



(11)

**EP 4 560 680 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**28.05.2025 Bulletin 2025/22**

(51) International Patent Classification (IPC):  
**H01H 50/30 (2006.01)**

(21) Application number: **23398025.9**

(52) Cooperative Patent Classification (CPC):  
**H01H 50/30; H01H 1/54; H01H 50/20; H01H 50/546**

(22) Date of filing: **22.11.2023**

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA**  
Designated Validation States:  
**KH MA MD TN**

(71) Applicants:  
• **TE Connectivity Solutions GmbH**  
**8200 Schaffhausen (CH)**  
• **Tyco Electronics Componentes Electromecânicos Lda**  
**7005-797 Évora (PT)**

(72) Inventors:  
• **Duarte Silva, António Perdigão**  
**7005-797 Evora (PT)**

• **Teixeira, Tiago**  
**7005-797 Evora (PT)**  
• **Haehnel, Thomas**  
**8200 Schaffhausen (CH)**  
• **Kroeker, Matthias**  
**8200 Schaffhausen (CH)**  
• **Weigel, Christfried**  
**8200 Schaffhausen (CH)**  
• **Habur, Fabian**  
**8200 Schaffhausen (CH)**  
• **Fontes, Hugo**  
**8200 Schaffhausen (CH)**

(74) Representative: **Patentanwaltskanzlei WILHELM & BECK**  
**Prinzenstraße 13**  
**80639 München (DE)**

(54) **HIGH-CURRENT SWITCH AND METHOD FOR OPERATING THE HIGH-CURRENT SWITCH**

(57) The invention relates to a high-current switch (10) and to a method for operating the high-current switch (10), wherein the high-current switch (40) has a housing (15), a braking device (20), a first switching contact (40), a second switching contact (45) arranged offset from the first switching contact (40) and a switching device (25) having a bridge element (35), wherein the bridge element (35) is movable along a lifting axis (60) between an open position, an intermediate position and a contact position in the housing (15), wherein, in the open position and in the intermediate position of the bridge element (35), the bridge element (35) is spaced apart from the first switching contact (40) and second switching contact (45), and the first and second switching contacts (40, 45) are electrically isolated from each other, wherein the braking device (20) has a holding unit (600), which is operatively connected in the intermediate position to the bridge element (35) by means of an operative connection and provides a braking force (FB), which acts on the bridge element (35), wherein, in the contact position, the operative connection between the holding unit (600) and the bridge element is reduced, wherein, during a movement of the bridge element (35) from the open position in the direction of the contact position, at least in the intermediate position, the holding unit (600) acts with the braking force (FB) counter to the movement of the bridge element

(35).

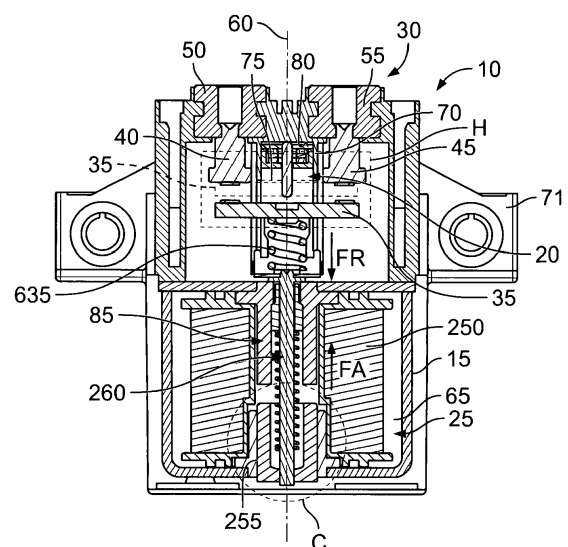


**Fig. 1**

## Description

**[0001]** The invention relates to a high-current switch according to Claim 1 and to a method for operating the high-current switch according to Claim 12.

**[0002]** A high-current switch is known from GB 2 347 270 A.

**[0003]** It is the object of the invention to provide a high-current switch, in particular a contactor, in particular a bridge contactor, for an electrical energy store of an electric vehicle and an improved method for operating the high-current switch.

**[0004]** This object is achieved by means of a high-current switch according to Claim 1, and by means of a method according to Claim 12. Advantageous embodiments are specified in the dependent claims.

**[0005]** It has been recognized that an improved high-current switch, in particular a contactor, in particular a bridge contactor, can be provided for an electrical energy store of a vehicle in that the high-current switch has a housing, a braking device, an electrical switching device having a bridge element, a first switching contact and a second switching contact arranged offset from the first switching contact. The bridge element is movable along a lifting axis between an open position, an intermediate position and a contact position in the housing. In the contact position of the bridge element, the bridge element contacts the first switching contact and the second switching contact and electrically connects them to each other. In the open position and in the intermediate position of the bridge element, the bridge element is arranged spaced apart from the first switching contact and second switching contact, and the first and second switching contacts are electrically isolated from each other. The intermediate position is arranged between the open position and the contact position with respect to the lifting axis. The braking device has a holding unit, which is operatively connected in the intermediate position to the bridge element by means of an operative connection and provides a braking force, which acts on the bridge element. The holding unit can be operatively connected here directly or indirectly to the bridge element. In the contact position, the operative connection between the holding unit and the bridge element is reduced, wherein, during a movement of the bridge element from the open position in the direction of the contact position, in the intermediate position of the holding unit, the braking force acts along the lifting axis counter to the movement of the bridge element.

**[0006]** This configuration has the advantage that, when an acceleration acting, for example, along the lifting axis, is introduced into the high-current switch, the bridge element is prevented by the braking device from moving unintentionally into the contact position and, in the process, contacting the first and second switching contacts. In particular, when the electrical energy store is configured, for example, as a high-voltage system, for example with an operating voltage of 800 volts, this would lead to

an electrical short circuit within the electrical energy store when the high-current switch is configured to guide the bridge contactor.

**[0007]** In another embodiment, the holding unit has a permanent magnet, wherein the permanent magnet provides a magnetic field, wherein, in the intermediate position, the permanent magnet provides the operative connection. This configuration has the advantage that the holding unit is configured particularly simply and, in the contact position of the bridge element, the permanent magnet is only slightly and not indirectly operatively connected to the bridge element.

**[0008]** In a further embodiment, the switching device has a coil device and an armature arranged on the coil device, wherein the armature is mechanically connected to the bridge element. When the coil device is energized with an electric current, the coil device is configured to move the armature along the lifting axis in such a manner that the armature moves the bridge element between the open position via the intermediate position into the contact position.

**[0009]** In a further embodiment, the switching device has a sleeve which extends along the lifting axis, wherein the armature is arranged at least in sections in the sleeve, wherein the sleeve on a side facing the permanent magnet has a stop surface arranged at an inclination with respect to the lifting axis, wherein the permanent magnet has a second end face and the armature on a side facing the permanent magnet has an armature end surface, wherein, in the open position, the permanent magnet lies against the armature end face and is arranged spaced apart from the stop surface, wherein, in the intermediate position, the permanent magnet lies against the stop surface and couples the armature magnetically to the sleeve and generates the braking force. This configuration has the advantage that the bridge element can be held particularly stably in the intermediate position.

**[0010]** In a further embodiment, the braking device has a plunger which extends along the lifting axis and is arranged movably in the housing along the lifting axis independently of the bridge element, wherein, in the open position, the plunger is arranged spaced apart from the bridge element, wherein, during a movement of the bridge element from the open position in the direction of the contact position in the intermediate position, the bridge element contacts the plunger in order to form the operative connection. This configuration has the advantage that the plunger is particularly simple. Furthermore, a particularly high braking force is ensured by the arrangement of the plunger portion in the effective range of the magnetic field, and therefore, even at great accelerations of the braking device, an unintentional movement of the bridge element into the contact position can be prevented.

**[0011]** In another embodiment, in the intermediate position and/or in the open position, the permanent magnet secures the plunger

**[0012]** In a further embodiment, the permanent magnet

is annular and has a first pole and a second pole. The first pole is arranged on a side facing away from the bridge element and the second pole is arranged on a side facing the bridge element. This configuration has the advantage that the permanent magnet is particularly simple and cost-effective, and the plunger can reach through the permanent magnet using the pin. This ensures a compact configuration of the braking device.

**[0013]** In a further embodiment, the plunger has a plunger portion extending outwards in the radial direction and a pin which is connected to the plunger portion and extends along the lifting axis, wherein the plunger portion is arranged on a side of the pin facing away from the bridge element, wherein, in the open position and the intermediate position, the plunger portion is arranged in an effective range of the magnetic field. This configuration has the advantage that the plunger is magnetically coupled to the permanent magnet with little friction.

**[0014]** In a further embodiment, the permanent magnet has a first through-opening extending along the lifting axis, wherein the plunger reaches through the first through-opening and, on a side facing the bridge element, protrudes over the permanent magnet, wherein the plunger has a lateral surface extending around the lifting axis, wherein a first radial gap is arranged between the lateral surface and a first inner surface of the first through-opening.

**[0015]** In a further embodiment, the braking device has a coupling unit, wherein the coupling unit is connected to the housing and has a second through-opening, wherein the plunger penetrates the second through-opening at least in sections, wherein, preferably, the plunger and the second through-opening are formed corresponding to the guiding of the plunger along the lifting axis. This prevents the plunger from tilting. Furthermore, this configuration has the advantage that the magnetic field can be introduced in a targeted manner into the plunger by means of the coupling unit in the open and intermediate positions. Furthermore, in the contact position or on a path between the intermediate position and the contact position, a targeted short-circuiting of the magnetic field can be achieved by the coupling unit in connection with the plunger portion.

**[0016]** In a further embodiment, the holding unit has at least one spring arrangement, wherein the plunger is connected to the spring arrangement, wherein the spring arrangement provides the braking force, wherein, during a movement of the bridge element from the intermediate position in the direction of the contact position, the spring arrangement is tensioned, wherein, preferably, the spring arrangement is pretensioned in the intermediate position, wherein, preferably, the spring arrangement has at least one spring configured in the manner of a disc spring, or a plurality of springs arranged in a stack, wherein, in the contact position, the spring arrangement is at least partially relaxed. The spring arrangement is mechanically particularly simple and durable and makes a particularly simply constructed high-current switch possible.

**[0017]** In a further embodiment, the spring arrangement is arranged between the housing and the plunger, wherein the plunger lies against the spring arrangement and the spring arrangement acts against the plunger, wherein, during the movement of the bridge element from the open position in the direction of the contact position, the plunger between the intermediate position and the contact position tensions the spring arrangement. This configuration has the advantage that the actuating force for the movement of the bridge element from the open position into the intermediate position is small and the switching device can thus be configured particularly simply and compactly.

**[0018]** The high-current switch can be particularly readily operated in that the bridge element is moved into the open position, wherein the bridge element is moved from the open position in the direction of the contact position, in particular on the basis of an unintentional acceleration, with an actuating force along the lifting axis, wherein, at least in the intermediate position, the holding unit is operatively connected to the bridge element and the braking force acts on the bridge element along the lifting axis counter to the movement of the bridge element and the actuating force, wherein the bridge element, after overcoming the braking force, is moved from the intermediate position into the contact position and the operative connection is reduced. This configuration has the advantage that the braking force can be overcome by the bridge element only in the event of driving and actively switching the switching device and, when an acceleration is introduced into the bridge element, only the bridge element can move between the open position and the intermediate position.

**[0019]** It is of particular advantage when, in the intermediate position, the braking force acting on the bridge element is formed magnetically, wherein, during the movement of the bridge element from the intermediate position into the contact position, the magnetic effect of the permanent magnet decreases. This allows the switching device to be energized with a low current in order to move the bridge element into the contact position.

**[0020]** In one embodiment, in the open position, the permanent magnet lies against the armature, wherein, in the intermediate position, the permanent magnet strikes with the second end face against the stop surface and operatively connects the armature magnetically to the sleeve, wherein, during a movement of the bridge element from the intermediate position into the contact position, the armature is separated from the permanent magnet.

**[0021]** Furthermore, it is of particular advantage if, as the distance from the intermediate position to the contact position increases, the braking force acting on the plunger decreases, preferably decreases degressively. The disc spring, like the magnetic arrangement, also provides a degressive force progression from the intermediate position to the contact position such that, after the braking

force is overcome, the actuating force acting on the armature braking device by means of the braking device is less than the actual braking force. This has the advantage that the surplus of force in the completely closed state of the high-current switch is not reduced excessively.

**[0022]** The invention is explained in more detail below with reference to figures, in which:

Figure 1 shows a longitudinal section through a high-current switch according to a first embodiment;

Figure 2 shows a perspective illustration of the longitudinal section shown in Figure 1 through the high-current switch;

Figure 3 shows an enlarged illustration, marked with the letter H in Figure 1, of a braking device of the high-current switch shown in Figures 1 and 2 in the open position, shown in Figures 1 and 2, of a bridge element of the high-current switch shown in Figure 1;

Figure 4 shows a schematic illustration of the braking device in an intermediate position of the bridge element of the high-current switch shown in Figure 1;

Figure 5 shows the braking device of the high-current switch in a contact position of the bridge element of the high-current switch shown in Figure 1;

Figure 6 shows a flow diagram of a method for operating the high-current switch shown in Figures 1 to 5;

Figure 7 shows a diagram of forces plotted over a travel distance of the bridge element between the open position and the contact position;

Figure 8 shows a perspective sectional view of the high-current switch shown in Figures 1 to 5, in which the bridge element is in the intermediate position;

Figure 9 shows a perspective sectional view through the high-current switch shown in Figures 1 to 5, in which the bridge element is in the contact position;

Figure 10 shows a section of a braking device of a high-current switch according to a second embodiment;

Figure 11 shows the high-current switch shown in Figure 10 according to the second embodiment in the contact position of the bridge element.

Figure 12 shows a section C, marked in Figure 1, of a high-current switch according to a third embodiment;

Figure 13 shows a section E, marked in Figure 12, of the high-current switch shown in Figure 12 in an open position of the bridge element of the high-current switch;

Figure 14 shows a section E, shown in Figure 12, of the high-current switch in the contact position of the bridge element;

Figure 15 shows a second diagram of a progression of the magnetic force plotted over a distance of the second end face to the armature end surface;

Figure 16 shows a section E, marked in Figure 1, of a high-current switch according to a fourth embodiment;

Figure 17 shows the section E, shown in Figure 1, of the high-current switch in the intermediate position of the bridge element;

Figure 18 shows a diagram of a spring force plotted over a compression distance;

Figure 19 shows the section E, shown in Figures 16 and 17, while the bridge element is located between the contact position and the intermediate position;

Figure 20 shows a diagram of a third graph of the actuating force over the travel distance of the armature for displacing the bridge element from the open position via the intermediate position into the contact position;

Figure 21 shows a section E, marked in Figure 1, of a high-current switch according to a fifth embodiment; and

Figure 22 shows a perspective illustration of the spring of the spring arrangement of the high-current switch shown in Figure 21.

**[0023]** Figure 1 shows a longitudinal section through a high-current switch 10 according to a first embodiment.

**[0024]** The high-current switch 10 can, for example, be configured as a contactor, in particular as a bridge contactor, for an electrical energy store of an electrically

driven vehicle, in particular a fully electric vehicle. In this case, the high-current switch 10 can be used in particular in a high-voltage system, for example in an 800 volt system, to connect two battery packs, each having a pack output voltage of, for example, 400 volts, in series or parallel. The high-current switch 10 in its function as a bridge contactor can be connected in such a way that the high-current switch 10 is closed when charging at a 400 volt charging station, while in normal operation of the electric vehicle, the high-current switch 10 is opened such that the battery packs are connected in series and an output voltage of the electrical energy store in normal operation is a sum of the pack output voltages.

**[0025]** It has to be ensured that the high-current switch 10 in its function as a bridge contactor is not unintentionally closed, for example due to sharp accelerations. This would result in a short circuit within the electrical energy store with corresponding consequences, especially with a high fire risk when using lithium ion cells. Unintentional closing of the high-current switch 10 therefore has to be avoided.

