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(54) **A MEDIUM VOLTAGE SWITCHING POLE**

(57) A Medium Voltage switching pole (1) comprises a vacuum interruption chamber (10) housing a fixed contact (2) and a movable contact (3) moving between an open position in which it is separated from the fixed contact (2) and a closed position in which it is electrically coupled to the fixed contact (2). In the closed position said movable contact (3) has a closed condition in which it is electrically coupled to the fixed contact (2) and a closed and pressed condition in which it is electrically coupled to the fixed contact (2) under a mechanical load forcing it against said fixed contact (2). The Medium Voltage switching pole (1) comprises a movable contact assembly (4) which is placed outside said vacuum interruption chamber (10) and which comprises:
- a pushrod (5) having a first end (51) which is operatively connected to an actuating drive (100) and a second end (52) which is operatively connected to said movable contact (3);
- a load counterbalancing assembly (6) comprising a supporting and guiding element (61) positioned fixed with respect to said vacuum interruption chamber (10) and an elastic load counterbalancing element (62) which is interposed between said supporting and guiding element (61) and a first coupling surface (31) on said movable contact (3);
- a pressing assembly (7) positioned at said second end (52) of said pushrod (5) and comprising an elastic pressing element (71) which is interposed between said pushrod (5) and a second coupling surface (32) on said movable contact (3).

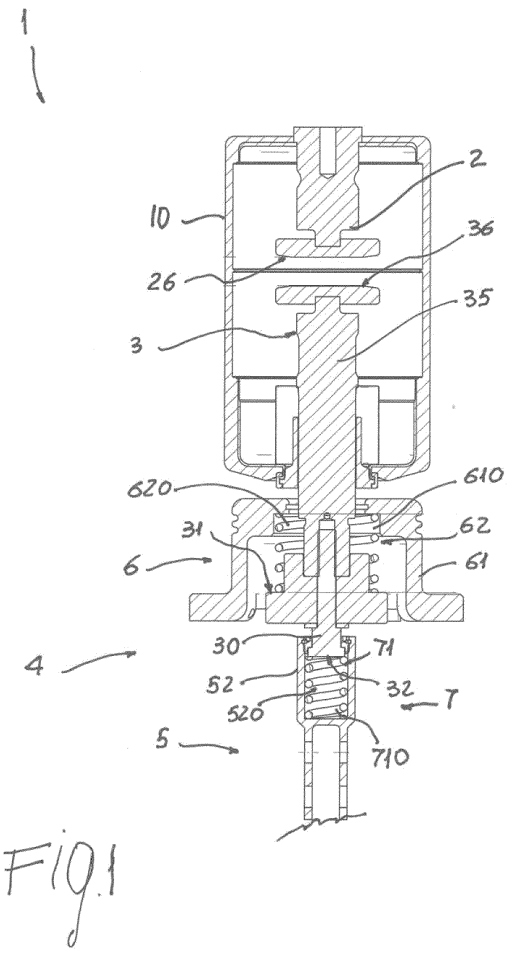

Fig.1

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Description

[0001] The present invention relates to a Medium Voltage switching pole and to a Medium Voltage switching unit comprising such pole. More in particular, the present invention relates to a Medium Voltage switching pole having a vacuum interruption chamber and provided with an improved assembly for the opening/closing manoeuvre thereof and to a Medium Voltage switching unit comprising a gas tight enclosure housing such pole.

[0002] For the purposes of the present invention, the term Medium Voltage is intended to designate electrical systems operating at voltage levels higher than 1 kV AC and 1.5 kV DC up to some tens of kV, e.g., up to 72 kV AC and 100 kV DC.

[0003] Medium Voltage switching poles based on vacuum interruption switching technology and Medium Voltage switching units comprising a gas tight enclosure housing the interruption units are well known in the field of medium-voltage electrical systems.

[0004] In particular, the traditional Medium Voltage load-break switches have their electric poles immersed in a sulphur hexafluoride (SF_6) atmosphere as this insulation gas ensures excellent performances in terms of dielectric insulation and arc-quenching capabilities when currents are interrupted. As is known, however, SF_6 is a very potent greenhouse gas, and its usage is subject to severe restrictions for environmental preservation purposes. For this reason, over the years, there has been made a considerable effort to design load-break switches not employing SF_6 as an insulation gas.

[0005] Most recent Medium Voltage load-break switches have electric poles housed in a gas tight enclosure and immersed in pressurized dry air or in an environment-friendly insulation gas, such as mixtures of oxygen, nitrogen, carbon dioxide and/or fluorinated gases.

[0006] Unfortunately, the experience has shown that these modern switching apparatuses still have some aspects to improve, especially in relation to the management of the high mechanical loads developing during the movement of the movable contact since the beginning of the opening/closing manoeuvre.

[0007] The contribution to these high mechanical loads is mainly based on the very high pressurized environment (5 bar absolute) acting on each vacuum interruption unit immediately since the beginning of the movement and in every position during the travelling stroke of the movable contact.

[0008] Both the presence of an overpressure inside the enclosure and the vacuum inside the interruption chamber(s) contribute to increase the load during the closing operation. Conversely, during the opening operation, the overpressure inside the enclosure and the vacuum inside the interruption chamber(s) contribute to a resistant load since the beginning of each operation when the masses are more difficult to be moved.

[0009] As a result, these high mechanical loads due to pressure effects have an impact on the operating speeds of the system. In practice, the system is too fast during the closing operation, thus reducing the mechanical product life, and too slow during the opening operation, thus contributing to an inefficient breaking capacity of the system.

[0010] In practice, the traditional mechanical actuators have difficult applicability due to energy lack at the beginning of operations since they are substantially designed to generate the highest torque at the end of the operation.

[0011] Substantially the same problems are faced when the actuator is of the electro-mechanical type, e.g., a servomotor. When only one electro-mechanical actuator is used, i.e., in a three-pole operated system, the same problem of energy lack at the beginning of operations has to be faced. It is therefore necessary to apply more than one electro-mechanical actuator, i.e., using a single-pole operated configuration, but this implies an overall cost increase, a more difficult coordination between the electro-mechanical actuators, and an increase of engaged space in a limited installation site.

[0012] The main aim of the present invention is to provide a Medium Voltage switching system which allows overcoming or mitigating the drawbacks of the known art.

[0013] Within this aim, a purpose of the present invention is to provide a Medium Voltage switching system which allows overcoming the problems deriving from overpressure conditions of the environment in which the system is installed.

[0014] A further purpose of the present invention is to provide a Medium Voltage switching system, which allows governing the opening/closing operation more efficiently than the conventional systems.

[0015] A further purpose of the present invention is to provide a Medium Voltage switching system, in which the problems of excessive loads at the final stage of the closing operation are mitigated or minimized.

[0016] A further purpose of the present invention is to provide a Medium Voltage switching system, in which the mechanical product life is increased compared to conventional systems.

[0017] A further purpose of the present invention is to provide a Medium Voltage switching system, in which the problems of low contact separation speed at the beginning of the opening operation are mitigated or minimized.

[0018] A further purpose of the present invention is to provide a Medium Voltage switching system, in which the breaking capacity of the system is improved compared to conventional systems.

[0019] A further purpose of the present invention is to provide a Medium Voltage switching system, which has a simple and compact structure with a relatively low number of internal components. A further purpose of the present invention is to provide a Medium Voltage switching system, which is relatively simple and cheap to be manufactured at industrial levels.

