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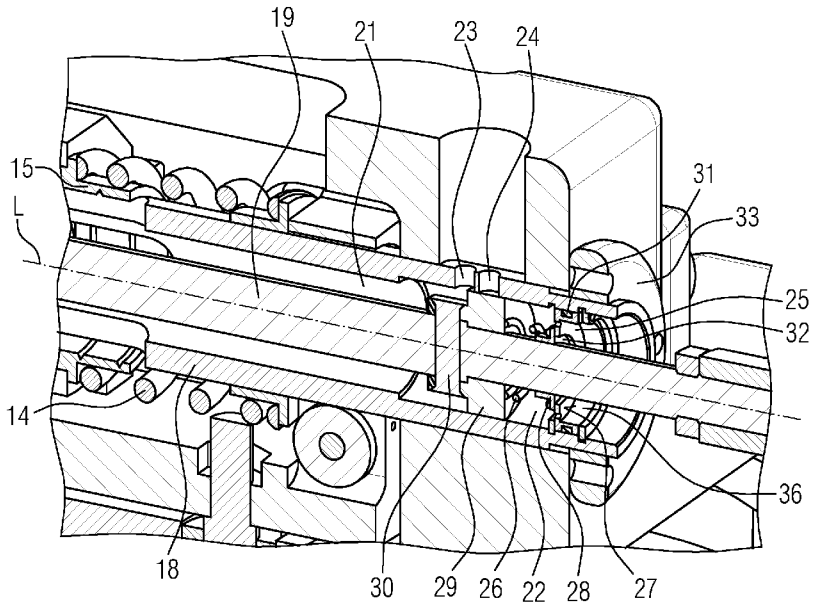
(54) Title: VACUUM INTERRUPTER ASSEMBLY FOR A POWER DIVERTER SWITCH, POWER DIVERTER SWITCH FOR A TRANSFORMER LOAD TAP CHANGER AND TRANSFORMER LOAD TAP CHANGER

Fig. 4



(57) Abstract: Vacuum interrupter assembly (10) for a power diverter switch, comprising a vacuum interrupter (11) and a driving mechanism (12) which is coupled to the vacuum interrupter (11) and which is configured to drive opening and closing of electrical contacts of the vacuum interrupter (11). The driving mechanism (12) includes a driving rod (19) and a guiding tube (18) enclosing the driving rod (19) such that the driving rod (19) is axially movable inside the guiding tube (18) along a longitudinal axis (L) of the vacuum interrupter assembly (10). A damping unit (20) is coupled to the driving mechanism (12) and comprises a first and a second chamber (21, 22) and a piston (29) arranged there between with respect to the longitudinal axis (L). The chambers (21, 22) are coupled to each other hydraulically and limited by the guiding tube (18) and the piston (29). The piston (29) is coupled to the driving rod (19)

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axially movable inside the guiding tube (18) along the longitudinal axis (L). The damping unit (20) comprises an elastic member (26) and a shutter element (28) coupled together and arranged inside the second chamber (22) configured to affect hydraulic damping during operation of the vacuum interrupter assembly (10) based on the elastic force caused by the elastic member (26) and acting on the shutter element (28), such that in interaction with a fluid the damping unit (20) provides hydraulic damping both when opening and when closing the electrical contacts of the vacuum interrupter (11) due to movement of the driving rod (19) and the piston (29).

Description

Vacuum interrupter assembly for a power diverter switch, power diverter switch for a transformer load tap changer and transformer load tap changer

The present disclosure is related to a vacuum interrupter assembly for a power diverter switch. The present disclosure is further related to a corresponding power diverter switch for a transformer load tap changer and to a transformer load tap changer.

Vacuum interrupters are widely used in utility power transmission systems, power generation units and power-distribution systems for railways, for example. Therein, the vacuum interrupter realizes a switch of a medium-voltage circuit-breaker, generator circuit-breaker, or high-voltage circuit-breaker which uses electrical contacts in a vacuum to reliably separate the electrical contacts resulting in a metal vapour arc, which is quickly extinguished.

In this respect, it is a challenge to provide stable and reliable mechanisms to transmit motion to a contact rod of a vacuum interrupter to connect or disconnect electrical contacts.

Embodiments of the present disclosure relate to a vacuum interrupter assembly for a power diverter switch that enables secure and reliable switching of electrical contacts of the vacuum interrupter and contributes to an enhanced life of the vacuum interrupter. Further embodiments of the present disclosure relate to a corresponding power diverter switch

for a transformer load tap changer and a transformer load tap changer including such a vacuum interrupter assembly.

According to an embodiment, a vacuum interrupter assembly for a power diverter switch comprises a vacuum interrupter which is configured to open and close associated electrical contacts, and a driving mechanism which is coupled to the vacuum interrupter and which is configured to drive opening and closing of the electrical contacts of the vacuum interrupter. The driving mechanism includes a driving rod and a guiding tube enclosing the driving rod such that the driving rod is axially movable inside the guiding tube along a longitudinal axis of the vacuum interrupter assembly.

The vacuum interrupter assembly further comprises a damping unit which is coupled to the driving mechanism and includes a first chamber, a second chamber and a piston arranged there between with respect to the longitudinal axis. The chambers are coupled to each other hydraulically and limited by the guiding tube and the piston. The piston is coupled to the driving rod axially movable inside the guiding tube along the longitudinal axis. The damping unit further comprises an elastic member and a shutter element coupled together and arranged inside the second chamber configured to affect hydraulic damping during operation of the vacuum interrupter assembly based on the elastic force caused by the elastic member acting on the shutter element. In interaction with a fluid the damping unit provides hydraulic damping both when opening and when closing the electrical contacts of the vacuum interrupter due to movement of the driving rod and the piston.

Due to the described configuration a vacuum interrupter assembly is feasible that enables secure and reliable switching of electrical contacts of the vacuum interrupter and contributes to reduced wear of interacting components and an enhanced life of the vacuum interrupter and a corresponding power diverter switch. The damping unit realizes a cost-efficient design of a damping mechanism for precise vacuum interrupter control.

It is a recognition of the present disclosure that conventional designs for power diverter switches and control of a vacuum interrupter often has a relatively complex mechanism with many moving parts and modules. These modules are interdependent and follow specific sequences, which lead to their complex design and further difficulties during manufacturing and maintenances.

By use of the vacuum interrupter assembly of the present disclosure and the improved damping system incorporated therein it is possible to counteract the aforementioned adverse effects at least. Due to the simple and compact design of the damping unit including the shutter element and the elastic member acting on it, a precise control of the movement of the driving rod in both directions is possible and the vacuum interrupter assembly contributes to reduce bouncing through closing of the vacuum interrupter and its electrical contacts resulting in reduced wear and enhanced assembly life. The vacuum interrupter assembly can be assembled with a low number of components and enables simplified installation and adjustment processes.

According to an embodiment, the vacuum interrupter assembly further comprises a disc that is fixedly arranged to the

guiding tube and limits the second chamber opposite the piston with respect to the longitudinal axis. The disc comprises at least one orifice defining a fluid passage out and into the second chamber. The disc can further comprise an inner recess defining another fluid passage out and into the second chamber. The elastic member and the shutter element are arranged between and coupled to both the piston and the disc such that the shutter element covers the orifice and/or the inner recess of the disc based on the elastic force caused by the elastic member acting on the shutter element towards the disc. Consequently, when the hydraulic force that is acting on the shutter element in direction towards the elastic member is greater than the elastic force provided by the elastic member the shutter element is pushed in direction towards the elastic member and the orifice is no longer covered.