**[0026]** Of course, it is also possible to use the high-current switch 10 in a different position or with a different function. For example, it is also conceivable that the high-current switch 10 is used, for example, as a central contactor and the two battery packs mentioned above are connected in series in normal operation of the vehicle.

**[0027]** In the embodiment, the high-current switch 10 is configured to transmit at least 100 amperes to 1000 amperes. In particular, the high-current switch 10 can transmit 150 amperes to 300 amperes.

**[0028]** The high-current switch 10 shown by way of example in Figure 1 according to the first embodiment has, for example, a housing 15, a braking device 20, an electrical switching device 25 having a switching bridge, a connection terminal 30, a first switching contact 40 and a second switching contact 45.

**[0029]** The connection terminal 30 has a first terminal connection 50 and a second terminal connection 55, the connection terminal 30 enabling the high-current switch 10 to be integrated in a high-voltage system of the electric vehicle. The first terminal connection 50 is arranged, for example, on the first switching contact 40 and electrically connected to the first switching contact 40. The second terminal connection 55 is electrically and mechanically connected to the second switching contact 45.

**[0030]** The housing 15 encloses a housing interior 65, wherein the switching device 25, the braking device 20 and the first and second switching contacts 40, 45 and the bridge element 35 are arranged in the housing interior 65. The housing 15 is produced from an electrically non-conductive material and electrically insulates the switching contacts 40, 45 and the first terminal connection 50 from the second terminal connection 55. The connection terminal 30 is arranged, for example, on the outside of the housing 15 and serves for the electrical connection of the high-current switch 10 to other components of the high-voltage system.

**[0031]** The bridge element 35 is movably arranged along a lifting axis 60 between an open position (shown in Figure 1 with a solid line) via an intermediate position and a contact position different from the open position (shown in Figure 1 by a dashed line). The intermediate position is arranged in the axial direction with respect to the lifting axis 60 between the open position and the contact position. The bridge element 35 extends, for example, radially outwards with respect to the lifting axis 60. The first switching contact 40 and the second switching contact 45 are arranged spaced apart from each other and offset from each other in the radial direction with respect to the lifting axis 60.

**[0032]** The housing 15 and thus the high-current switch 10 are aligned in the electric vehicle via fastening tabs 71 of the housing 15 defined in the vehicle. In particular, the lifting axis 60 can be aligned in the direction of gravity. Of course, it is also possible for the lifting axis 60 to be aligned differently in space.

**[0033]** By means of the proposed alignment, the connection terminal 30 is arranged by way of example on the top side of the housing 15 and the switching device 25 on the bottom side in the housing 15.

**[0034]** The housing 15 has a first receptacle 70 on the inner side. The first receptacle 70 is arranged, for example, centred on the lifting axis 60 and can have, for example, a circular cross section. The first receptacle 70 has a receptacle opening 75 and a first receptacle base 80. The first receptacle base 80 is arranged on a side facing away from the switching device 25 and the bridge element 35 in the axial direction with respect to the lifting axis 60. The receiving opening 75 faces the bridge element 35 axially. The first receptacle 70 is open at the receptacle opening 75. The braking device 20 is arranged at least in sections in the first receptacle 70.

**[0035]** In the open position, the bridge element 35 is spaced apart, preferably at a maximum axial distance from a respective contact surface of the first and second switching contacts 40, 45, said contact surface facing the bridge element 35. The switching device 25 is, for example, mechanically connected to the bridge element 35 and is configured to move the bridge element 35 between the open position and the contact position in the axial direction along the lifting axis 60. It has to be ensured that the contact position is reached only when the switching device 25 is actively actuated, for example energized. In particular, an unintentional contacting of the bridge element 35 at the first switching contact 40 and the second switching contact 45 with the switching device 25 deactivated has to be avoided. Even at a high acceleration of, for example, 90 g along the lifting axis 60 acting on the bridge element 35, the contacting of the first and second switching contacts 40, 45 by the bridge element 35 should be prevented.

**[0036]** So that the bridge element 35 remains in the open position without application of current to the switching device 25, the switching device 25 can have a restoring unit 85, for example with a restoring spring, which is in

the open position of the bridge element 35 in a relieved state. The restoring unit 85 is configured, for example, to return the bridge element 35 into the open position and/or to hold it in the open position. In particular when the switching device 25 is deactivated, the restoring unit 85 moves the bridge element 35 into the open position.

**[0037]** In the contact position (indicated schematically by dashed lines in Figure 1), the bridge element 35 contacts both the first switching contact 40 and the second switching contact 45 on the side facing the bridge element 35 and electrically connects the first switching contact 40 to the second switching contact 45. For this purpose, the bridge element 35 can be manufactured, for example, in an annular or plate-like form, from a metallic material. For improved electrical contacting and for reducing a contact resistance, an electrically conductive coating, for example comprising silver, can be provided on contact surfaces of the bridge element 35 and/or of the respectively associated switching contact 40, 45.

**[0038]** The switching device 25 further has, in addition to the restoring unit 85, a coil device 250 and an armature 255 which is surrounded by the coil device 250 and is mechanically connected, for example, to the restoring unit 85 and via a connecting means 260 to the bridge element 35.

**[0039]** In particular, the connecting means can have a connecting bolt 630 and an overlift spring 635, wherein the connecting bolt 630 is connected to the armature 255 on one side. The connecting bolt is connected to the bridge element 35 via the overlift spring 635. The overlift spring 635 mechanically connects the bridge element 35 to the connecting bolt 630 to move the bridge element 35 between the open position and the contact position.

**[0040]** The coil device 250 has one or more electric coils which are configured to generate a further electromagnetic field acting on the armature 255 in order to move the bridge element 35 between the open position and the contact position by an axial displacement of the armature 255. The configuration of the switching device 25 is selected, for example, in such a way that the contact position is maintained exclusively when the coil device 250 is energized and, if the coil device 250 is energized only slightly, if at all, the electromagnetic field is too weak to keep the bridge element 35 in the contact position. In this case, the restoring unit 85 causes an automatic return of the bridge element 35 and thus also of the armature 255 coupled to the bridge element 35 into the open position such that, in the event of insufficient energization, if any at all, of the coil device 250, the high-current switch 10 is opened.

**[0041]** Figure 2 shows a perspective illustration of the longitudinal section shown in Figure 1 through the high-current switch 10.

**[0042]** In order to transmit the high current of preferably 100 to 1000 amperes between the first switching contact 40 and the second switching contact 45, the bridge element 35 may have a plate-like basic shape. In this case, the bridge element 35 has a second receptacle 95 on a

first end face 90 facing the braking device 20. The second receptacle 95 is arranged, for example, as a depression in the bridge element 35. The second receptacle 95 may be arranged spaced apart from a first outer circumferential side 100 of the bridge element 35. Axially, the second receptacle 95 is aligned with the first receptacle 70 and with the braking device 20.

**[0043]** Figure 3 shows an enlarged illustration, marked with the letter H in Figure 1, of the braking device 20 in the open position of the bridge element 20 shown in Figures 1 and 2.

**[0044]** In Figure 3, the illustration of further components, in particular the housing 15 and the connection terminal 30, is omitted for reasons of clarity. The bridge element 35 is also only indicated schematically in Figure 3.

**[0045]** The braking device 20 has a holding unit 600 with a permanent magnet 105 and a plunger 110. In addition, the braking device 20 may furthermore have a coupling unit 115. In the embodiment, the coupling unit 115 is arranged in the first receptacle 70 of the housing 15 and is mechanically connected to the housing 15. In the embodiment, the permanent magnet 105 is mechanically connected to the coupling unit 115 and thus indirectly via the coupling unit 115 to the housing 15. The plunger 110 is arranged axially displaceably along the lifting axis 60 relative to the coupling unit 115 and to the permanent magnet 105 and also relative to the bridge element 35 and thus independently of the bridge element 35.

**[0046]** The plunger 110 has, by way of example, a cylindrical pin 120 and a plunger portion 125. The pin 120 has a first stop surface 130 on a first end facing the bridge element 35. The first stop surface 130 may be formed obtusely on the pin 120 and extends, for example, at an inclination, in particular perpendicularly, to the lifting axis 60. The pin 120 furthermore has a lateral surface 135. Furthermore, the pin 120 may be manufactured, for example, from a paramagnetic material or a diamagnetic material.

**[0047]** On a second end of the pin 120 facing away from the first stop surface 130 and thus the bridge member 35, the plunger portion 125 is arranged on the pin 120 and mechanically connected to the pin 120. The plunger portion 125 may, for example, be annular. The plunger portion 125 protrudes over the pin 120 in the radial direction with respect to the pin 120. The plunger portion 125 preferably comprises a ferromagnetic material.

**[0048]** The permanent magnet 105 provides a magnetic field 140. The magnetic field 140 is indicated schematically in Figure 3 by means of field lines. The permanent magnet 105 has, for example, a first pole 145, for example a north pole N, and a second pole 150, for example a south pole S. The first pole 145 of the permanent magnet 105 is arranged, for example, on an axial side of the permanent magnet 105 facing away from the bridge element 35 and the second pole 150 on an axial side facing the bridge element 35. The permanent magnet 105 has, for example, an annular configuration and

extends in the circumferential direction around the lifting axis 60, for example on a circular path. Radially on the outside of the permanent magnet 105 and in the embodiment, for example, on both sides in the axial direction, the coupling unit 115 adjoins the permanent magnet 105 and mechanically connects the permanent magnet 105 to the housing 15.

**[0049]** The permanent magnet 105 has a first inner surface 175, which forms a first through-opening 176 in the permanent magnet 105. The pin 120 reaches through the first through-opening 176 in the axial direction and is arranged on the lifting axis 60. A first radial gap 180 is arranged between the first inner surface 175 and the lateral surface 135 of the pin 120. In this case, the pin 120 on the side facing the bridge element 35 protrudes over the permanent magnet 105 and the coupling unit 115.

**[0050]** In the embodiment, the coupling unit 115 has, for example, a first coupling element 155 and a second coupling element 160. Of course, one of the two coupling elements 155, 160 or even the entire coupling unit 115 may also be omitted.

**[0051]** The first coupling element 155 is annular. The first coupling element 155 may, for example, be produced from a ferromagnetic material. The first coupling element 155 is arranged by way of example on an axial side of the permanent magnet 105 facing away from the bridge element 35. In this case, the first coupling element 155 can lie directly against a second end face 165 of the permanent magnet 105 and can be mechanically fastened to the permanent magnet 105.

**[0052]** The first coupling element 155 has a first contact surface 170 on an axial side facing away from the bridge element 35. The first contact surface 170 is substantially flat and extends by way of example in a plane perpendicular to the lifting axis 60. The first coupling element 155 may be chamfered radially on the inside and/or radially on the outside of the first contact surface 170.

**[0053]** In the embodiment, the second coupling element 160 is by way of example pot-shaped. Of course, it would also be possible for the second coupling element 160 to have a different geometrical configuration. The second coupling element 160 has a first coupling element portion 185 and a second coupling element portion 190. The first coupling element portion 185 is substantially plate-like or annular and extends in a plane perpendicular to the lifting axis 60. The second coupling element portion 190 is hollow-cylindrical and extends around the lifting axis 60.

**[0054]** For example, the first coupling element 155 and the permanent magnet 105 are arranged radially on the inside of the second coupling element portion 190. Preferably, the permanent magnet 105 and/or the first coupling element 155 are arranged spaced apart radially from the second coupling element portion 190. The second coupling element portion 190 is connected to the first coupling element portion 185 on an axial side facing the bridge element 35. Preferably, the first coupling element

portion 185 and the second coupling element portion 190 are produced integrally from the same material, preferably from a ferromagnetic material.

**[0055]** The first coupling element portion 185, which is annular by way of example, is connected in the axial direction on an axial side of the permanent magnet 105 facing the bridge element 35. Thus, the permanent magnet 105 is arranged on both sides in the axial direction between the first coupling element 155 and the second coupling element 160, in particular the first coupling element portion 185.

**[0056]** The first coupling element portion 185 has a second through-opening 195 radially on the inside. The second through-opening 195 is arranged in the radial direction spaced apart from the lateral surface 135 of the pin 120 such that a second radial gap 205 is formed between a second inner surface 200 of the second through-opening 195 and the lateral surface 135, wherein the second radial gap 205 is preferably more slender in the radial direction than the first radial gap 180. Of course, it would also be possible for the first coupling element portion 185 to have a similar width in the radial direction as the permanent magnet 105 such that the second inner surface 200 ends in the radial direction level with the first inner surface 175.

**[0057]** The second coupling element portion 190 has a third inner surface 210. A third radial gap 220 is arranged between a second outer circumferential side 215 of the first coupling element 155 and the third inner surface 210.

**[0058]** The plunger portion 125 has a second contact surface 225 on the side facing the bridge element 35. The first contact surface 170 and the second contact surface 225 can preferably be arranged in a plane perpendicular to the lifting axis 60. In the open position of the bridge element 35, as shown in Figure 3, the first contact surface 170 lies against the second contact surface 225.

**[0059]** Radially on the outside of the contact between the first and second contact surface 170, 225, the second coupling element portion 190 furthermore has a third contact surface 230. The first contact surface 170 and the third contact surface 230 are preferably arranged in a common plane, preferably perpendicular to the lifting axis 60. In the open position, as shown in Figure 3, the plunger portion 125 lies with the second contact surface 225 against the first contact surface 170 and the third contact surface 230.

**[0060]** As already explained above, the permanent magnet 105 provides the magnetic field 140. The magnetic field 140 is indicated schematically in Figure 3 by way of example by means of magnetic field lines. In the open position of the bridge element 35, a magnetic flux of the magnetic field 140 is closed. The magnetic flux of the permanent magnet 105 into the plunger portion 125 takes place, for example, on the end face on the side facing away from the bridge element 35 from the first pole 145 via the first coupling element 155 and the contact between the first and second contact surfaces 170, 225. Thus, the plunger portion 125 is magnetically operatively

connected to the permanent magnet 105, and the permanent magnet 105 holds the plunger portion against the first coupling element 155 via the magnetic field 140.

**[0061]** The magnetic flux is closed radially on the outside of the plunger portion 125 via the contact between the second contact surface 225 and the third contact surface 230. The magnetic field 140 enters the second coupling element 160 via the second and third contact surfaces 225, 230 from the plunger portion. The second coupling element 160 guides the magnetic field 140 by means of the second coupling element portion 190 towards the first coupling element portion 185. At the first coupling element portion 185, the magnetic field 140 from the first coupling element portion 185 enters the second pole 150 of the permanent magnet 105 again on the axial side facing away from the bridge element 35.

**[0062]** The first radial gap 180 and the second radial gap 205 between the permanent magnet 105 and the first coupling element portion 185 have the effect that the magnetic field 140 essentially does not act on the pin 120, and instead the coupling of the plunger 110 substantially takes place via the plunger portion 125. Furthermore, a magnetic short circuit between the permanent magnet 105 and the second coupling element portion 190 is prevented by the third radial gap 220 and by the radially spaced-apart arrangement of the permanent magnet 105 from the third inner surface 210.

**[0063]** Figure 4 shows a schematic illustration of the braking device 20 in the intermediate position of the bridge element 35.

**[0064]** In the intermediate position of the bridge element 35, the braking device 20 has the same arrangement of the components with respect to one another as in the open position of the bridge element 35. Therefore, only the differences of the high-current switch 10 when the bridge element 35 is in the intermediate position compared to the open position will be discussed.

**[0065]** In the intermediate position, the pin 120 lies with the first stop surface 130 against the second receiving base 236 of the second receptacle 95. The intermediate position of the bridge element 35 is preferably arranged in the axial direction with respect to the lifting axis 60 between the contact position and the open position (cf. Figure 3). In the intermediate position, the bridge element 35 comes into touching contact with the first stop surface 130, but does not contact the first and second switching contacts 40, 45, and therefore the high-current switch 10 is also open in the intermediate position. Furthermore, the plunger 110 is magnetically connected to the housing 15 by the permanent magnet 105 via the coupling unit 115 and the permanent magnet 105. In the intermediate position, the permanent magnet 105 prevents axial displaceability of the pin 120 relative to the housing 15.

