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(54) **SWITCH ASSEMBLY, CONTACTOR DEVICE AND TRANSPORTATION VEHICLE**

(57) The present invention relates to a switch assembly (10, 10', 10'', 10''', 10''') for switching medium to high voltage contactor devices in transportation vehicles, comprising:
at least two first fixed electric contacts (2, 3) distanced from each other,
at least one moving contact (6) configured to be movable between a first position to contact both of the at least two fixed electric contacts (2, 3) for electrically connecting the at least two first fixed electric contacts (2, 3) and a second position away from at least one of the at least two fixed electric contacts (2, 3) for disconnecting the at

least two first fixed electric contacts (2, 3), and
at least one actuator (9, 9', 9'') facing the at least one moving contact (6) and configured to be movable toward and away from the at least one moving contact (6), wherein at least one first magnetic member (8, 8', 8'') is comprised by or affixed to the at least one actuator (9, 9', 9'') and/or the moving contact (6) configured to provide a magnetic force to move the moving contact (6) in the first position depending on a distance (D) between the at least moving contact (6) and the at least one actuator (9, 9', 9'').

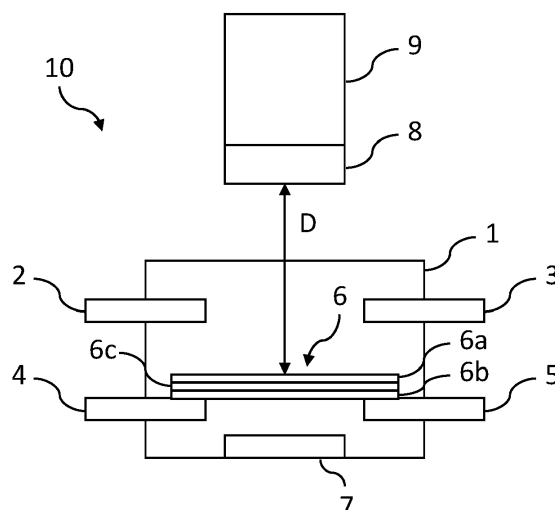


Fig. 1

Description

[0001] The present invention relates to a switch assembly for providing information on an open / closed state of medium to high voltage contactor devices in transportation vehicles, a contactor device for transportation vehicles, and a transportation vehicle.

[0002] Contactor devices in medium and/or high voltage applications such as contactors, disconnectors or high-speed breakers for railway vehicles, other transportation vehicles or heavy industrial applications comprise a switch assembly to switch between an open state and a closed state of the contactor devices. For example, opening and closing of the contactor device may be mechanically repeated by means of mechanically-operated low-voltage miniature snap switches. These miniature snap switches may be capable of allowing the indirect detection of an open or closed state of the respective medium/high voltage contactor device by an external low voltage circuit detecting the open or closed state of the switch. By way of example, by opening or closing the contactor device, a rod or cam as mechanical component moves to exert a pressure on a button external to the miniaturized switch. The relative motion is transmitted inside the miniaturized switch by means of a system of rods, springs, leaf springs or the like. Accordingly, the miniaturized switch moves from the open to the closed position, or vice versa. An external low voltage circuit detects the change in state of the miniaturized switch and consequently indirectly detects the change in state of the contactor device without being physically connected to medium/high voltage components.

[0003] However, the above concept has a low degree of reliability, since the miniaturized switch is based on a certain number of mechanical components such as buttons, rods, springs, leaf springs, levers and the like necessary to transmit the motion. Such mechanical components may be subject to production errors, wear due to contact, or deformations.

[0004] It is an object of the present invention to provide a voltage circuit, preferably a low voltage circuit, with information about the open / closed state of a medium to high voltage contactor device by a switch assembly with a reduced number of mechanical components.

[0005] The object is solved by the subject matters of the independent claims. Further aspects of the present invention are subject to the dependent claims.

[0006] According to the present invention a switch assembly for providing information on an open / closed state of medium to high voltage contactor devices in transportation vehicles comprises at least two first fixed electric contacts distanced from each other, and at least one moving contact. The moving contact is configured to be movable between a first position that electrically connects the first fixed electric contacts, for example to signal an open position of the contactor device and a second position away from the first position. The fixed contacts can be two or more. The movement of the movable contact is obtained via an actuator facing the at least one moving contact and configured to be movable toward and away from the at least one moving contact. More in detail, at least one first magnetic member is comprised by or affixed to the at least one actuator and/or the moving contact configured to provide a magnetic force to move the moving contact into or away from the first position depending on a distance between the at least moving contact and the at least one actuator.

[0007] A medium to high voltage contactor device, hereinafter also referred to as contactor device, may be any kind of contactor device for medium and/or high voltage applications, such as contactors, disconnectors or high-speed circuit breakers. In a first instance, a medium voltage or a high voltage is to be understood as a comparably higher voltage than the one of the low voltage circuit to detect information on the open / closed state of the contactor device. Specifically, a medium voltage may be equal to or more than 150 V and equal to or less than 500 V, preferably between 220 V and 400 V. Thereby, a high voltage may be more than 500 V and a low voltage less than 150 V.

[0008] In the above configuration, the at least two first fixed electric contacts, i.e. at least two first conductive members to provide electric contacts, can be electrically connected by the moving contact. For such connection, the moving contact, which is also at least partially conductive to electrically connect the at least two first fixed electric contacts, is moved into the first position. In the first position, for example, one end of the moving contact contacts one of the first fixed electric contacts, while the other end of the moving contact contacts the other one of the first fixed electric contacts. Consequently, a current may flow from the one of the first fixed electric contacts to the other one of the first fixed electric contacts via the moving contact. The connection or disconnection of the at least two first fixed electric contacts by the moving contact may be representative of an open or closed state of a contactor device actuating the moving contact in response to an opening and/or closing procedure of the contactor device. Therefore, an open / closed state of the contactor device may be indirectly detected, for example, by an impedance measurement on the switch assembly with respect to the at least two first fixed electric contacts. The connected state of the at least two first fixed electric contacts, i.e. the moving contact being in the first position, may correspond to a closed state of the contactor device. However, alternatively, the connected state of the at least two first fixed electric contacts, i.e. the moving contact being in the first position, may correspond to an open state of the contactor device. The assignment of the connected state of the at least two first fixed electric contacts is a matter of definition for a respective circuit connected thereto for detection purposes.