In principle, the described configuration of the elastic member and the shutter element realizes the function of a pressure relief valve in the damping unit and counteract unwanted pressure fluctuations. The vacuum interrupter assembly is configured to be immersed in a predetermined fluid, for example a mineral transformer oil, inside a tank of a transformer load tap changer and thus, the size of the one or more intentionally implemented fluid openings can influence the hydraulic damping force depending on the viscosity of the fluid or the temperature of the fluid as well.

According to a further embodiment of the vacuum interrupter assembly, the at least one orifice is circularly limited and has a diameter that is formed in coordination with the first chamber and/or the second chamber to provide hydraulic

damping when opening and/or closing the electrical contacts of the vacuum interrupter. The size of the orifice can also be formed in coordination with a viscosity of a fluid that is intended to fill inner spaces in the vacuum interrupter assembly.

According to a further embodiment of the vacuum interrupter assembly, the disc can comprise a central inner recess surrounding the driving rod in a predetermined distance. The shutter element is configured to cover the recess of the disc based on the elastic force caused by the elastic member acting on the shutter element towards the disc.

According to a further embodiment of the vacuum interrupter assembly, the elastic member is formed as or comprises a spring element that encloses the driving rod and that is on the one hand coupled to the piston and on the other hand coupled to the shutter element. The spring element provides a stable and reliable elastic force or spring force given to push the piston and the shutter element away from each other.

According to a further embodiment of the vacuum interrupter assembly, the shutter element is formed as a disc and/or a sleeve that encloses the driving rod. For example, the shutter element comprises a sleeve portion and an adjacent ring portion bigger than the sleeve portion. For example, if the elastic member is formed as the aforementioned spring element it can be stably arranged around the sleeved portion contacting and pushing against the ring portion of the shutter element.

According to a further embodiment of the vacuum interrupter assembly, the piston, the elastic member, the shutter element

and/or if present the disc all are arranged inside the guiding tube along the longitudinal axis radially surrounding the driving rod. Thus, preferably all of the aforementioned elements are arranged radially between the guiding tube and the driving rod and substantially, the guiding tube, the driving rod, the disc, the piston, the shutter element and the elastic member are formed rotationally symmetrical, for example.

According to a further embodiment of the vacuum interrupter assembly, the guiding tube comprises two recesses penetrating a wall of the guiding tube defining a first channel and a second channel hydraulically coupled to the first chamber and the second chamber such that a fluid passage is defined by the first chamber, the first channel, the second channel and the second chamber, wherein the piston is connected to the driving rod at a given position such that it at least temporarily covers the second channel when closing the electrical contacts of the vacuum interrupter and it at least temporarily covers the first channel when opening the electrical contacts of the vacuum interrupter due to movement of the driving rod.

Thus, in view of an arrangement of the disc inside the guiding tube, a fluid could flow from an open space outside the guiding tube through the orifice of the disc into the guiding tube and the second chamber and then through the second channel out of the guiding tube again. Accordingly, fluid from outside can flow through the second channel into the guiding tube and from inside through the orifice of the disc to the outside again. Moreover, fluid from outside can flow through the first channel into the guiding tube at opposite side of the piston with respect to the disc. The

permitted flow direction depends on the size and the position of the piston inside the guiding tube. To beneficially control the fluid flow and the hydraulic damping force, the piston is connected to the driving rod such that it closes the first channel when opening the electrical contacts of the vacuum interrupter and such that it closes the second channel when closing the electrical contacts of the vacuum interrupter due to movement of the driving rod. Thus, preferably a distance of the first and the second channel is configured in coordination with a thickness of the piston with respect to the longitudinal axis.

According to a further embodiment of the vacuum interrupter assembly, a size of the piston and/or a size of the shutter element and/or a size of the orifice of the disc and/or a size of the recess of the disc and/or a location of the first and the second channel in the wall of the guiding tube are configured in coordination with each other to provide a predetermined hydraulic damping force in interaction with a fluid that is intended to flow inside and outside the guiding tube with respect to an operational state of the vacuum interrupter assembly.

Alternatively or additionally, the orifice of the disc and the first channel and the second channel comprise a respective size configured in coordination with a given viscosity of a fluid that is intended to flow inside and outside the guiding tube to provide a predetermined hydraulic damping force in interaction with the fluid during operation of the vacuum interrupter assembly. The fluid is intended to wash around the vacuum interrupter assembly and to flow inside and outside the guiding tube with respect to an operational state of the vacuum interrupter assembly.

At least one orifice of the disc can comprise a circular shape or is limited circularly by the disc and may have a diameter of 0.5 mm to 3 mm. The orifice of the disc may have a diameter of 1 mm to 2mm. Thus, a higher damping force can be provided using a smaller orifice. The disc can further comprise a second or more orifices which can have the same or different size.

According to an embodiment, a power diverter switch for a transformer load tap changer comprises an insulation plate, a control cam and an embodiment of the described vacuum interrupter assembly, which is coupled to both the insulation plate and the control cam. The control cam is configured to drive the driving mechanism of the vacuum interrupter assembly in order to open or close the electrical contacts of the vacuum interrupter.

According to an embodiment, a transformer load tap changer for setting a gear ratio comprises a tank that encloses a fluid and at least one embodiment of the aforementioned power diverter switch which is arranged inside the tank immersed in the fluid.

Such a configuration of a power diverter switch and a transformer load tap changer using an embodiment of the described vacuum interrupter assembly with an improved damper enables secure and reliable switching or separation of electrical contacts of the vacuum interrupter.

As a result of that the power diverter switch and the transformer load tap changer comprise an embodiment of the vacuum interrupter assembly, described features and

characteristics of the vacuum interrupter assembly are also disclosed with respect to the power diverter switch and the transformer load tap changer and vice versa. Thus, the present disclosure comprises several aspects, wherein every feature described with respect to one of the aspects is also disclosed herein with respect to the other aspect, even if the respective feature is not explicitly mentioned in the context of the specific aspect.

The damping unit comprises the piston, the shutter element and the elastic member and interacts with features on the guiding tube and the driving rod of the vacuum interrupter mechanism. The shutter element, the piston and the elastic member are preferably included in combination with exact position of holes, orifices and/or channels on the guiding which allow to reach precise moment of the damp force action. In addition, the diameter of the one or more orifices, holes and/or channels enable to achieve necessary reactance of the fluid and respectively the damping force. Accordingly, it is possible to protect against unwanted vacuum effects caused by differences in viscosity at different temperatures which can be a major problem with mechanisms that operate over a wide temperature range. For example, the temperature range can be from −25°C to 100°C. Lower and/or higher temperature ranges are possible as well.

Moreover, it is feasible to achieve required opening and closing speeds of the vacuum interrupter as well as reducing the unwanted bouncing effect. Opening speed can be 0.4–0.6 m/s on average and with a maximum speed in the beginning of opening the electrical contacts with 1 m/s, for example. Closing speed can be 0.1–0.4 m/s on average, for example.

Lower and/or higher opening and/or closing speeds are possible as well.

With respect to an operational state assembled in the transformer the described configuration of the vacuum interrupter assembly and its specific hydraulic damper are immersed in a dielectric fluid and allows for beneficial control of opening and closing the electrical contacts of the vacuum interrupter. The damping unit with the piston, the shutter element and the orifice disc enables precise and reliable operating mode of the vacuum interrupter and the transformer load the tap changer, respectively. The described configuration allows for a cost-effective assembly with an improved damping implemented in the driving mechanism and in addition one or more of the following advantageous effects:

- precise control of the movement of the driving rod in two directions
- reduced bouncing through closing of the vacuum interrupter
- control of the opening and closing speed of the vacuum interrupter
- simple and clear design
- improved stability and reliable function even in high temperature ranges up to 100°C or higher.

