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

(11) **EP 3 933 867 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
07.06.2023 Bulletin 2023/23

(21) Application number: **20184035.2**

(22) Date of filing: **03.07.2020**

(51) International Patent Classification (IPC):
H01H 1/54 *(2006.01)* ***H01H 50/42*** *(2006.01)*
H01H 50/62 *(2006.01)* ***H01H 39/00*** *(2006.01)*
H01H 89/00 *(2006.01)* ***H01H 9/30*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01H 50/62; H01H 1/54; H01H 3/0253; H01H 9/30; H01H 39/00; H01H 50/42; H01H 89/00; H01H 9/32; H01H 9/36; H01H 9/44; H01H 50/643; H01H 89/10; H01H 2039/008

(54) **CONTACTOR DEVICE, ENERGY STORAGE SYSTEM AND METHOD FOR CONTROLLING A CONTACTOR DEVICE**

SCHÜTZVORRICHTUNG, ENERGIESPEICHERSYSTEM UND VERFAHREN ZUR STEUERUNG EINER SCHÜTZVORRICHTUNG

DISPOSITIF DE CONTACTEUR, SYSTÈME DE STOCKAGE D'ÉNERGIE ET PROCÉDÉ DE COMMANDE D'UN DISPOSITIF DE CONTACTEUR

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
05.01.2022 Bulletin 2022/01

(73) Proprietor: **Munich Electrification GmbH**
81373 Munich (DE)

(72) Inventors:
- **Goldman, Mark**
  Los Altos Hills, CA 94022 (US)
- **Graf, Georg-Friedrich**
  80469 München (DE)
- **Goede, Stefan**
  80799 München (DE)
- **Kleppe, Sebastian**
  80637 München (DE)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(56) References cited:
WO-A1-2010/061576
FR-A- 919 488
FR-A- 974 161
JP-Y1- S47 898
US-A- 4 647 737
US-A- 6 046 661

EP 3 933 867 B1

Description

[0001] The present invention relates to a contactor device, an energy storage system comprising the contactor device and a corresponding method for controlling the contactor device.

[0002] The use of contactor devices for connecting and disconnecting electronic circuits in an energy storage system is known state of the art. With the advanced development of electric vehicles (EV) or hybrid electric vehicles (HEV), high voltage energy storage systems become more and more common in vehicles. As such high voltage systems nowadays are typically capable of supplying voltages in a typical range between 400 V and 1 kV and may be even capable of supplying higher voltages in future applications, these high voltage energy storage systems present a greater shock hazard than traditional powertrains. Accordingly, the prevention of safety hazards and overcurrent protection is of utmost importance for these systems. For example, it is important to ensure the safety of the vehicle's passengers, of roadside assistance or of maintenance workers, in cases of malfunctions of the high voltage energy storage system or of an accident of the vehicle, which affects the electronic circuits of the energy storage system.

[0003] Accordingly, the safety requirements for contactor devices used to control current flow in an energy storage system are increasing, especially where the energy storage system is used for storing energy to drive a vehicle.

[0004] It is therefore a requirement, that the contactor device is capable of carrying large load currents, when the contacts of the contactor device are in contact with each other in an ON state of the contactor device, and of providing high voltage isolation, when the contacts of the contactor device are separated from each other in an OFF state of the contactor device. For example, it is known to enhance the isolation between separated contacts of a contactor device by providing a sealed housing for the internal components of the contactor device and to create a vacuum or provide an electronegative gas atmosphere inside the sealed housing.

[0005] Further, the contactor device should be capable of withstanding large electromagnetic repulsion forces, which may be induced between the contacts of the contactor device during current flow due to electromagnetic effects including the Lorentz force, as such large electromagnetic repulsion forces may lead to unwanted separation between the contacts of the contactor device. This separation of the contacts can easily lead to high voltage arcs between the contacts, thus causing significant contact degradation or even permanent welding of the contacts, which leads to permanent malfunction of the contactor device and makes it difficult or impossible to break fault currents should they occur.

[0006] For this purpose, it is for example known to increase the holding force provided by an actuation mechanism, which holds the contacts of the contactor device in contact with one another during current flow, by enlarging a solenoid, which drives the actuation mechanism, or by increasing the amount of current energizing the solenoid.

[0007] FR 974 161 A discloses an electrical contactor with a main electro-magnetic device, having a movable armature, which cooperates with an operating coil and a fixed magnetic frame thereof. The main electro-magnetic device is not directly integral with the movable contact system, but acts on the latter by means of a stop device allowing the said armature to return independently of the said contact system. An auxiliary electro-magnetic device, comprising an auxiliary magnetic frame with an auxiliary magnetic coil, and an auxiliary armature, is provided to retain the moveable contact system in the closed position after the main electro-magnetic device is de-energized.

[0008] US 6 046 661 A discloses a device for switching an electrical circuit having a contact element, which closes or opens the circuit between a first and a second terminal. One end of the contact element is connected to the first terminal in a conducting fashion. The second free end of the contact element closes the circuit in a first end position and opens the circuit in a second end position. A switchable magnetic field moves by means of an actuator device, the contact element into one of its two end positions.

[0009] WO 2010/061576 A1 discloses a contactor, which is provided with an actuator having a gas generator and a gas operating mechanism. The gas generator generates a high-pressure gas by having a gas-generating agent react in the case where a movable contactor and a fixed contactor are fused to each other. The gas operating mechanism is driven by the high-pressure gas generated by the gas generator and pulls away the movable contactor from the fixed contactor. However, the inventors of the present invention have recognized that the conventional approaches for providing high voltage isolation and for enhancing the resilience against large electromagnetic repulsion forces may lead to complicated design and control requirements, which render the fabrication and mounting of the contactor device more complicated or may even introduce new sources for malfunctions. For example, the high voltage isolation may drop dramatically in a hermetically sealed contactor device, as soon as the sealing of the contactor devices becomes leaky or breaks. Accordingly, the performance of the contactor device critically depends on the tightness of the sealing. Similarly, the implementation of larger solenoids consumes precious space and complicates the fabrication process as well as the control of the energization of the solenoid.

[0010] It is therefore an objective of the present invention to provide an improved contactor device for high voltage applications, a high voltage energy storage system comprising the contactor device and a corresponding method for controlling the contactor device, which provide high reliability in current breaking and current car-

rying operations and can simplify the design and control of the contactor device. Furthermore, it is an object of the present invention to provide a simple and economic solution.

[0011] At least one of these objectives is solved by the subject matter of the independent claims. Advantageous aspects of the invention are the subject matter of the dependent claims.

[0012] In particular, the present invention provides a contactor device for high voltage applications. The contactor device comprises a stationary part having at least one fixed contact and a moveable part having at least one moveable contact.

[0013] The present invention is based on the idea that the contactor device further comprises a first actuator, which is configured to move the at least one moveable contact between an open position and a closed position, wherein in the open position, the at least one moveable contact is electrically separated from the at least one fixed contact, and in the closed position, the at least one moveable contact electrically contacts the at least one fixed contact, and a second actuator, which is adapted to hold the at least one moveable contact in the closed position.

[0014] The idea underlying the present invention is to provide separate actuators for specific operations of the contactor device, namely one actuator for moving the at least one moveable contact between the open position and the closed position, and one actuator for holding the at least one moveable contact in the closed position. Consequentially, each of the separated actuators can be optimized in view of its respective operation.

