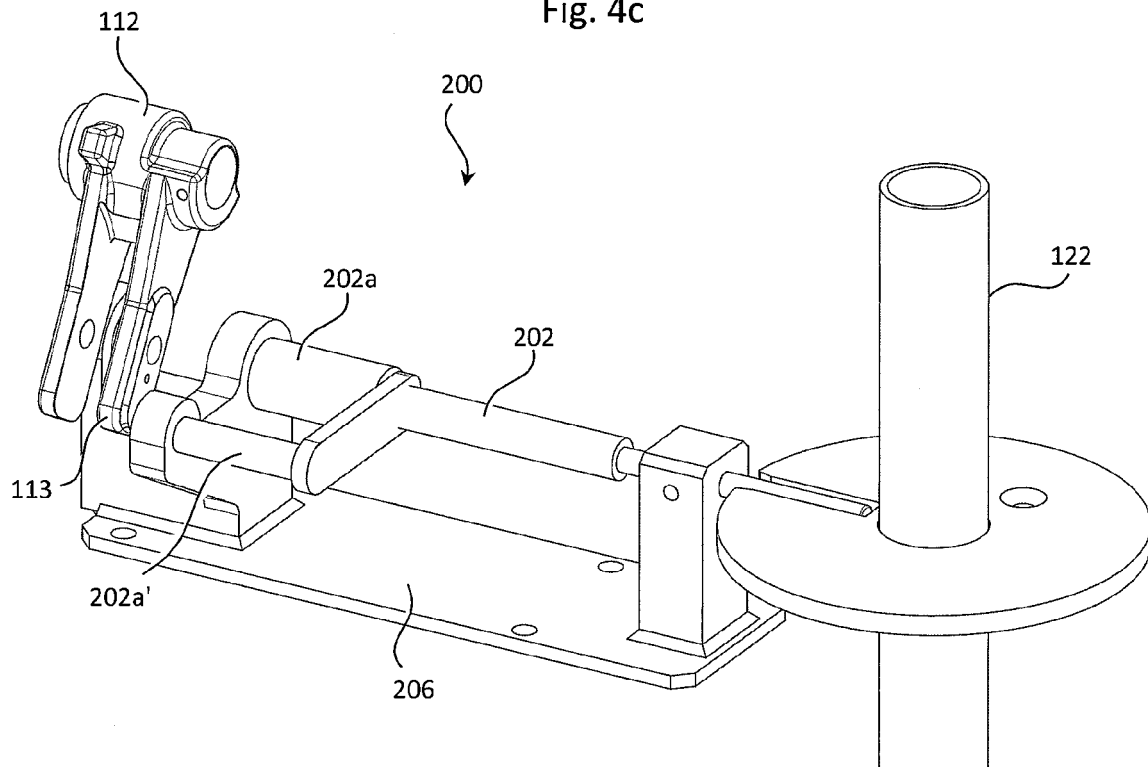


Fig. 5

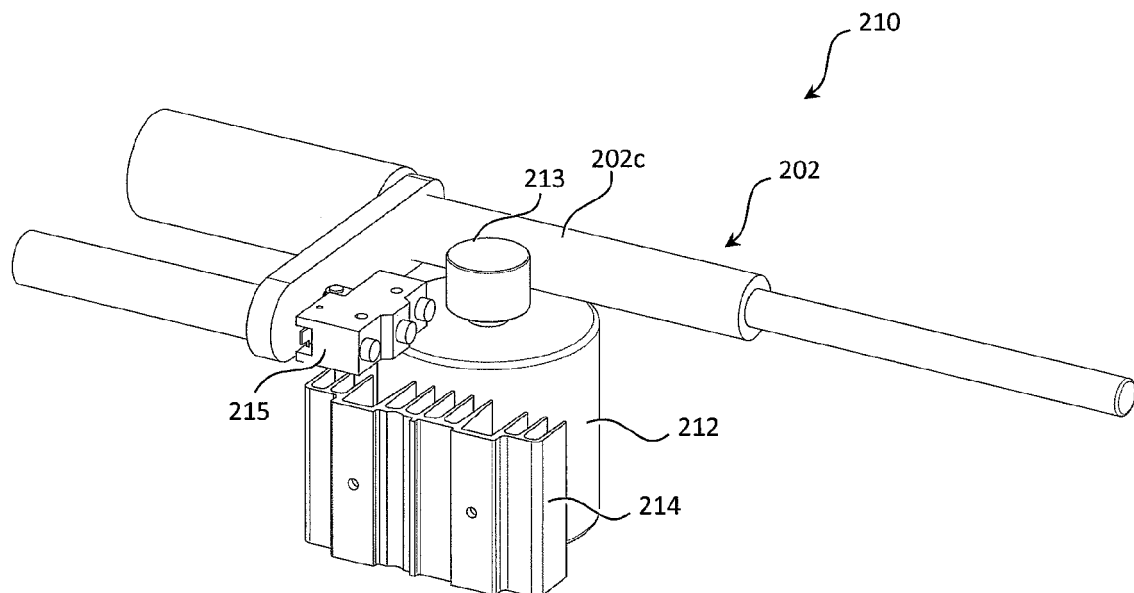


Fig. 6

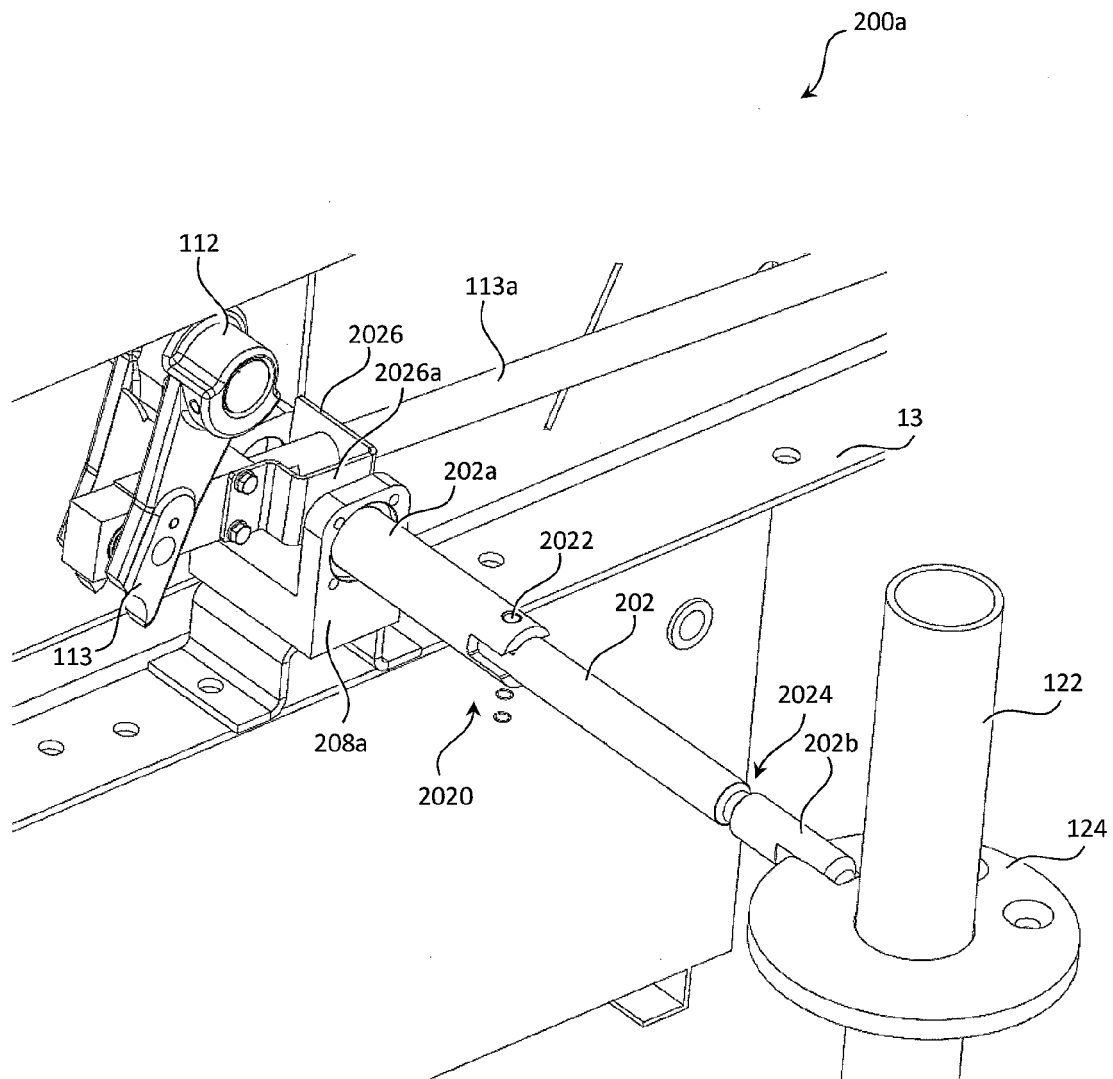


Fig. 7

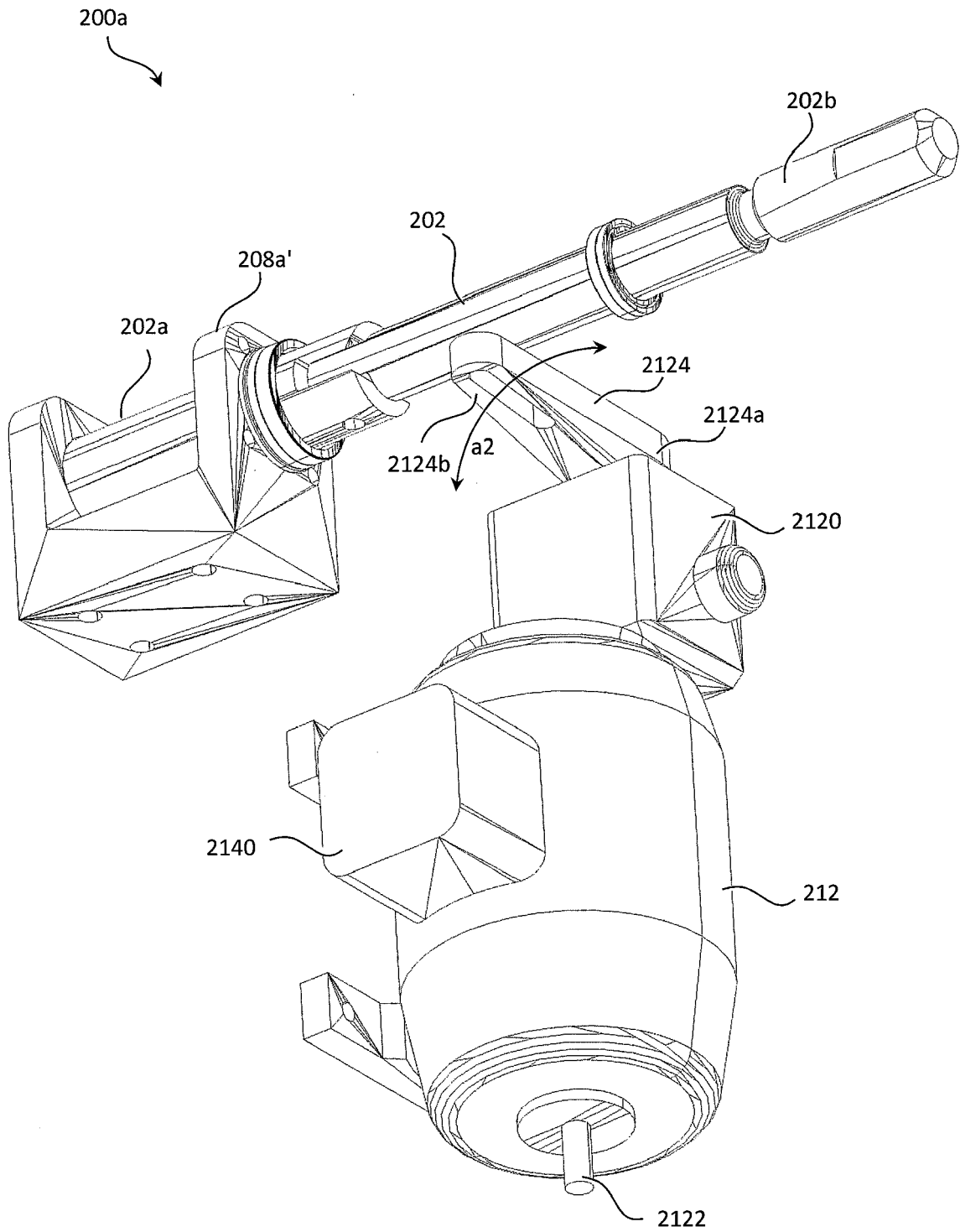