[0009] To move the moving contact into the first position, the switch assembly comprises the at least one actuator to actuate the moving contact to move toward and/or away from the at least two first fixed electric contacts. The at least

one actuator may be moved correspondingly with an opening and/or closing procedure of the contactor device. For example, the at least one actuator may be operatively coupled to a contactor device actuator or contactor device switching member, such as by a mechanical transfer mechanism. Alternatively or in addition, the at least one actuator may be controlled by an actuating mechanism in accordance with a control signal provided by a control to move the at least one actuator.

[0010] The movement of the at least one moving contact toward and/or away from the at least two first fixed electric contacts by the at least one actuator is based on a magnetic force provided by the at least one first magnetic member. The at least one first magnetic member may be affixed or comprised by the at least one moving contact. In such event, the at least one actuator is configured to provide magnetic properties, such as by being at least partially made of a ferromagnetic material or comprising a ferromagnetic member or another magnetic member, to allow the at least one first magnetic member and thereby the at least one moving contact to be moved toward or away from the at least one actuator in dependence on a distance between the at least one moving contact and the at least one first magnetic member, respectively, and the at least one actuator. For example, the at least one first magnetic member may provide an attraction force with respect to the at least one actuator. When the at least one actuator is moved toward the at least one first magnetic member and the at least one moving contact, respectively, the attraction force increases to allow the at least one moving contact to be moved, for example, into the first position. Alternatively, the attraction force may move the at least one moving contact away from the first position. Alternatively, the at least one first magnetic member may provide a repellant force with respect to the at least one actuator. When the at least one actuator is moved toward the at least one first magnetic member and the at least one moving contact, respectively, the repellant force increases to allow the at least one moving contact to be moved, for example, away from the first position. Alternatively, the repellant force may move the at least one moving contact into the first position. With an electro-magnet as at least one first magnetic member with switchable polarity, it may also be possible to change between the attraction and repellant force to change the movement direction of the at least one moving contact for moving the at least one moving contact into and away from the first position on demand.

[0011] Alternatively or in addition, the at least one first magnetic member may be affixed to or comprised by the at least one actuator to attract or to repel the at least one moving contact to move into or away from the first position. Accordingly, the at least one moving contact is configured to provide magnetic properties, such as by being at least partially made of a ferromagnetic material or comprising a ferromagnetic member or another magnetic member, to allow the at least one moving contact to be moved toward or away from the at least one first magnetic member and thereby the at least one actuator in dependence on a distance between the at least one moving contact and the at least one actuator and the at least one first magnetic member, respectively.

[0012] For example, the at least one first magnetic member may provide an attraction force with respect to the at least one moving contact. When the at least one actuator and the at least one moving contact, respectively, is moved toward the at least one first magnetic member the attraction force increases to allow the at least one moving contact to be moved, for example, into the first position. Alternatively, the attraction force may move the at least one moving contact away from the first position. Alternatively, the at least one first magnetic member may provide a repellant force with respect to the at least one moving contact. When the at least one actuator and the at least one first magnetic member, respectively, is moved toward the at least one moving contact, the repellant force increases to allow the at least one moving contact to be moved, for example, away from the first position. Alternatively, the repellant force may move the at least one moving contact into the first position. Analogously to the above, with an electro-magnet as at least one first magnetic member with switchable polarity, it may also be possible to change between the attraction and repellant force to change the movement direction of the at least one moving contact for moving the at least one moving contact into and away from the first position on demand.

[0013] With respect to the at least one first magnetic member being comprised by or affixed to the at least one actuator and/or the at least one moving member, it is noted that the term "and" represents a configuration in which at least one first magnetic member is comprised by or affixed to the at least one actuator while another at least one first magnetic member is comprised by or affixed to the at least one moving member. The at least one first magnetic member affixed to the at least one actuator and/or the at least one moving contact by being glued on the at least one actuator and/or the at least one moving contact, for example, by applying aeronautical glues, or by being welded. However, alternative or additional ways of a respective fixation may be possible, such as screwing. In principle, the respective fixation should withstand the magnetic forces exerted on the at least one first magnetic member.

[0014] Preferably, the at least two first fixed electric contacts are disposed between the at least one moving contact and the at least one actuator with respect to the moving direction of the at least one moving contact. Thereby, the at least two first fixed electric contacts may act as an abutment for the moving contact in the event of an attraction force to move the at least one moving contact toward the at least one actuator. This may prevent the at least one moving contact from adhering to the at least one actuator, which may otherwise require higher forces to release the at least one moving contact from the at least one actuator.

[0015] In view of the above, the switch assembly is capable of providing a switching concept, in particular a miniaturized

snap-action switch based on at least one magnetic member instead of or at least with a reduced number of mechanical components. In other words, the switch assembly is capable of replacing the mechanical operation of switches with the action of an organ moved by the interaction of at least one magnetic member. Accordingly, the switch assembly is capable of avoiding or at least reducing the mechanically based phenomena of wear, deformation and the like and the consequent reduction in reliability of the functionality of the switch assembly.

[0016] In some embodiments, at least one second magnetic member is arranged on a side of the at least one moving contact facing away from the at least one actuator.

[0017] The second magnetic member may provide a counterforce to the first magnetic member. For example, the at least one moving contact is configured to provide magnetic properties, such as by being at least partially made of a ferromagnetic material or comprising a ferromagnetic member or another magnetic member, and is attracted by the at least one second magnetic member. In such configuration, the at least one second magnetic member is capable of holding the at least one moving contact in a rest position, i.e. in a predetermined position such as the second position, in which no moving effect occurs with respect to the at least one moving contact by the at least one actuator, as long as the distance of the at least one actuator and the at least one moving contact is decreased, such that the magnetic force between the at least one actuator and the at least one moving contact exceeds the magnetic force between the at least one moving contact and the at least one second magnetic member. The at least one second magnetic member may also provide a sufficient magnetic force to hold the at least one moving contact in the rest position with respect to different operating conditions, such as mechanical vibrations induced on the switch assembly.

[0018] Preferably, the magnetic force provided by the at least one second magnetic member is less than the magnetic force by the at least one first magnetic member falling below a predetermined distance between the at least one actuator and the at least one moving contact. However, alternatively or in addition, the at least one second magnetic member may be an electromagnetic member, which may be configured to be switchable in polarity and/or in an amount of a magnetic force to be applied.

[0019] In some embodiments, the switch assembly further comprises at least two second fixed electric contacts distanced from each other and opposed to the at least two first fixed electric contacts, and wherein the at least one moving contact is disposed between the at least two first fixed electric contacts and the at least two second fixed electric contacts and extends to contact the at least two first fixed electric contacts in the first position and to contact the at least two second fixed electric contacts in the second position.