[0015] The advantage of such a configuration can be firstly seen in the fact that the first actuator can be optimized to provide a large contact travel distance for the at least one moveable contact between the open and closed position, so that high voltage isolation between the at least one moveable contact and the at least one fixed contact can be provided, even if the contactor device is used in a voltage range between 400 V and 1 kV or even at larger voltages. Therefore, the need of sealing the contactor device is dispensed, so that the fabrication of the contactor device becomes less complicated and more cheap and the operation of the contactor device is rendered more reliable as it becomes independent from the tightness of the sealing. Similarly, the second actuator can be optimized in view of a holding force, which can provide low contact resistance and withstand repulsive forces such that the device is capable of supporting continuous currents of 500 A or more, current peaks of up to 5 kA for at least 1 second or up to 10 kA or more for at least 50 ms. By providing separate actuators, also higher flexibility for the arrangement of the actuators in the contactor device can be achieved, so that the limited space in the contactor device can be used more efficiently, while at the same time high reliability of operation is provided. While high efficiency in the transmission of the holding force can be achieved by arranging the second actuator nearby a contact point or contact part of the at least one moveable contact, it is possible to arrange the first actuator locally separated from the second actuator in a peripheral region of the contactor device.

[0016] The second actuator is operated independently from the first actuator. In this manner, it is possible to optimize the first actuator for providing efficient closing transition of the at least one moveable contact between the open position and the closed position, while the second actuator can be simultaneously optimized for holding the at least one moveable contact in the closed position. Overall, the operation complexity of the contactor device can be reduced.

[0017] Furthermore, by providing independently operated actuators, especially the first actuator, which is configured for moving the at least one moveable contact, is rendered less sensitive to manufacturing tolerance and can thus be produced more cheaply. The achieved manufacturing tolerance makes it also practical to either exclude a weight of an armature of the first actuator from influences introduced by external accelerations like gravitational shocks or to even use the a weight of the armature of the first actuator as a counterbalance for compensating external accelerations. Accordingly, the shock tolerance of the contactor device and therefore the operation reliability of the contactor device can be further enhanced.

[0018] In order to prevent current flow through the contactor device, when the contactor device is unpowered, the at least one moveable contact is in the open position, when the first actuator and the second actuator are in an idle state, i.e. are not energized.

[0019] The moveable part comprises a lever, which is adapted to transfer a force from the first actuator to the at least one moveable contact. In this manner, it is possible to arrange the first actuator in a peripheral region of the contactor device, while a transmission force provided by the first actuator, is efficiently transmitted to a contact point or contact part of the at least one moveable contact, which is moved between the open position and the closed position. However, the principles of the present disclosure can also be applied to a situation, where the transmission force is directly transmitted to the contact point or contact part of the at least one moveable contact by a linearly moveable mechanical element, like a shaft or any equivalent thereof.

[0020] The lever is rotatable mounted around a hinge, which is fixed to a case of the contactor device or a frame of the moveable part. In this manner, the lever principle allows to provide especially high efficiency for the force transmission between the first actuator and the at least one moveable contact, while by the rotational movement, a movement path of the at least one moveable contact, which is easy to realize, can be provided.

[0021] According to another preferred aspect, the at least one moveable contact is formed in such a way that it is able to deflect elastically between the open position and the closed position. Accordingly, the transition force generated by the first actuator does not need to move

the at least one moveable contact as a whole, but may only move the contact point or contact part of the at least one moveable contact between the open and the closed position. Hence, the complete generated transition force can be used to deflect the at least one moveable contact, and can therefore be used more efficiently. This arrangement is especially advantageous for single-break style contactor devices, which allow to apply the generated transition and holding forces to one or more single contacts, thus allowing to use the limited forces more efficiently than conventional double-break style contactor devices. Accordingly, the contact resistance of single-break style contactor devices can be substantially reduced, so that the thermal performance at higher currents is improved.

[0022] Preferably, the elasticity of the at least one moveable contact is achieved by forming the at least one moveable contact of a multi-layer structure, which comprises a plurality of layers of electrically conductive material.

[0023] The second actuator is an electromagnetic actuator, which comprises an armature, a yoke and at least one coil. The moveable part comprises the armature of the second actuator and the stationary part comprises the yoke and the at least one coil of the second actuator. Consequently, an especially efficient transmission of the holding force between the moveable part and the stationary part of the contact device can be achieved, as the arrangement of the electromagnetic actuator directly holds the moveable part in contact to the stationary part. Since the holding force between the armature and the yoke decreases with the distance between them, the force from the second actuator can be minimized in the open position of the at least one moveable contact, so that only actuation of the first actuator can move the at least one moveable contact between the open and the closed position, i.e. change the state of the contactor device from current breaking to conducting. Consequently, the holding force can be increased for withstanding large repulsion forces in the current carrying state, without affecting the voltage isolation in the current breaking state.

[0024] For transmitting the holding force from the armature to the at least one moveable contact, the moveable part comprises a support element, which is mounted to the armature and the at least one moveable contact. Consequently, the armature and the at least one moveable contact is mechanically connected by the support element to the lever. In this manner, it can be also ensured that the armature is kept away from the yoke of the second actuator, when the at least one moveable contact is in the open position, so that a holding force resulting from the magnetic interaction between the armature and the yoke is minimized in the open position of the at least one moveable contact.

[0025] Preferably, the support element may comprise a base portion, which at least partly encompasses the armature and at least one projection for holding the at least one moveable contact.

[0026] For absorbing small displacements and vibrations, the at least one projection may be formed of a spring element. In this manner, an elastic connection between the armature and the at least one moveable contact can be provided, so that small displacements or vibrations of the at least one moveable contact can be absorbed by the projections without affecting the first actuator or the second actuator.

[0027] According to another preferred aspect, the contactor device comprises a plurality of fixed contacts and a plurality of moveable contacts, and the first actuator is adapted to move the plurality of moveable contacts simultaneously. In this manner, the transition force generated by the first actuator can be efficiently used to simultaneously move a plurality of moveable contacts between the open and the closed position.

[0028] The present invention also relates to an energy storage system, which comprises at least one energy storage device and the contactor device according to the present invention. The energy storage system may be for example provided in a vehicle for powering the motor of the vehicle. Alternatively, the energy storage system may be a stationary energy storage system, for example used for storing renewable energy.

[0029] Preferably, the energy storage system may further comprise a controller, which is adapted to control the first actuator to move the at least one moveable contact between the open position and the closed position and to control the second actuator to hold the at least one moveable contact in the closed position.

[0030] The present invention also relates to a method of controlling a contactor device for high voltage applications, wherein the contactor device comprises, a stationary part having at least one fixed contact and a moveable part having at least one moveable contact. The method comprises the steps of:

controlling a first actuator, to move the at least one moveable contact between an open position and a closed position, wherein in the open position, the at least one moveable contact is electrically separated from the at least one fixed contact, and in the closed position, the at least one moveable contact electrically contacts the at least one fixed contact; and

controlling a second actuator to hold the at least one moveable contact in the closed position.

[0031] In the following, the invention is described in more detail in reference to the attached figures and drawings. Similar or corresponding details in the figures are marked with the same reference numerals.

[0032] The accompanying drawings are incorporated into the specification and form a part of the specification to illustrate several aspects of the present invention. These drawings, together with the description, serve to explain the principles of the invention. The drawings are

merely for the purpose of illustrating the preferred and alternative examples of how the invention can be made and used, and are not to be construed as limiting the invention to only the illustrated and described aspects.

[0033] Further features and advantages will become apparent from the following, more particular description of the various aspects of the invention, as illustrated in the accompanying drawings in which like references refer to like elements, and wherein:

Fig. 1 shows a schematic perspective view of a contactor device according to an aspect of the present invention;
Fig. 2 shows a schematic side view of the contactor device of Fig. 1 in an open position of the contactor device;
Fig. 3 shows a schematic side view of the contactor device of Fig. 1 in a closed position of the contactor device;
Fig. 4 shows a schematic top view of the contactor device of Fig. 1 in the closed position of the contactor device;
Fig. 5 shows a schematic top view of the contactor device of Fig. 1 in a fired position of the contactor device;
Fig. 6 shows a graphic illustrating a state diagram of the contactor device.

[0034] The present invention will now be explained in more detail with reference to the Figures and firstly referring to Fig. 1. Fig. 1 shows a perspective view of a contactor device 100 according to a first aspect of the present invention, which comprises a stationary part 102 and a moveable part 104. The stationary part 102 and the moveable part 104 are preferably provided unsealed, but may be also housed in a sealed housing.