Fig. 8

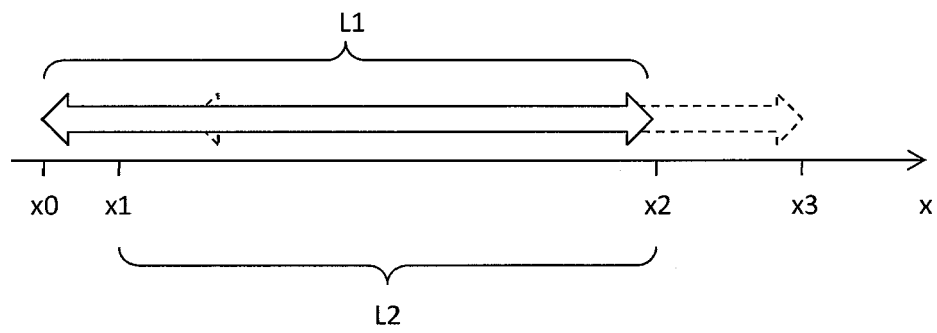
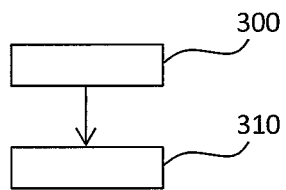


Fig. 9





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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 October 2015	Examiner Hristov, Stefan
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 October 2015	Examiner Hristov, Stefan
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