Exemplary embodiments are explained in the following with the aid of schematic drawings and reference numbers. The figures show:

Figures 1–8 an embodiment of a vacuum interrupter module for a transformer load tap changer in different views, and

Figures 9–17 embodiments of components of a damping unit of the vacuum interrupter module in different views.

The accompanying figures are included to provide a further understanding. It is to be understood that the embodiments shown in the figures are illustrative representations and are not necessarily drawn to scale. Identical reference numbers designate elements or components with identical functions. In so far as elements or components correspond to one another in terms of their function in different figures, the description thereof is not repeated for each of the following figures. For the sake of clarity elements might not appear with corresponding reference symbols in all figures possibly.

Figure 1 illustrates a power diverter switch assembly or vacuum interrupter module 1 of a transformer load tap changer in a perspective view. The figures 2 to 8 show different cross section and/or perspective views of the vacuum interrupter module 1 or components thereof. The vacuum interrupter module 1 is intended to be arranged in a tank of a transformer load tap changer. The tank is configured to enclose a fluid, and one or more power diverter switches are arranged inside the tank and immersed in the fluid.

The vacuum interrupter module 1 comprises an insulation plate 3 and a current transformer 2 attached to the insulation plate 3. The insulation plate 3 forms a support structure for the vacuum interrupter module 1 and may be composed of a

rigid dielectric material, such as fiber-reinforced dielectric plastic. On a front side of the insulation plate 3 a bypass switch assembly and a vacuum interrupter assembly 10 is mounted. A back-side of the insulation plate 3 can be used for carrying copper bars used for schematic connection. Incoming motion from a selector is transferred to a cam end of a control cam 13 through the means of insulation shafts. The control cam 13 is configured to actuate the bypass contacts 4 through corresponding bypass levers 5. At the same time the control cam 13 is configured to load and discharge a spring accumulator inside a driving mechanism 12 of the vacuum interrupter assembly 10.

The vacuum interrupter module 1 comprises the vacuum interrupter assembly 10 including a vacuum interrupter 11 and the driving mechanism 12 that is coupled with the vacuum interrupter 11 and that is configured to drive opening and closing of electrical contacts of the vacuum interrupter 11. A corresponding transformer load tap changer and respective vacuum interrupter modules 1 may further include for each phase a winding, a selector switch assembly and a bypass switch module. The selector switch assembly can be configured to make connections between taps, while the bypass switch module may be configured to connect the tap to a main power source. During tap changes, the vacuum interrupter module 1 safely carries the current between the tap and a main power circuit. A drive system is configured to move a selector switch, the bypass switch module and the vacuum interrupter module 1. The vacuum interrupter module 1 further comprises a driving spring 14, guiding bushings 15 and a guiding pin 17 all arranged inside a housing 16. The guiding tube 18 is penetrating the housing 16 and is connected to flanges 33 at respective opposite sides outside the housing 16.

The vacuum interrupter 11 is configured to open and close the associated electrical contacts. An opening speed can be set at 0.45–0.55 m/s on average, for example, wherein preferably starting of the opening process is performed with higher speed than finishing. Closing speed can be set at 0.2–0.3 m/s on average, for example, wherein preferably starting of the closing process is performed with a higher speed than finishing. The opening and closing of the electrical contacts is driven by the driving mechanism which includes a driving rod 19 and a guiding tube 18 enclosing the driving rod 19. The driving rod 19 is arranged axially movable inside the guiding tube 18 along a longitudinal axis L of the vacuum interrupter assembly 10.

The vacuum interrupter assembly 10 further includes a damping unit 20 coupled to the driving mechanism 12. The damping unit 20 comprises a first chamber 21, a second chamber 22 and a piston 29 arranged there between with respect to the longitudinal axis L (e.g. see Figs. 3 and 4). The chambers 21, 22 are coupled to each other hydraulically and limited by the guiding tube 18 and the piston 29. The piston is fixed to the driving rod 19 by means of a fixing element 30. The vacuum interrupter assembly 10 further comprises a disc 25 with orifices 27 (see Figs. 9–12) arranged inside the guiding tube 18 that limits the second chamber 22 on the other side opposite the piston 29. Thus, the second chamber 22 is smaller than the first chamber 21 and predominantly affects damping force and hydraulic effect of the damping unit 20. The first chamber 21 is a relative open volume inside the guiding tube 18 and therefore may be designated alternatively as an open space or free volume. On the other side of the disc 25 opposite the second chamber 22 there is an open space

36 which is connected to the remaining volume in the tank of the transformer.

The disc 25 with its upper and lower orifice 27 is fixed in its position relative to the guiding tube 18. The piston 29 is coupled to the driving rod 19 axially movable inside the guiding tube 18 along the longitudinal axis L. Thus, the second chamber 22 is closed in the space between the piston 29 and the disc 25 with a predefined and changeable volume depending on the movement of the piston 29. For example, a stroke of the piston 29 is about 3–6 mm depending on settings and erosion in the vacuum interrupter electrical contacts. Preferably, the disc 25 comprises a sealing recess 35 (see Figs. 9, 11 and 12) configured to receive a sealing element such as an O-ring 31 that is arranged between the disc 25 and the guiding tube 18 (see Figs. 4–6). The O-ring 31 contributes to prevent unwanted leakage of fluid between the guiding tube 18 and the disc 25 such that the fluid has to pass the orifices 27 and if present an inner disc recess 32 which allows further flow if released (see Figs. 4, 5, 9 and 10). Thus, the disc 25 is formed surrounding the driving rod 19 contacting it or with a given distance away from it. The orifices 27 and if present the inner disc recess 32 define respective fluid passages out and into the second chamber 22.

The damping unit 20 further comprises an elastic member formed as a spring element 26 and a sleeve-shaped shutter element 28 coupled together and both arranged inside the second chamber 22 surrounding the driving rod 19. The shutter element 28 comprises a ring portion 282 and a sleeve portion 281 adjacent to the ring portion 282 both limiting a central recess 283 (see Figs. 13–17). The spring element 26 and the shutter element 28 are configured to affect hydraulic damping

during operation of the vacuum interrupter assembly 10 based on the spring force caused by the spring element 26. The spring element 26 is arranged between the piston 29 and the shutter element 28 contacting both. The spring element 26 is partially arranged around the sleeve portion 281 and presses against the ring portion 282 of the shutter element 28 and against the piston 29 on the opposite side. Accordingly, the spring element 26 acts on the shutter element 28 with a spring force depending on the formation of the spring element 28 itself and depending on the position of the piston 29. The shutter element 28 is configured to force-dependent cover the fluid passages through the disc 25 formed by the orifices 27 (see Fig. 3) and/or by the central disc recess 32 (see Fig. 4), such that in interaction with a fluid the damping unit 20 provides hydraulic damping both when opening and when closing the electrical contacts of the vacuum interrupter 11 due to movement of the driving rod 19 and the piston 29.

The guiding tube 18 comprises two recesses penetrating a wall defining a first channel 23 and a second channel 24 hydraulically coupled to the first chamber 21 and the second chamber 22. Consequently, a fluid passage is defined by the first chamber 21, the first channel 23, the second channel 24, the second chamber 22 and the orifices 27. The piston 29 is connected to the driving rod 19 at a given position such that it at least temporarily covers the second channel 24 when closing the electrical contacts of the vacuum interrupter 11 and it at least temporarily covers the first channel 23 when opening the electrical contacts of the vacuum interrupter 11 due to movement of the driving rod 19.