[0035] In the example of Fig. 1, the stationary part 102 has two fixed contact 106 and the moveable part 104 has two moveable contacts 108, so that the contactor device 100 can function as a 2 pole combination contactor, which under normal operating conditions functions as 2 pole single-break style contactor. Here, the functions of each of the fixed contacts 106 and each of the moveable contacts 108 are mirrored. However, it should be noted here that the number two moveable contacts 108 and two fixed contacts 106 is not essential for the present invention, but the present invention is applicable for contactor devices having any number of moveable contacts and fixed contacts. In particular, the contactor device 100 may solely comprise one moveable contact and one fixed contact. Similarly, it should be noted that the present invention may not only be applied to single-break style contactor devices, but may be also applied to double-break style contactor devices, comprising a pair of fixed contacts and one moveable contact or any other break configuration, involving variable numbers of fixed contacts and moveable contacts.

[0036] The fixed contacts 106 and the moveable contacts 108 can be made from any suitable electrically conducting material, which may comprise for example various metals or metallic materials like copper and its alloys or any electric conducting material that is known in the art.

[0037] Fig.1 shows the moveable contacts 108 in a closed position, where each of the moveable contacts 108 electrically contacts one of the fixed contacts 106, so that a flow of electric current from each of the terminals 112 of the moveable part 104 to each of the terminals 114 of the stationary part 102 is enabled. The terminals 112 and 114 may be used for conductively coupling the contactor device 100 to external electronic circuits, for example an energy storage device or an electric load, which is driven by the voltage of the energy storage device. For reversibly connecting and disconnecting the current path through the contactor device 100, the contactor device comprises a motion actuator 110, which is capable of reversibly moving the at least one moveable contact 108 between the closed position and an open position, for example by use of a solenoid. While the position of the moveable contacts 108 is changed by the motion actuator 110, the fixed contacts 106 remain stationary during activation of the motion actuator 110 and the movement of the moveable contacts 108.

[0038] In the open position, the moveable contacts 108 are separated from the fixed contacts 106, so that the flow of electrical current through the contactor device 100 is prevented. In the closed position, the moveable contacts 108 electrically contact the fixed contacts 106, so that the flow of electrical current through the contactor device 100 is enabled.

[0039] In order to facilitate the reversible transition between the open position and the closed position, the moveable contacts 108 are formed in such a way that they are able to deflect elastically between the open and closed position. Preferably, this can be achieved by forming the moveable contacts 108 of a multi-layer structure, which comprises for example 10 to 15 layers of copper or other suitable electrically conducting material. For example, the multi-layered structure may be fabricated by welding, brazing, or diffusion bonding, in order to provide high quality joints between the layers. However, also any other suitable fabrication method may be used. In addition, each of the moveable contacts 108 may further comprise a bulge 115, for supporting the deflection capability of the moveable contacts 108

[0040] For transmitting a force applied by the motion actuator 110, the moveable part 104 comprises a lever 116, which is rotatable mounted around a hinge 118. Accordingly, a longitudinal axis of the hinge 118 defines an axis of mechanical motion of the moveable contacts 108 during movement between the closed position and the open position.

[0041] In addition, the contactor device 100 further comprises an electromagnetic actuator 120, which is configured to hold the moveable contacts 108 in the closed position. The electromagnetic actuator 120 comprises a yoke 122, an armature 124 and at least one coil

126 (for example, two coils are shown in Fig. 4). A support element 128, which at least partly encompasses the armature 124, mechanically connects the lever 116 and the armature with the moveable contacts 108.

[0042] Elastic projections 130 or other spring elements, like a coiled spring, can be provided at the sides of the support element 128 for holding the moveable contacts 108. In this manner, it can be ensured that small dislocations or imbalances between the moveable contacts 108 during operation of the contactor device 100 can be absorbed by the support element 128 and do not affect the motion actuator 110 or greatly impact the force applied between the fixed contacts 106 and the moveable contacts 108, when the contactor device 100 is in the closed state. Accordingly, tolerances between the moveable contacts 108 and the fixed contacts 106 introduced during fabrication of the contactor device 100 can be better compensated. As shown in Fig. 1, the elastic projections may be formed in a U-shaped form to enhance the elasticity and may be fixed to the armature 124 at a peripheral end for enhancing the stability.

[0043] The fixed contacts 106 are mechanically connected to the yoke 122 by holding elements 132 (see Fig. 2), which for example may be affixed to the yoke 122 by welding or gluing. Alternatively, the holding elements 132 may be an integral part of the yoke 122 and may be formed already, when the yoke 122 is manufactured.

[0044] The electromagnetic actuator 120 is activated, when the moveable contacts 108 are in the closed position, so that a holding force, which results from the magnetic flux through the yoke 122 and the armature 124 is applied between the moveable contacts 108 and the fixed contacts 106. The magnetic flux is generated by energization of the coil (or coils) 126, so that the strength of the holding force can be determined by the number of wound turns of the coil 126 and the current flowing through the coil 126. Accordingly, the moveable contacts 108 are held in the closed position, when the coil 126 is energized.

[0045] The operation of the motion actuator 110 and the electromagnetic actuator 120 will now be explained in more detail with respect to Figs. 2 and 3.

[0046] Fig. 2 shows the contactor device 100 in an unpowered state, where the motion actuator 110 and the electromagnetic actuator 120 are not energized, so that the moveable contacts 108 are in an open position. As shown in Fig. 2, in the open position, the moveable contacts 108 are separated from the fixed contacts 106 by a spatial gap 134, which electrically isolates the moveable contacts 108 from the fixed contacts 106. Accordingly, in the open position of the moveable contacts 108, current flow through the contactor device 100 is prevented. By the separation of the actuation mechanism for moving and holding the moveable contacts, the spatial gap 134 can be made large enough, so that sufficient electrical isolation between the contacts can be provided for normal atmosphere. Accordingly, the need for providing a sealed housing or for using an electronegative gas can be dispensed, so that the design of the contactor device 100 can be remarkably simplified. However, it is also possible to provide a sealed housing and an electronegative gas for the internal components of the contactor device 100, in order to enhance the electrical isolation between separated contacts.

[0047] Furthermore, the spatial gap 134 may be chosen large enough, so that even accidental energization of the coil 126, for example due to a short of the coils electronics, does not result in a force large enough, to move the moveable contacts 108 into the closed position, as long as the motion actuator 110 is in the open position. In this manner, operation safety of the contactor device 100 can be further enhanced.

[0048] Fig. 3 shows the contactor device 100 in a powered state, where the moveable contacts 108 are in the closed position, so that the moveable contacts 108 electrically contact the fixed contacts 106 at least at contact points 136 of the fixed contacts 106. For reducing a contact resistance, the contact points of the fixed contacts 106 and of the moveable contacts 108 may be formed of silver or any silver alloy. However, also other suitable electrically conducting materials are possible.

[0049] For bringing the moveable contacts 108 from the open position into the closed position, the motion actuator actuates the lever 116 at an actuation point 135 of the lever 116, which is arranged on an opposite side of the lever from the support element 128. For example, the lever rotatably moves the moveable contacts 108 around the hinge 118 and the spatial gap 134 is reduced. For bringing the moveable contacts 108 from the closed position back into the open position, the contactor device 100 preferably comprises a spring (not shown in the Figures), which may be integrated into the motion actuator 110 or may be affixed to the lever 116.

[0050] Once, the spatial gap 134 is fully closed and the moveable contacts 108 electrically contact the fixed contacts 106, the coil 126 is energized. Because of the energization of the coil 126, a magnetic force is generated between the yoke 122 and the armature 124, which presses the armature 124 against the magnetic yoke 122, thereby holding the moveable contacts 108 in the closed position. A direction of the holding force, which points in the direction from the moveable contacts 108 to the fixed contacts 106, is indicated in Fig. 3 by the arrow 138.