[0020] The above aim and purposes, as well as other purposes that will emerge clearly from the following

description and attached drawings, are provided, according to the invention, by a Medium Voltage switching pole, according to the following claim 1 and the related dependent claims.

[0021] In a further aspect, the present invention also relates to a Medium Voltage switching unit, e.g., a load-break switching system, comprising a Medium Voltage switching pole as described herein.

[0022] In a general definition, the Medium Voltage switching pole of the present invention comprises a vacuum interruption chamber housing a fixed contact and a movable contact moving between an open position in which it is separated from the fixed contact and a closed position in which it is electrically coupled to the fixed contact.

[0023] In the closed position said movable contact has a closed condition in which it is electrically coupled to the fixed contact and a closed and pressed condition in which it is electrically coupled to the fixed contact under a mechanical load forcing it against said fixed contact.

[0024] In other words, the Medium Voltage switching pole has two operating positions, open and closed. When it is in a closed position, the Medium Voltage switching pole can take two operating conditions, simply closed and closed and pressed.

[0025] The Medium Voltage switching pole of the present invention is characterized in that it comprises a movable contact assembly which is placed outside said vacuum interruption chamber and which comprises:

- a pushrod having a first end operatively connected to an actuating drive and a second end operatively connected to said movable contact;
- a load counterbalancing assembly comprising a supporting and guiding element positioned fixed with respect to said vacuum interruption chamber and an elastic load counterbalancing element interposed between said supporting and guiding element and a first coupling surface on said movable contact;
- a pressing assembly positioned at said second end of said pushing rod and comprising an elastic pressing element interposed between said pushing rod and a second coupling surface on said movable contact.

[0026] For the purposes of the present invention, the terms "first end" and "second end" are not meant to designate the physical limits of the rod but the operational points of the pushrod in which the designated functions are carried out.

[0027] In practice, and as better explained hereinafter, in the Medium Voltage switching pole of the invention, the load counterbalancing assembly provides an efficient system for controlling the loads and the speeds during the opening and closing operation of the movable contact, thereby improving both the mechanical life and the current breaking performances of the switching pole.

[0028] According to some embodiments, in the Medium Voltage switching pole of the invention, the elastic load counterbalancing element is in a discharged or preloaded condition when the movable contact is in said open position, and it is in a loaded condition when said movable contact is in said closed position and closed condition.

[0029] According to some embodiments, in the Medium Voltage switching pole of the invention, the elastic pressing element is in a discharged or preloaded condition when the movable contact is in said open position and in said closed position and closed condition, and it is in a loaded condition when said movable contact is in said closed position and closed and pressed condition.

[0030] According to other embodiments of the invention, in the Medium Voltage switching pole the elastic load counterbalancing element and the elastic element are springs, e.g., coil springs, cup springs, or similar springs. Advantageously, the elastic constant k_p of the elastic pressing element normally greater than the elastic constant k_c of the elastic load counterbalancing element.

[0031] According to some embodiments of the Medium Voltage switching pole of the invention, the movable contact preferably comprises an elongated body extending along the travel direction of said movable contact between said open/closed positions. Typically, the elongated body is provided at one end with a first contact surface which is adapted for electrically coupling with a second contact surface on said fixed contact, and is provided at an opposite end with said first coupling surface.

[0032] For the purposes of the present invention, the terms "one end" and "opposite end" are not meant to designate the physical limits of the elongated body of the movable contact but the operational points of the elongated body in which the designated functions are carried out.

[0033] In such an arrangement, said elastic load counterbalancing element is conveniently positioned so as to rests on said first coupling surface.

[0034] More in particular, according to the above embodiment of the Medium Voltage switching pole of the invention, the first coupling surface extends transversally with respect to the travel direction of said movable contact between said open/closed positions, i.e., substantially perpendicular to the extension direction of the elongated body of the movable contact.

[0035] In such an arrangement, said elastic load counterbalancing element is preferably a first coil spring, e.g., a coil spring or a cup spring, which is coaxially mounted around at least a portion of said elongated body, a first end of said first coil spring resting on said first coupling surface and a second end of said first coil spring being housed in a seat formed on the supporting and guiding element.

[0036] For the purposes of the present invention, the terms "first end" and "second end" are not meant to designate the physical limits of the first spring but the operational points of the first spring in which the desig-

nated functions are carried out.

[0037] According to some embodiments of the invention, during operation, said first spring is advantageously compressed during the movement of said movable contact from said open position to said closed position and closed condition, and it is released during the opposite movement of said movable contact from said closed position and closed condition to said open position.

[0038] According to some embodiments of the invention, in the Medium Voltage switching pole said elastic pressing element is preferably a second spring, e.g., a coil spring or a cup spring, which is housed in a cavity provided in the second end of said pushrod.

[0039] In such an arrangement, said movable contact is provided with a T-shaped protrusion extending from said movable contact and forming said second coupling surface transversally extending with respect to the travel direction of said movable contact between said open/-closed positions, i.e., substantially perpendicular to the travel direction of the movable contact between the open and closed positions.

[0040] Advantageously, the T-shaped protrusion is slidingly inserted into the cavity provided in the second end of said pushrod, and the second coil spring has one end resting on said second coupling surface and a second end resting on a bottom portion of said cavity.

[0041] For the purposes of the present invention, the terms "first end" and "second end" are not meant to designate the physical limits of the second spring but the operational points of the second spring in which the designated functions are carried out.

[0042] According to some embodiments of the invention, during operation, said pushrod moves together with said movable contact during a first phase of the closing manoeuvre in which the movable contact moves from its open position to its closed position and closed condition (free stroke), and slides along said T-shaped protrusion during a second phase of the closing manoeuvre in which said second coil spring is compressed and said movable contact is brought in said closed and pressed condition (pressing stroke).

[0043] According to some embodiments of the invention, during operation, said pushrod slides along said T-shaped protrusion during a first phase of the opening manoeuvre in which said second coil spring is released bringing said movable contact from said closed and pressed condition to said closed condition (inverse pressing stroke). Then, during a second phase of the opening manoeuvre, said pushrod moves together with the movable contact moving it from the closed position to the open position (free stroke).

[0044] A Medium Voltage switching unit comprising a Medium Voltage switching pole as described herein is also part of the present invention.

[0045] In particular, according to some embodiments of the invention, the Medium Voltage switching unit comprises a gas tight enclosure housing, for each phase, one or more switching poles as described herein. Typically, an environment-friendly insulation gas, such as mixtures of oxygen, nitrogen, carbon dioxide and/or fluorinated gases, is contained in the enclosure under overpressure conditions, e.g., up to 5 bar.

[0046] Further features and advantages of the present invention will be more apparent from the description of preferred but not exclusive embodiments of the present invention, shown by way of examples in the accompanying drawings, wherein:

- Figure 1 is section view of a Medium Voltage switching pole, according to the present invention, in the open position;
- Figure 2 is section view of a Medium Voltage switching pole, according to the present invention, in the closed position and in the closed condition;
- Figure 3 is section view of a Medium Voltage switching pole, according to the present invention, in the closed position and in the closed and pressed condition;
- Figure 4 is a schematic view of a first embodiment of a Medium Voltage switching unit comprising a Medium Voltage switching pole, according to the present invention;
- Figure 5 is a schematic view of a second embodiment of a Medium Voltage switching unit comprising a Medium Voltage switching pole, according to the present invention;
- Figure 6 is a Load vs. Stroke graph showing the behavior of a Medium Voltage switching pole, according to the present invention compared with a Medium Voltage switching pole of conventional type.