[0020] Accordingly, the at least one moving contact is movable between the first position represented by the at least two first fixed contacts, i.e. a contact surface of the at least two first fixed contacts facing the at least one moving contact, and the second position represented by the at least two second fixed contacts, i.e. a contact surface of the at least two second fixed contacts facing the at least one moving contact. A detection circuit may thereby indirectly detect an open or closed state of the contactor device, for example, by an impedance measurement on the switch assembly with respect to the impedance of the at least two first fixed electric contacts and the at least two second fixed electric contacts.

[0021] For example, the at least two first fixed electric contacts electrically connected by the at least one moving contact in the first position represent a closed state of the contactor device. In turn, the at least two second fixed electric contacts electrically connected by the at least one moving contact in the second position represent an open state of the contactor device. According to the exemplary impedance measurement, the detection circuit may detect a low impedance between the at least two first fixed contacts and a high impedance between the at least two second fixed contacts with the at least one moving contact being in the first position. The detection circuit may then determine such impedance characteristic corresponding to the closed state of the contactor device. Consequently, according to this example, the detection circuit may detect a high impedance between the at least two first fixed contacts and a low impedance between the at least two second fixed contacts with the at least one moving contact being in the second position. In other words, in a configuration in which that least one moving contact is electrically connecting the at least two second fixed electric contacts. The detection circuit may then determine such impedance characteristic corresponding to the open state of the contactor device.

[0022] For example, the at least two second fixed electric contacts are distanced from each other and opposed to the at least two first fixed electric contacts. Further, in such configuration, the at least one moving contact is disposed between the at least two first fixed electric contacts and the at least two second fixed electric contacts. The at least one movable contact extends to contact the at least two first fixed electric contacts in the first position and to contact the at least two second fixed electric contacts in the second position. In such configuration, the at least two second fixed electric contacts may be arranged between the at least one moving contact and the at least one second magnetic member. For example, the at least one second magnetic member exerts a magnetic attraction force on the at least one moving contact to hold the at least one moving contact in the rest position, here the second position, since the attraction force urges the at least one moving contact against the at least two second fixed electric contacts. With the at least one moving contact being in the rest position or second position, respectively, the at least one actuator is sufficiently distanced from the at least one moving contact, such that a magnetic force between the at least one moving contact and the at least one actuator due to the at least one first magnetic member does not exceed the magnetic force by the at least one second magnetic

member. However, when the at least one actuator approaches the at least one moving contact, the magnetic force between the at least one moving contact and the at least one actuator due to the at least one first magnetic member increases. Accordingly, with the distance falling below a certain threshold, the magnetic force between the at least one moving contact and the at least one actuator due to the at least one first magnetic member exceeds the magnetic force applied by the at least one second magnetic member. In such event, the at least one moving contact is moved into the first position.

[0023] In some embodiments, the at least one second magnetic member is affixed to or comprised by at least one of the at least two second fixed electric contacts, preferably on a side facing the at least one moving contact, and/or the at least one second magnetic member is affixed to or comprised by the at least one moving contact, preferably on at least one side facing at least one of the at least two second fixed electric contacts.

[0024] Accordingly, the at least one second magnetic member may not be provided as separately disposed magnetic member but is directly provided by at least one of the at least two second fixed electric contacts and/or the at least one moving contact. Providing at least two second magnetic members, i.e. at least one of the at least two second magnetic members by each of the second fixed electric contacts in respective positions opposed to the at least one moving contact and/or by the at least one moving contact in respective positions each opposed to one of the at least two second fixed electric contacts, supports securing the electric connection in the rest position or second position, respectively.

[0025] The at least one second magnetic member may be affixed to at least one of the at least two second fixed electric contacts and/or the at least one moving contact by being glued or welded thereto. Alternatively, the at least one second magnetic member may be comprised by at least one of the at least two second fixed electric contacts, e.g. as internal second magnetic member, or may directly build at least one of the at least two second fixed electric contacts.

[0026] In some embodiments, the at least one moving contact comprises at least one ferromagnetic portion facing the at least one actuator, preferably two ferromagnetic portions opposed to each other in the moving direction of the at least one moving contact between the first position and the second position with an intermediate portion disposed between the two ferromagnetic portions.

[0027] Accordingly, the at least one moving contact may be provided as a moving multilayer contact with an intermediate layer as intermediate portion disposed between two ferromagnetic layers as ferromagnetic portions. The intermediate portion separates the ferromagnetic portions, for example, to provide a greater height in the moving direction of the at least one moving contact to allow reduction in the moving distance to electrically connect the at least two first fixed electric contacts in the first position and the at least two second fixed electric contacts in the second position. Accordingly, the ferromagnetic material consumption for the at least one moving contact may be reduced, which may allow a reduction in costs and/or weight. Preferably, the intermediate portion is an insulating portion according to a respective material selection. The ferromagnetic portion may be made of or at least comprise a ferromagnetic material of a soft ferromagnetic material, e.g. annealed iron, such as to minimize the effects of residual magnetization over time.

[0028] In some embodiments, the at least two first fixed electric contacts and/or the at least two second fixed electric contacts are at least partially arranged within a housing.

[0029] The at least two first fixed electric contacts and/or the at least two second fixed electric contacts are at least partially arranged within the housing to protrude in the interior of the housing. Consequently, the at least one moving contact is also arranged within the housing to allow the at least one moving contact to at least electrically connect the at least two first fixed electric contacts in the first position. The housing is preferably made of an insulating material.

[0030] In some embodiments, the interior of the housing provides a vacuum.

[0031] Thereby, the occurrence of undesired electric arcs may be reduced. Moreover, the movement of the movable contact is easier.

[0032] In some embodiments, the at least one actuator is at least partially arranged within the housing.

[0033] Since the at least one actuator is at least partially arranged within the housing, at least one first magnetic member may not have to be configured to provide a magnetic force which has to be effective outside the housing. In other words, since the actuator and the at least one moving contact are not separated by the housing, the magnetic force associated with the at least one first magnetic member is not shielded or attenuated by the housing. For example, with the at least one first magnetic member affixed to the actuator, the respective magnetic force may directly act on the at least one movable contact without a housing wall in between.

[0034] In some embodiments, the at least one actuator is entirely arranged within the housing, and the switch assembly further comprises an operating member at least partially arranged outside the housing, wherein the operating member operates the at least one actuator to move at least towards the at least one moving contact.