[0051] When the coil 126 is fully energized and full holding force is applied to the moveable contacts 108, the motion actuator 110 may be powered off again, so that only the electromagnetic actuator 120 holds the moveable contacts 108 in the closed position. However, the motion actuator 110 may be also further actuated, when the coil 126 is fully energized, so as to additionally support the electromagnetic actuator 120 in holding the moveable contacts 108 in the closed position. Accordingly, the holding force applied in the contactor device 100 can be enhanced, without enlarging the coil 126.

[0052] As further shown in Fig. 1 and Figs. 4 to 6, the contactor device 100 may also comprises a pyrotechnic

actuator 202, which is configured to permanently disconnect the fixed contacts 106 from the moveable contacts 108 when activated. Further details about the function and operation of the pyrotechnic actuator 202 can be found in co-pending patent application publication EP 3 933 878 A1 titled "Contactor device, energy storage system and method for controlling a contactor device", which has been filed by the applicant simultaneously with the present application.

[0053] The present invention also relates to an energy storage system, which comprises the contactor device 100. The energy storage system may for example be an energy storage apparatus, which comprises the contactor device 100 and at least one energy storage device, like a battery cell or a capacitor. The energy storage system may further comprise a controller or battery management system, which controls the operation of the at least one energy storage device and of the contactor device 100 and may monitor the operation conditions of the energy storage system.

[0054] The controller or battery management system independently controls the motion actuator 110 and the electromagnetic actuator 120 of the contactor device 100 to reversibly move and hold the moveable contacts 108 between the open position and the closed position, when safe operating conditions are detected.

REFERENCE NUMERALS

100	Contactor device
102	Stationary part
104	Moveable part
106	Fixed contact
108	Moveable contact
110	Motion actuator
112	Terminal of the moveable contact
114	Terminal of the fixed contact
115	Bulge
116	Lever
118	Hinge
120	Electromagnetic actuator
122	Yoke
124	Armature
126	Coil
128	Support element
130	Projection
132	Holding element
134	Spatial gap
135	Actuation point
136	Contact point
138	Direction of the holding force
140	Hinge flexure
202	Pyrotechnic actuator

Claims

1. A contactor device (100) for high voltage applications, the contactor device comprising:

a stationary part (102) having at least one fixed contact (106);
a moveable part (104) having at least one moveable contact (108);
a first actuator (110), which is configured to move the at least one moveable contact (108) between an open position and a closed position, wherein in the open position, the at least one moveable contact (108) is electrically separated from the at least one fixed contact (106), and in the closed position, the at least one moveable contact (108) electrically contacts the at least one fixed contact (106); and
a second actuator (120), which is operated independently from the first actuator (110), and is adapted to hold the at least one moveable contact (108) in the closed position;
wherein the second actuator (120) is an electromagnetic actuator, which comprises an armature (124), a yoke (122) and at least one coil (126),
wherein the moveable part (104) comprises the armature (124) of the second actuator (120), a lever (116), which is adapted to transfer a force from the first actuator (110) to the at least one moveable contact (108), and a support element (128) which is mounted to the armature (124) and the at least one moveable contact (108),
wherein the lever (116) is rotatable mounted around a hinge (118), which is fixed to a case of the contactor device (100) or a frame of the moveable part (104), and the first actuator (110) is configured to actuate the lever (116) at an actuation point (135) of the lever (116),
wherein the support element (128) mechanically connects the armature (124) and the at least one moveable contact (108) to the lever (116) at a side of the lever (116) opposite to the actuation point (135) of the lever (116), and
wherein the stationary part (102) comprises the yoke (122) and the at least one coil (126) of the second actuator (120) and the at least one fixed contact (106) is mechanically connected to the

yoke (122) by a holding element (132).

2. The contactor device (100) according to claim 1, wherein the at least one moveable contact (108) is in the open position, when the first actuator (110) and the second actuator (120) are in an idle state.

3. The contactor device (100) according to one of claims 1 or 2, wherein the at least one moveable contact (108) is formed in such a way that it is able to deflect elastically between the open position and the closed position.

4. The contactor device according to claim 3, wherein the at least one moveable contact (108) is formed of a multi-layer structure, which comprises a plurality of layers of electrically conductive material.

5. The contactor device (100) according to one of claims 1 to 4, wherein the support element (128) comprises a base portion, which at least partly encompasses the armature (124) and at least one projection (130) for holding the at least one moveable contact (108).

6. The contactor device (100) according to claim 5, wherein the at least one projection (130) is formed of a spring element.

7. The contactor device (100) according to any claims 1 to 6, wherein the contactor device comprises a plurality of fixed contacts (106) and a plurality of moveable contacts (108), and wherein the first actuator (110) is adapted to move the plurality of moveable contacts (108) simultaneously.

8. An energy storage system, which comprises at least one energy storage device and the contactor device (100) according to any of claims 1 to 7.

9. The energy storage system according to claim 8, further comprising a controller, which is adapted to control the first actuator (110) to move the at least one moveable contact (108) between the open position and the closed position and to control the second actuator (120) to hold the at least one moveable contact (108) in the closed position.

10. A method of controlling a contactor device (100) for high voltage applications, wherein the contactor device comprises, a stationary part (102) having at least one fixed contact (106) and a moveable part (104) having at least one moveable contact (108), the method comprising the steps of:

controlling a first actuator (110), to move the at least one moveable contact (108) between an open position and a closed position, wherein in the open position, the at least one moveable contact (108) is electrically separated from the at least one fixed contact (106), and in the closed position, the at least one moveable contact (108) electrically contacts the at least one fixed contact (106); and
controlling a second actuator (120), which is operated independently from the first actuator (110), to hold the at least one moveable contact (108) in the closed position;
wherein the second actuator (120) is an electromagnetic actuator, which comprises an armature (124), a yoke (122) and at least one coil (126),
wherein the moveable part (104) comprises the armature (124) of the second actuator (120), a lever (116), which is adapted to transfer a force from the first actuator (110) to the at least one moveable contact (108), and a support element (128) which is mounted to the armature (124) and the at least one moveable contact (108),
wherein the lever (116) is rotatable mounted around a hinge (118), which is fixed to a case of the contactor device (100) or a frame of the moveable part (104), and the first actuator (110) is configured to actuate the lever (116) at an actuation point (135) of the lever (116),
wherein the support element (128) mechanically connects the armature (124) and the at least one moveable contact (108) to the lever (116) at a side of the lever opposite to the actuation point of the lever (116), and
wherein the stationary part (102) comprises the yoke (122) and the at least one coil (126) of the second actuator (120) and the at least one fixed contact (106) is mechanically connected to the yoke (122) by a holding element (132).

Patentansprüche

1. Schaltschütz-Vorrichtung (100) für Hochspannungsanwendungen, wobei die Schaltschütz-Vorrichtung umfasst:

einen stationären Teil (102), der wenigstens einen festen Kontakt (106) aufweist;
einen beweglichen Teil (104), der wenigstens einen beweglichen Kontakt (108) aufweist;
ein erstes Stellglied (110), das so ausgeführt ist, dass es den wenigstens einen beweglichen Kontakt (108) zwischen einer offenen Position und einer geschlossenen Position bewegt, wobei in der offenen Position der wenigstens eine bewegliche Kontakt (108) elektrisch von dem wenigstens einen festen Kontakt (106) getrennt ist und in der geschlossenen Position der wenigstens eine bewegliche Kontakt (108) in elek-