**[0066]** Figure 5 shows the braking device 20 of the high-current switch 10 in the contact position of the bridge element 35.

**[0067]** In the open position of the bridge element 35, the bridge element 35 lies with the second receiving base

236 against the first stop surface 130. Furthermore, radially on the outside of the second receptacle 95, the bridge element 35 contacts both the first switching contact 40 and the second switching contact 45 and connects the first switching contact 40 to the second switching contact 45 (not shown in Figure 5). The high-current switch 10 is thus closed in the contact position of the bridge element 35 and the high current can flow via the first terminal connection 50 and the first switching contact 40 via the bridge element 35 to the second switching contact 45 and from the second switching contact 45 to the second terminal connection 55.

**[0068]** Compared to the open position and the intermediate position of the bridge element 35, in the contact position, the plunger 110 is pushed axially more deeply into the first receptacle 70 than in the open position or the intermediate position of the bridge element 35. In this case, in the contact position, the plunger portion 125 on the side facing away from the bridge element 35 is arranged axially spaced apart from the first coupling element 155 and, for example, the second coupling element 160, in particular from the first contact surface 170 and the third contact surface 230. In the open position, a first axial gap 240 is formed between the first contact surface 170 and the second contact surface 225, the first axial gap 240 having an axial first gap width  $b_1$ . Furthermore, a second axial gap 245 is formed between the first contact surface 170 and the third contact surface 230, the second axial gap having, for example, the same axial first gap width  $b_1$  as the first axial gap 240. The first axial gap 240 and the second axial gap 245 are wider in the axial direction than a second gap width  $b_2$  in the radial direction of the third radial gap 220.

**[0069]** This configuration has the advantage that the magnetic field 140 is short-circuited by the first coupling element 155 in the contact position and the plunger portion 125 is arranged outside an effective range of the magnetic field 140. The magnetic field 140 exits from the permanent magnet 105 at the first pole 145, for example, and is guided through the first coupling element 155 to the third radial gap 220. The magnetic field 140 exits from the first coupling element 155 radially on the outside of the second outer circumferential side 215 and passes through the third radial gap 220 between the first coupling element 155 and the second coupling element portion 190. On the third inner surface 210, the magnetic field 140 enters the second coupling element portion 190 and is guided by the second coupling element portion 190 in the direction of the bridge element 35. From the second coupling element portion 190, the magnetic field 140 enters the first coupling element portion 185 and is guided from the first coupling element portion 185 towards the second pole 150 of the permanent magnet 105 such that the magnetic field 140 is closed.

**[0070]** Thus, the magnetic field 140 is guided in the contact position substantially exclusively in the coupling unit 115 and the permanent magnet 105, and the plunger portion 125 and/or the pin 120 are arranged outside an

effective range of the magnetic field 140. Thus, in the contact position, the plunger 110 is substantially decoupled from the permanent magnet 105 and the magnetic field 140 is short-circuited via the coupling unit 115.

**[0071]** Figure 6 shows a flow diagram of a method for operating the high-current switch 10 shown in Figures 1 to 5. Figure 7 shows a diagram of an actuating force FA plotted over a travel distance D of the armature 255 for the movement of the bridge element 35 between the open position OP and the contact position KP for transferring the bridge element 35 from the open position OP into the contact position. Figure 8 shows a perspective sectional view of the high-current switch 10 shown in Figures 1 to 5, in which the bridge element 35 is in the intermediate position. Figure 9 shows a perspective sectional view through the high-current switch 10 shown in Figures 1 to 5, in which the bridge element 35 is in the contact position.

**[0072]** The diagram shown in Figure 7 shows a first graph 500. The first graph 500 shows the progression of the actuating force FA over the travel distance D between the open position OP and the contact position KP.

**[0073]** The open position OP is located at the right end of the abscissa. During the movement of the bridge element 35 from the open position OP into the contact position, the actuating force FA is provided by a corresponding energization of the coil device 250 of the switching device 25. The actuating force FA shown is applied to the armature 255. Here, the armature 255 has the greatest travel distance D, which decreases as the bridge element 35 draws closer to the contact position.

**[0074]** The first graph 500 has a first graph section 501, a second graph section 502, a third graph section 503 and at least one fourth graph section 504.

**[0075]** In a first method step 305, the high-current switch 10 is provided with the bridge element 35 in the open position. For this purpose, energization of the coil device 250 is interrupted, and therefore the restoring unit 85 may move the bridge element 35 into the open position and the armature 255 into a starting position. In the open position, the high-current switch 10 is open and a power transmission between the terminal connections 50, 55 is interrupted.

**[0076]** In a second method step 310, the coil device 250 is energized. The coil device 250 generates the electromagnetic field which acts on the armature 255 with an actuating force FA. The armature 255 is moved in the axial direction along the lifting axis 60 by the actuating force FA and, in the process, actuates the restoring unit 85. The restoring unit 85 is tensioned by the armature 255 and provides a restoring force FR (cf. Figure 1). The restoring force FR acts counter to the actuating force FA. By means of the actuating force FA, the bridge element 35 is moved from the open position in the direction of the contact position along the lifting axis 60 counter to the effect of the restoring force FR. The restoring unit 85 is tensioned by the actuating force FA as the travel distance D decreases in the first graph section 502.

**[0077]** However, the actuating force FA can also act on the armature 255 by means of an acceleration. The acceleration may be of such a magnitude that the actuating force FA induced by the acceleration in the armature is greater than the restoring force FR.

**[0078]** In a third method step 315, the pin 120 protruding via the receiving opening 75 into the housing interior 65 enters at the first stop surface 130 into touching contact with the second receiving base 236 of the second receptacle 95. The bridge element 35 is located in the intermediate position ZP (cf. Figure 4).

**[0079]** By means of the magnetic coupling of the plunger 110 to the permanent magnet 105, preferably via the coupling unit 115, the braking device 20 provides a braking force FB, which acts along the lifting axis 60 in the opposite direction to the actuating force FA (cf. Figure 4). On the one hand, the braking force FB prevents the bridge element 35 from moving further in the direction of the contact position. The braking force FB, together with the restoring force FR, thus increases the necessary actuating force FA for moving the bridge element 35 from intermediate position ZP in the direction of the contact position. Since the braking force FB and the restoring force FR both act counter to the actuating force FA, a gradient of the first graph 500 in the second graph section 502 is significantly steeper than in the first graph section 501 (cf. Figure 7).

**[0080]** If the actuating force FA is greater than the sum of the restoring force FR and the braking force FB, the switching device 25 displaces the bridge element 35 further in the direction of the contact position KP (cf. Figure 5). In this case, the bridge element 35 carries along the plunger 110 with it. As a result, the plunger portion 125 is moved away from the first and third contact surfaces 170, 230 in the axial direction. In this case, with the formation of the first and second axial gaps 240, 245 between the plunger portion 125 and the coupling unit 115 between the first to third contact surfaces 170, 225, 230, the braking force FB greatly decreases as the formation of the first and second axial gaps 240, 245 increases in the third graph section 503, and therefore the switching device 25 is no longer prevented by the braking force FB from moving the bridge element 35 out of the intermediate position in the direction of the contact position.

**[0081]** Owing to the fact that the braking force FB in the intermediate position ZP is preferably significantly greater than the restoring force FR, it is ensured that, when the actuating force FA is generated by an acceleration, the actuating force FA is less than the sum of the restoring force FR and the braking force FB. In the event of sharp accelerations, this prevents further movement of the bridge element 35 beyond the intermediate position in the direction of the contact position and thus the closing of the contacts, by the bridge element 35 in the intermediate position striking against the pin.

**[0082]** In a fourth method step 320, the bridge element 35 enters into touching contact with the first and second

switching contacts 40, 45 and connects the first switching contact 40 electrically to the second switching contact 45 such that the high-current switch 10 is electrically closed. In the contact position, the restoring force FR of the restoring unit 85 substantially acts counter to the actuating force FA, and the braking force FB is substantially cancelled by the magnetic decoupling of the plunger 110 from the permanent magnet 105.

**[0083]** In order to ensure secure contact between the bridge element 35 and the switching contacts 40, 45, the bridge element 35 is subjected to excessive pressure by the switching device 25. In this case, the armature 250 is moved further in the direction of the switching contact 40, 45 and its end position, with the overlift spring 635 in the fourth graph section 504 being tensioned. The rigid configuration of the overlift spring 635 and the addition of the braking force to an overlift spring force of the overlift spring 635, which acts counter to the actuating force, means that the progression of the fourth graph section 504 is steeper than in the first graph curve.

**[0084]** In a fifth method step 325, the energization of the coil device 250 is cancelled in order to open the high-current switch 10. In this case, the switching device 25 essentially does not provide any actuating force FA. Here, the armature 255 is moved out of its end position in the direction of the starting position firstly by means of the overlift spring 635 and the restoring unit 85, and, from the contact position KP in the direction of the starting position, exclusively by means of the restoring unit 85.

**[0085]** Furthermore, the restoring unit 85 substantially transfers the bridge element 35 by the restoring force FR from the contact position in the direction of the intermediate position. In this case, shortly before the intermediate position ZP is reached, when the first and second axial gaps 240, 245 are narrower than the third radial gap 220, the magnetic short circuit within the braking device 20 is cancelled and the braking device 20 assists the movement of the bridge element 35 shortly before the intermediate position is reached. When the intermediate position is reached, the assistance is removed by the travel achieved by the plunger 110, and from the intermediate position in the direction of the open position, the restoring unit 85 transfers the bridge element 35 into the open position by means of the restoring force FR.

**[0086]** Here, it is advantageous that the force of the braking element to be added during the reduction of the overlift additionally accelerates the armature. This results in faster separation of the contact pieces.

**[0087]** As already explained above, in the case of the high-current switch 10, the reaching of the contact position due to unintentional accelerations should be prevented. This is achieved in the embodiment by the restoring unit 85 and additionally by the braking device 20 together. In this case, lesser accelerations (for example, less than 20 g) are ensured exclusively by the restoring force FR of the restoring unit 85, which is preferably already pretensioned into the open position. In order to prevent the reaching of the contact position in the event of

high accelerations, for example accelerations of preferably between 50 g and up to 90 g along the lifting axis 60 of the bridge element 35, the bridge element 35, which is accelerated out of the open position, on the way to the contact position along the lifting axis 60 strikes against the first stop surface 130 of the pin 120. The braking device 20 provides the braking force FB independently of the switching device 25 and, in the intermediate position, greatly increases the necessary actuating force FA. The braking force FB decelerates the already accelerated bridge element 35 and prevents the bridge element 35 from further movement out of the intermediate position ZP in the direction of the contact position KP. The braking device 20 is dimensioned here in such a way that, even in the event of sharp accelerations, the actuating force induced in the armature 255 is less than the minimally required actuating force FA.

**[0088]** The braking device 20 has the advantage here that an easy movability of the bridge element 35 between the contact position and the intermediate position or out of the intermediate position into the contact position is ensured by the magnetic short circuit or the rapid decoupling of the plunger portion 125 from the magnetic field 140. This ensures secure contacting of the first and second switching contacts 40, 45 with a high contact force for the electrical connection and for closing the high-current switch 10.

**[0089]** The magnetic braking force FB, which greatly decreases over the travel distance D, ensures that the switching device 25 is not overloaded after the intermediate position ZP is exceeded and as the distance of the bridge element 35 increases, by provision of the actuating force FA. Furthermore, an increase in a spring rate for determining the restoring force FR can be dispensed with, and thus the restoring unit 85 can be configured mechanically particularly simply and compactly.

**[0090]** Furthermore, the decoupling of the plunger portion 125 from the magnetic field 140 has the effect that, in the contact position, secure pressing of the bridge element 35 against the switching contacts 40, 45 is ensured by means of the actuating force FA.

**[0091]** For example, the braking force FB can be 10 N to 35 N, for example 0.5 to 1.5 mm, in particular 1 mm, before the contact position is reached.

**[0092]** Furthermore, the above-described configuration of the high-current switch 10 has the advantage that the high-current switch 10 is particularly shock-resistant, in particular to accelerations along the lifting axis 60. Thus, the high-current switch 10 is suitable in particular as a central switch or as a bridge contactor for an electrical energy store of an electric vehicle. Furthermore, the braking device 20 can be integrated particularly simply and cost-effectively in an already existing design of a high-current switch 10. In particular, the braking device 20, by means of the braking force FB, prevents the bridge element 35, which is moving in the direction of the contact position because of the acceleration, from a further movement out of the intermediate position in the direction

of the contact position.

**[0093]** Figure 10 shows a section of a braking device 20 of a high-current switch 10 according to a second embodiment.

**[0094]** In Figure 10, the braking device 20 of the high-current switch 10 is substantially identical to the braking device 20 shown in Figures 1 to 5, 8 and 9. Only the differences of the braking device 20, shown in Figure 10, of the high-current switch 10 according to the second embodiment in relation to the braking device 20, shown in Figures 1 to 5, 8 and 9, of the high-current switch 10 according to the first embodiment will be discussed below.

**[0095]** The coupling unit 115 is adapted in such a way that the coupling unit 115, for example, has only the first coupling element 155. Furthermore, the first coupling element 155 is arranged on the side of the permanent magnet 105 facing the bridge element 35 and, for example, is connected mechanically to the permanent magnet 105 and mechanically to the housing 15. The configuration of the first coupling element 155 can be annular.

**[0096]** In the embodiment, the plunger portion 125 is stepped. In this case, the plunger portion 125 is adapted to the effect that the second contact surface 225 has a first partial region 400 and a second partial region 405, wherein the first partial region 400 is axially offset with respect to the second partial region 405. In the open position and in the intermediate position of the bridge element 35, the second contact surface 225 lies with the first partial region 400 against the permanent magnet 105 on an axial side facing away from the bridge element 35. The second partial region 405 arranged radially on the inside of the first partial region 400 lies against the first coupling element 155 such that, in the open position, the magnetic flux of the magnetic field 140 is closed by the first coupling element 155 and the plunger portion 125 and also by the permanent magnet 105.

**[0097]** Figure 11 shows the high-current switch 10 shown in Figure 10 according to the second embodiment in the contact position of the bridge element 35.

**[0098]** In the contact position, the plunger portion 125 is axially spaced apart from the permanent magnet 105 and the first coupling element 155. In this configuration, the plunger portion 125 is not removed from the effective range of the magnetic field 140, but rather is arranged only so far from the magnetic field 140 of the permanent magnet 105 that the braking force FB generated by the magnetic field 140 is greatly attenuated compared to the open position and intermediate position shown in Figure 10.

**[0099]** The second embodiment of the high-current switch 10 shown in Figures 10 and 11, in particular the braking device 20, has the advantage that the braking device 20 is configured particularly simply and cost-effectively.

**[0100]** FIG 12 shows a section C, marked in Figure 1, of a high-current switch 10 according to a third embodiment.

**[0101]** The high-current switch 10 is substantially identical to the high-current switch 10 shown in Figure 1 according to the first embodiment. Only the differences of the high-current switch 10, shown in Figure 12, according to the third embodiment in relation to the high-current switch 10, explained in Figure 1, of the first embodiment will be discussed below.

**[0102]** Compared to Figure 1, the braking device 20 is arranged with respect to the switching device 25 axially with respect to the lifting axis 60 opposite the arrangement of the braking device 20, shown in Figure 1, in the first receptacle 70. In the embodiment, the switching device 25 has a sleeve 610 next to the coil device 250 and the armature 255. The sleeve 610 is connected, for example, to the coil device 250. The sleeve 610 extends along the lifting axis 60 and surrounds the armature 255 circumferentially. For example, the sleeve 610 is arranged radially outwards with respect to the armature 255.