[0047] With reference to the figures, the present invention in its more general definition, relates to a Medium Voltage switching pole 1.

[0048] The Medium Voltage switching pole 1 comprises a vacuum interruption chamber 10 housing a fixed contact 2 and a movable contact 3 which moves between an open position in which it is separated from the fixed contact 2 and a closed position in which it is electrically coupled to the fixed contact 2.

[0049] Vacuum interruption chambers and the related contact systems are well known in the art and will not be described with further details.

[0050] In the closed position, the movable contact 3 has a closed condition in which it is electrically coupled to the fixed contact 2 and a closed and pressed condition in which it is electrically coupled to the fixed contact 2 under a mechanical load forcing it against said fixed contact 2. With reference to the attached Figures, the open position of the movable contact 3 is represented in Figure 1, the closed position and closed condition of the movable contact 3 is represented in Figure 2, and the closed position and closed and pressed condition of the movable contact 3 is represented in Figure 3.

[0051] The Medium Voltage switching pole 1 generally comprises a movable contact assembly 4 which is placed

outside said vacuum interruption chamber 10 and which comprises a pushrod 5 having a first end 51 which is operatively connected to an actuating drive 100 and a second end 52 which is operatively connected to said movable contact 3.

[0052] The actuating drive 100 can be any according to the state of the art. For instance, actuating drive of the mechanical type can be used, as well as electro-mechanical actuators, e.g., based on servomotors, or hydraulic actuators, or any similar actuating device.

[0053] The movable contact assembly 4 further comprises a load counterbalancing assembly 6 comprising a supporting and guiding element 61 which is positioned fixed with respect to said vacuum interruption chamber 10. The movable contact assembly 4 also comprises an elastic load counterbalancing element 62 which is interposed between said supporting and guiding element 61 and a first coupling surface 31 formed on said movable contact 3.

[0054] Moreover, the movable contact assembly 4 also comprises a pressing assembly 7 which is positioned at said second end 52 of said pushrod 5 and which comprises an elastic pressing element 71 that is interposed between said pushrod 5 and a second coupling surface 32 on said movable contact 3.

[0055] In this way, the elastic load counterbalancing element 62 provides a resistance force to the movement of the actuating pushrod 5 and of the movable contact 3 during the movement from the open position to the closed position (and closed condition) and provides an active contribution at the contacts separation instant, by acting as a counterforce with respect to the external pressure, thereby helping the opening operation.

[0056] Moreover, once the movable contact 3 is in the closed position (and closed condition), the movement of the actuating pushrod 5 is decoupled from the movable contact 3 which is stationary positioned against the fixed contact 2. The actuating pushrod 5 continues its movement so that the elastic pressing element 71 is loaded and provides the necessary pressing force on the contacts 2,3 when the contacts 2,3 are closed, determining the passage from the closed condition to the closed and pressed condition of the contacts system.

[0057] According to a principle of functioning that will be better described hereinafter, said elastic load counterbalancing element 62 is in a discharged or preloaded condition when the movable contact 3 is in said open position, and it is in a loaded condition, preferably a fully loaded condition, when said movable contact 3 is in the closed position and closed condition.

[0058] Thus, with reference to the attached Figures, in the position of Figure 1 the elastic load counterbalancing element 62 is in a discharged or preloaded condition, and preferably in a preloaded condition, while in the position of Figure 2 it is in a loaded condition, preferably a fully loaded condition, thereby storing energy, as better explained hereinafter.

[0059] From an operational standpoint, the elastic pressing element 71 is in a discharged or preloaded condition when the movable contact 3 is in said open position and in said closed position and closed condition, and it is in a loaded condition, preferably a fully loaded condition, when the movable contact 3 is in said closed position and closed and pressed condition.

[0060] In practice, with reference to the attached Figures, in the position of Figure 1 and 2 the elastic pressing element 71 is in a discharged or preloaded condition, while in the position of Figure 3 it is in a loaded condition, preferably a fully loaded condition, thereby providing the required necessary pressing force on the contacts 2,3.

[0061] In the embodiments of the Medium Voltage switching pole 1 shown in the attached figures, the elastic load counterbalancing element 62 is a spring 620, e.g., a coil spring or a cup spring. The elastic pressing element 71 is also a spring 710, e.g., a coil spring or a cup spring.

[0062] In general, the elastic constant k_p of the elastic pressing element 71 is preferably greater than the elastic constant k_c of the elastic load counterbalancing element 62, so that the former is charged only when the latter is loaded or fully loaded.

[0063] In practice, with reference to the attached figures, during the movement of the pushrod 5 from the position of Figure 1 to the position of Figure 2, the spring 620 is progressively loaded to a substantially full loaded condition represented in Figure 2. Then, during the movement of the pushrod 5 from the position of Figure 2 to the position of Figure 3, the spring 710 is progressively loaded to a substantially full loaded condition represented in Figure 2. According to a preferred embodiment of the Medium Voltage switching pole 1 represented in the attached Figures, the movable contact 3 advantageously comprises an elongated body 35 which extends along the travel direction of the movable contact 3 between said open/closed positions. For instance, with reference to the attached Figures, the elongated body 35 may be a substantially cylindrical body having its longitudinal axis which extends along the vertical direction of movement of the movable contact 3 from the open position of Figure 1 to the closed position of Figures 2 and 3, and vice versa.

[0064] As shown in the attached Figures, the elongated body 35 is conveniently provided at one end with a first contact surface 36 which is adapted for electrically coupling with a second contact surface 26 which is positioned on the fixed contact 2.

[0065] The first coupling surface 31 is conveniently positioned at an opposite end of the elongated body 35 with respect to the first contact surface 36 and the elastic load counterbalancing element 62 is operatively coupled with said first coupling surface 31.

[0066] In particular, in the embodiments of the Medium Voltage switching pole 1 shown in the attached figures, the first coupling surface 31 extends transversally with respect to the travel direction of the movable contact 3 between the open/closed positions.

[0067] In practice, according to an embodiment, the

first coupling surface 31 is conveniently positioned substantially perpendicular to the extension direction of the elongated body 35 of the movable contact 3.

[0068] The elastic load counterbalancing element 62 can be, for instance, a first spring 620 which is coaxially mounted around at least a portion of the elongated body 35, in particular around a bottom portion of the movable contact 3 protruding outside the vacuum interruption chamber 10.

[0069] A first operative end of the first spring 620 is operatively coupled with said first coupling surface 31 while a second operative end of the first spring 620 is housed in a seat 610 which is formed on the supporting and guiding element 61.

[0070] In practice, according to this embodiment, the first spring 620, e.g., a coil spring, is mounted on a terminal portion of the movable contact 3 opposite to the contact surface 36. An extreme of the first spring 620 rests on the first coupling surface 31, while the other extreme is inserted in the seat 610 on the supporting and guiding element 61.

[0071] The supporting and guiding element 61 can be a supporting flange forming a cavity having a U-shaped section, as shown in the attached Figures, into which the bottom portion of the movable contact 3 is housed together with the elastic load counterbalancing element 62. Other arrangements are however possible. For instance, the elastic load counterbalancing element 62 can be at least partially positioned inside the vacuum interruption chamber 10, the shape of the supporting and guiding element 61 can be different, provided that it carries out the supporting and guiding function of the movable contact 3.