trischem Kontakt mit dem wenigstens einen festen Kontakt (106) ist; sowie ein zweites Stellglied (120), das unabhängig von dem ersten Stellglied (110) betätigt wird und so eingerichtet ist, dass es den wenigstens einen beweglichen Kontakt (108) in der geschlossenen Position hält;
wobei das zweite Stellglied (120) ein elektromagnetisches Stellglied ist, das einen Anker (124), ein Joch (122) und wenigstens eine Spule (126) umfasst,
wobei der bewegliche Teil (104) den Anker (124) des zweiten Stellgliedes (120), einen Hebel (116), der so eingerichtet ist, dass er eine Kraft von dem ersten Stellglied (110) auf den wenigstens einen beweglichen Kontakt (108) überträgt, sowie ein Trageelement (128) umfasst, das an dem Anker (124) und dem wenigstens einen beweglichen Kontakt (108) angebracht ist,
der Hebel (116) um ein Scharnier (118) herum drehbar montiert ist, das an einem Gehäuse der Schaltschütz-Vorrichtung (100) oder einem Rahmen des beweglichen Teils (104) befestigt ist, und das erste Stellglied (110) so ausgeführt ist, dass es den Hebel (116) an einem Betätigungspunkt (135) des Hebels (116) betätigt,
das Trageelement (128) den Anker (124) und den wenigstens einen beweglichen Kontakt (108) an einer Seite des Hebels (116), die dem Betätigungspunkt (135) des Hebels (116) gegenüberliegt, mechanisch mit dem Hebel (116) verbindet, und
der stationäre Teil (102) das Joch (122) und die wenigstens eine Spule (126) des zweiten Stellgliedes (120) umfasst und der wenigstens eine feste Kontakt (106) über ein Halteelement (132) mechanisch mit dem Joch (122) verbunden ist.

2. Schaltschütz-Vorrichtung (100) nach Anspruch 1, wobei sich der wenigstens eine bewegliche Kontakt (108) in der offenen Position befindet, wenn sich das erste Stellglied (110) und das zweite Stellglied (120) in einem Ruhezustand befinden.

3. Schaltschütz-Vorrichtung (100) nach einem der Ansprüche 1 oder 2, wobei der wenigstens eine bewegliche Kontakt (108) so ausgebildet ist, dass er sich elastisch zwischen der offenen Position und der geschlossenen Position biegen kann.

4. Schaltschütz-Vorrichtung nach Anspruch 3, wobei der wenigstens eine bewegliche Kontakt (108) aus einer mehrschichtigen Struktur besteht, die eine Vielzahl von Schichten aus elektrisch leitendem Material umfasst.

5. Schaltschütz-Vorrichtung (100) nach einem der Ansprüche 1 bis 4, wobei das Trageelement (128) einen Basisabschnitt, der den Anker (124) wenigstens teilweise umschließt, sowie wenigstens einen Vorsprung (130) zum Halten des wenigstens einen beweglichen Kontakts (108) umfasst.

6. Schaltschütz-Vorrichtung (100) nach Anspruch 5, wobei der wenigstens eine Vorsprung (130) aus einem Federelement besteht.

7. Schaltschütz-Vorrichtung (100) nach einem der Ansprüche 1 bis 6, wobei die Schaltschütz-Vorrichtung eine Vielzahl fester Kontakte (106) sowie eine Vielzahl beweglicher Kontakte (108) umfasst, und das erste Stellglied (110) so eingerichtet ist, dass es die Vielzahl beweglicher Kontakte (108) gleichzeitig bewegt.

8. Energiespeicherungs-System, das wenigstens eine Energiespeicherungs-Vorrichtung sowie die Schaltschütz-Vorrichtung (100) nach einem der Ansprüche 1 bis 7 umfasst.

9. Energiespeicherungs-System nach Anspruch 8, das des Weiteren eine Steuerungseinrichtung umfasst, die so eingerichtet ist, dass sie das erste Stellglied (120) so steuert, dass es den wenigstens einen beweglichen Kontakt (108) zwischen der offenen Position und der geschlossenen Position bewegt und das wenigstens eine zweite Stellglied (120) so steuert, dass es den wenigstens einen beweglichen Kontakt (108) in der geschlossenen Position hält.

10. Verfahren zum Steuern einer Schaltschütz-Vorrichtung (100) für Hochspannungsanwendungen, wobei die Schaltschütz-Vorrichtung einen stationären Teil (102), der wenigstens einen festen Kontakt (106) aufweist, sowie einen beweglichen Teil (104) umfasst, der wenigstens einen beweglichen Kontakt (108) aufweist, wobei das Verfahren die folgenden Schritte umfasst:

Steuern eines ersten Stellgliedes (110) so, dass es den wenigstens einen beweglichen Kontakt (108) zwischen einer offenen Position und einer geschlossenen Position bewegt, wobei in der offenen Position der wenigstens eine bewegliche Kontakt (108) elektrisch von dem wenigstens einen festen Kontakt (106) getrennt ist und in der geschlossenen Position der wenigstens eine bewegliche Kontakt (108) in elektrischem Kontakt mit dem wenigstens einen festen Kontakt (106) ist; sowie Steuern eines zweiten Stellgliedes (120), das unabhängig von dem ersten Stellglied (110) betätigt wird, so, dass es den wenigstens einen beweglichen Kontakt (108) in der geschlossenen Position hält;
wobei das zweite Stellglied (120) ein elektromagnetisches Stellglied ist, das einen Anker (124),

ein Joch (122) und wenigstens eine Spule (126) umfasst,
wobei der bewegliche Teil (104) den Anker (124) des zweiten Stellgliedes (120), einen Hebel (116), der so eingerichtet ist, dass er eine Kraft von dem ersten Stellglied (110) auf den wenigstens einen beweglichen Kontakt (108) überträgt, sowie ein Trageelement (128) umfasst, das an dem Anker (124) und dem wenigstens einen beweglichen Kontakt (108) angebracht ist,
der Hebel (116) um ein Scharnier (118) herum drehbar montiert ist, das an einem Gehäuse der Schaltschütz-Vorrichtung (100) oder einem Rahmen des beweglichen Teils (104) befestigt ist, und das erste Stellglied (110) so ausgeführt ist, dass es den Hebel (116) an einem Betätigungspunkt (135) des Hebels (116) betätigt,
wobei das Trageelement (128) den Anker (124) und den wenigstens einen beweglichen Kontakt (108) an einer Seite des Hebels, die dem Betätigungspunkt des Hebels (116) gegenüberliegt, mechanisch mit dem Hebel (116) verbindet, und der stationäre Teil (102) das Joch (122) und die wenigstens eine Spule (126) des zweiten Stellgliedes (120) umfasst und der wenigstens eine feste Kontakt (106) über ein Halteelement (132) mechanisch mit dem Joch (122) verbunden ist.

Revendications

1. Dispositif contacteur (100) pour des applications à haute tension, le dispositif contacteur comprenant :

une partie stationnaire (102) comportant au moins un contact fixe (106) ;
une partie mobile (104) comportant au moins un contact mobile (108) ;
un premier actionneur (110) qui est configuré pour déplacer ledit au moins un contact mobile (108) entre une position ouverte et une position fermée, dans lequel, dans la position ouverte, ledit au moins un contact mobile (108) est séparé électriquement dudit au moins un contact fixe (106), et dans la position fermée, ledit au moins un contact mobile (108) est en contact électrique avec ledit au moins un contact fixe (106) ; et
un deuxième actionneur (120) qui est commandé indépendamment du premier actionneur (110) et qui est adapté pour maintenir ledit au moins un contact mobile (108) dans la position fermée ;
dans lequel le deuxième actionneur (120) est un actionneur électromagnétique qui comporte un induit (124), une culasse (122) et au moins une bobine (126),
dans lequel la partie mobile (104) comprend l'induit (124) du deuxième actionneur (120), un levier (116) qui est adapté pour transférer une force du premier actionneur (110) audit au moins un contact mobile (108), et un élément de support (128) qui est monté sur l'induit (124) et ledit au moins un contact mobile (108),
dans lequel le levier (116) est monté de manière rotative autour d'une charnière (118) qui est fixée à un boîtier du dispositif contacteur (100) ou à une monture de la partie mobile (104), et le premier actionneur (110) est configuré pour actionner le levier (116) à un point d'actionnement (135) du levier (116),
dans lequel l'élément de support (128) connecte mécaniquement l'induit (124) et ledit au moins un contact mobile (108) au levier (116) sur un côté du levier (116) opposé au point d'actionnement (135) du levier (116), et
dans lequel la partie stationnaire (102) comprend la culasse (122) et ladite au moins bobine (126) du deuxième actionneur (120), et ledit au moins un contact fixe (106) est connecté mécaniquement à la culasse (122) par un élément de maintien (132).