**[0103]** The armature 255 has an armature end face 605 facing away from the bridge element 35 (not shown in Figure 12). The armature end face 605 is arranged at an inclination, preferably perpendicularly, with respect to the lifting axis 60. Radially on the inside of the armature end face 605, the armature 255 has a third receptacle 615, wherein a restoring spring 620 is arranged at least in sections in the third receptacle 615. The restoring spring 620 is supported on an axial side on the housing 15 and opposite on a third receiving base 625 of the third receptacle 615. The third receptacle 615 extends from the bridge element 35 towards the third receiving base 625. The restoring spring 620 is supported on the third receiving base 625. Furthermore, the connecting bolt 630 is guided in the third receptacle 615 along the lifting axis 60, said connecting bolt 630 being connected to the bridge element 35 directly or indirectly on a side facing away from the armature 255.

**[0104]** The sleeve 610 has, for example, a first sleeve portion 640 and a second sleeve portion 645 axially adjoining the first sleeve portion 640 on an axial side facing the bridge element 35. The sleeve 610 has a first radial extent on the inside in the first sleeve portion 640 and a second radial extent on the inside in the second sleeve portion 645, wherein the second radial extent in the second sleeve portion 645 is selected to be smaller than in the first sleeve portion 640. Furthermore, in the axial direction, the first sleeve portion 640 adjoins a sleeve end face 650, which is arranged on a side facing away from the bridge element 35.

**[0105]** Owing to the different inside radial extent of the sleeve 610 in the first sleeve portion 640 and in the second sleeve portion 645, the sleeve 610 has a step on which the sleeve 610 has a second stop surface 655. The second stop surface 655 may be oriented, for example, at an inclination, preferably perpendicularly, to the lifting axis 60. The second stop surface 655 is arranged axially offset with respect to the sleeve end face 650 and is offset in the direction of the bridge element 35.

**[0106]** In the embodiment, the permanent magnet 105 of the braking device 20 is annular. In this case, the permanent magnet 105 is arranged on a side facing away from the bridge element 35 with respect to the switching device 25.

**[0107]** In Figure 12, the bridge element 35 is arranged in the open position, by way of example. Similarly, in the axial direction, the armature 255 is thus also arranged spaced apart as far as possible from the switching contacts 40, 45. In the open position, the permanent magnet 105 of the holding unit 600 can at least partially protrude over the sleeve end face 650 and is only partially arranged in the first sleeve portion 640. In this case, the permanent magnet 105 lies with the second end face 165, which faces the bridge element 35 in Figure 12, against the armature end surface 605 and, by means of the magnetic field 140 provided by the permanent magnet 105, is magnetically connected to the armature 255 by means of a magnetic force FM. The magnetic force FM acts counter to the actuating force FA, for example. The magnetic force FM secures the permanent magnet 105 on the armature 255 in the open position such that they are connected to each other with a force fit.

**[0108]** In addition, the holding unit 600 can comprise the coupling unit 115 with the first coupling element 155. The second coupling element 160 can be omitted. The first coupling element 155 engages, for example, radially on the inside in the permanent magnet 105 and rests on a third end face 660 of the permanent magnet 105 facing away from the bridge element 35.

**[0109]** However, the first coupling element 155 may also be dispensed with in the embodiment. The first coupling element 155 has, for example, a T-shaped configuration in cross section. The first coupling element 155 is formed from ferromagnetic material and is displaceable axially in relation to the armature 255.

**[0110]** In the open position of the bridge element 35, the permanent magnet 105 is arranged axially between the first coupling element 155 and the armature end surface 605. In addition, the first coupling element 155 can reach with an engagement portion 665 arranged radially on the inside through the annular permanent magnet 105 and can engage in the third receptacle 615 of the armature 255 which is also produced from ferromagnetic material.

**[0111]** By means of the first coupling element 155, the magnetic field 140 of the permanent magnet 105 is guided in the open position in such a way that there is a magnetic closure between the permanent magnet 105, the armature 255 and the first coupling element 155, and the magnetic field 140 couples them to one another.

**[0112]** Figure 13 shows a section E, marked in Figure 12, of the high-current switch 10.

**[0113]** In Figure 13, the bridge element 35 is moved into the intermediate position by means of the actuating force FA. As a result, the armature 255 is arranged axially offset in relation to Figure 12 (offset upwards in Figure 13). In the intermediate position, the permanent magnet

105 enters into contact with the second stop surface 655 and continues to lie with the second end face 165 against the armature end surface 605. The magnetic coupling of the permanent magnet 105 with the armature 255 causes the permanent magnet 105 to form a type of shoulder or edge.

**[0114]** Furthermore, further movement of the permanent magnet 105 and of the armature 255 together is blocked by the permanent magnet 105 lying with the second end face 165 against the first stop surface 655. Furthermore, the force-fitting connection between armature 255 and permanent magnet 105 by means of the magnetic force FM is maintained by the permanent magnet 105 lying directly against the armature 255. In this case, a particularly high braking force FB is provided by the holding unit 600 in order to prevent an unintentional movement of the armature 255 from the intermediate position in the direction of the contact position.

**[0115]** Figure 14 shows a section E, shown in Figure 12, of the high-current switch 10 in the contact position of the bridge element 35.

**[0116]** In the contact position, the armature 255 is separated from the permanent magnet 105 such that a third axial gap 670 is present between the armature end surface 605 and the second end face 165. In the contact position, the magnetic field 140 acts only slightly, if at all, on the armature 255, and therefore the magnetic force FM is greatly reduced compared to the open position and the intermediate position. The magnetic force FM decreases as the distance a3 between the second end face 165 and the armature end surface 605 increases, and therefore the contact pressure force with which the armature 255 acts on the bridge element 35 is reduced only slightly, if at all, by the magnetic field 140.

**[0117]** In the embodiment, in the contact position, the magnetic field 140 of the permanent magnet 105 is guided between the sleeve 610 and the first coupling element 155. The magnetic field 140 enters the first coupling element 155 on the side facing away from the second stop surface 655, wherein the first coupling element 155 guides the magnetic field 140 back to the permanent magnet 105 such that a magnetic flux of the magnetic field 140 is closed in the contact position. This can further minimize the effect of the magnetic field 140 on the armature 255.

**[0118]** Figure 15 shows a second diagram of a gradient of the magnetic force FM plotted over the distance a3 of the second end face 165 to the armature end surface 605.

**[0119]** The second diagram shows a second graph 505. The second graph 505 has a fifth graph section 515 and a sixth graph section 520 adjoining the fifth graph section 515.

**[0120]** If the high-current switch 10 is operated by active control according to the method described in Figure 6, the actuating force FA has the progression shown in Figure 7.

**[0121]** In this case, as the distance A3 increases, the magnetic force FM acting counter to the actuating force

FA greatly decreases, wherein the magnetic force FM at the transition between the fifth graph section 515 and the sixth graph section 520 further decreases once again by the fact that the first coupling element 155 leaves the third receptacle 615.

**[0122]** It is noted that the third embodiment of the high-current switch 10 shown in Figures 12 to 14 can of course also be combined with the first and/or second embodiment shown in Figures 1 to 11.

**[0123]** In particular, it is possible, for example, that the third embodiment shown in Figures 12 to 14 is provided on the side facing away from the bridge element 35 in addition to the first and/or second embodiment shown in Figures 1 to 11. The combination of the first and/or second embodiment shown in Figures 1 to 11 with the third embodiment shown in Figures 12 to 14 has the advantage that the bridge element 35 can also be subjected to very sharp accelerations without the bridge element 35 passing via the intermediate position into the contact position. The braking force FB is particularly high here.

**[0124]** Figure 16 shows a section E, marked in Figure 1, of a high-current switch 10 according to a fourth embodiment.

**[0125]** The high-current switch 10 is substantially identical to the high-current switch 10 shown in Figures 1 to 9 according to the first embodiment. Only the differences of the high-current switch, shown in Figure 16, according to the fourth embodiment in relation to the high-current switch 10, shown in Figure 1, according to the first embodiment will be discussed below.

**[0126]** In the embodiment, the permanent magnet 105 of the holding unit 600 is dispensed with and the permanent magnet 105 is replaced by a spring arrangement 700. The spring arrangement 700 has at least one spring 705, preferably a plurality of springs 705 arranged in a stack along the lifting axis 60. The spring 705 can be configured, for example, as a disc spring. The spring 705 has at least one spring opening 710, which is arranged on the lifting axis 60. The spring 705 can be, for example, rotationally symmetrical around the lifting axis 60. In particular in the case of the arrangement of a plurality of springs 705 in the stack, the springs 705 can be arranged alternately to one other.

**[0127]** The coupling unit 115 is modified to the effect that the first coupling element 155 is dispensed with and the second coupling element 160 is reduced to the first coupling element portion 185, which forms a guide element 715. The guide element 715 can be, for example, annular and is connected to the housing 15. The second through-opening 195 is reduced to the effect that it forms a guide opening 720, which extends along the lifting axis 60 completely through the guide element 715.

**[0128]** The plunger 110 may be substantially formed as explained in Figure 3. In a departure therefrom, the pin 120 has a first pin portion 725 and a second pin portion 730. The first pin portion 725 extends along the lifting axis 60 between the plunger portion 125 and the first stop

surface 130 arranged on the first pin portion 725.

**[0129]** Axially opposite the first pin portion 725, the second pin portion 730 is connected to the plunger portion 125 and to the first pin portion 725 on a side of the plunger portion 125 facing away from the bridge element 35. The second pin portion 730, like the first pin portion 725, is configured extending in a pin-like manner on the lifting axis 60. The second pin portion 730 can be, for example, shorter axially along the lifting axis 60 than the first pin portion 725. Furthermore, laterally in the circumferential direction, the plunger portion 125 protrudes over both the first pin portion 725 and the second pin portion 730. The first and/or second pin portion 725, 730 can be configured, for example, rotationally symmetrically, in particular cylindrically, around the lifting axis 60.

**[0130]** The second pin portion 730 is arranged in the first receptacle 70. The second pin portion 730 reaches, for example, through the spring arrangement 700, through the respectively provided spring opening 710. In this case, at least in the contact position of the bridge element 35, the second pin portion 730 can completely reach through the spring arrangement 700 along the lifting axis 60 and protrude axially with a free end over the spring arrangement 700 on the side facing away from the first pin portion 725.

**[0131]** The first pin portion 725 reaches through the guide opening 720. In this case, the guide opening 720 and a third outer circumferential side 731 of the first pin portion 725 are formed correspondingly to each other. In this case, the third outer circumferential side 731 of the first pin portion 725 lies on the inside against the guide opening 720, wherein the guide opening 720 is configured to prevent tilting of the plunger 110 about an axis perpendicular to the lifting axis 60. In particular, the guide opening 720 guides the first pin portion 725 during a movement of the plunger 110 along the lifting axis 60.

**[0132]** In Figure 16, the bridge element 35 is in the open position, and therefore the bridge element 35 is arranged spaced apart axially with respect to the lifting axis 60 from the first stop surface 130. Of particular advantage, in the open position of the bridge element 35, is if the spring 705, in particular the springs 705, of the spring arrangement 700 in the first receptacle 70 is or are pretensioned.

**[0133]** Figure 17 shows the section E, shown in Figure 1, of the high-current switch 10 in the intermediate position of the bridge element 35.

**[0134]** In Figure 17, the bridge element 35, as already explained in Figures 1 to 9, is displaced along the lifting axis 60 due to an acceleration or due to an actuation by the armature 255 along the lifting axis 60 in the direction of the first and second switching contacts 40, 45. In this case, the bridge element 35 strikes with the second receiving base 236 against the first stop surface 130. The holding unit 600, by means of the pretensioned spring arrangement 700, provides the braking force FB which acts along the lifting axis 60 in the direction of the bridge element 35 counter to the actuating force FA. Here, the plunger 110 is held in its position by the braking

force FB and the pretensioned spring arrangement 700, and the plunger portion 125 lies with the second contact surface 225 against a fourth end face 735 of the guide element 715.

**[0135]** The fourth end face 735 is preferably oriented with an inclination, preferably perpendicularly, to the lifting axis 60 and is arranged on an axial side of the guide element 715 facing away from the bridge element 35. The spring arrangement 700 presses the plunger portion 125 against the fourth end face 735 by means of the braking force FB. By the second contact surface 225 lying flat against the fourth end face 735, a defined alignment of the plunger 110 is also ensured.

**[0136]** The pretensioned spring arrangement 700 therefore ensures the alignment of the plunger 110. Furthermore, the braking force FB with which the plunger 110 is held both in the open position and in the intermediate position on the guide element 715 can be particularly high.

**[0137]** Figure 18 shows a diagram of a spring force FF plotted over a compression distance n.

**[0138]** The compression distance n is the distance by which the spring arrangement 700 is compressed.

**[0139]** In the embodiment, for example, the spring 705 of the spring arrangement 700 can be configured as a steel disc spring and, for example, can comprise X10 CrNi 18-8 as the material. The spring force FF increases greatly as the compression increases along the compression distance n until the spring force FF reaches a maximum force 740 after a short compression distance n. After exceeding the maximum force 740, the spring force FF decreases sharply until the spring 705 cannot be compressed further and is compressed.

**[0140]** Figure 19 shows the section E, shown in Figures 16 and 17, while the bridge element 35 is located between the contact position and the intermediate position.

**[0141]** In this case, during the movement of the plunger 110 along the lifting axis 60, the first pin portion 725 is guided through the guide opening 720. On the path of the bridge element 35 from the intermediate position towards the contact position (in Figure 19, the movement of the bridge element 35 is symbolically indicated by means of arrows), the guide element 715 remains fixed in position in the housing 15.

**[0142]** The plunger portion 125 compresses the spring arrangement 700 and the springs 705 and presses them against the first receiving base 80. Owing to the spring force FF/compression distance n progression of the spring arrangement 700 already shown in Figure 17, in the intermediate position the braking force FB, which acts counter to the actuating force FA along the lifting axis 60, is particularly strong and increases sharply as the distance of the bridge element 35 increases from the intermediate position towards the contact position up to the maximum force 740.

**[0143]** This has the advantage that, even if the bridge element 35 is moved beyond the intermediate position in the direction of the contact position due to a high accel-

eration, the braking force FB increases as the contact position is increasingly approached, and the braking force FB prevents that, in the event of an unintentional acceleration of the bridge element 35, the bridge element 35 reaches the contact position.

**[0144]** In this case, it is of particular advantage if the spring arrangement 700 with regard to its maximum force 740 is configured such that the maximum force 740 is already achieved well before the contact position. As a result, it can be ensured that, even when the maximum force 740 is reached, there is sufficient distance of the bridge element 35 from the switching contacts 40, 45.

**[0145]** Figure 20 shows a diagram of a third graph 515 of the actuating force FA over the travel distance D of the armature 255 for displacing the bridge element 35 from the open position OP via the intermediate position ZP into the contact position KP.

**[0146]** The second graph 505 is basically identical to the first graph 500. Thus, the second graph 505 has the first graph section 501, the second graph section 502, the third graph section 503 and at least the fourth graph section 504.

**[0147]** If the high-current switch 10 is operated by active control according to the method described in Figure 6, the actuating force FA has the progression shown in Figure 20.

**[0148]** In the second method step 310, the armature 255 is moved along the lifting axis 60 by energization of the coil device 250, and the switching device 25 provides the actuating force FA.

**[0149]** By means of the coupling of the armature 255, in the third method step 315 with the bridge element 35, the spring arrangement 700 is compressed by the actuating force FA beyond the maximum force 740.

**[0150]** The configuration of the spring 705 as a disc spring has the advantage that, as explained in Figure 19, the spring force FF decreases with further compression of the spring arrangement 700. Thus, the braking force FB in the third graph section 503 is attenuated and the switching device 25 can easily compress the spring arrangement 700 until the bridge element 35 reaches the contact position.