When opening the vacuum interrupter 11 or its electrical contacts, there is a movement to the left with respect to the

orientations as shown in the figures. When moving the driving rod 19 and the fixed piston 29, the opening movement basically includes two sections. A first movement can be set until the piston 29 reaches the first channel 23 in the guiding tube 18, and the second movement after the piston 29 has passed this point or the first channel 23 which is associated to an opened vacuum interrupter 11.

In the first movement, at the set opening speeds, the fluid is sucked from the external environment and from the open space 36 through the disc 25 and the second channel 24 into second chamber 22 and a vacuum effect is observed. The spring element 26 and the shutter element 28 realize a pressure relief valve. As in this case, under the influence of vacuum, the force of the spring element 26 is overcome and a free zone is released for the entry of fluid into the second chamber 22. In the second movement, there is a consciously introduced fluid leakage through the first channel 23 which is an additional released hole now in the guiding tube 18, such that a decrease in the speed of the piston 29 and respectively the driving rod 19 is initiated.

When closing the vacuum interrupter 11 or its electrical contacts, there is a movement to the right with respect to the orientations as shown in the figures. Here again, the closing movement can be divided into two sections, but in reverse order. In the first movement or section, the piston 29 passes the first channel 23 in the tube and covers the second channel 24. In the first movement, the driving rod 19 and the piston 29 are moved with a higher closing speed. The fluid has the possibility to flow both through the small holes of the orifices 27 and through the first channel 23 in the guiding tube 18. In the second movement or section of the

stroke of the piston 29, the closing speed drops because the fluid flows only through the two small holes of the orifices 27, while the pressure built up in the second chamber 22 creates a tight contact such that the shutter element 28 strongly covers the inner recess 32 of the disc 25 (see Fig. 4).

According to the embodiment as shown in Fig. 3 the shutter element 28 is preferably formed to cover a percentage of the one or more orifices 27. The damping fluid can escape through the free portion of the orifice 27, but much restricted in the compressive direction. If the contact should bounce back up, it can do that with less restriction as a check valve shudder will open again on vacuum. In this way it doesn't make many bounces converting this energy to heat passing it thought the restrictions. Alternatively or additionally, there can be another path for the fluid to enter or exit the second chamber 22.

The precise positions of the channels 23, 24 in the wall of the guiding tube 18 enables to provide an exact moment of the damping force and with default of a diameter of the orifices 27 it is possible to achieve a desired reactance of the fluid – respectively damping force. Due to such a configuration, the damping unit 20 enables to beneficially influence the opening and closing speeds of the vacuum interrupter 11 and reduce unwanted bouncing effects during closing of the vacuum interrupter 11. The described vacuum interrupter assembly 10 provides a beneficial robustness and contributes to reduced manufacturability and maintenance criteria.

The embodiments shown in the Figures 1 to 7 as stated represent exemplary embodiments of the improved vacuum

interrupter assembly 10, the power diverter switch or vacuum interrupter module 1 and the transformer load tap changer, respectively. Therefore, they do not constitute a complete list of all embodiments. Actual arrangements may vary from the embodiments shown in the figures.

Reference signs

1	vacuum interrupter module
2	current transformer
3	insulation plate
4	bypass contact
5	bypass lever
10	vacuum interrupter assembly
11	vacuum interrupter
12	driving mechanism
13	control cam
14	driving spring
15	guiding bushing
16	housing
17	guiding pin
18	guiding tube
19	driving rod
20	damping unit
21	first chamber
22	second chamber
23	first channel
24	second channel
25	disc
26	spring element
27	orifice
28	shutter element
281	sleeve portion
282	ring portion
283	shutter recess
29	piston
30	fixing element
31	sealing element
32	disc recess

33 flange
34 adjusting unit
35 sealing recess
36 open space

L longitudinal axis of the vacuum interrupter assembly

Claims

1. Vacuum interrupter assembly (10) for a power diverter switch, comprising:

- a vacuum interrupter (11) which is configured to open and close associated electrical contacts,

- a driving mechanism (12) which is coupled to the vacuum interrupter (11) and which is configured to drive opening and closing of the electrical contacts of the vacuum interrupter (11), wherein the driving mechanism (12) includes a driving rod (19) and a guiding tube (18) enclosing the driving rod (19) such that the driving rod (19) is axially movable inside the guiding tube (18) along a longitudinal axis (L) of the vacuum interrupter assembly (10), and

- a damping unit (20) coupled to the driving mechanism (12) and comprising a first chamber (21), a second chamber (22) and a piston (29) arranged there between with respect to the longitudinal axis (L), wherein the chambers (21, 22) are coupled to each other hydraulically and limited by the guiding tube (18) and the piston (29), and wherein the piston (29) is coupled to the driving rod (19) axially movable inside the guiding tube (18) along the longitudinal axis (L), and wherein the damping unit (20) further comprises an elastic member (26) and a shutter element (28) coupled together and arranged inside the second chamber (22) configured to affect hydraulic damping during operation of the vacuum interrupter assembly (10) based on the elastic force caused by the elastic member (26) and acting on the shutter element (28), such that in interaction with a fluid the damping unit (20) provides hydraulic damping both when opening and when closing the electrical contacts of the vacuum interrupter (11) due to movement of the driving rod (19) and the piston (29).

2. Vacuum interrupter assembly (10) according to claim 1, comprising:

a disc (25) that is fixedly arranged to the guiding tube (18) and limits the second chamber (22) opposite the piston (29), wherein the disc (25) comprises at least one orifice (27) defining a fluid passage out and into the second chamber (22), and wherein the elastic member (26) and the shutter element (28) are arranged between the piston (29) and the disc (25) such that the shutter element (28) covers the orifice (27) of the disc (25) based on the elastic force caused by the elastic member (26) acting on the shutter element (28) towards the disc (25).

3. Vacuum interrupter assembly (10) according to claim 2, preceding claims, wherein the at least one orifice (27) is circularly limited and has a diameter that is formed in coordination with the first chamber (21) and/or the second chamber (22) to provide hydraulic damping when opening and/or closing the electrical contacts of the vacuum interrupter (11).

4. Vacuum interrupter assembly (10) according to any of the preceding claims, wherein the disc (25) comprises a central recess (32) surrounding the driving rod (19) in a predetermined distance, and wherein the shutter element (28) covers the recess (32) of the disc (25) based on the elastic force caused by the elastic member (26) acting on the shutter element (28) towards the disc (25).

5. Vacuum interrupter assembly (10) according to any of the preceding claims, wherein the elastic member (26) comprises a spring element that encloses the driving rod (19) and that is

on the one hand coupled to the piston (29) and on the other hand coupled to the shutter element (28).

6. Vacuum interrupter assembly (10) according to any of the preceding claims, wherein the shutter element (28) is formed as a disc and/or a sleeve that encloses the driving rod (19).

7. Vacuum interrupter assembly (10) according to any of the preceding claims, wherein the piston (29), the elastic member (26), the shutter element (28) and/or the disc (25) all are arranged inside the guiding tube (18) along the longitudinal axis (L) surrounding the driving rod (19).