[0072] During operation of the Medium Voltage switching pole 1, the first spring 620 is compressed during the movement of the movable contact from 3 the open position of Figure 1 to the closed position and closed condition of Figure 2, providing a resistance force to the movement of the actuating pushrod 5 and of the movable contact 3 during the closing operation, thereby making smoother the closing operation, and storing energy in its compressed condition to be used in the opening operation.

[0073] Then, the first spring 620 is released during the opposite movement of said movable contact 3 from the closed position and closed condition of Figure 2 to the open position of Figure 1 and provides an active contribution to the opening operation, by increasing the speed of the movable contact 3 at the contacts separation instant and by counterbalancing the external pressure effects.

[0074] Thus, in general, the elastic load counterbalancing element 62 acts only during the free-stroke of the pushrod 5 (i.e., during the passage from the open position to the closed positions and closed condition of the contacts 2,3), as a force-resistant element during the closing operation and as a force-active element during the opening operation.

[0075] The elastic pressing element 71 can be, for instance, a second spring 710 which is housed in a cavity 520 provided in the second end 52 of said pushrod 5. The movable contact 3 can be conveniently provided with a T-shaped protrusion 30 which extends from the movable contact 3, in particular in an opposite direction with respect to the fixed contact 2.

[0076] The T-shaped protrusion 30 forms the second coupling surface 32 which transversally extends with respect to the travel direction of said movable contact 3 between said open/closed positions. Moreover, the T-shaped protrusion 30 is slidingly inserted into the cavity 520 provided in the second end 52 of the pushrod 5, so as to allow free movement of the pushrod 5 with respect to the moving contact 3.

[0077] A first operative end of second spring 710 is operatively coupled with said second coupling surface 32 and a second end of second spring 710 is operatively coupled with a bottom portion of said cavity 520.

[0078] In practice, according to this embodiment, the second spring 710, e.g., a cup spring or a coil spring, has a first operative end which rests the second coupling surface 32 formed on the T-shaped protrusion 30 slidingly inserted into the cavity 520 and a second operative end which rests on the bottom of the cavity 520.

[0079] With reference to the attached Figures, under operative conditions of Medium Voltage switching pole 1, the pushrod 5 moves together with the movable contact 3 during a first phase of the closing manoeuvre in which the movable contact 3 moves from its open position to its closed position and closed condition, i.e., from the position of Figure 1 to the position of Figure 2 (free-stroke of the pushrod 5).

[0080] Then, during a second phase of the closing manoeuvre, i.e., from the position of Figure 2 to the position of Figure 3 (pressing stroke of the pushrod 5), the movement of the pushrod 5 is decoupled from the movable contact 3, the pushrod 5 slides around the T-shaped protrusion 30, said second spring 710 is compressed, and said movable contact 3 is brought in the closed and pressed condition.

[0081] Similarly, in the opening operation of the Medium Voltage switching pole 1, during a first phase of the opening manoeuvre the pushrod 5 slides around said T-shaped protrusion 30 and the second spring 710 is released bringing the movable contact 3 from the closed and pressed condition to closed condition, i.e., from the position of Figure 3 to the position of Figure 2 (pressing stroke of the pushrod 5).

[0082] Then, during a second phase of the opening manoeuvre, i.e., from the position of Figure 2 to the position of Figure 1 (free-stroke of the pushrod 5), said pushrod 5 moves together with the movable contact 3 moving it from the closed position to the open position.

[0083] Thus, in general, the elastic pressing element 71 acts only during the pressing stroke of the pushrod 5 (i.e., during the passage from the closed positions and closed condition to the closed positions and closed pressed condition of the contacts 2,3), and provides

the required contact pressure on the contact system.

[0084] As shown in the attach graph of Figure 6, the elastic load counterbalancing element 62 has a beneficial effect in both the opening and closing operation of the Medium Voltage switching pole 1.

[0085] In the graph, the section 400 of the stroke represents the load vs. stroke behaviour of the system during the free-stroke of the pushrod 5, while the section 300 represents the load vs. stroke behaviour of the system during the pressing stroke of the pushrod 5. The solid line is the behaviour of a conventional system, i.e., without the elastic load counterbalancing element 62, while the dashed line is the behaviour of a Medium Voltage switching pole 1 according to the invention.

[0086] The initial points of the curves on the left-hand side correspond the open position of the Medium Voltage switching pole 1, while the terminal points of the curves on the right-hand side correspond the closed position and closed and pressed condition of the Medium Voltage switching pole 1. The 0 correspond to the closed position and closed condition of the Medium Voltage switching pole 1, i.e., the point of the stroke of the pushrod 5 at which the movable contact 3 comes into contact with the fixed contact 2 during the closing operation and starts detaching from it during the opening operation.

[0087] Thus, the graph, shows the load variations during the closing operations when read form the left to the right, and the load variations during the opening operations when read form the right to the left.

[0088] As shown by the comparison between the dashed line (invention system) and the solid line (conventional system), in the closing operations (from left to right) the elastic load counterbalancing element 62 provides a resistant load which is relatively low at the beginning of the closing operation. Moving forward, the elastic load counterbalancing element 62 becomes more and more compressed providing a gradually higher resistant load (as indicated by the different slope of the dashed line in the invention system with respect to the solid line of the invention) until conclusion of the free-stroke of the pushrod at point 0, when the closed position and closed condition of the contacts is reached and the elastic load counterbalancing element 62 is substantially fully charged.

[0089] This situation corresponds to the passage from the position of Figure 1 to the position of Figure 2 of the Medium Voltage switching pole 1.

[0090] At point 0 the movable contact 2 stops moving while the pushrod 5 continues its movement charging the elastic pressing system 71 as shown in the section 300 of the graph. In this section the lines of the invention system and of the conventional system overlaps, since only the elastic pressing system 71 are charged while the elastic load counterbalancing element 62 does not act and remains in its substantially fully charged condition.

[0091] This situation corresponds to the passage from the position of Figure 2 to the position of Figure 3 of the Medium Voltage switching pole 1.

[0092] As clearly shown in the graph, there is an abrupt increase of the load at the 0 point but this increase is substantially reduced with the system of the invention, thereby reducing the mechanical stresses and enhancing the mechanical product life of the system.

[0093] In the opening operations (from right to left) the elastic load counterbalancing element 62 does not act during the initial phase of contact pressure release in the section 300 and remains charged and contacts 2,3 remain electrically coupled with each other. Only the elastic pressing system 71 are gradually released during the opening movement of the pushrod 5.

[0094] This situation corresponds to the passage from the position of Figure 3 to the position of Figure 2 of the Medium Voltage switching pole 1.

[0095] At point 0 the elastic load counterbalancing element 62 starts its release movement helping the opening operation. Its contribution at the beginning is high because it is fully loaded and at the end it becomes it is low because it is discharged or fully discharged. This is clearly indicated by the different slopes of the dashed line (invention) with respect to the solid line (conventional), the former being steeper than the latter. Due to the higher contact separation speeds with respect to the conventional system, in the presently claimed switching pole 1 the current breaking performances are greatly improved.

[0096] Thus, in this operation, the elastic load counterbalancing element 62 applies a counterbalancing force with respect to the pressure force (difference in pressure between the vacuum chamber 10 and the over-pressurized environment outside of it).

[0097] In a further aspect the present invention also relates to a Medium Voltage switching unit 200 which comprises a Medium Voltage switching pole 1 as described herein, schematically represented in the attached Figure 5 and 6.

[0098] In particular, the Medium Voltage switching unit 200 according to the present invention comprises a gas tight enclosure 250 which houses, for each phase, a switching pole 1 having one or more switching chambers 10 as described and claimed in the present disclosure.