[0035] Accordingly, the at least one actuator arranged entirely within the housing may provide a modular switching assembly unit with an operating member adapted to the specific design requirements of the contactor design. To operate the at least one actuator by the operating member, the housing may provide an interface, such as an opening for an operating member to extend within the housing to actuate the at least one actuator.

[0036] In some embodiments, the actuator comprises the at least one first magnetic member, and the switch assembly further comprises a stationary magnetic member facing the at least one first magnetic member on a side facing away

from the at least one moving contact. The at least one first magnetic member is relatively movably with respect to the stationary magnetic member when moving the actuator toward and away from the at least one moving contact. The facing sides of the stationary magnetic member and the first magnetic member provide reversed polarities.

[0037] In other words, the at least one first magnetic member affixed to or comprised by the at least one actuator is arranged between the stationary magnetic member and the at least one closing contact with respect to the moving direction of the at least one moving contact between the first and second position or the moving direction of the at least one actuator, respectively. Accordingly, by moving the at least one actuator towards and away from the at least one moving contact, the at least one first magnetic member is relatively moved with respect to the stationary magnetic member and the at least one moving contact. In concrete, when the at least one actuator is moved toward the at least one moving contact, the at least one first magnetic member is moved toward the at least one moving contact and away from the stationary magnetic member. Since the facing sides of the stationary magnetic member and the first magnetic member provide reversed polarities, the attraction force between the at least one first magnetic member and the stationary magnetic member decreases with the at least one actuator moving toward the at least one moving contact. However, the actuating force for a corresponding movement has to overcome the attraction force between the at least one first magnetic member and the stationary magnetic member. An unintended movement, e.g. due to vibrations or the like may be prevented. Furthermore, upon release of the actuation force, the at least one first magnetic member may be automatically moved back toward the stationary magnetic member to cause the at least one actuator to move away from the at least one moving contact to allow the moving contact to achieve the second position.

[0038] In some embodiments, the actuator further comprises a retracting magnetic member, which is disposed on a side of the at least one first magnetic member facing away from the at least one moving contact with the stationary magnetic member being disposed between the at least one first magnetic member and the retracting magnetic member, wherein the facing sides of the stationary magnetic member and the retracting magnetic member provide equal polarities.

[0039] The retraction magnetic member allows to support an automatic movement of the at least one actuator away from the at least one moving contact upon the release of the actuation force. This is due to the increase in the repellant force between the stationary magnetic member and the retracting magnetic member, when the at least one actuator is moved toward the at least one moving contact, according to which the retracting magnetic member approaches the stationary magnetic member. Otherwise, i.e. without the retracting magnetic member, a situation may occur, in which the attraction force between the at least one first magnetic member and the at least one moving contact, and the attraction force between the at least one first magnetic member and the stationary magnetic member cancel each other or would at least decrease the recall force for the at least one actuator to an extent preventing an automatic backward movement.

[0040] In some embodiments, the at least two first fixed electric contacts and the at least one moving contact are implemented as a reed switch.

[0041] The use of a reed switch allows to implement the switching ability to provide information of an open / closed state of a contactor device by a standard component of high availability. Furthermore, the reed switch allows a compact design suitable for miniaturized switch assemblies.

[0042] In some embodiments, at least one of the at least one first magnetic member, the at least one second magnetic member, the stationary magnetic member and the retracting magnetic member is a permanent magnet.

[0043] Permanent magnets provide the ability of a robust design with respect to the application of required magnetic forces. However, to increase flexibility, at least one of the at least one first magnetic member, the at least one second magnetic member, the stationary magnetic member and the retracting magnetic member may be an electromagnet. An electromagnet may provide the ability to be turned on and off, and/or to influence the amount of magnetic force applied and/or the polarity.

[0044] In another aspect, the present invention relates to a contactor device for transportation vehicles, comprising a switch assembly as previously described, and a detection circuit configured to detect an open / closed state of the contactor device by the switch assembly by being configured to detect an impedance between the at least two first fixed electric contacts.

[0045] Alternatively or in addition, the detection circuit may also be comprised by the switch assembly.

[0046] Any feature described with respect to the switch assembly is also applicable to the contactor device. In turn, any feature described for the contactor device is also applicable to the switch assembly.

[0047] In another aspect, the present invention relates to a transportation vehicle comprising at least one switch assembly as previously described and/or contactor device as previously described, wherein the transportation vehicle is a railway vehicle, a commercial vehicle and/or an electrically powered or hybrid vehicle.

[0048] Further advantages, aspects and details of the invention are subject to the claims, the following description of exemplary embodiments applying the principles of the invention, and the respective exemplary drawings.

Figure 1 is a schematic cross-sectional view of a switch assembly according to a first exemplary embodiment;

Figure 2 is a schematic cross-sectional view of a switch assembly according to a second exemplary embodiment;

Figure 3 is a schematic cross-sectional view of a switch assembly according to a third exemplary embodiment;

Figure 4 is a schematic cross-sectional view of a switch assembly according to a fourth exemplary embodiment; and

Figure 5 is a schematic cross-sectional view of a switch assembly according to a fifth exemplary embodiment.

[0049] **Figure 1** shows a schematic cross-sectional view of a switch assembly 10 according to a first exemplary embodiment. In the first exemplary embodiment, the switch assembly comprises a housing 1 with two first fixed electric contacts 2, 3 and two second fixed electric contacts 4, 5 protrude in the interior of the housing 1. The housing 1 in the exemplary embodiment is made of an insulating material and provides a vacuum in the interior, in which the two first fixed electric contacts 2, 3 and two second fixed electric contacts 4, 5 protrude. However, in other embodiments, no vacuum may be provided in the interior of the housing 1. The two first fixed electric contacts 2, 3 are arranged in one plane, here a plane in parallel to the bottom of the housing 1. The two second fixed electric contacts 4, 5 are arranged in a plane in parallel to the plane of the two first fixed electric contacts 2, 3, here between the two first fixed electric contacts 2, 3 and the bottom of the housing 1.

[0050] The switch assembly 10 further comprises a moving contact 6, arranged in the housing 1 between the two first fixed electric contacts 2, 3 and two second fixed electric contacts 4, 5. The moving contact 6 is configured to electrically connect the two first fixed electric contacts 2, 3 in a first position, and to electrically connect the two second fixed electric contacts 4, 5 in a second position. Accordingly, here, the moving contact 6 extends in a plane in parallel to the plane of the two first fixed electric contacts 2, 3 and two second fixed electric contacts 4, 5 with a sufficient length with respect to such extension. In the exemplary embodiment, the moving contact 6 is to be moved in a moving direction perpendicular to the plane of the two first fixed electric contacts 2, 3 and two second fixed electric contacts 4, 5. The movement of the moving contact 6 beyond the first position is prevented by the two first fixed electric contacts 2, 3. Analogously, the movement of the moving contact 6 beyond the second position is prevented by the two second fixed electric contacts 4, 5. In other words, the electrical connection of the two first fixed electric contacts 2, 3 by the moving contact 6 in the first position and the electrical connection of two second fixed electric contacts 4, 5 by the moving contact 6 in the second position defines the moving range of the moving contact 6 in the moving direction.