8. Vacuum interrupter assembly (10) according to any one of the preceding claims, wherein the guiding tube (18) comprises two recesses penetrating a wall of the guiding tube (18) defining a first channel (23) and a second channel (24) hydraulically coupled to the first chamber (21) and the second chamber (22) such that a fluid passage is defined by the first chamber (21), the first channel (23), the second channel (24) and the second chamber (22), wherein the piston (29) is connected to the driving rod (19) at a given position such that it covers the second channel (24) when closing the electrical contacts of the vacuum interrupter (11) and it at least temporarily covers the first channel (23) when opening the electrical contacts of the vacuum interrupter (11) due to movement of the driving rod (19).

9. Vacuum interrupter assembly (10) according to any one of the preceding claims, wherein a size of the piston (29) and/or a size of the shutter element (28) and/or a size of the orifice of the disc (25) and/or a size of the recess (32) of the disc (25) and/or a location of the first and the

second channel (23, 24) in the wall of the guiding tube (18) are configured in coordination with each other to provide a predetermined hydraulic damping force in interaction with a fluid that is intended to flow inside and outside the guiding tube (18) with respect to an operational state of the vacuum interrupter assembly (10).

10. Vacuum interrupter assembly (10) according to claim 8 or 9, wherein the orifice (27) of the disc (25) and the first channel (23) and the second channel (24) comprise a respective size configured in coordination with a given viscosity of a fluid that is intended to flow inside and outside the guiding tube (18) to provide a predetermined hydraulic damping force in interaction with the fluid during operation of the vacuum interrupter assembly (10).

11. Power diverter switch for a transformer load tap changer, comprising:

- an insulation plate (3),
- a control cam (13), and
- a vacuum interrupter assembly (10) according to one of the preceding claims, that is coupled to both the insulation plate (3) and the control cam (13), wherein the control cam (13) is configured to drive the driving mechanism (12) of the vacuum interrupter assembly (10) to open and close the electrical contacts of the vacuum interrupter (11).

12. Transformer load tap changer, comprising:

- a tank that encloses a fluid, and
- at least one power diverter switch according to claim 11, that is arranged inside the tank and immersed in the fluid.