**[0151]** In order to ensure a particularly good hold of the electrical contact in the contact position, the overlift spring 635 can be actuated and compressed when the armature 255 is actively actuated (cf. fourth graph section 504). In the end position of the armature 255, the armature 255 can lie against a yoke of the switching device 25, and the magnetic flux is closed via the armature 255, and therefore the contact position of the bridge element 35 can be securely maintained.

**[0152]** Figure 21 shows a section E, marked in Figure 1, of a high-current switch 10 according to a fifth embodiment.

**[0153]** The high-current switch 10 is substantially identical to the high-current switch 10 shown in Figures 16 to 20. Only the differences of the high-current switch 10, shown in Figure 21, according to the fifth embodiment in

relation to the high-current switch 10, shown in Figures 16 to 20, according to the fourth embodiment will be discussed below.

**[0154]** In the embodiment, the first receptacle 70 is radially expanded with respect to the lifting axis 60. As a result, the spring arrangement 700 is wider than shown in Figures 16 to 20. Furthermore, the number of springs 705 can be reduced compared to Figures 16 to 20. In the embodiment, the spring arrangement 700 exclusively has a spring 705.

**[0155]** The spring 705 can be configured in the manner of a disc spring. In this case, the spring 705 is fixedly connected to the housing 15 at a radially outer end 745, for example.

**[0156]** Figure 22 shows a perspective illustration of the spring 705 of the spring arrangement 700 of the high-current switch 10 shown in Figure 21.

**[0157]** The spring 705 is configured in the manner of a disc spring. In this case, the spring 705 can be reduced in relation to a rotationally symmetrical disc spring to the effect that the spring 705 is substantially configured in a strip-like manner in a direction perpendicular to the lifting axis 60. Radially on the outside, the spring 705 can have a plate-like first partial section 750 for engagement in the housing 15. Radially on the inside of the first partial portion 750, the spring 705 has a substantially S-shaped curved progression towards the spring opening 710. By means of the S-shaped curved second partial portion 755, the force progression of the spring 705 shown in Figure 20 can be achieved. The spring opening 710 is arranged centrally and, at the spring opening 710, the spring 705 is formed offset axially from the first partial portion 750.

## Claims

1. High-current switch (10), in particular contactor, in particular bridge contactor, for an electrical energy store of a vehicle,

- wherein the high-current switch (10) has a housing (15), a braking device (20), a first switching contact (40), a second switching contact (45) arranged offset from the first switching contact (40) and a switching device (25) having a bridge element (35),
- wherein the bridge element (35) is movable along a lifting axis (60) between an open position, an intermediate position and a contact position in the housing (15),
- wherein, in the contact position of the bridge element (35), the bridge element (35) contacts the first switching contact (40) and the second switching contact (45) and electrically connects them to each other,
- wherein, in the open position and in the intermediate position of the bridge element (35), the

bridge element (35) is arranged spaced apart from the first switching contact (40) and second switching contact (45), and the first and second switching contacts (40, 45) are electrically isolated from each other,

- wherein the intermediate position is arranged between the open position and the contact position with respect to the lifting axis (60),
- wherein the braking device (20) has a holding unit (600), which is operatively connected in the intermediate position to the bridge element (35) by means of an operative connection and provides a braking force (FB), which acts on the bridge element (35),
- wherein, in the contact position, the operative connection between the holding unit (600) and the bridge element is reduced,
- wherein, during a movement of the bridge element (35) from the open position in the direction of the contact position, at least in the intermediate position, the holding unit (600) acts with the braking force (FB) counter to the movement of the bridge element (35).

2. High-current switch (10) according to Claim 1,

- wherein the holding unit (600) has a permanent magnet (105),
- wherein the permanent magnet (105) provides a magnetic field (140),
- wherein, in the intermediate position, the permanent magnet (105) provides the operative connection.

3. High-current switch (10) according to either of the preceding claims,

- wherein the switching device (25) has a coil device (250) and an armature (255) arranged on the coil device (250),
- wherein the armature (255) is mechanically connected to the bridge element (35),
- wherein, when the coil device (250) is energized with an electric current, the coil device (250) is configured to move the armature (255) along the lifting axis (60) in such a manner that the armature (255) moves the bridge element (35) between the open position via the intermediate position into the contact position.

4. High-current switch according to Claims 2 and 3,

- wherein the switching device (25) has a sleeve (610) which extends along the lifting axis (60),
- wherein the armature (255) is arranged at least in sections in the sleeve (610),
- wherein the sleeve (610) on a side facing the permanent magnet (105) has a stop surface

- (655) arranged at an inclination with respect to the lifting axis (60),  
 - wherein the permanent magnet (105) has a second end face (165) and the armature (255) on a side facing the permanent magnet (105) has an armature end surface (605),  
 - wherein, in the open position, the permanent magnet (105) lies against the armature end face (605) and is arranged spaced apart from the stop surface (655),  
 - wherein, in the intermediate position, the permanent magnet (105) lies against the stop surface (655) and generates the braking force (FB).
5. High-current switch according to any one of the preceding claims,  
 - wherein the braking device (20) has a plunger (110) which extends along the lifting axis (60) and is arranged movably in the housing (15) along the lifting axis (60) independently of the bridge element (35),  
 - wherein, in the open position, the plunger (110) is arranged spaced apart from the bridge element (35),  
 - wherein, during a movement of the bridge element (35) from the open position in the direction of the contact position in the intermediate position, the bridge element (35) contacts the plunger (110) in order to form the operative connection.
6. High-current switch (10) according to Claim 5 and Claim 2,  
 - wherein, in the intermediate position and/or in the open position, the permanent magnet (105) secures the plunger (110).
7. High-current switch (10) according to Claim 5 or 6,  
 - wherein the plunger (110) has a plunger portion (125) extending outwards in the radial direction and a pin (120) which is connected to the plunger portion (125) and extends along the lifting axis (60),  
 - wherein the plunger portion (125) is arranged on a side of the pin (120) facing away from the bridge element (35),  
 - wherein, in the open position and the intermediate position, the plunger portion (125) is arranged in an effective range of the magnetic field (140).
8. High-current switch (10) according to any one of Claims 5 to 7,  
 - wherein the braking device (20) has a coupling unit (115),  
 - wherein the coupling unit (115) is connected to the housing (15) and has a second through-opening (195),  
 - wherein the plunger (110) penetrates the second through-opening (195) at least in sections,  
 - wherein, preferably, the plunger (110) and the second through-opening (195) are formed corresponding to the guiding of the plunger (110) along the lifting axis (60).
9. High-current switch (10) according to any one of the preceding claims,  
 - wherein the holding unit (600) has at least one spring arrangement (700),  
 - wherein the plunger (110) is connected to the spring arrangement (700),  
 - wherein the spring arrangement (700) provides the braking force (FB),  
 - wherein, during a movement of the bridge element (35) from the intermediate position in the direction of the contact position, the spring arrangement (700) is tensioned,  
 - wherein, preferably, the spring arrangement (700) is pretensioned in the intermediate position,  
 - wherein, preferably, the spring arrangement (700) has at least one spring (705) configured in the manner of a disc spring, or a plurality of springs (705) arranged in a stack,  
 - wherein, in the contact position, the spring arrangement (700) is at least partially relaxed.
10. High-current switch according to Claim 9 and Claim 5,  
 - wherein the spring arrangement (700) is arranged between the housing (15) and the plunger (110),  
 - wherein the plunger (110) lies against the spring arrangement (700) and the spring arrangement (700) acts against the plunger (110).
11. Method for operating a high-current switch (10) according to any one of the preceding claims,  
 - wherein the bridge element (35) is moved into the open position,  
 - wherein the bridge element (35) is moved from the open position in the direction of the contact position, in particular on the basis of an unintentional acceleration, with an actuating force (FA) along the lifting axis (60),  
 - wherein, at least in the intermediate position, the holding unit (600) is operatively connected to the bridge element (35) and the braking force (FB) acts on the bridge element (35) counter to

the movement of the bridge element (35) and the actuating force (FA),

- wherein the bridge element (35), after overcoming the braking force (FB), is moved from the intermediate position into the contact position and the operative connection is reduced.

**12.** Method according to Claim 11 for operating the high-current switch according to Claim 2,

- wherein, in the intermediate position, the braking force (FB) acting on the bridge element (35) is formed magnetically,

- wherein, during the movement of the bridge element (35) from the intermediate position into the contact position, the magnetic effect of the permanent magnet (105) decreases.

**13.** Method according to Claim 11 or 12 for operating the high-current switch (10) according to Claim 10,

- wherein, during the movement of the bridge element (35) from the intermediate position into the contact position, the spring arrangement (700) is tensioned and acts with the braking force (FB) on the bridge element (35),

- wherein, as the bridge element (35) comes increasingly closer to the contact position, the braking force (FB) decreases.

**14.** Method according to any one of Claims 11 to 13 for operating a high-current switch (10) according to any one of Claims 4 to 10,

- wherein, in the open position, the permanent magnet (105) lies against the armature (255),

- wherein, in the intermediate position, the permanent magnet (105) strikes with the second end face (165) against the stop surface (655) and operatively connects the armature (255) magnetically to the sleeve (610),

- wherein, during a movement of the bridge element from the intermediate position into the contact position, the armature (255) is separated from the permanent magnet (105).