2. Dispositif contacteur (100) selon la revendication 1, dans lequel ledit au moins un contact mobile (108) est dans la position ouverte quand le premier actionneur (110) et le deuxième actionneur (120) sont dans état inactif.

3. Dispositif contacteur (100) selon l'une des revendications 1 ou 2, dans lequel ledit au moins un contact mobile (108) est conformé de manière à être capable de fléchir élastiquement entre la position ouverte et la position fermée.

4. Dispositif contacteur selon la revendication 3, dans lequel ledit au moins un contact mobile (108) est constitué d'une structure multicouche qui comprend une pluralité de couches de matériau électroconducteur.

5. Dispositif contacteur (100) selon l'une des revendications 1 à 4, dans lequel l'élément de support (128) comprend une portion de base qui englobe au moins partiellement l'induit (124), et au moins une projection (130) pour maintenir ledit au moins un contact mobile (108) .

6. Dispositif contacteur (100) selon la revendication 5, dans lequel ladite au moins une projection (130) est constituée d'un élément de ressort.

7. Dispositif contacteur (100) selon l'une quelconque des revendications 1 à 6, dans lequel le dispositif contacteur comprend une pluralité de contacts fixes (106) et une pluralité de contacts mobiles (108), et

dans lequel le premier actionneur (110) est adapté pour déplacer simultanément la pluralité de contacts mobiles (108).

8. Système de stockage d'énergie comprenant au moins un dispositif de stockage d'énergie et le dispositif contacteur (100) selon l'une quelconque des revendications 1 à 7.

9. Système de stockage d'énergie selon la revendication 8, comprenant en outre un contrôleur qui est adapté pour contrôler le premier actionneur (110) afin de déplacer ledit au moins un contact mobile (108) entre la position ouverte et la position fermée, et pour contrôler le deuxième actionneur (120) afin de maintenir ledit au moins un contact mobile (108) dans la position fermée.

10. Procédé de contrôle d'un dispositif contacteur (100) pour des applications à haute tension, dans lequel le dispositif contacteur comprend une partie stationnaire (102) comportant au moins un contact fixe (106) et une partie mobile (104) comportant au moins un contact mobile (108), le procédé comprenant les étapes suivantes :

contrôle d'un premier actionneur (110) pour déplacer ledit au moins un contact mobile (108) entre une position ouverte et une position fermée, dans lequel, dans la position ouverte, ledit au moins un contact mobile (108) est séparé électriquement dudit au moins un contact fixe (106), et dans la position fermée, ledit au moins un contact mobile (108) est en contact électrique avec ledit au moins un contact fixe (106) ; et
contrôle d'un deuxième actionneur (120) qui est commandé indépendamment du premier actionneur (110), pour maintenir ledit au moins un contact mobile (108) dans la position fermée ;
dans lequel le deuxième actionneur (120) est un actionneur électromagnétique qui comporte un induit (124), une culasse (122) et au moins une bobine (126),
dans lequel la partie mobile (104) comprend l'induit (124) du deuxième actionneur (120), un levier (116) qui est adapté pour transférer une force du premier actionneur (110) audit au moins un contact mobile (108), et un élément de support (128) qui est monté sur l'induit (124) et ledit au moins un contact mobile (108),
dans lequel le levier (116) est monté de manière rotative autour d'une charnière (118) qui est fixée à un boîtier du dispositif contacteur (100) ou à une monture de la partie mobile (104), et le premier actionneur (110) est configuré pour actionner le levier (116) à un point d'actionnement (135) du levier (116),
dans lequel l'élément de support (128) connecte mécaniquement l'induit (124) et ledit au moins un contact mobile (108) au levier (116) sur un côté du levier opposé au point d'actionnement du levier (116), et
dans lequel la partie stationnaire (102) comprend la culasse (122) et ladite au moins bobine (126) du deuxième actionneur (120), et ledit au moins un contact fixe (106) est connecté mécaniquement à la culasse (122) par un élément de maintien (132).

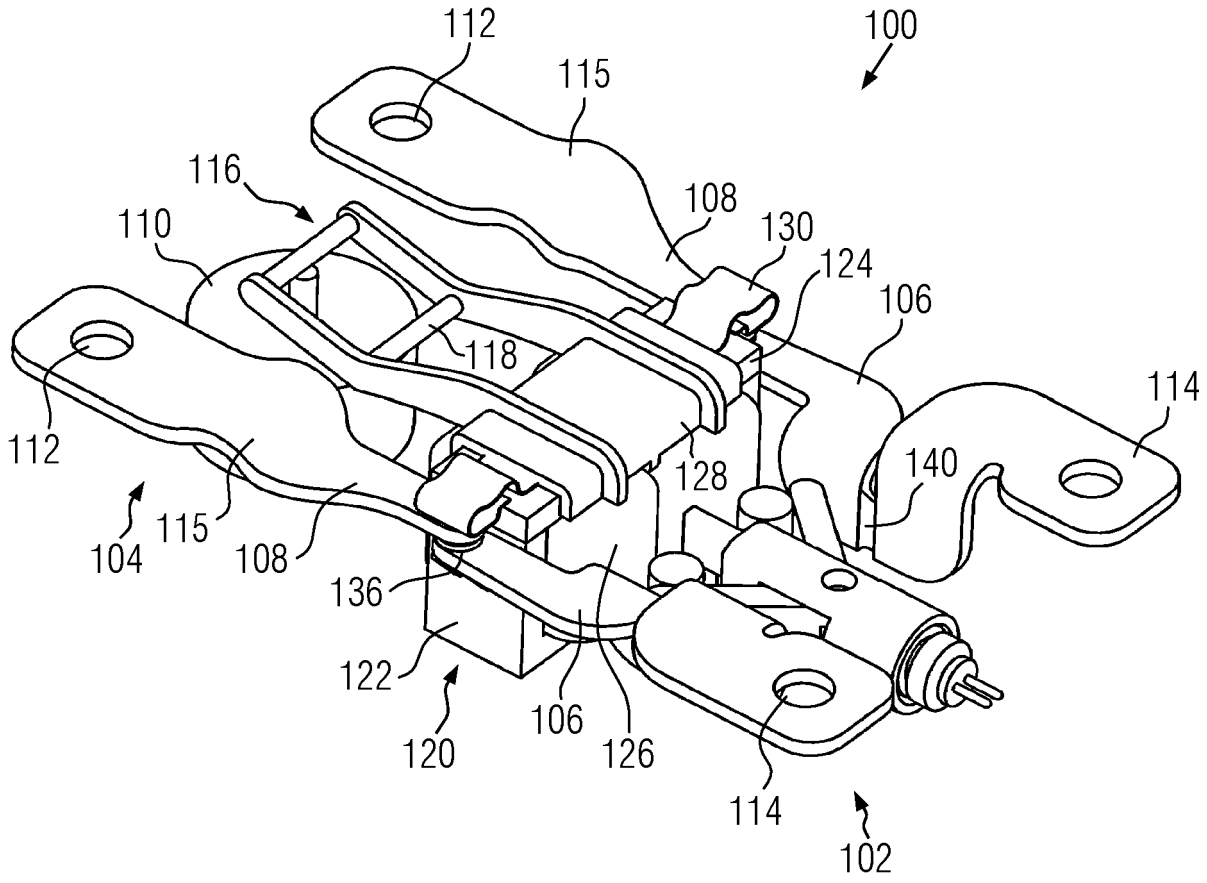
112
100
115
116
108
110
130
124
106
118
114
112
128
140
104
115
108
136
122
120
106
126
114
102