[0051] The moving contact 6 is a multilayer moving contact with an intermediate layer 6c as intermediate portion disposed between two ferromagnetic layers 6a, 6b as ferromagnetic portions. The intermediate layer 6c is made of an insulating material. The two ferromagnetic layers 6a, 6b are of a soft ferromagnetic material, here annealed iron.

[0052] The switch assembly further comprises a second magnetic member 7, which is also disposed within the housing 1 on a side of the two second fixed electric contacts 4, 5 facing away from the two first fixed electric contacts 4, 5, here a bottom side of the housing 1. In the exemplary embodiment, the second magnetic member 7 is a permanent magnet configured and arranged to provide an attraction force on the moving contact 6, specifically on the ferromagnetic layer 6b facing the second magnetic member 7. The magnetic force provided by the second magnetic member 7 is sufficient to attract the moving contact 6 to move in the second position and hold the moving contact 6 in the second position as a rest position as long as the switch assembly is not actuated as described below.

[0053] For an actuation of the switch assembly 10, the switch assembly 10 further comprises an actuator 9, which is disposed outside the housing 1 on a side facing the moving contact 6 in the moving direction. On the side of the actuator 9 facing the moving contact 6, a first magnetic member 8 is affixed to the actuator 9 by gluing. The first magnetic member 8 is arranged and configured to provide an attraction force on the moving contact 6. In the exemplary embodiment, the first magnetic member 8 is a permanent magnet to provide the attraction force on the moving contact 6, specifically on the ferromagnetic layer 6a facing the first magnetic member 8. The magnetic force provided by the first magnetic member 8 is sufficiently greater than the magnetic force of the second magnetic member 7 to move the moving contact 6, when the first magnetic member 8 is at least in a certain distance as explained below with respect to the operation of the switch assembly 10. The first magnetic member 8 may be supplied as kit, for example, together with an aeronautical glue with or without the actuator 9 and/or other parts of the switch assembly 10, to allow modular combination options. Further, in alternative embodiments, the actuator 9 may be arrangeable within the housing 1 to be actuated from the outside.

[0054] The operation of the switch assembly 10 is described by assuming a connector device (not shown), to which the actuator 9 is operationally connected to receive an actuating force to move the actuator 9 toward the moving contact 6. The applying of the actuating force corresponds to a closing action of the contactor device. Accordingly, in an open state of the contactor device as a rest condition, the actuator 9 and thereby the first magnetic member 8 are positioned in a distance D, in which the attraction force of the first magnetic member 8 on the moving contact 6 is less than the attraction force of the second magnetic member 7. Under the rest condition, the second magnetic member 7 holds the moving contact 6 in the second position to electrically connect the two second fixed electric contacts 4, 5. A low voltage circuit detection circuit (not shown) is operationally connected to the first fixed electric contacts 2, 3 and the second fixed electric contacts 4, 5 to detect an impedance between the first fixed electric contacts 2, 3 and to detect an impedance between the second fixed electric contacts 4, 5. Under the rest condition with the two second fixed electric contacts 4,

5 being electrically connected by the moving contact 6, the low voltage detection circuit detects a low impedance for the two second fixed electric contacts 4, 5 and a high impedance for the two first fixed electric contacts 2, 3. The low voltage detection circuit determines this state as an open state of the contactor device.

[0055] In the event of a closing action of the contactor device, an actuating force is applied on the actuator 9 to move in the moving direction toward the moving contact 6. Thereby the distance D between the first magnetic member 8 and the moving contact 6 is decreased. In response to the decrease in the distance D, the attraction force of the first magnetic member 8 on the moving contact 6 increases. When the distance D falls below a certain threshold, the attraction force by the first magnetic member becomes sufficient to overcome the attraction force of the second magnetic member 7 on the moving contact 6, such that the moving contact 6 is moved into the first position, in which the moving contact 6 electrically connects the two first fixed electric contacts 2, 3. When the moving contact 6 is in the first position to electrically connect the two first fixed electric contacts 2, 3, the low voltage detection circuit detects a high impedance for the two second fixed electric contacts 4, 5 and a low impedance for the two first fixed electric contacts 2, 3. The low voltage detection circuit determines this state as a closed state of the contactor device.

[0056] Figure 2 shows a schematic cross-sectional view of a switch assembly 10' according to a second exemplary embodiment. Same or similar features provide the same or similar functionalities and therefore the same reference signs as per the first exemplary embodiment according to Fig. 1. Accordingly, only the differences between the first and the second exemplary embodiment are described.

[0057] In the second exemplary embodiment according to Fig. 2, the first magnetic member 8' is not affixed to the actuator 9' but to the moving contact 6 on a side thereof facing the actuator 9' in the moving direction. The first magnetic member 8' is arranged and configured to provide an attraction force with respect to the actuator 9', which is respectively made of or comprises a ferromagnetic material. Accordingly, the magnetic force to move the moving contact 6 in the first position is provided by the attraction force between the first magnetic member 8' and the actuator 9'. Here, which may also apply to other embodiments, the movement of the actuator 9' is controlled to be independent from the position of the moving contact 6 to avoid the actuator 9' being moved toward the moving contact 6 by the attraction force provided between the first magnetic member 8' and the actuator 9'. In other words, the movement of the actuator 9' toward the moving contact 6 is a result of the actuating force applied thereon but not of the position of the moving contact 6.

[0058] Figure 3 shows a schematic cross-sectional view of a switch assembly 10'' according to a third exemplary embodiment. Same or similar features provide the same or similar functionalities and therefore the same reference signs as per the first exemplary embodiment according to Fig. 1. Accordingly, only the differences between the first and the third exemplary embodiment are described.