[0099] In the attached Figures, only the relevant components are represented, and the other details not shown, for instance the various electrical connections or auxiliary devices, can be any according to the state of the art.

[0100] In the embodiment of Figure 4, a Medium Voltage switching unit 200 having one switching chamber 10 for each phase is shown, while in the embodiment shown in Figure 5, a Medium Voltage switching unit 200 having two series-connected switching chambers 10 for each phase is represented.

[0101] In the embodiments shown a Figures 4 and 5, a three-pole operated system with a single driving actuator 100 positioned outside the gas tight enclosure 250 is represented. However, a Medium Voltage switching unit 200 in which each phase is operated by its own driving actuator 100 is part of the present invention.

[0102] Also, the driving actuator 100 can be of any type according to the needs and can be positioned inside or outside the gas tight enclosure 250 depending on its features, the available space and the design needs.

[0103] The Medium Voltage switching pole 1 and the Medium Voltage switching unit 200, according to the invention, provides relevant advantages with respect to corresponding known systems of the state of the art.

[0104] Indeed, the arrangement of a movable contact assembly 4 in the Medium Voltage switching pole 1, as described above, allows remarkably reducing or preventing the problems of the known switching poles and units.

[0105] In particular, the arrangement of an elastic load counterbalancing element 62 as previously described, allows overcoming the problems deriving from the unbalanced pressure conditions between the vacuum chambers 10 and the overpressure environment in the gas tight enclosure 250.

[0106] As shown by experimental evidence, the load counterbalancing assembly 6, and in particular the elastic load counterbalancing element 62, provides an efficient system for controlling the loads and the speeds during the opening and closing operation of the movable contact 3. Both the mechanical life and the current breaking performances of the switching pole 1 are considerably improved in the switching pole 1 of the present invention.

[0107] The arrangement of Medium Voltage switching pole 1 of the present invention is relatively easy to carry out at industrial level and it does not have a substantial impact on the structural complexity and size of the electric poles.

[0108] The Medium Voltage switching pole 1 and the Medium Voltage switching unit 200, according to the invention, can thus be realized with a relatively simple and compact structure.

[0109] The switching pole and unit, according to the invention, are thus relatively easy to manufacture at industrial level and at competitive industrial costs compared to the available solutions of the state of the art.

Claims

1. A Medium Voltage switching pole (1) comprising a vacuum interruption chamber (10) housing a fixed contact (2) and a movable contact (3) moving between an open position in which it is separated from the fixed contact (2) and a closed position in which it is electrically coupled to the fixed contact (2), wherein in said closed position said movable contact (3) has a closed condition in which it is electrically coupled to the fixed contact (2) and a closed and pressed condition in which it is electrically coupled to the fixed contact (2) under a mechanical load forcing it against said fixed contact (2), **characterized in that** it comprises a movable contact assembly (4) placed outside said vacuum interruption chamber (10) and comprising:

- a pushrod (5) having a first end (51) which is operatively connected to an actuating drive (100) and a second end (52) which is operatively connected to said movable contact (3);
- a load counterbalancing assembly (6) comprising a supporting and guiding element (61) positioned fixed with respect to said vacuum interruption chamber (10) and an elastic load counterbalancing element (62) which is interposed between said supporting and guiding element (61) and a first coupling surface (31) on said movable contact (3);
- a pressing assembly (7) positioned at said second end (52) of said pushrod (5) and comprising an elastic pressing element (71) which is interposed between said pushrod (5) and a second coupling surface (32) on said movable contact (3).

2. The Medium Voltage switching pole (1), according to claim 1, wherein said elastic load counterbalancing element (62) is in a discharged or preloaded condition when the movable contact (3) is in said open position, and it is in a loaded condition when said movable contact (3) is in said closed position and closed condition.

3. The Medium Voltage switching pole (1), according to claim 1 or 2, wherein said elastic pressing element (71) is in a discharged or preloaded condition when the movable contact (3) is in said open position and in said closed position and closed condition, and it is in a loaded condition when said movable contact (3) is in said closed position and closed and pressed condition.

4. The Medium Voltage switching pole (1), according to one or more of the previous claims, wherein said elastic load counterbalancing element (62) and said elastic pressing element (71) are springs (620; 710), the elastic constant k_p of the elastic pressing element (71; 710) being greater than the elastic constant k_c of the elastic load counterbalancing element (62; 620).

5. The Medium Voltage switching pole (1), according to one or more of the previous claims, wherein said movable contact (3) comprises an elongated body (35) extending along the travel direction of said movable contact (3) between said open/closed positions, said elongated body (35) being provided at one end with a first contact surface (36) adapted for electrically coupling with a second contact surface (26) on said fixed contact (2), and being provided at an opposite end with said first coupling surface (31), and wherein said elastic load counterbalancing element (62) is operatively coupled with said first cou-

pling surface (31).

6. The Medium Voltage switching pole (1), according to claim 5, wherein said first coupling surface (31) extends transversally with respect to the travel direction of said movable contact (3) between said open/-closed positions, and wherein said elastic load counterbalancing element (62) is a first spring (620) coaxially mounted around at least a portion of said elongated body (35), a first end of said first spring (620) being operatively coupled with said first coupling surface (31) and a second end of said first spring (620) being housed in a seat (610) formed on said supporting and guiding element (61).

7. The Medium Voltage switching pole (1), according to claim 6, wherein said first spring (620) is compressed during the movement of said movable contact from (3) said open position to said closed position and closed condition, and it is released during the opposite movement of said movable contact (3) from said closed position and closed condition to said open position.

8. The Medium Voltage switching pole (1), according to one or more of the previous claims, wherein said elastic pressing element (71) is a second spring (710) housed in a cavity (520) provided in the second end (52) of said pushrod (5), and wherein said movable contact (3) is provided with a T-shaped protrusion (30) extending from said movable contact (3) and forming said second coupling surface (32) transversally extending with respect to the travel direction of said movable contact (3) between said open/-closed positions, the T-shaped protrusion (30) being slidingly inserted into said cavity (520), and wherein said second spring (710) has one end resting on said second coupling surface (32) and a second end resting on a bottom portion of said cavity (520).

9. The Medium Voltage switching pole (1), according to claim 8, wherein said pushrod (5) moves together with said movable contact (3) during a first phase of the closing manoeuvre in which the movable contact (3) moves from its open position to its closed position and closed condition, and slides along said T-shaped protrusion (30) during a second phase of the closing manoeuvre in which said second spring (710) is compressed and said movable contact (3) is brought in said closed and pressed condition.

10. The Medium Voltage switching pole (1), according to claim 9, wherein during a first phase of the opening manoeuvre said pushrod (5) slides along said T-shaped protrusion (30) and said second spring (710) is released bringing said movable contact (3) from said closed and pressed condition to said closed condition, and during a second phase of the opening manoeuvre said pushrod (5) moves together with the movable contact (3) moving it from the closed position to the open position.

11. A Medium Voltage switching unit (200) comprising a Medium Voltage switching pole (1) according to one or more of the previous claims.

12. The Medium Voltage switching unit (200) according to claim 11 comprising a gas tight enclosure (250) housing, for each phase, one or more switching poles (1) according to one or more of claims 1-10.