FIG. 1

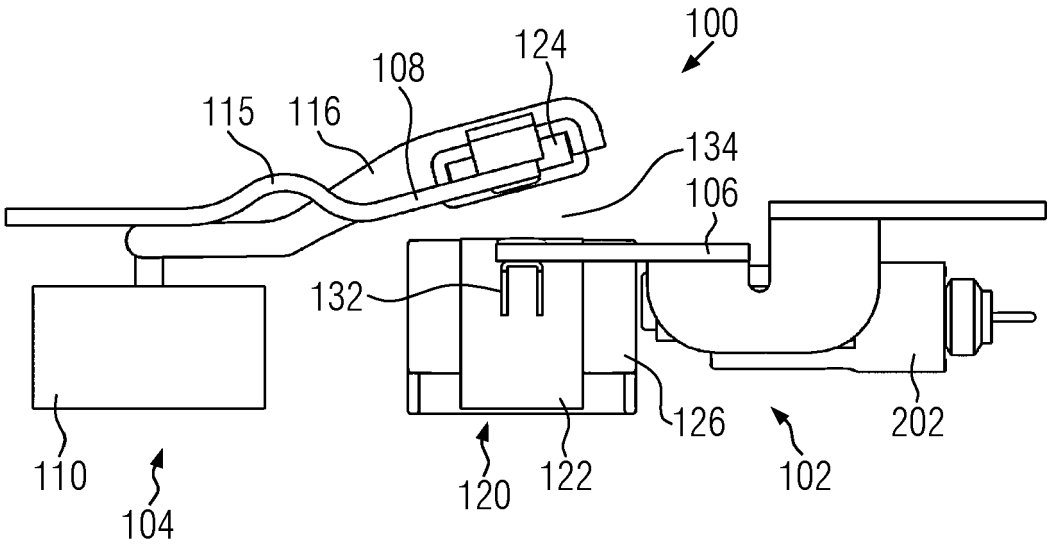
100
124
108
115
116
134
106
132
126
202
110
104
120
122
102

FIG. 2

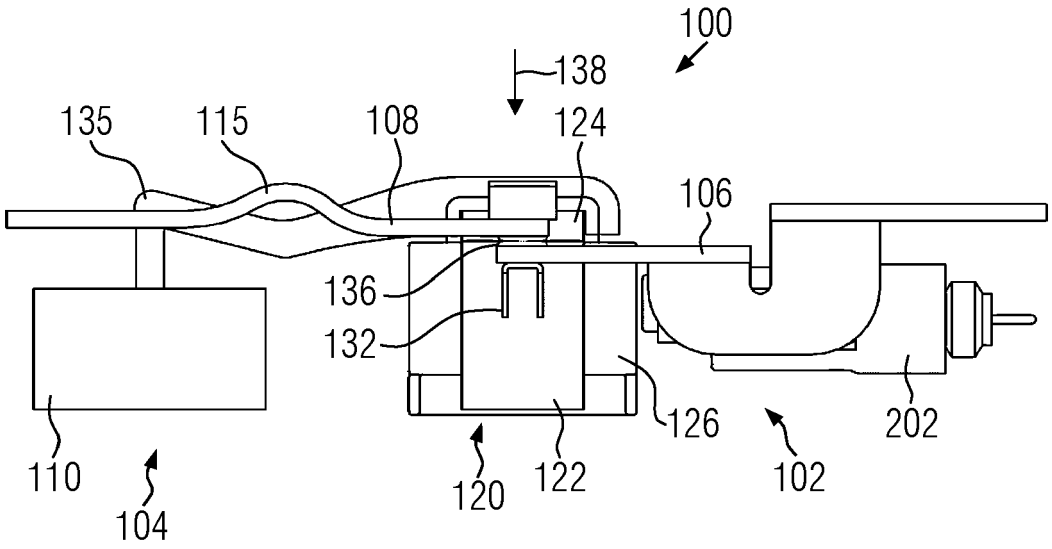
100
138
135
115
108
124
106
136
132
126
202
110
104
120
122
102

FIG. 3

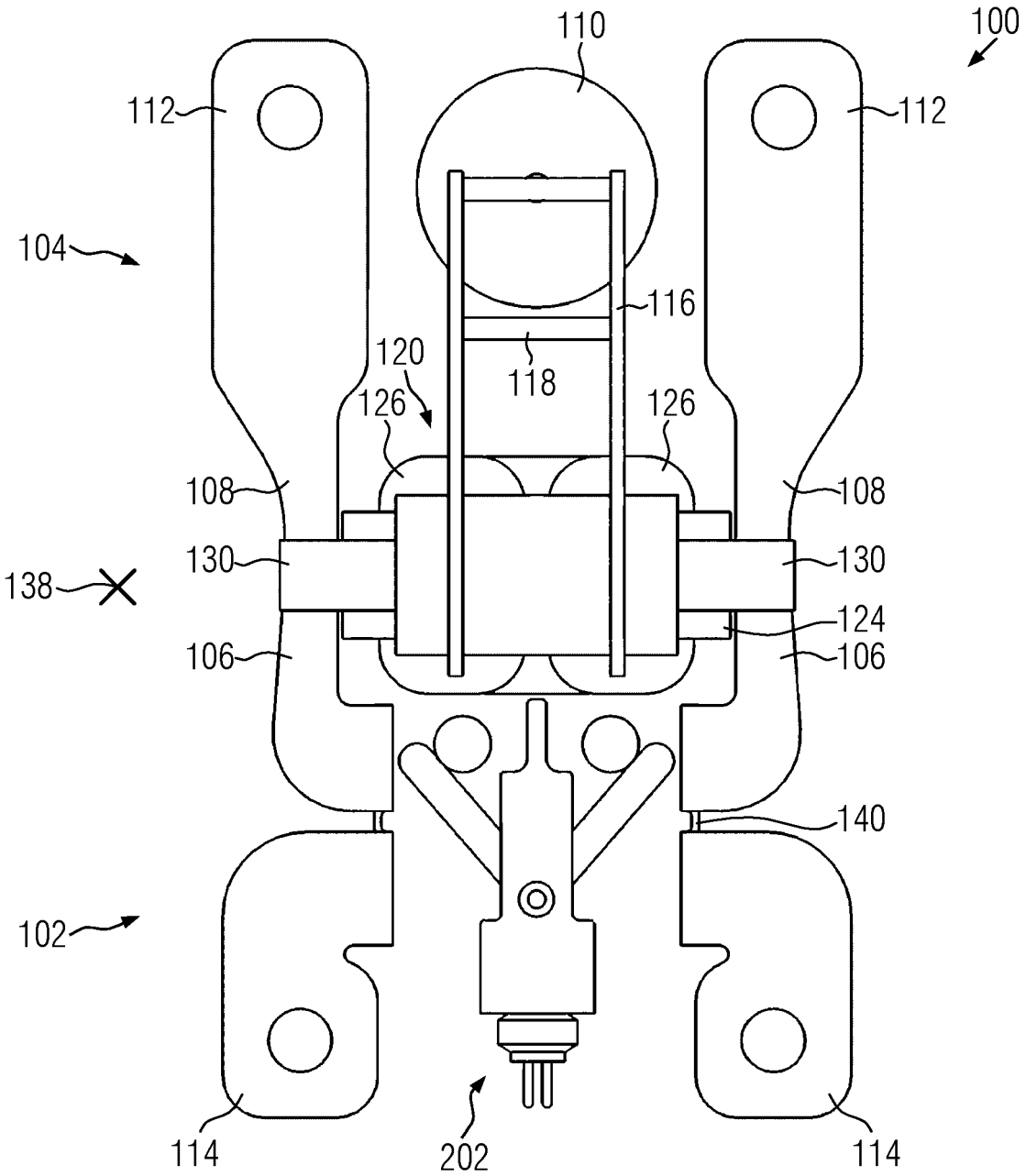
100
110
112
112
104
116
120
118
126
126
108
108
130
130
138
124
106
106
140
102
114
202
114