Fig. 1

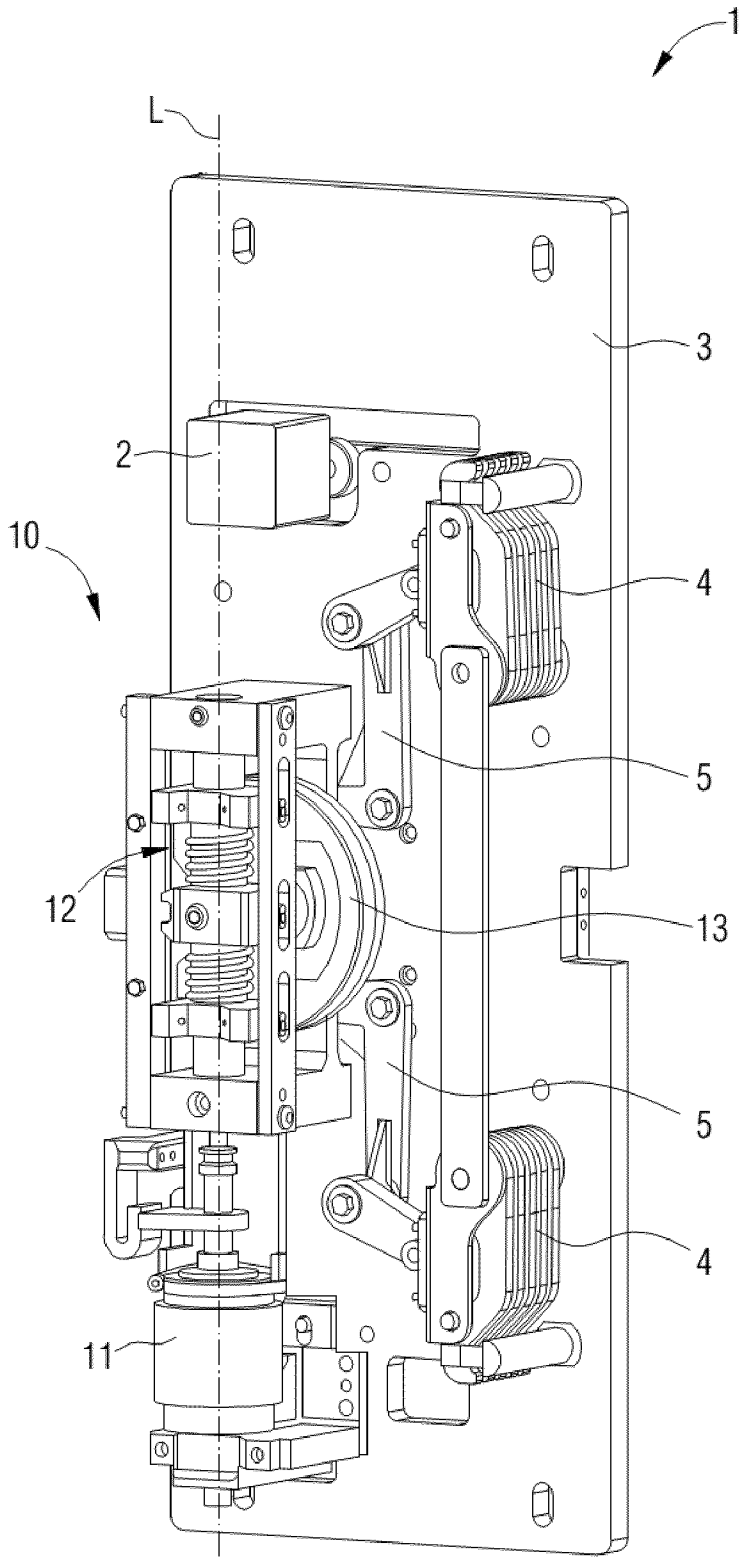

Fig. 2

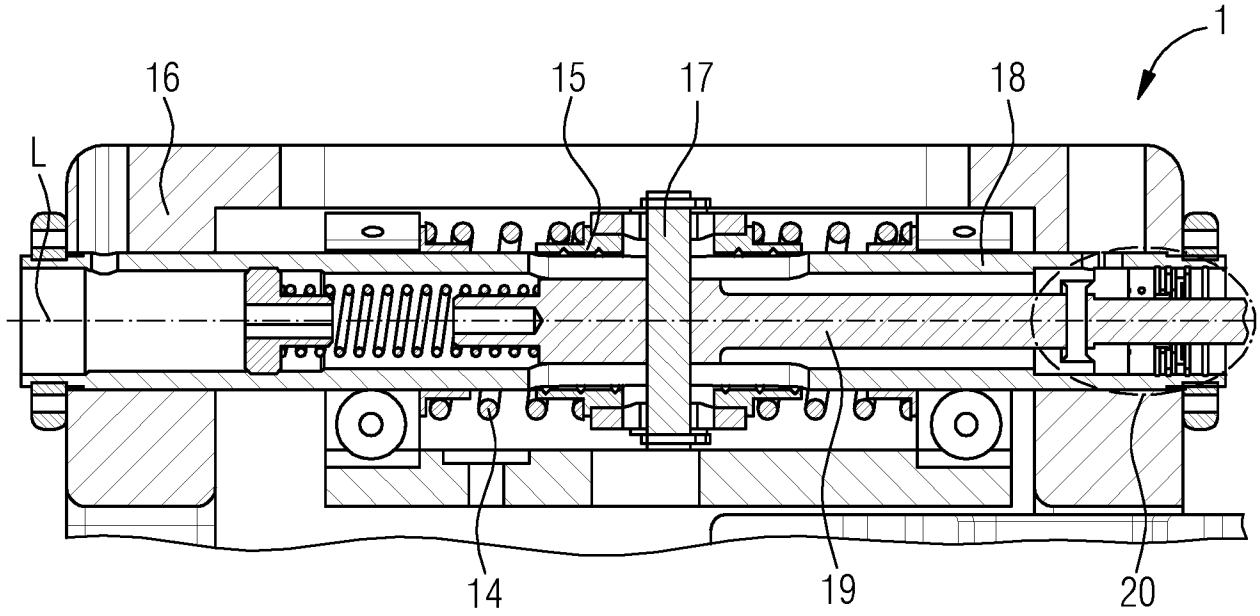

Fig. 3

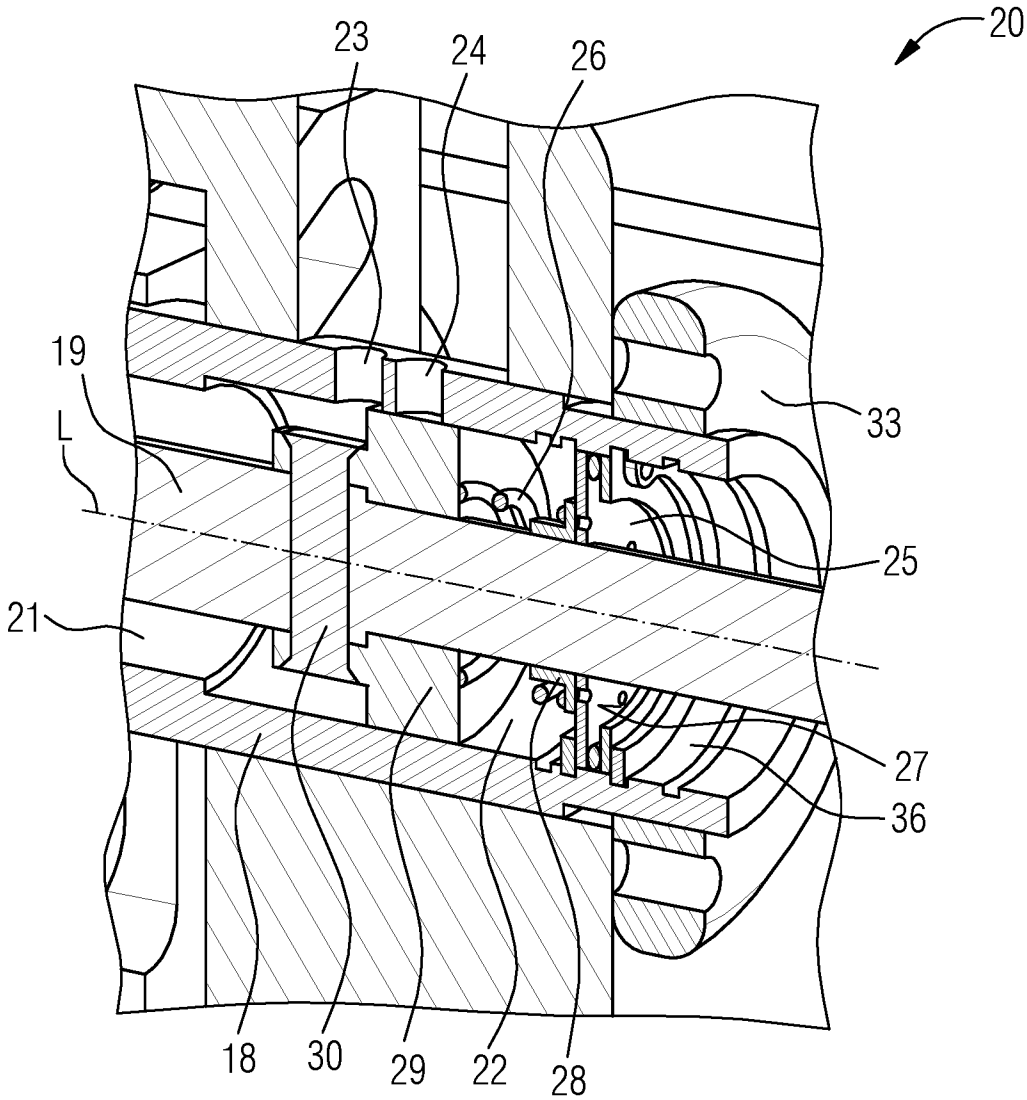

Fig. 4

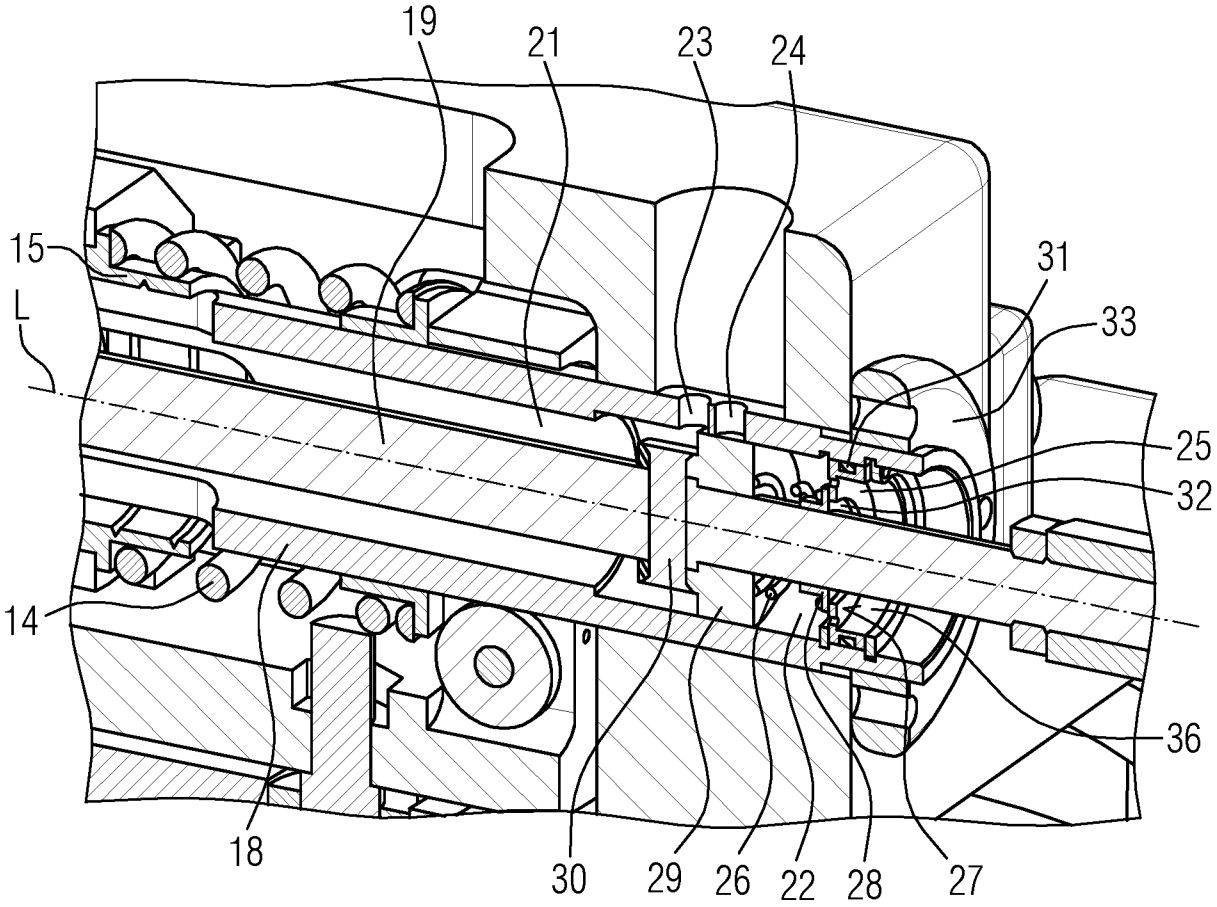
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Fig. 5