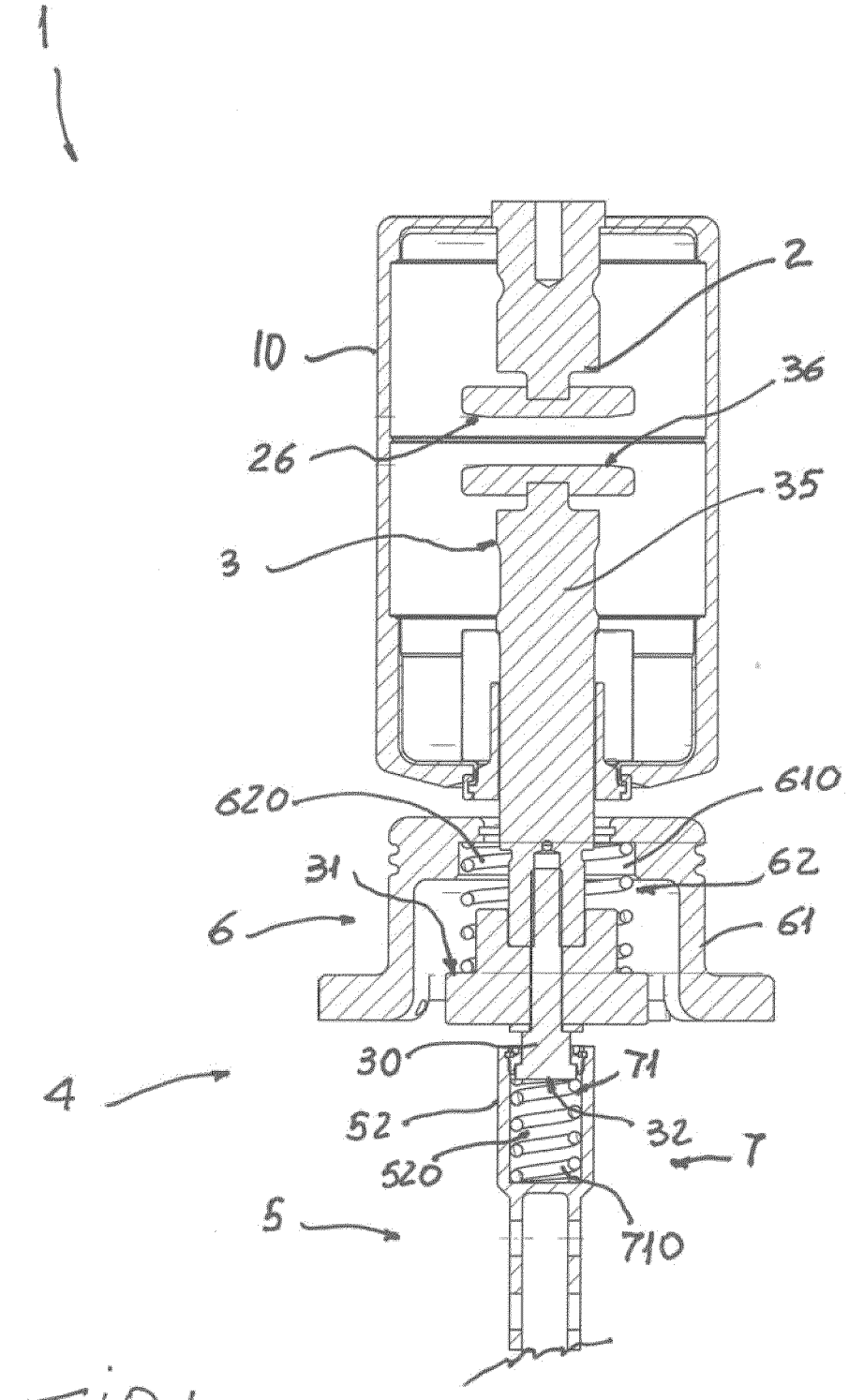

Fig.1

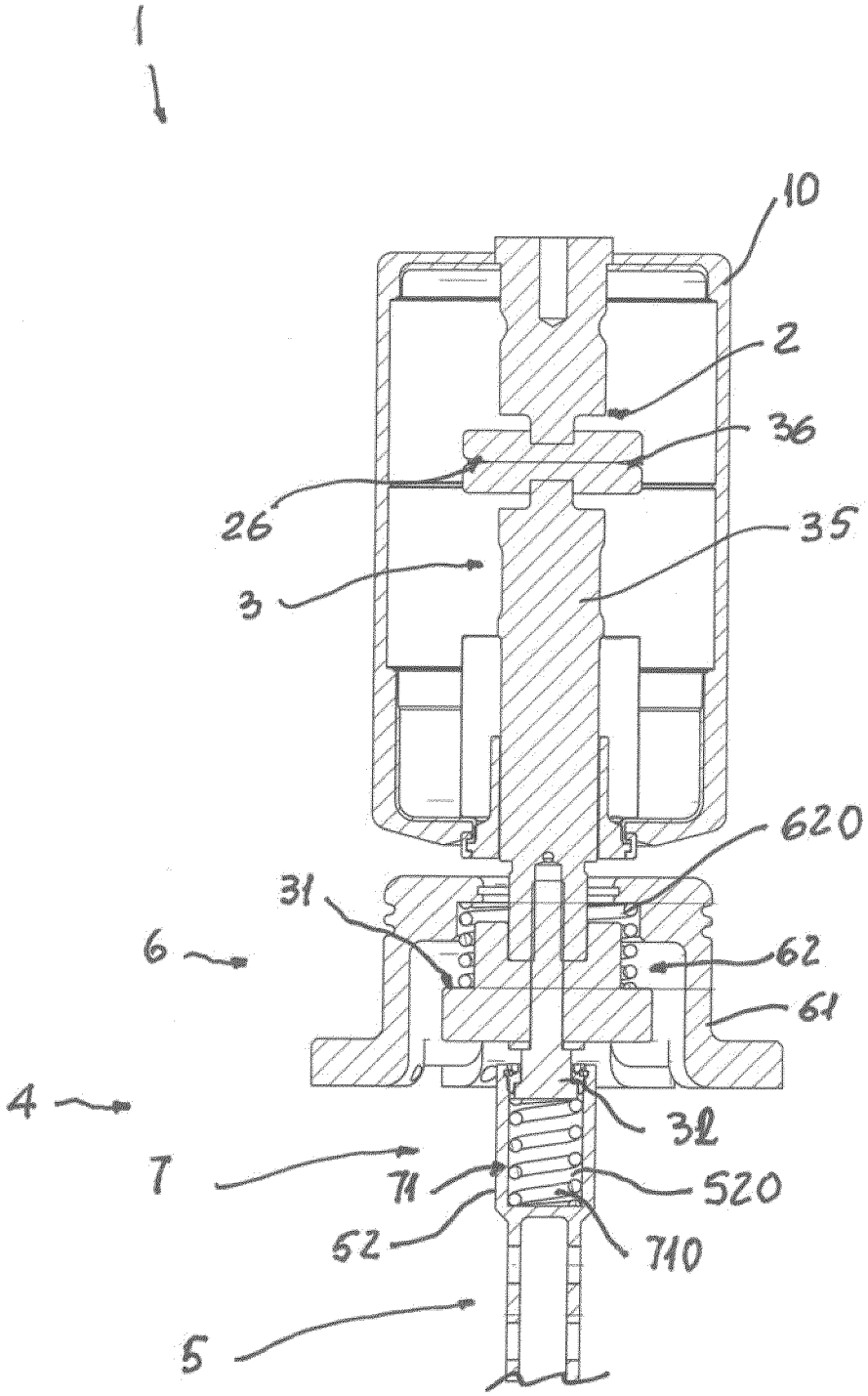

Fig.2

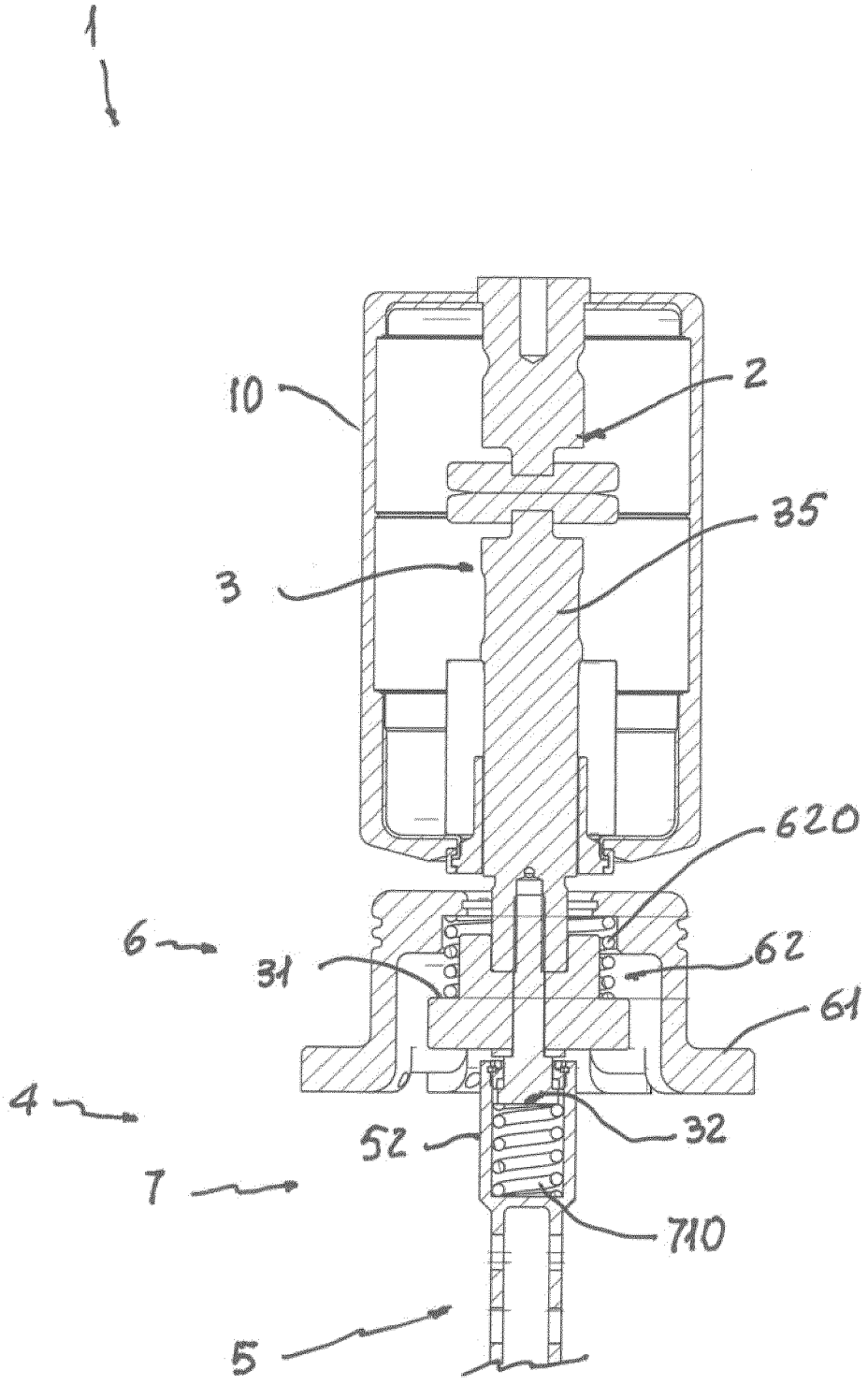

Fig.3

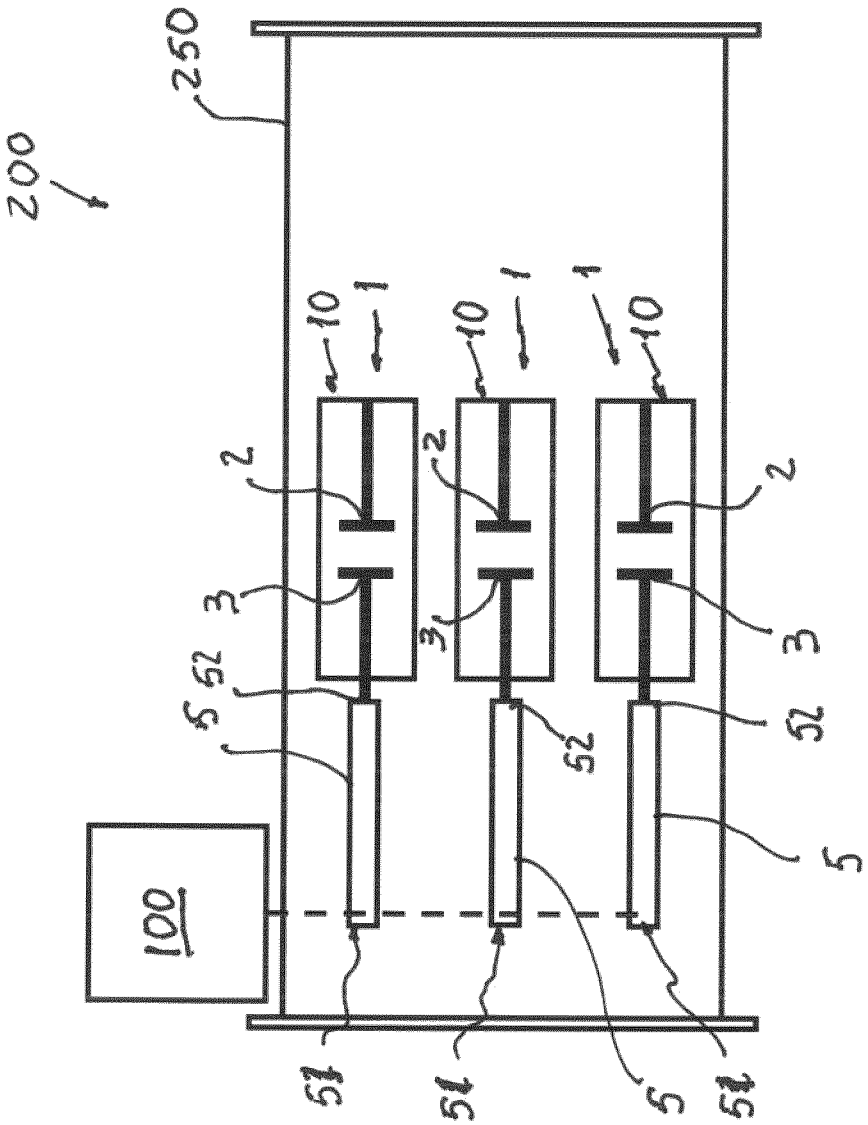

Fig. 4

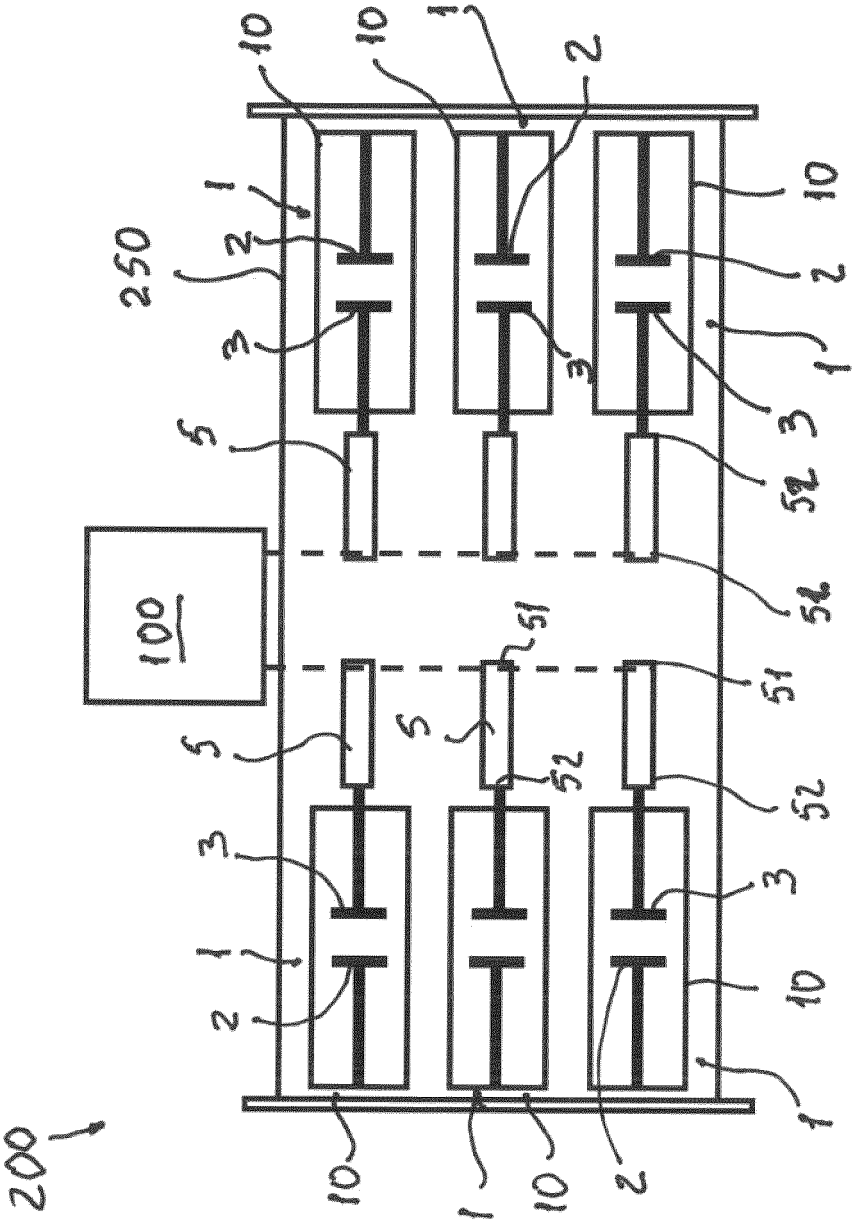

Fig. 5