[0059] In the third exemplary embodiment according to Fig. 3, the second magnetic member 7 of the first exemplary embodiment has been replaced by two second magnetic members 7a'', 7b'', each of which is affixed to the second fixed electric members 4, 5 on a side facing the moving contact 6. Alternatively or in addition, according to other embodiments, the two second magnetic members 7a'', 7b'' may be affixed to the moving contact 6 on a side facing the two second fixed electric contacts 4, 5. In such event, each of the two second fixed electric contacts 4, 5 provide, for example, a ferromagnetic portion to get in touch with one of the two second magnetic members 7a'', 7b'' to provide the moving contact 6 in the second position. The second magnetic members 7a'', 7b'' in the exemplary embodiment are each permanent magnets configured and arranged to provide an attraction force on the moving contact 6, specifically on the ferromagnetic layer 6b facing the second magnetic members 7a'', 7b''. The pair of second magnetic members 7a'', 7b'' provides the same functionality as the second magnetic member 7 according to the first exemplary embodiment such as is referred to the respective description of the second magnetic member 7.

[0060] Figure 4 shows a schematic cross-sectional view of a switch 10''' assembly according to a fourth exemplary embodiment. The fourth exemplary embodiment is a combination of the second and third embodiment. Accordingly, it is referred to the respective description of the second and third embodiment.

[0061] Figure 5 shows a schematic cross-sectional view of a switch assembly 10'''' according to a fifth exemplary embodiment. Here, the housing 1'''' contains a reed switch 30'''' such as a reed ampoule replacing the moving contact 6, the two first fixed electric contacts 2, 3 and the two second fixed electric contacts 4, 5 as per the previous embodiments. The reed switch 30'''' changes its state representative of an open / closed state of the contactor device operationally coupled an operating member 40'''' configured to move the actuator 9'''' toward the reed switch 30''''.

[0062] In the fifth exemplary embodiment, the actuator 9'''' is accommodated within the housing 1''''', wherein the switch assembly 10'''' comprises the operating member 40'''' protruding into the housing 1'''' to provide a respective actuating force on the actuator 9'''' to move toward the reed switch 30'''' to initiate a switching action. A first magnetic member 8'''' and a retracting magnetic member 9a'''' are affixed to the actuator 9'''' along the moving direction of the actuator 9'''' toward the reed switch 30''''. Further, a stationary magnetic member 20'''' is stationary affixed to the housing 1''''', is disposed between the first magnetic member 8'''' and the retracting magnetic member 9a'''' with respect to the moving direction of the actuator 9''''. The first magnetic member 8'''', the retracting magnetic member 9a'''' and the stationary magnetic member 20'''' are permanent magnets. The first magnetic member 8'''' and the stationary magnetic member 20'''' are configured and arranged such that the facing sides of the first magnetic member 8'''' and the stationary magnetic

member 20''' provide reverse polarity, i.e. different magnetic poles are facing each other. Further, the retracting magnetic member 9a''' and the stationary magnetic member 20''' are configured and arranged such that the facing sides of the retracting magnetic member 9a''' and the stationary magnetic member 20''' provide equal polarity, i.e. same magnetic poles are facing each other.

[0063] According to a closing action of a contactor device operationally connected to the operating member 40''' to provide a movement of the actuator 9''' toward the reed switch 30''' in accordance with the principles already described with respect to the first exemplary embodiment to provide a respective signal to the low voltage detection circuit, the first magnetic member 8''' is moved by the actuator 9''' toward the reed switch 30''' to provide an attraction force on the reed switch 30''' sufficient for a switching action due to the increase in the magnetic force upon approaching the reed switch 30'''. Such movement is performed against the attraction force between the first magnetic member ''' and the stationary magnetic member 20''' and the repellant force between the retracting magnetic member 9a''' and the stationary magnetic member 20'''. If the actuating force on the operating member 40''' and therefore the actuator 9''' is released, the actuator 9''' is automatically retracted in the moving direction away from the reed switch 30''' by the attraction force between the first magnetic member ''' and the stationary magnetic member 20''' and the repellant force between the retracting magnetic member 9a''' and the stationary magnetic member 20'''.

[0064] The invention has been described with respect to an exemplary embodiment. However, the invention is not limited to the exemplary embodiments. In particular, the actuating principle of the reed switch according to the fifth exemplary embodiment is not restricted to the use of a reed switch but may, for example, also apply for other switching principles with respect to the first and second fixed electric contacts as per the other embodiments.

LIST OF REFERENCE SIGNS

[0065]

1, 1'''	housing
2	first fixed electric contact
3	first fixed electric contact
4	second fixed electric contact
5	second fixed electric contact
6	moving contact
6a	ferromagnetic layer
6b	ferromagnetic layer
6c	intermediate layer
7	second magnetic member
7a''	second magnetic member
7b''	second magnetic member
8, 8', 8'''	first magnetic member
9, 9', 9'''	actuator
9a'''	retracting magnetic member
10, 10', 10'', 10''', 10''''	switch assembly
20'''	stationary magnetic member
30'''	reed switch
40'''	operating member
D	distance
N	magnetic pole (north)
S	magnetic pole (south)

Claims

1. Switch assembly (10, 10', 10'', 10''', 10'''') for providing information on an open / closed state of medium to high voltage contactor devices in transportation vehicles, comprising:

at least two first fixed electric contacts (2, 3) distanced from each other,
 at least one moving contact (6) configured to be movable between a first position to contact both of the at least two first fixed electric contacts (2, 3) for electrically connecting the at least two first fixed electric contacts (2, 3) and a second position away from at least one of the at least two fixed electric contacts (2, 3) for disconnecting the at least two first fixed electric contacts (2, 3), and

at least one actuator (9, 9', 9'') facing the at least one moving contact (6) and configured to be movable toward and away from the at least one moving contact (6),
 wherein at least one first magnetic member (8, 8', 8'') is comprised by or affixed to the at least one actuator (9, 9', 9'') and/or the moving contact (6) configured to provide a magnetic force to move the moving contact (6) into or away from the first position depending on a distance (D) between the at least moving contact (6) and the at least one actuator (9, 9', 9'').