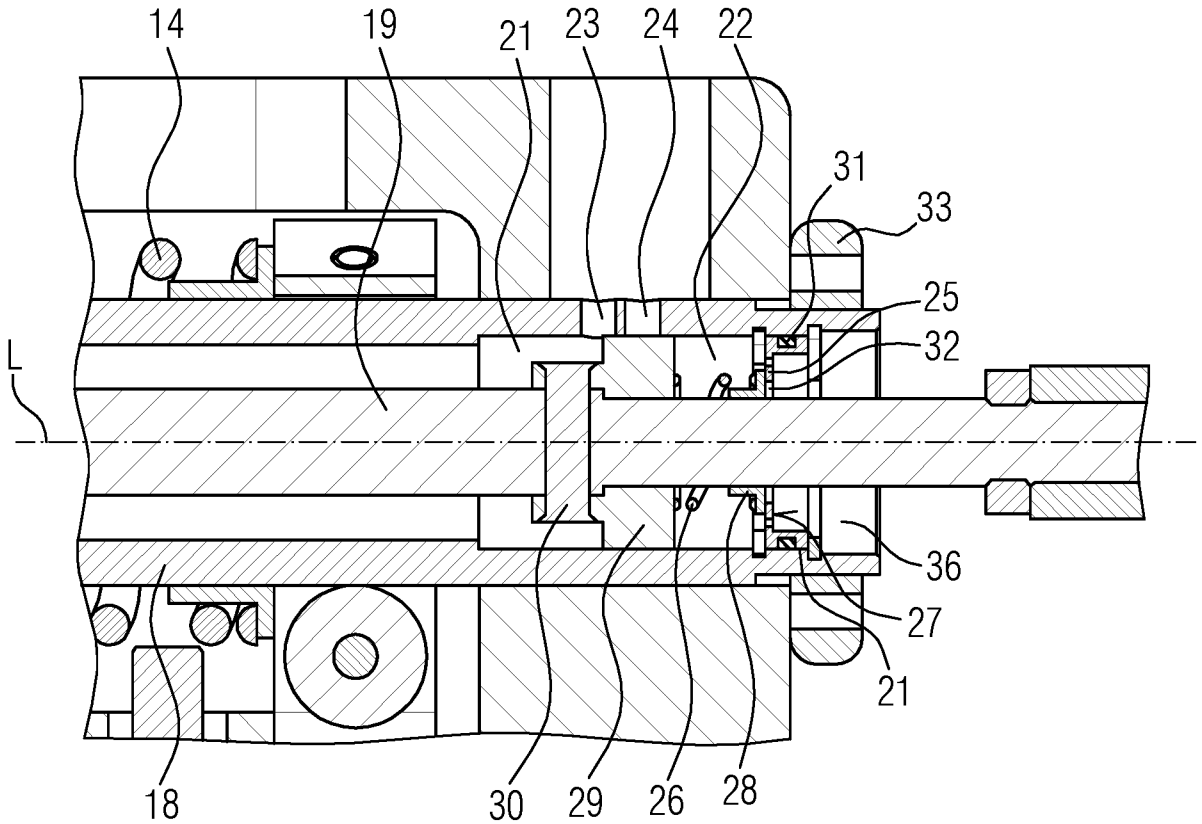
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Fig. 6