5

10

15

20

25

30

35

40

45

50

55

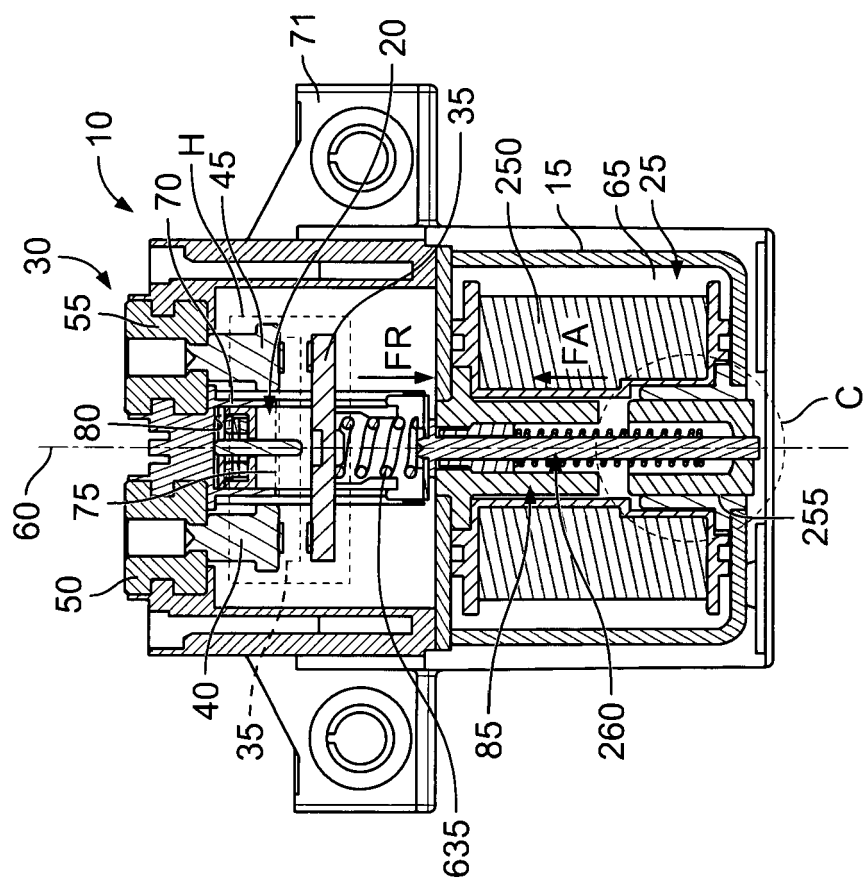


Fig. 1

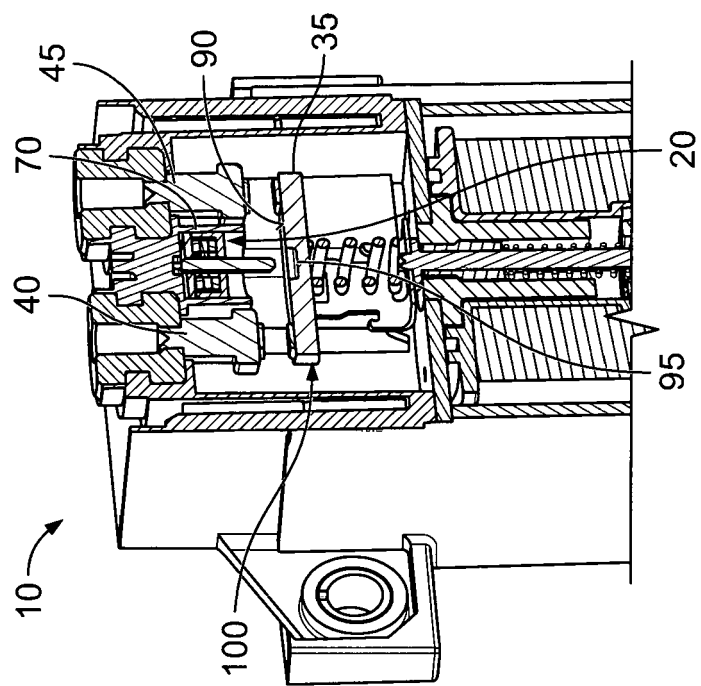


Fig. 2

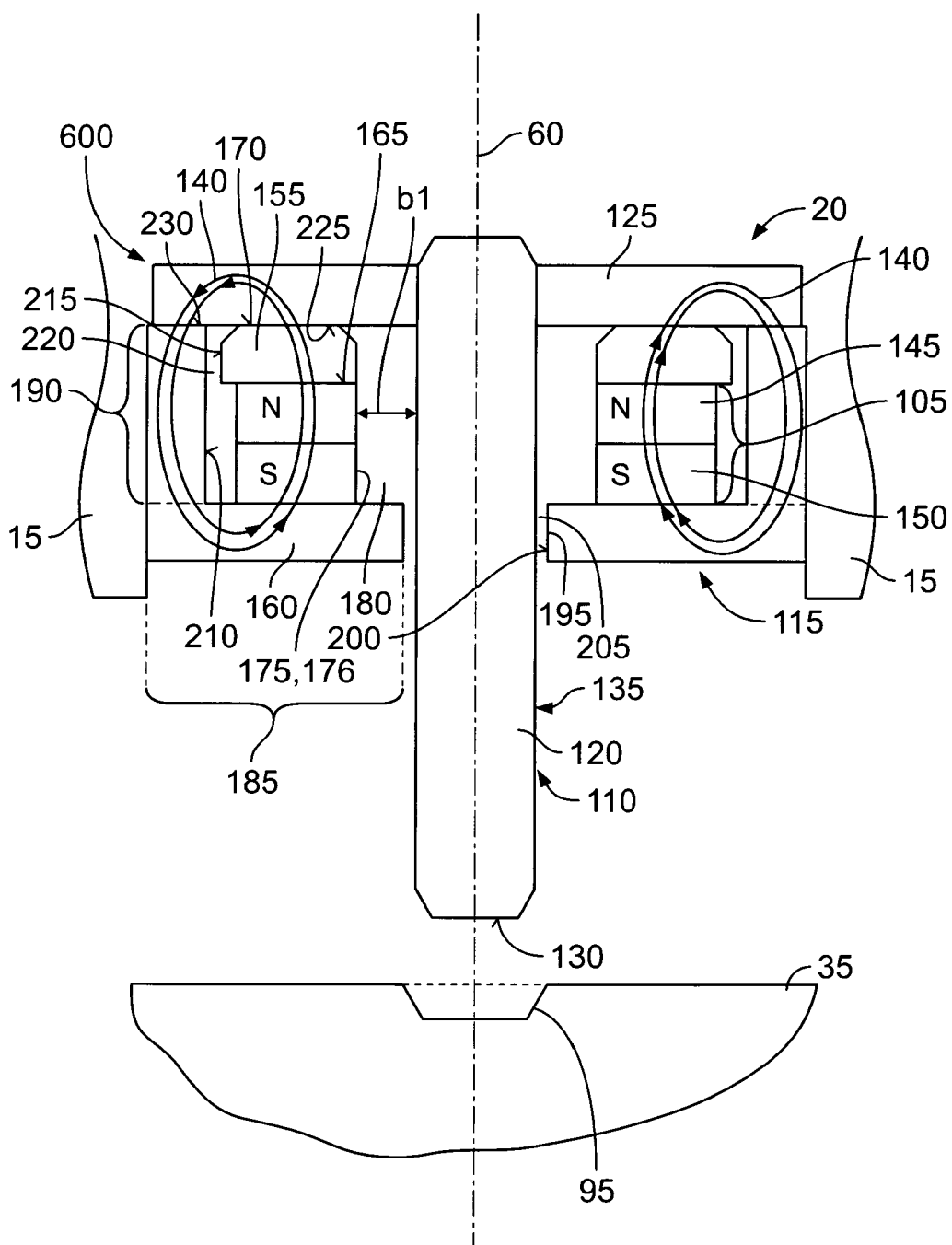
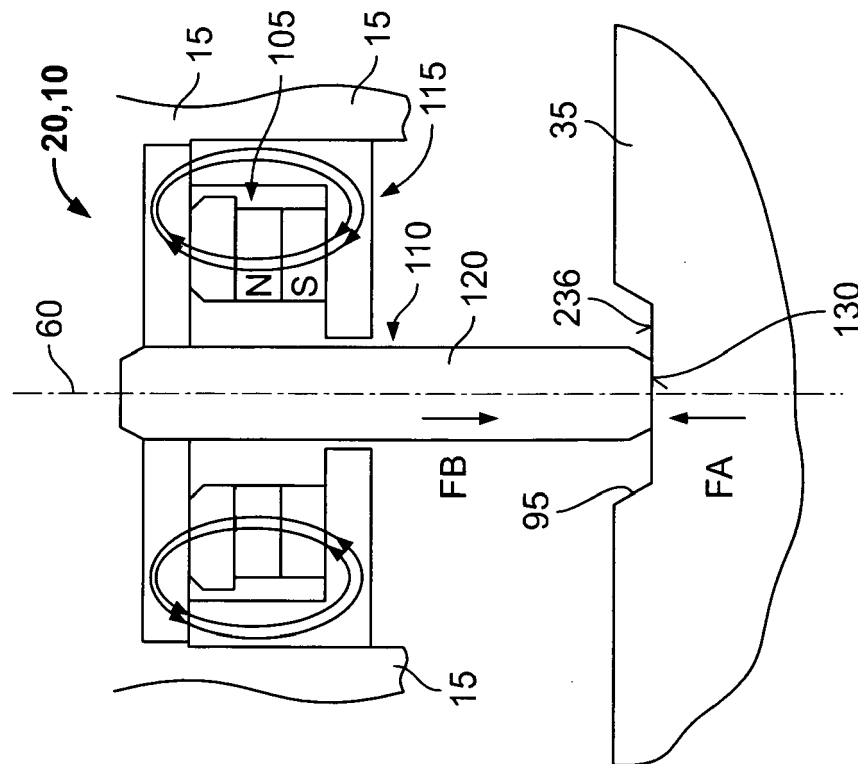
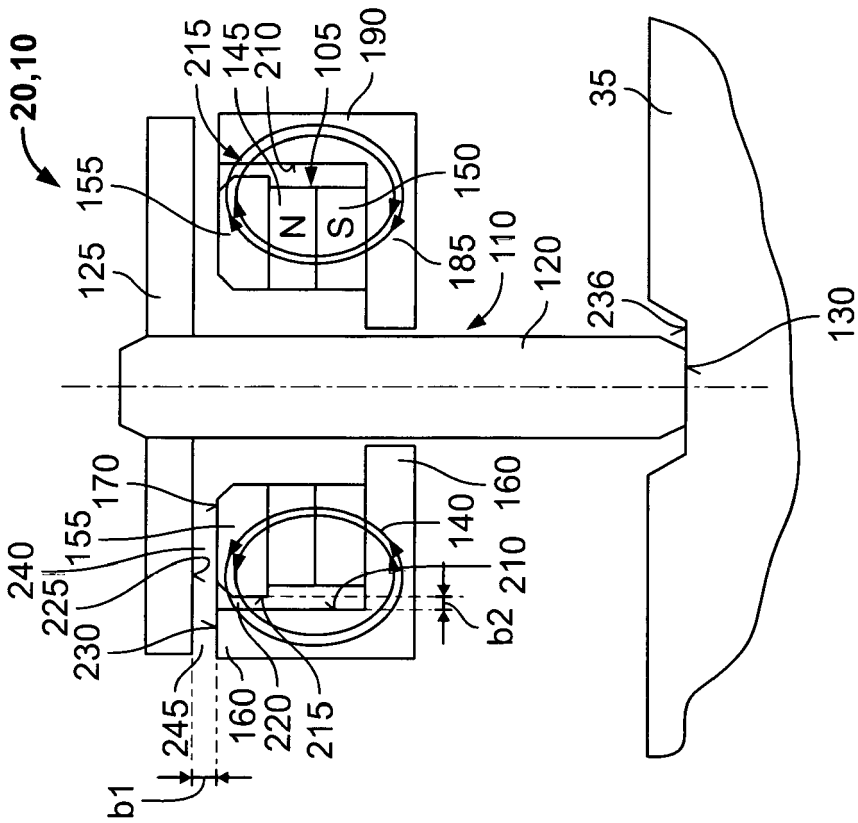


Fig. 3



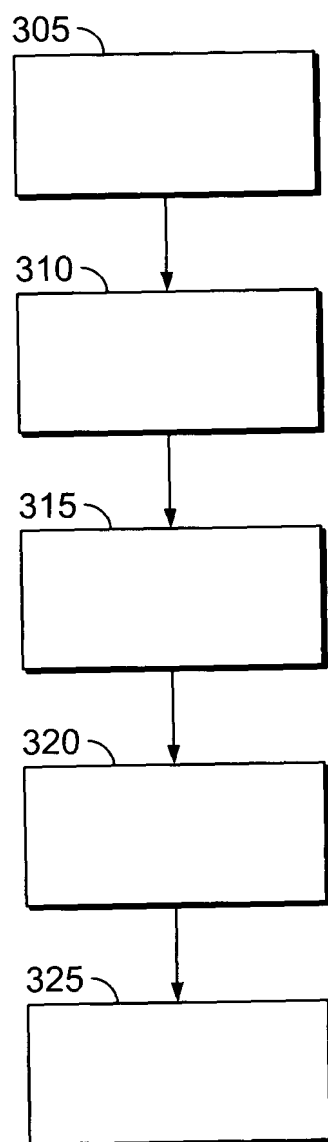


**Fig. 6**

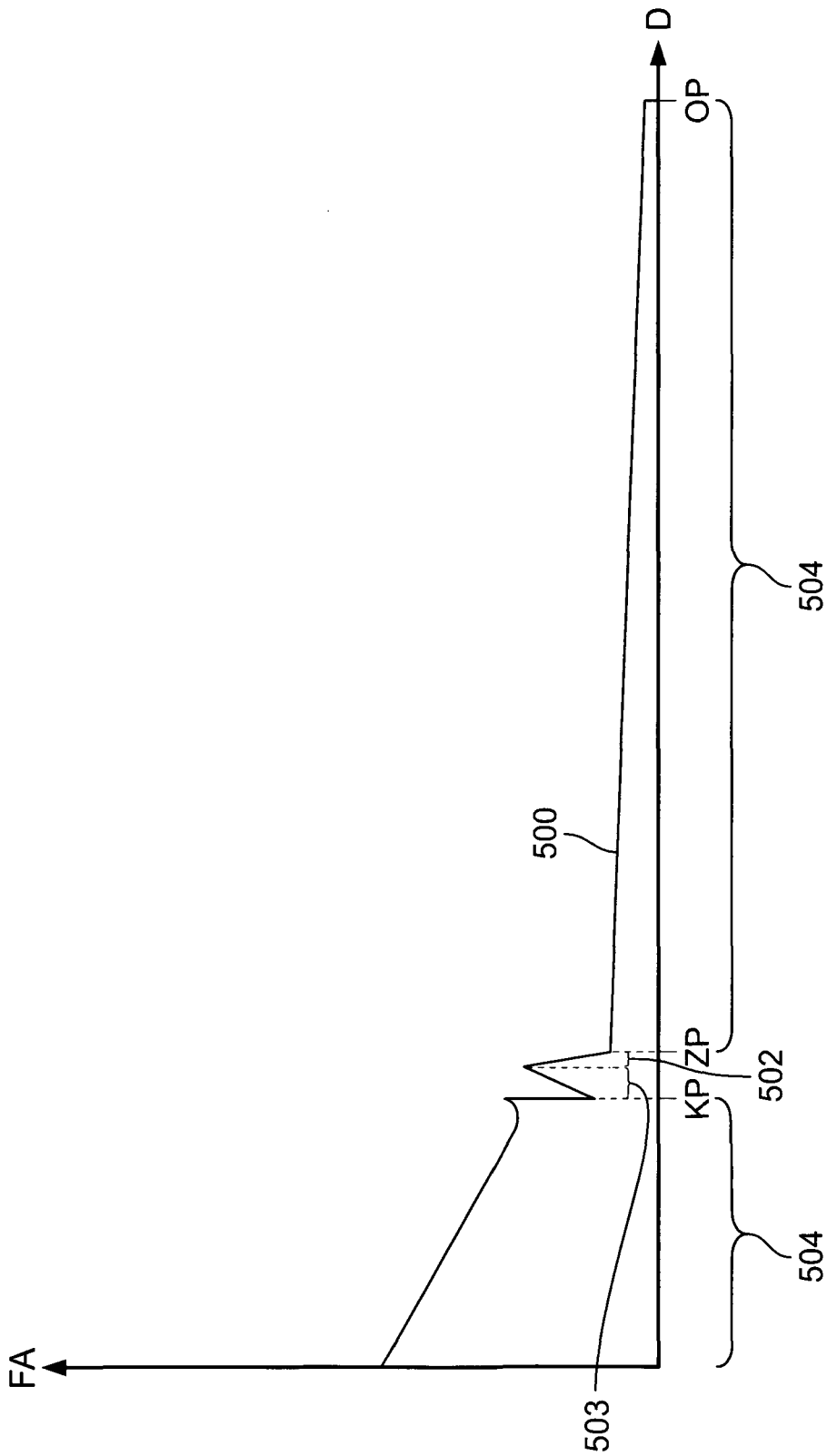
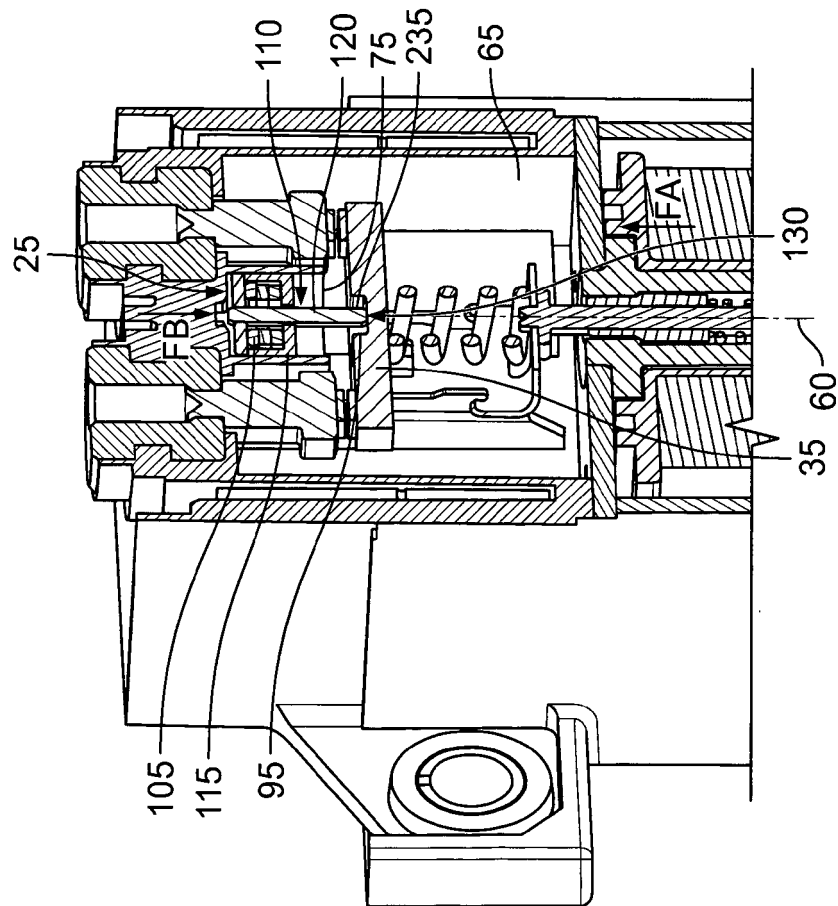
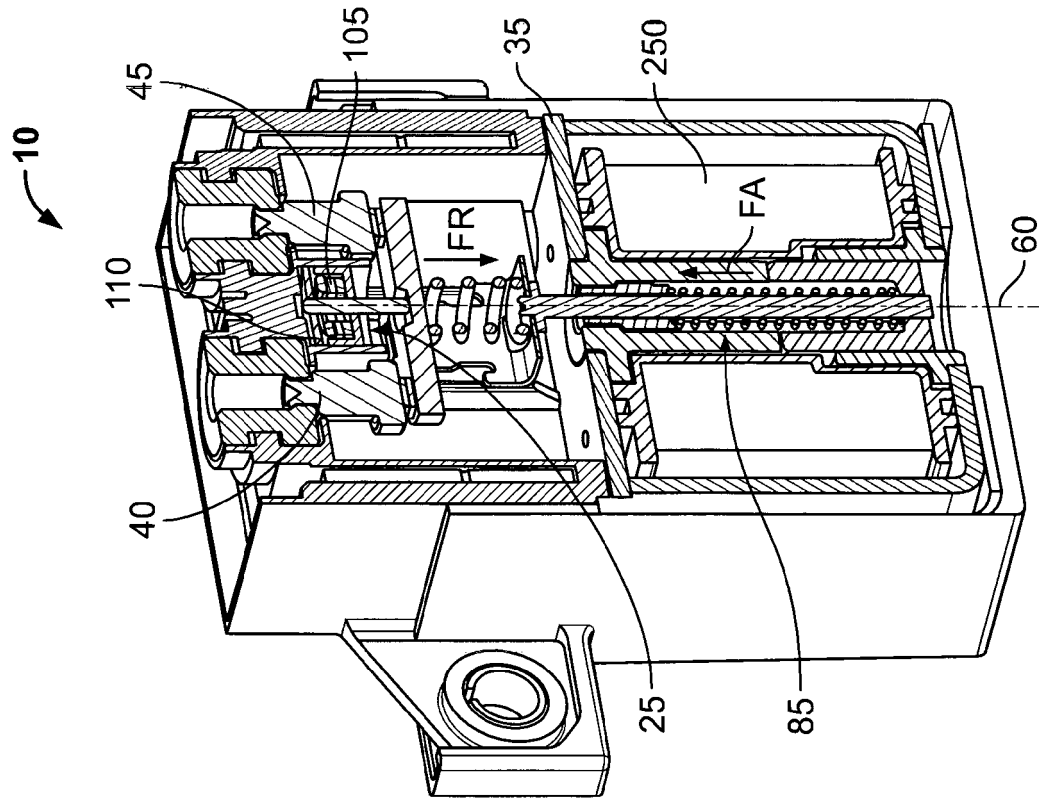