2. Switch assembly (10, 10', 10'', 10''') according to claim 1, wherein at least one second magnetic member (7, 7a'', 7b'') is arranged on a side of the at least one moving contact (6) facing away from the at least one actuator (9, 9').
3. Switch assembly (10, 10', 10'', 10''') according to claim 1 or 2, wherein the switch assembly (10, 10', 10'', 10''') further comprises at least two second fixed electric contacts (4, 5) distanced from each other and opposed to the at least two first fixed electric contacts (2, 3), and wherein the at least one moving contact (6) is disposed between the at least two first fixed electric contacts (2, 3) and the at least two second fixed electric contacts (4, 5) and extends to contact the at least two first fixed electric contacts (2, 3) in the first position and to contact the at least two second fixed electric contacts (4, 5) in the second position.
4. Switch assembly (10'', 10''') according to claim 2 and 3, wherein the at least one second magnetic member (7a'', 7b'') is affixed to or comprised by at least one of the at least two second fixed electric contacts (4, 5), preferably on a side facing the at least one moving contact (6), and/or wherein the at least one second magnetic member (7a'', 7b'') is affixed to or comprised by the at least one moving contact (6), preferably on at least one side facing at least one of the at least two second fixed electric contacts (4, 5).
5. Switch assembly (10, 10', 10'', 10''') according to any one of the preceding claims, wherein the at least one moving contact (6) comprises at least one ferromagnetic portion (6a) facing the at least one actuator (9, 9', 9'', 9'''), preferably two ferromagnetic portions (6a, 6b) opposed to each other in the moving direction of the at least one moving contact (6) between the first position and the second position with an intermediate portion (6c) disposed between the two ferromagnetic portions (6a, 6b).
6. Switch assembly (10, 10', 10'', 10''', 10''') according to any one of the preceding claims, wherein the at least two first fixed electric contacts (2, 3) and/or the at least two second fixed electric contacts (4, 5) are at least partially arranged within a housing (1).
7. Switch assembly (10, 10', 10'', 10''', 10''') according to claim 6, wherein the interior of the housing (1) provides a vacuum.
8. Switch assembly (10''') according claim 6 or 7, wherein the at least one actuator (9''') is at least partially arranged within the housing (1).
9. Switch assembly (10''') according claim 6 or 7, wherein the at least one actuator (9''') is entirely arranged within the housing (1), and the switch assembly (10''') further comprises an operating member (40''') at least partially arranged outside the housing (1), wherein the operating member (40''') operates the at least one actuator to move at least toward the at least one moving contact (6).
10. Switch assembly (10''') according to any one of the preceding claims, wherein the actuator (9''') comprises the at least one first magnetic member (8'''), and wherein the switch assembly (10''') further comprises a stationary magnetic member (20''') facing the at least one first magnetic member (8''') on a side facing away from the at least one moving contact (6), wherein the at least one first magnetic member (8''') is relatively movably with respect to the stationary magnetic member (20''') when moving the actuator (9''') toward and away from the at least one moving contact (6), and wherein the facing sides of the stationary magnetic member (20''') and the first magnetic member (8''') provide reversed polarities.
11. Switch assembly (10''') according to claim 10, wherein the actuator (9''') further comprises a retracting magnetic member (9a'''), which is disposed on a side of the at least one first magnetic member (8''') facing away from the at least one moving contact (6) with the stationary magnetic member (20''') being disposed between the at least one first magnetic member (8''') and the retracting magnetic member (9a'''), and wherein the facing sides of the stationary magnetic member (20''') and the retracting magnetic member (9a''') provide equal polarities.

12. Switch assembly (10''') according to any one of the preceding claims, wherein the at least two first fixed electric contacts (2, 3) and the at least one moving contact (6) are implemented as a reed switch (30''').

13. Switch assembly (10, 10', 10'', 10''', 10''''') according to any one of the preceding claims, wherein at least one of the at least one first magnetic member (8, 8', 8'''), the at least one second magnetic member (7, 7a'', 7b''), the stationary magnetic member (20''') and the retracting magnetic member (9a''') is a permanent magnet.

14. Contactor device for transportation vehicles, comprising

a switch assembly (10, 10', 10'', 10''', 10''''') according to any one of the preceding claims, and a detection circuit configured to detect an open / closed state of the contactor device by the switch assembly (10, 10', 10'', 10''', 10''''') by being configured to detect an impedance between at least the at least two first fixed electric contacts (2, 3).

15. Transportation vehicle comprising at least one switch assembly (10, 10', 10'', 10''', 10''''') according to any one of the claims 1 to 13 and/or contactor device according to claim 14, wherein the transportation vehicle is a railway vehicle, a commercial vehicle and/or an electrically powered or hybrid vehicle.