FIG. 4

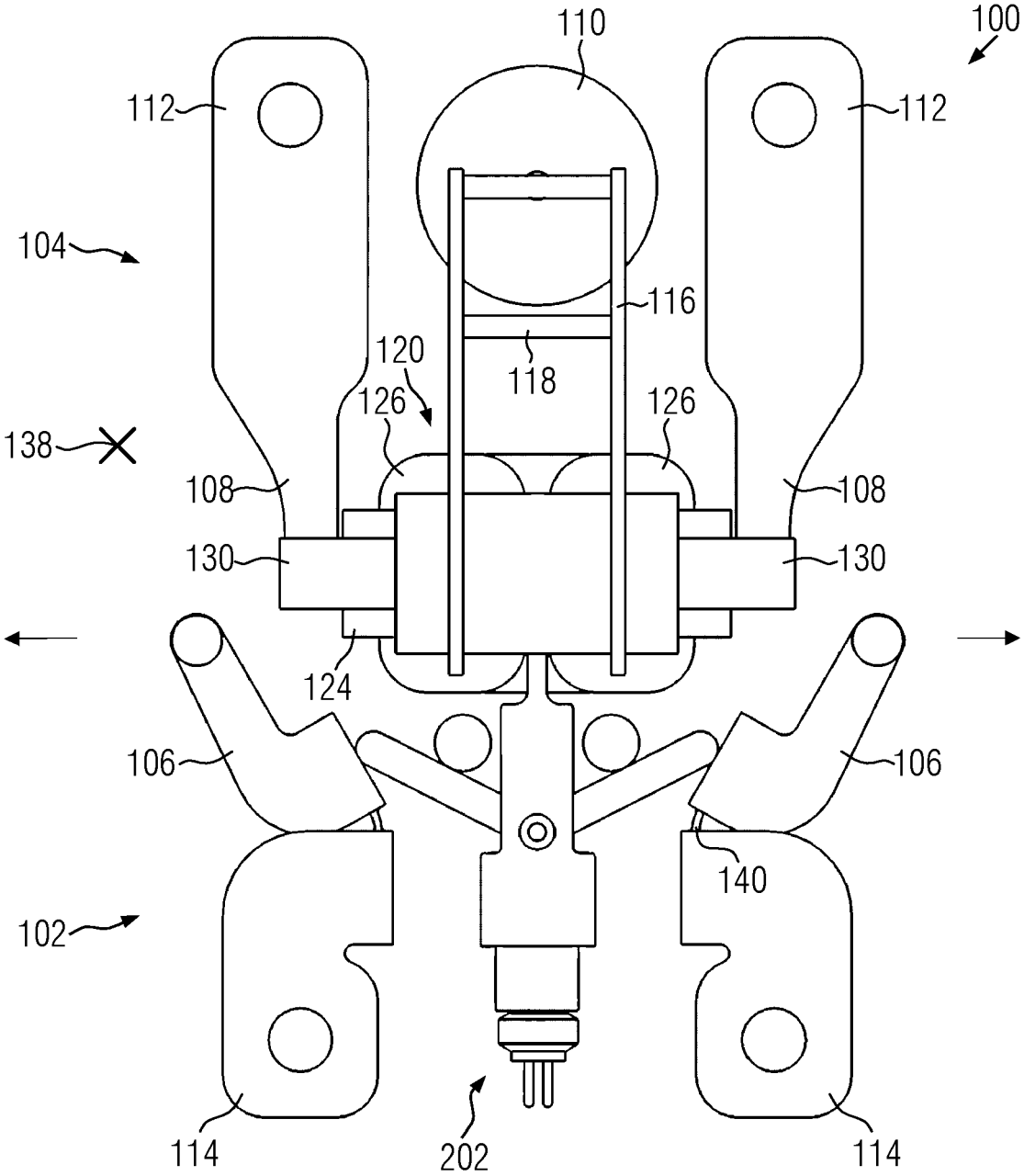
110
100
112
112
104
116
120
118
126
126
138
108
108
130
130
124
106
106
140
102
114
202
114

FIG. 5

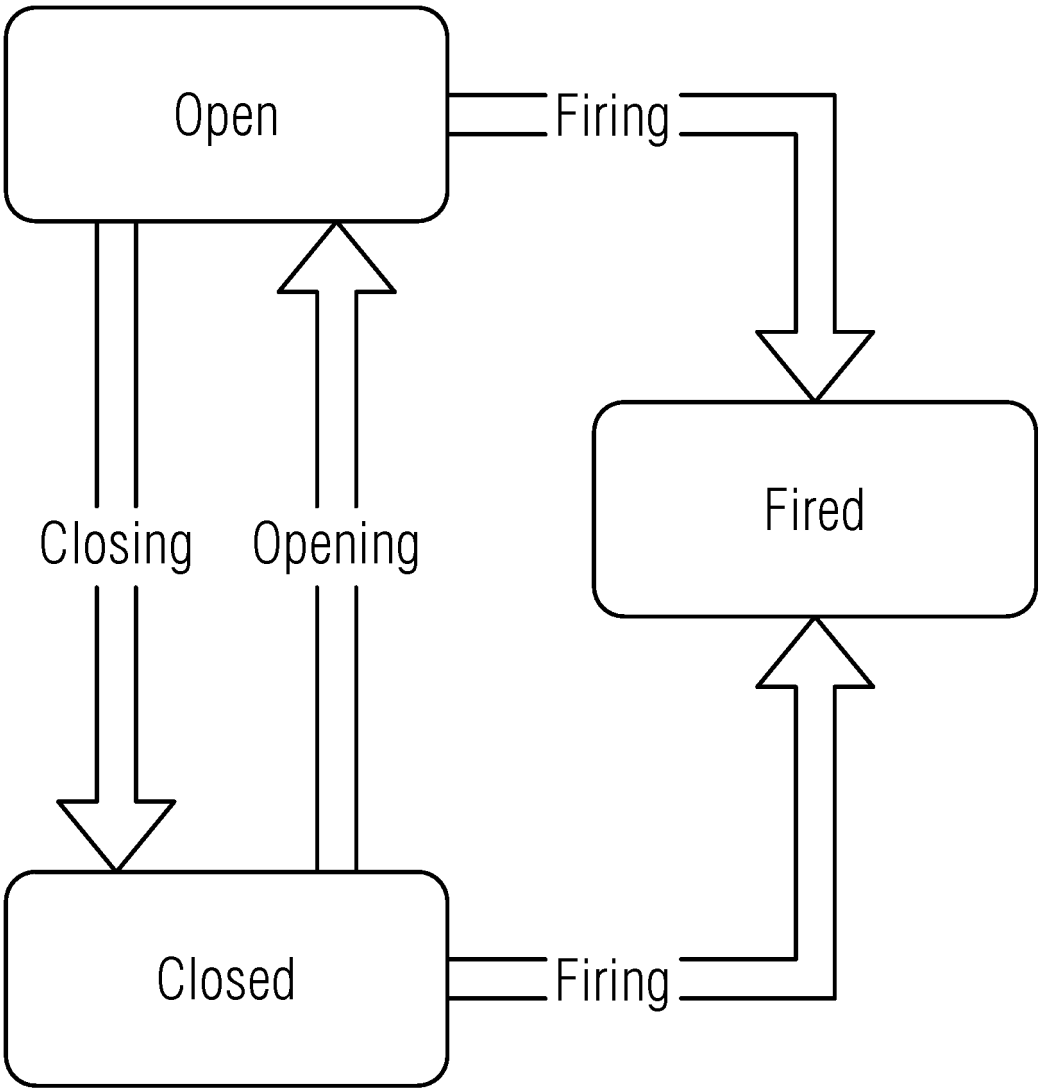

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- FR 974161 A **[0007]**
- US 6046661 A **[0008]**
- WO 2010061576 A1 **[0009]**
- EP 3933878 A1 **[0052]**