**Fig. 7**



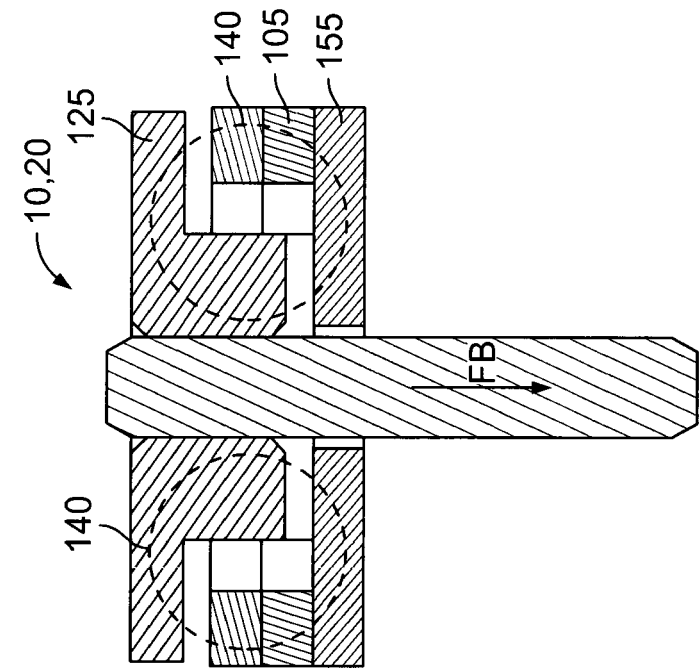


Fig. 11

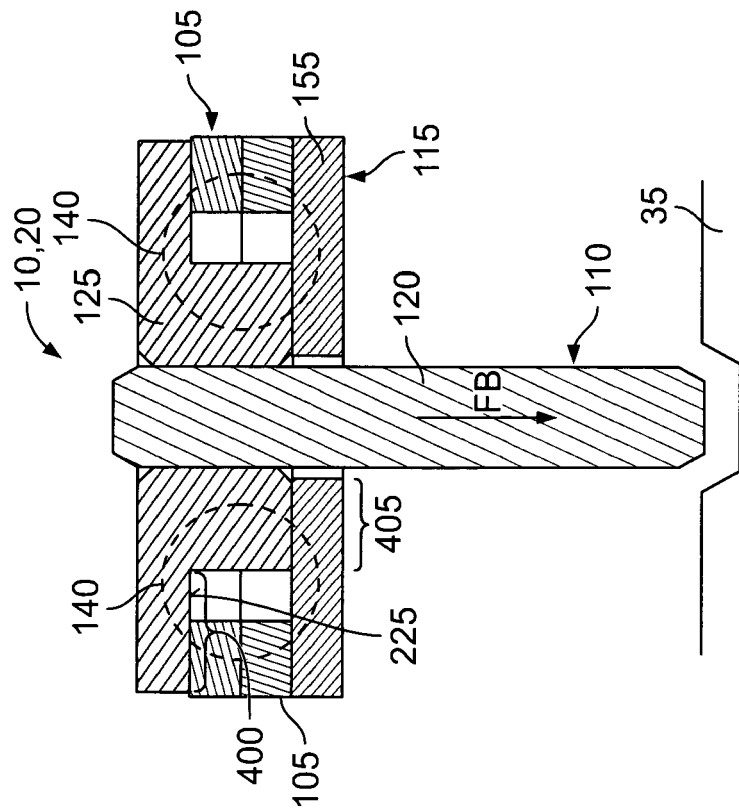


Fig. 10

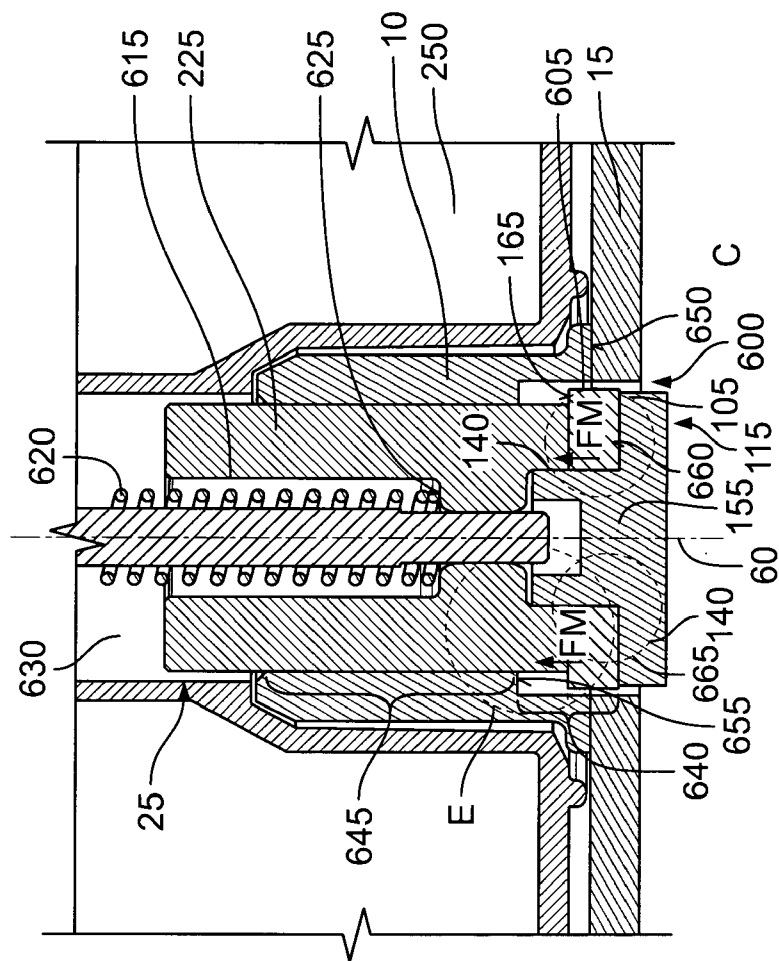
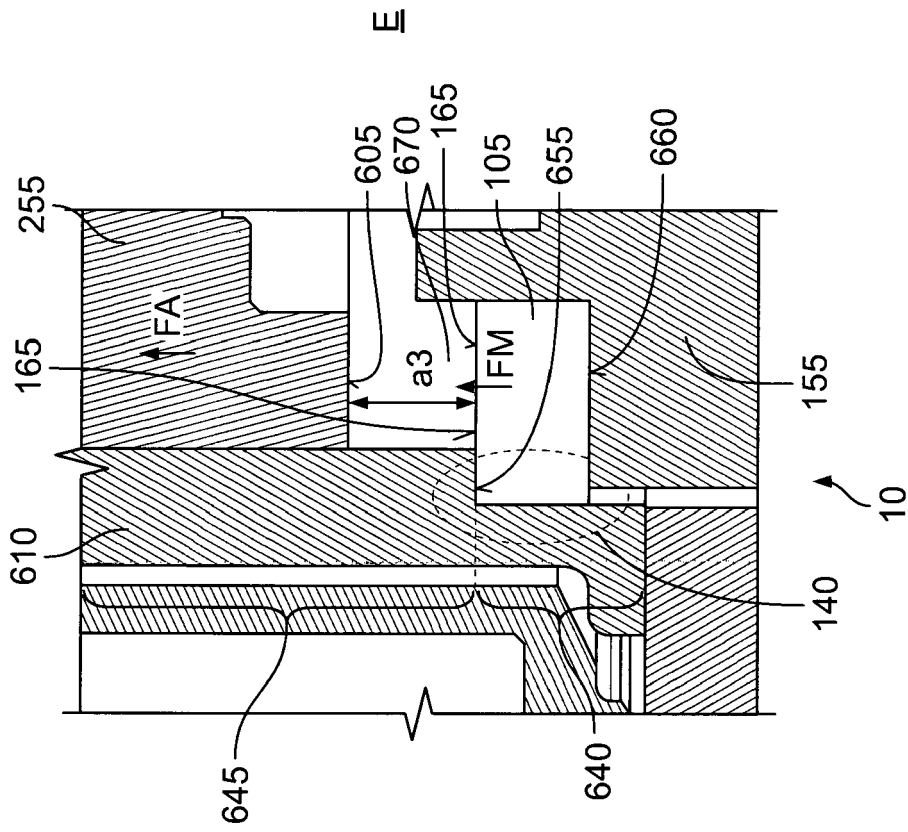
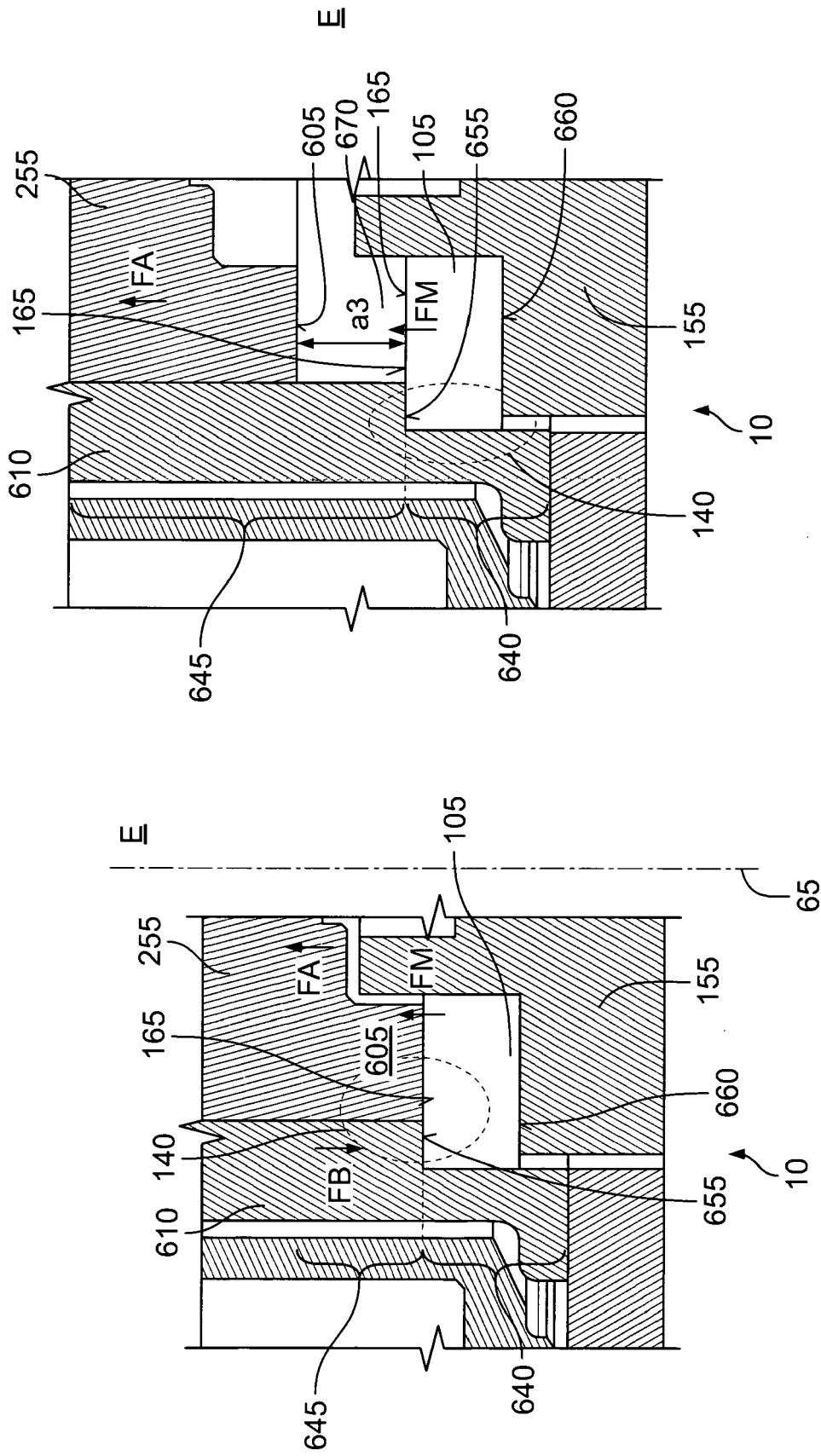