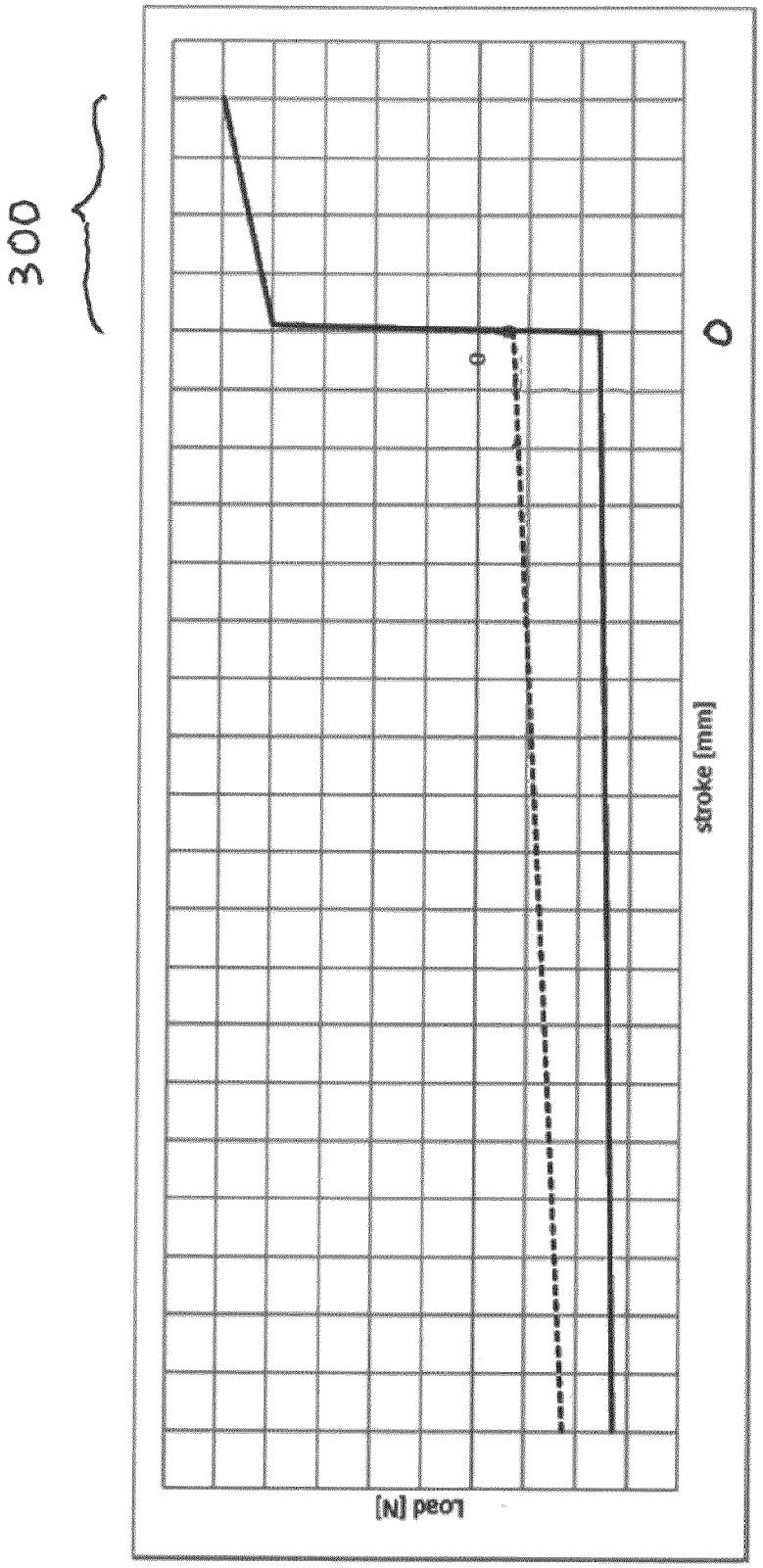

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 9111

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2021 124271 A1 (SCHNEIDER ELECTRIC IND SAS [FR]) 23 March 2023 (2023-03-23) * Same technical problem; paragraph [0003] - paragraph [0007]; figures 1-3 * * paragraph [0016] - paragraph [0022] *	1-12 8-12	INV. H01H1/50 H01H33/666
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 December 2023	Ernst, Uwe

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