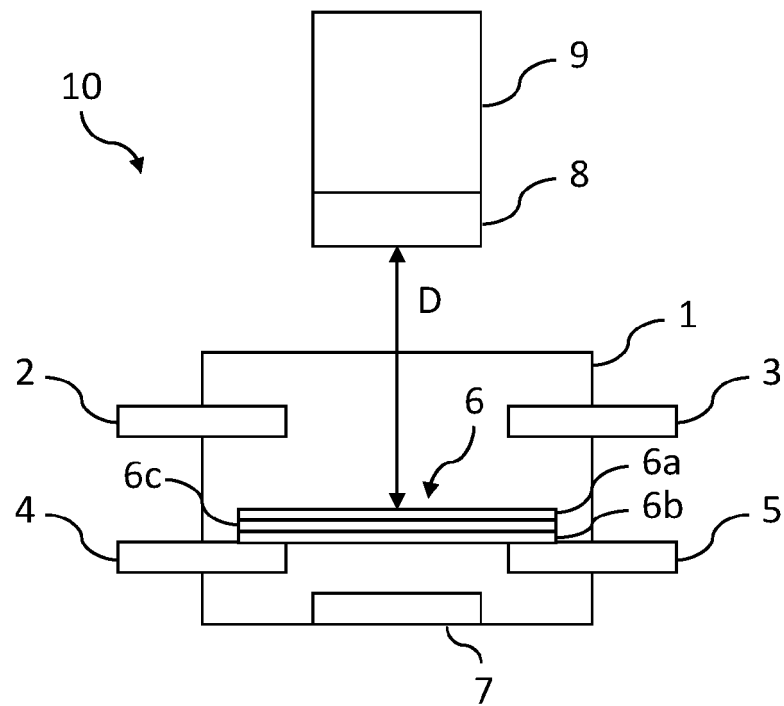


Fig. 1

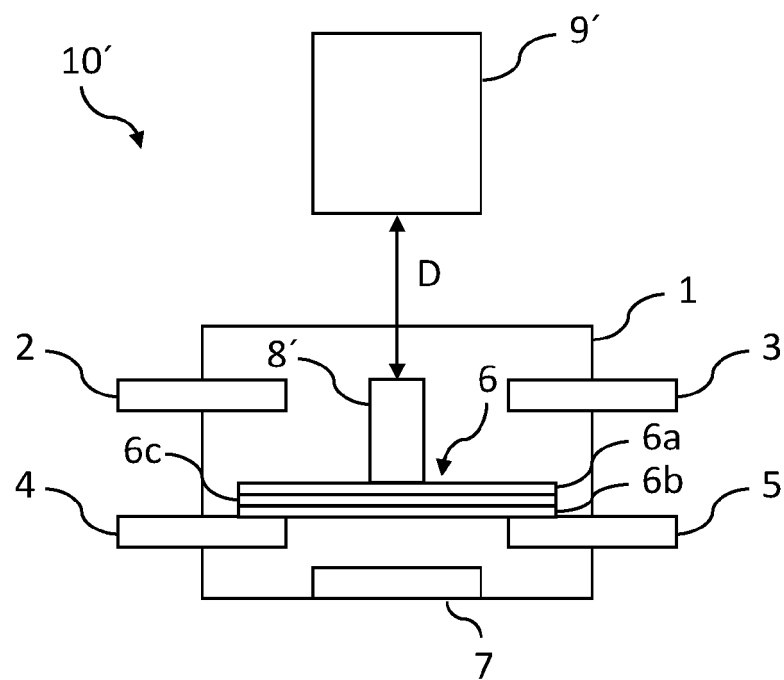


Fig. 2

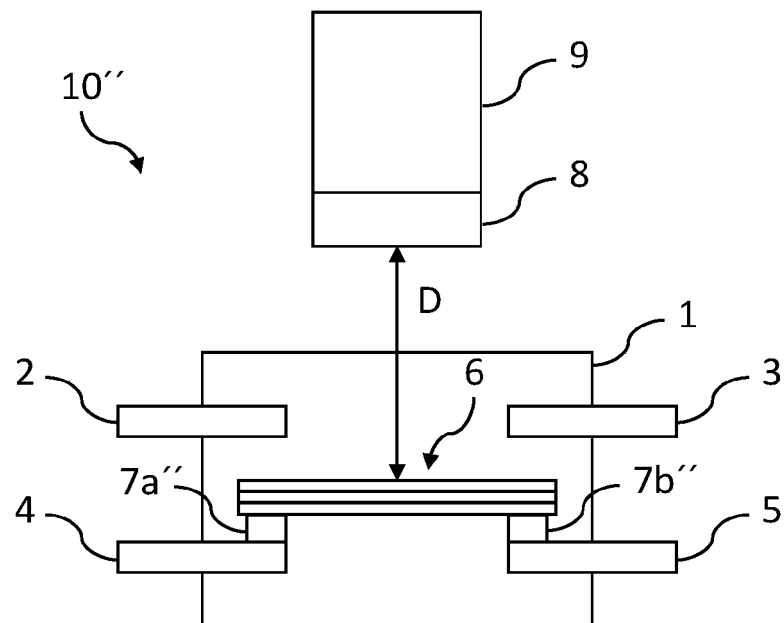


Fig. 3

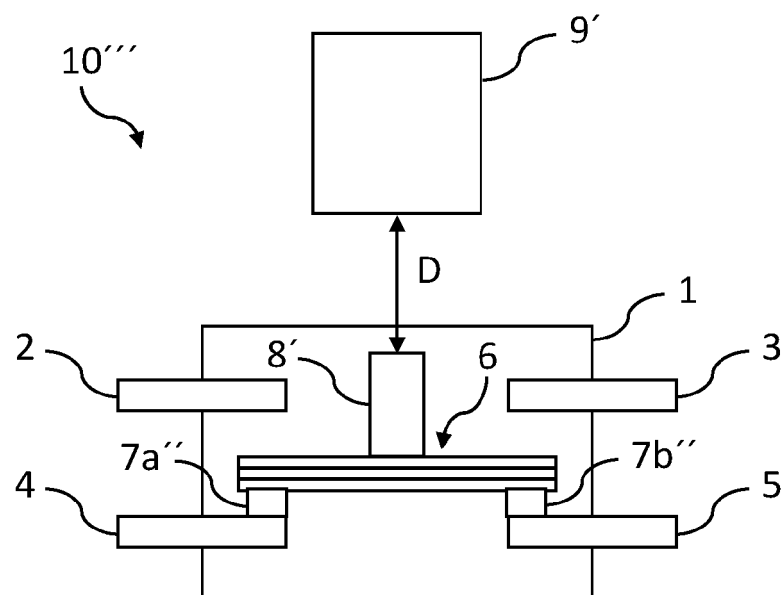


Fig. 4

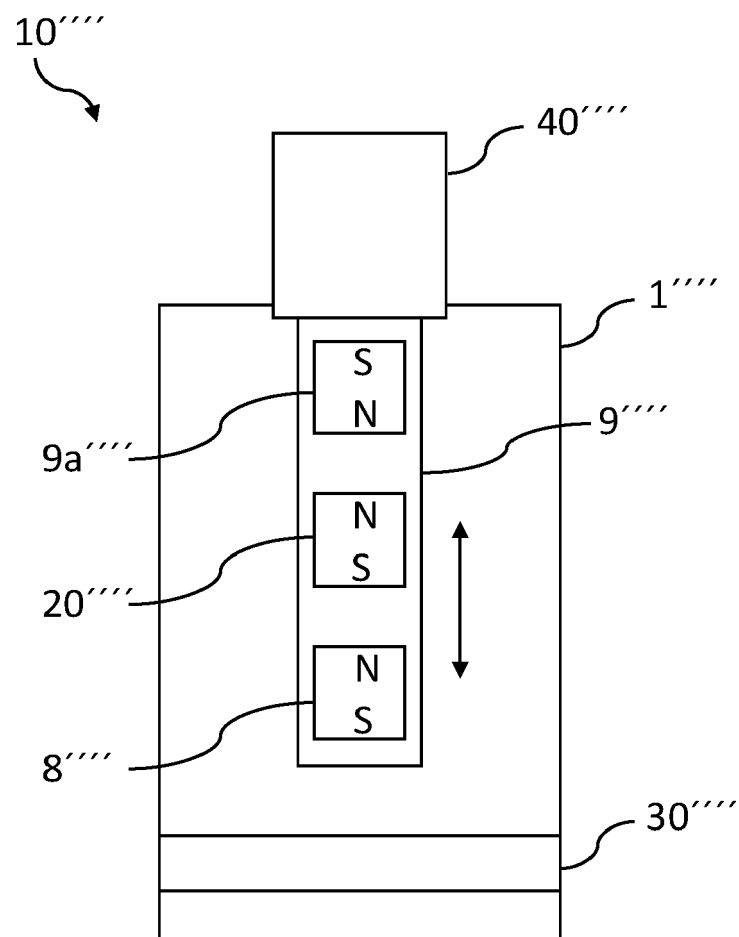


Fig. 5



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