**Fig. 12**



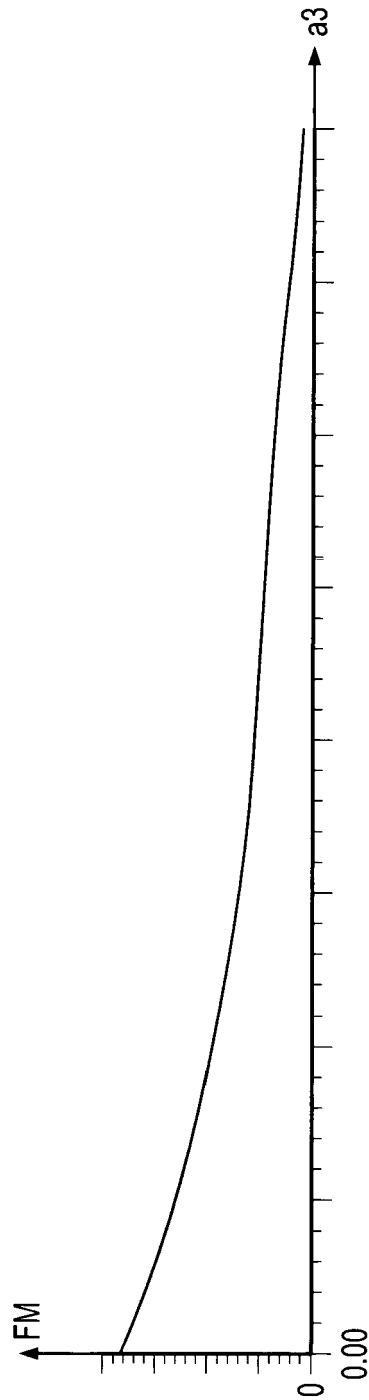


FIG. 15

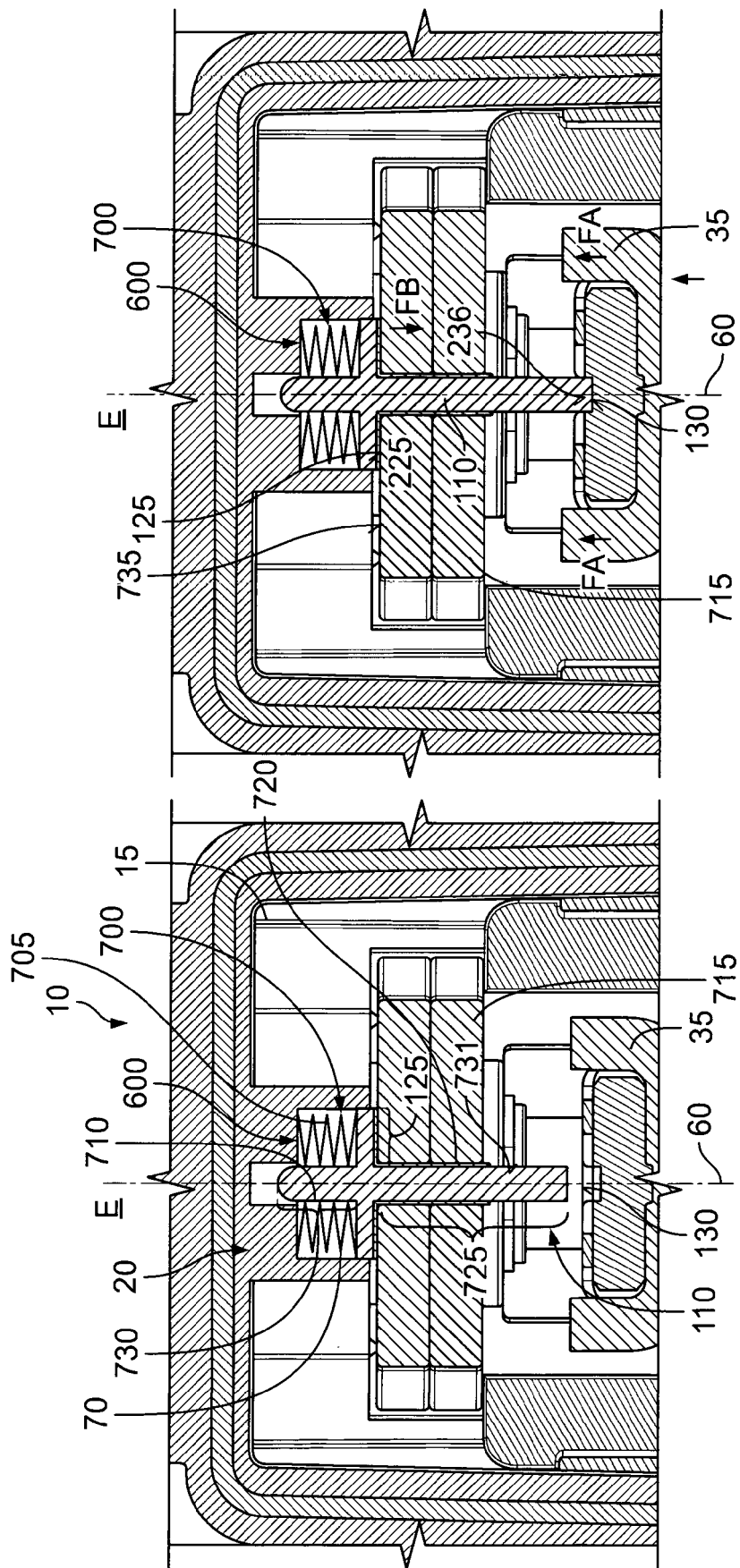


Fig. 16

Fig. 17

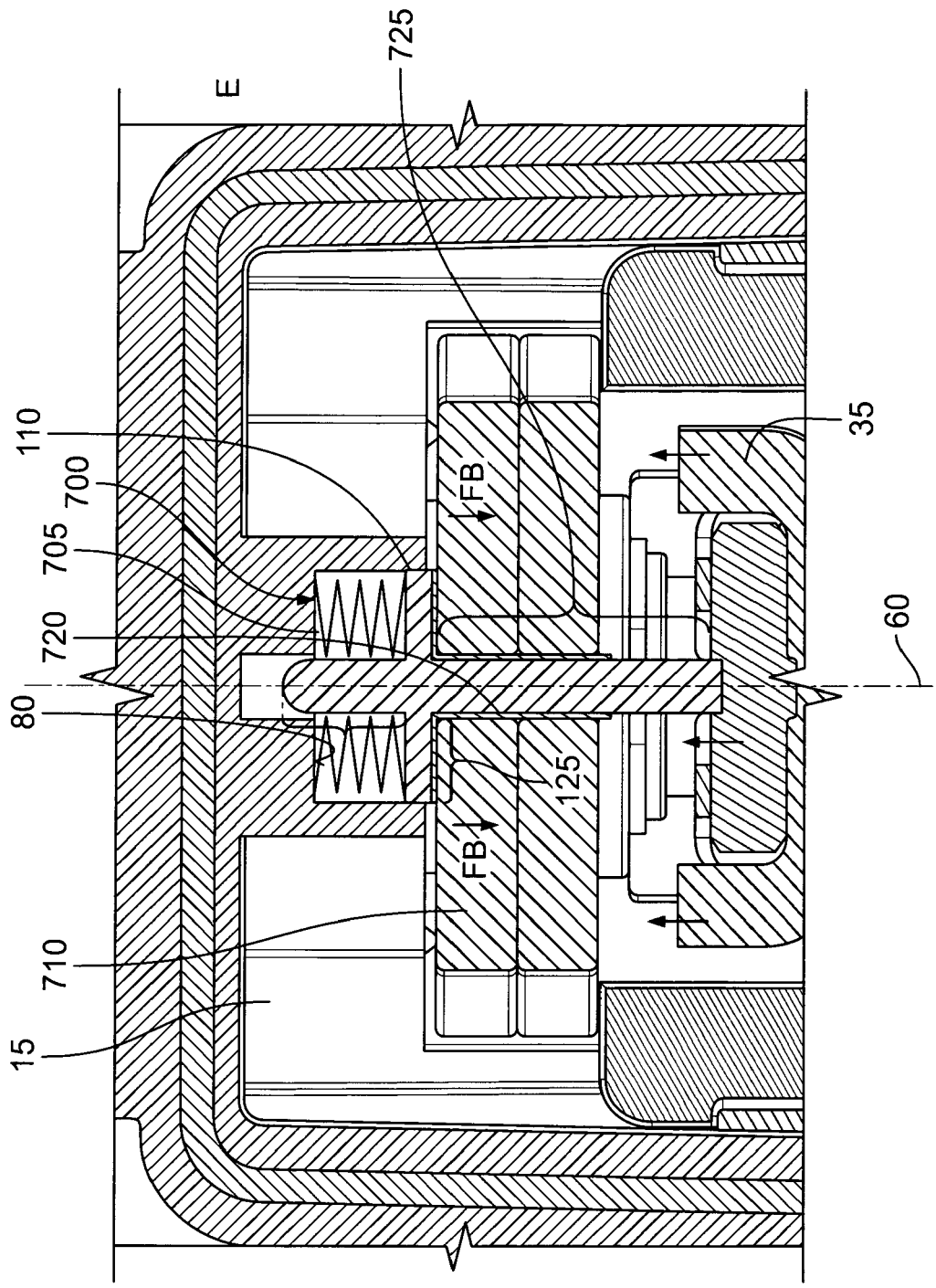


Fig-19

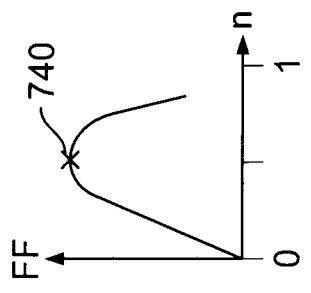


Fig-18

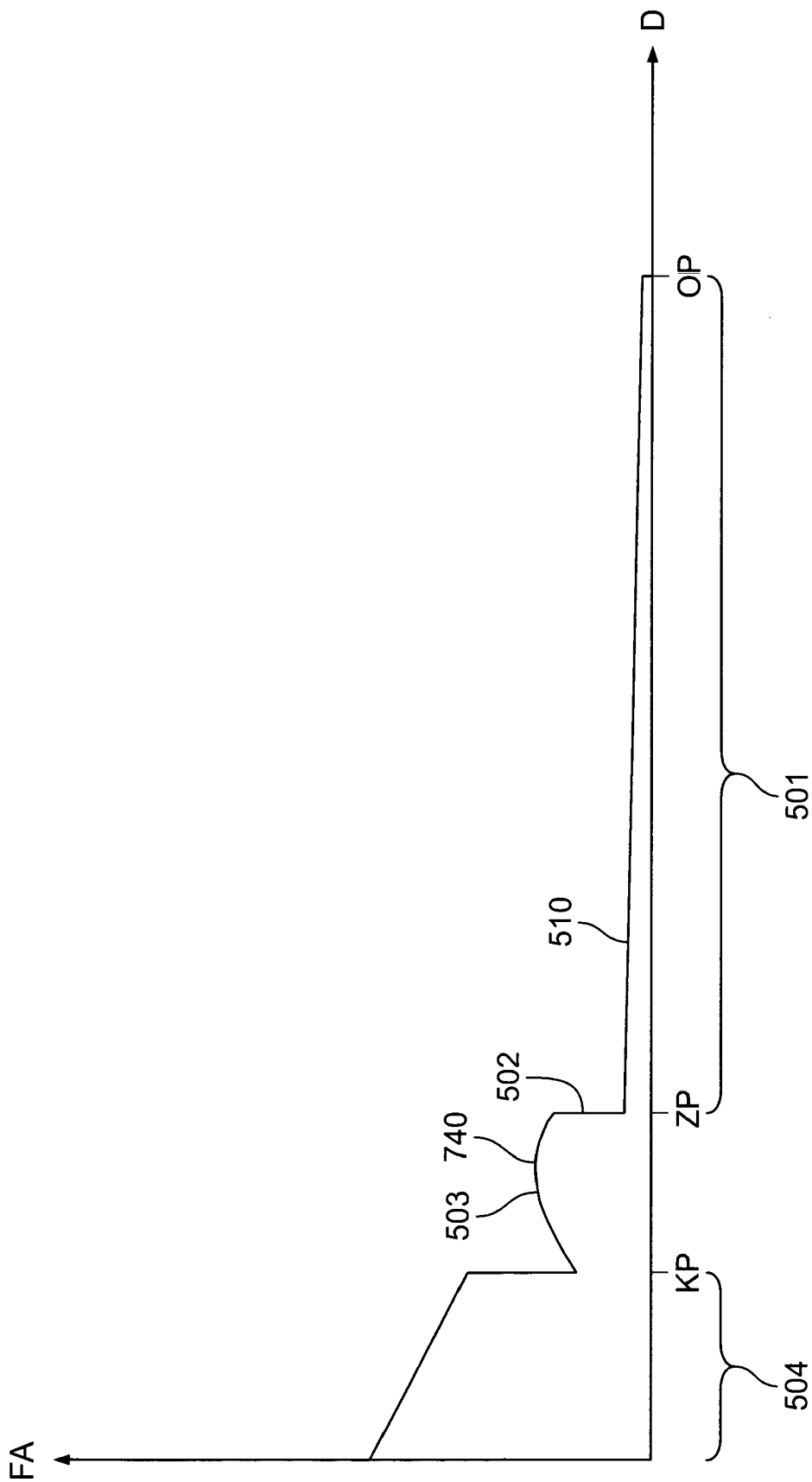


Fig. 20

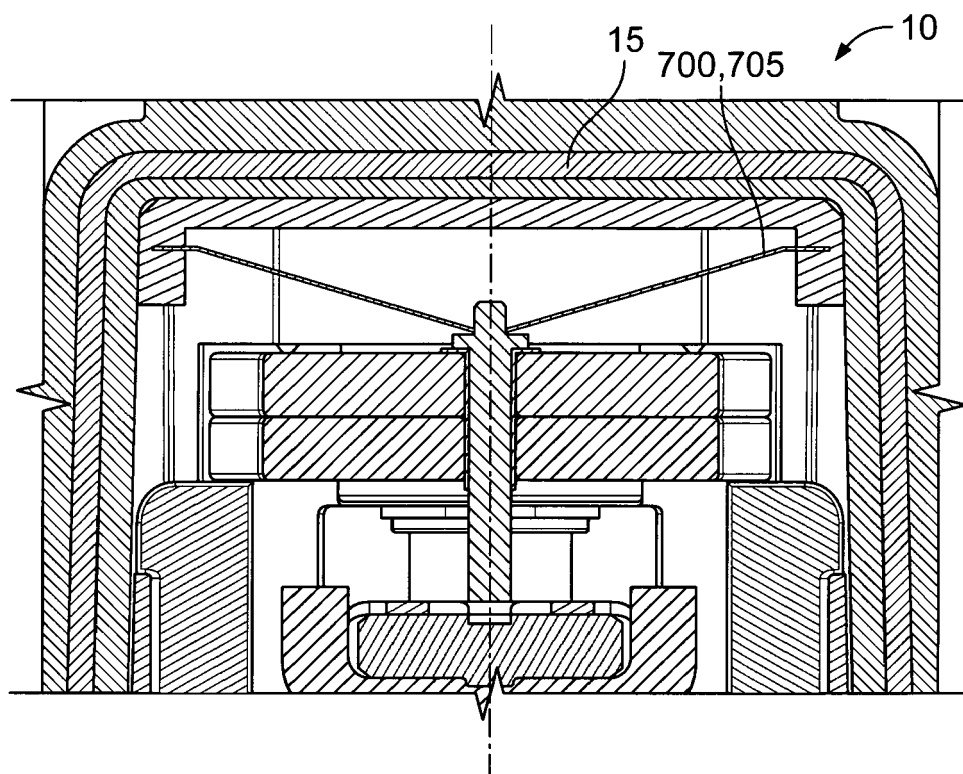


**Fig. 21**

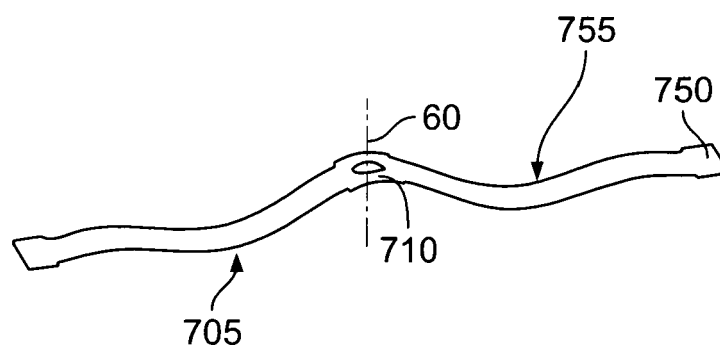


**Fig. 22**



## EUROPEAN SEARCH REPORT

Application Number

EP 23 39 8025

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category                                                                         | Citation of document with indication, where appropriate, of relevant passages                               | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------|-----------------------------------------|
| X                                                                                | KR 2013 0134169 A (LSIS CO LTD [KR])<br>10 December 2013 (2013-12-10)<br>* abstract; figure 1 *             | 1-3, 11           | INV.<br>H01H50/30                       |
| A                                                                                | -----<br>US 2017/053763 A1 (GUIGNOT ROMAIN [FR])<br>23 February 2017 (2017-02-23)<br>* abstract; figure 3 * | 4-10,<br>12-14    |                                         |
| A                                                                                | -----<br>US 2017/053763 A1 (GUIGNOT ROMAIN [FR])<br>23 February 2017 (2017-02-23)<br>* abstract; figure 3 * | 1, 11             |                                         |
| The present search report has been drawn up for all claims                       |                                                                                                             |                   | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                  |                                                                                                             |                   | H01H                                    |
| Place of search                                                                  |                                                                                                             |                   | Examiner                                |
| Munich                                                                           |                                                                                                             |                   | Simonini, Stefano                       |
| Date of completion of the search                                                 |                                                                                                             |                   |                                         |
| 9 April 2024                                                                     |                                                                                                             |                   |                                         |
| CATEGORY OF CITED DOCUMENTS                                                      |                                                                                                             |                   |                                         |
| X : particularly relevant if taken alone                                         |                                                                                                             |                   |                                         |
| Y : particularly relevant if combined with another document of the same category |                                                                                                             |                   |                                         |
| A : technological background                                                     |                                                                                                             |                   |                                         |
| O : non-written disclosure                                                       |                                                                                                             |                   |                                         |
| P : intermediate document                                                        |                                                                                                             |                   |                                         |
| T : theory or principle underlying the invention                                 |                                                                                                             |                   |                                         |
| E : earlier patent document, but published on, or after the filing date          |                                                                                                             |                   |                                         |
| D : document cited in the application                                            |                                                                                                             |                   |                                         |
| L : document cited for other reasons                                             |                                                                                                             |                   |                                         |
| & : member of the same patent family, corresponding document                     |                                                                                                             |                   |                                         |

EPO FORM 1503 03.82 (P04C01)

# **ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.**

EP 23 39 8025

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-04-2024

10

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| <b>KR 20130134169 A</b>                   | <b>10-12-2013</b>   | <b>NONE</b>                |                     |
| <hr/>                                     |                     |                            |                     |
| <b>US 2017053763 A1</b>                   | <b>23-02-2017</b>   | <b>CN 106463278 A</b>      | <b>22-02-2017</b>   |
|                                           |                     | <b>EP 3140842 A1</b>       | <b>15-03-2017</b>   |
|                                           |                     | <b>FR 3020715 A1</b>       | <b>06-11-2015</b>   |
|                                           |                     | <b>PL 3140842 T3</b>       | <b>08-02-2021</b>   |
|                                           |                     | <b>US 2017053763 A1</b>    | <b>23-02-2017</b>   |
|                                           |                     | <b>WO 2015170028 A1</b>    | <b>12-11-2015</b>   |
| <hr/>                                     |                     |                            |                     |

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**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**

- GB 2347270 A [0002]