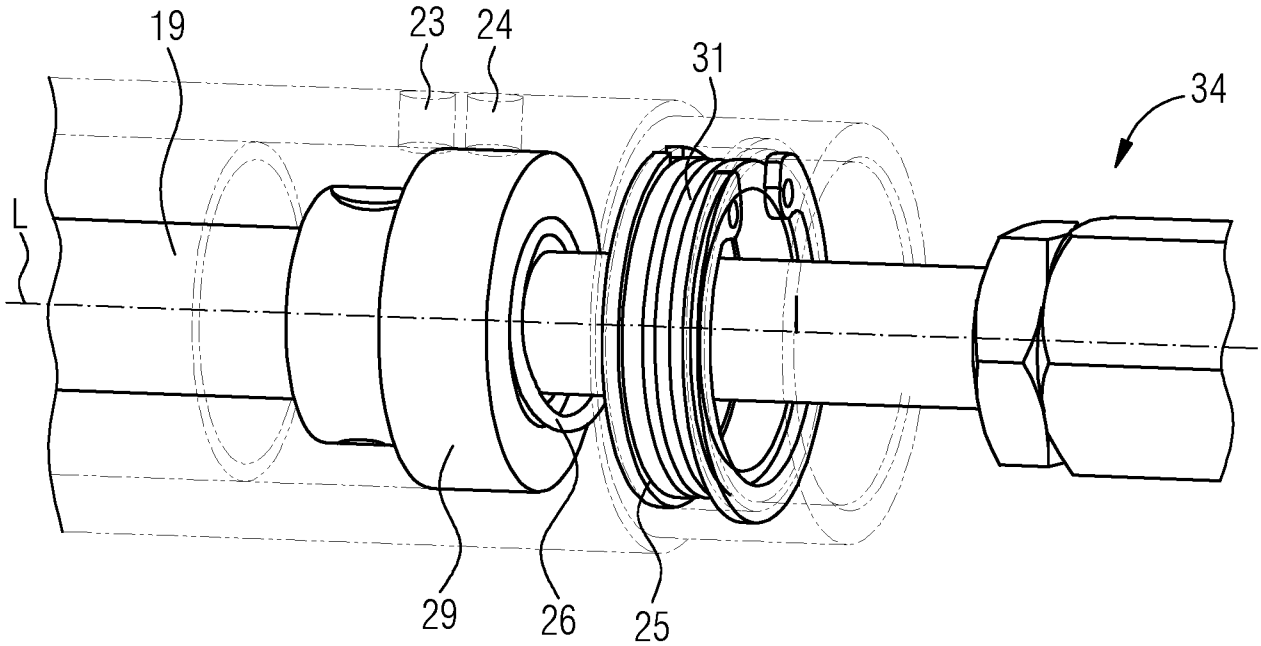


Fig. 7

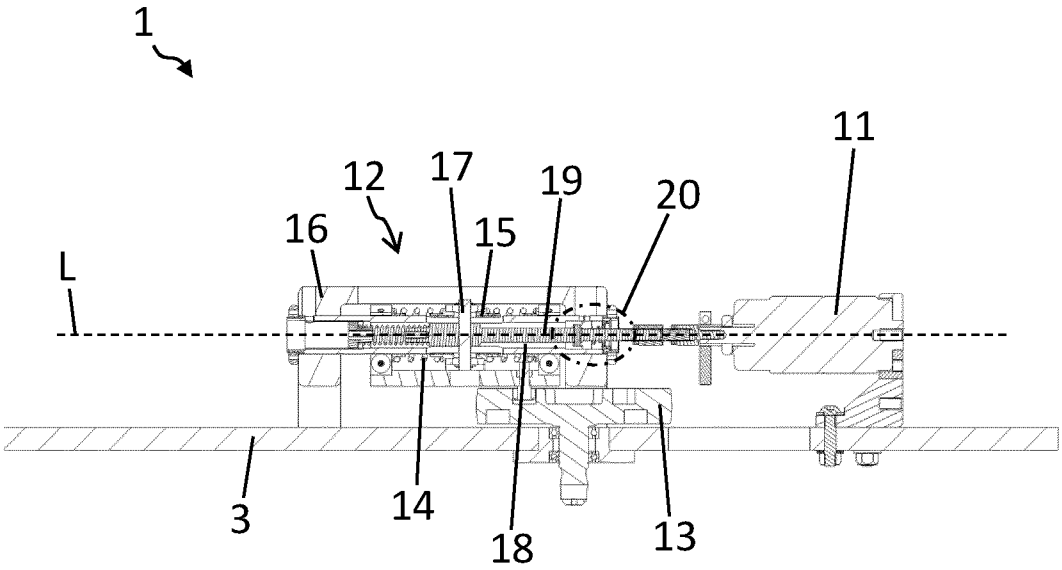


Fig. 8

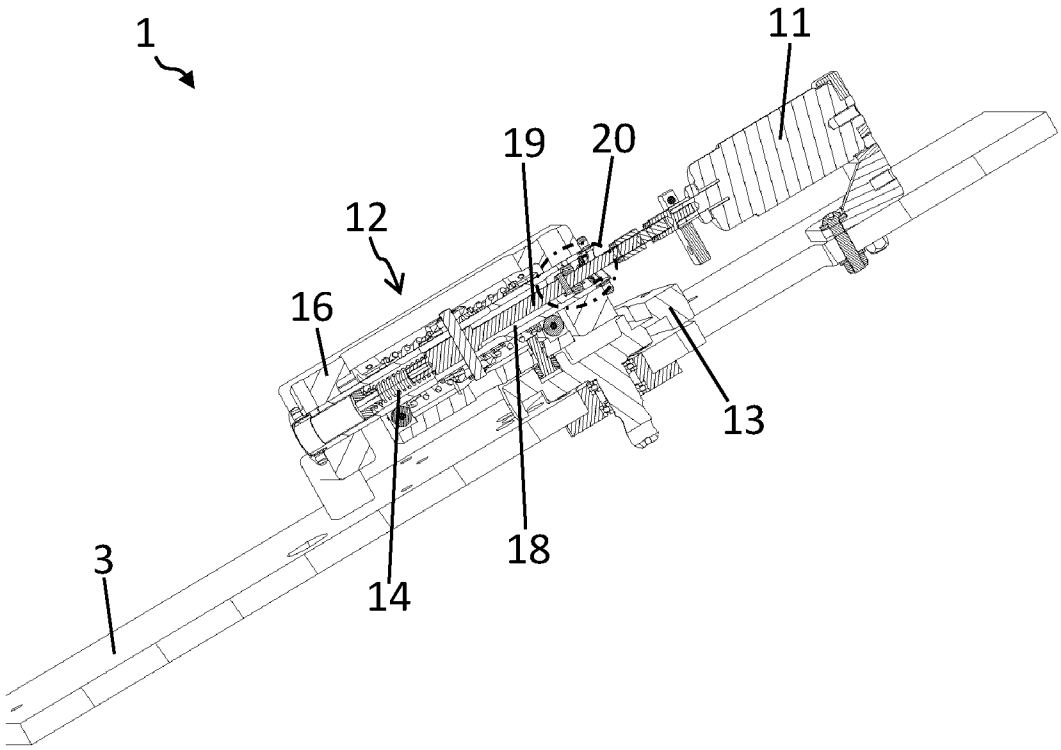


Fig. 9

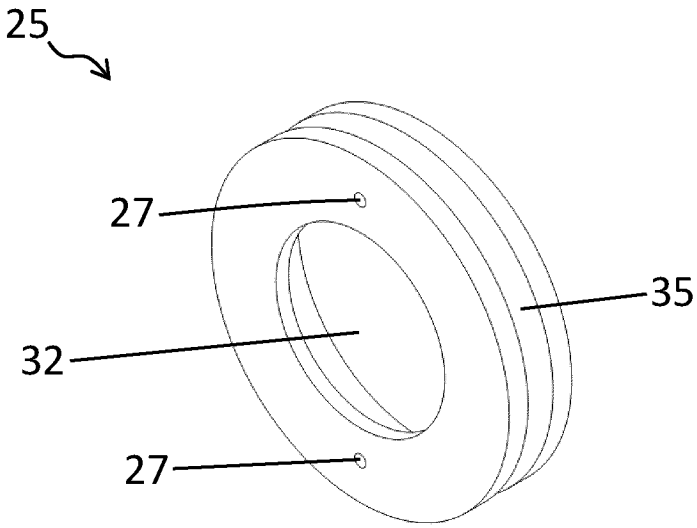


Fig. 10

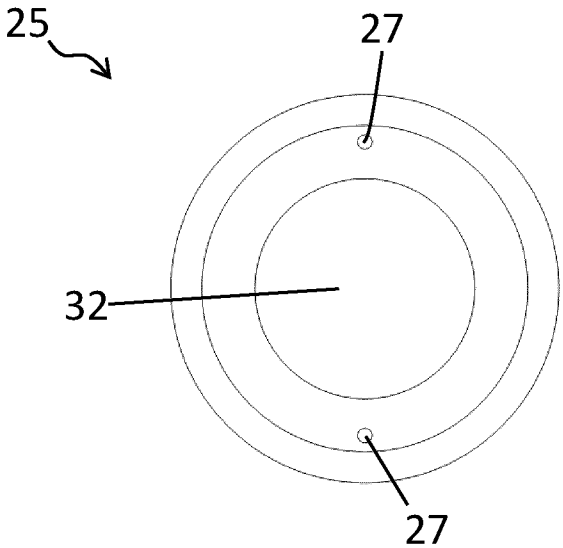


Fig. 11

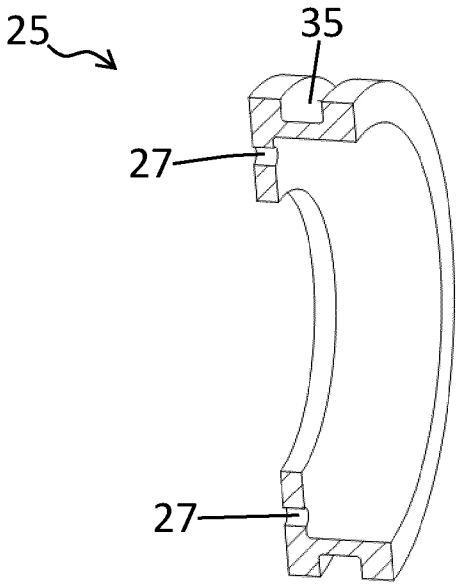


Fig. 12

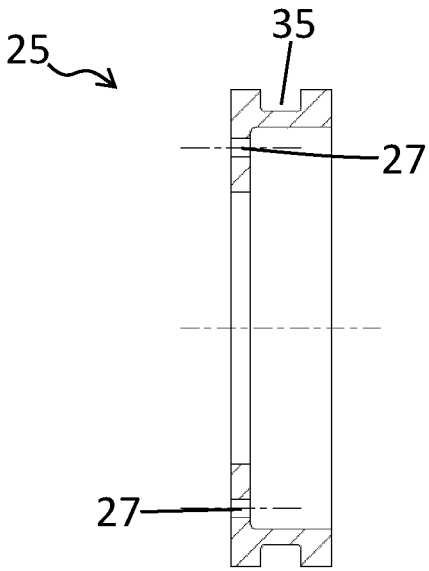


Fig. 13

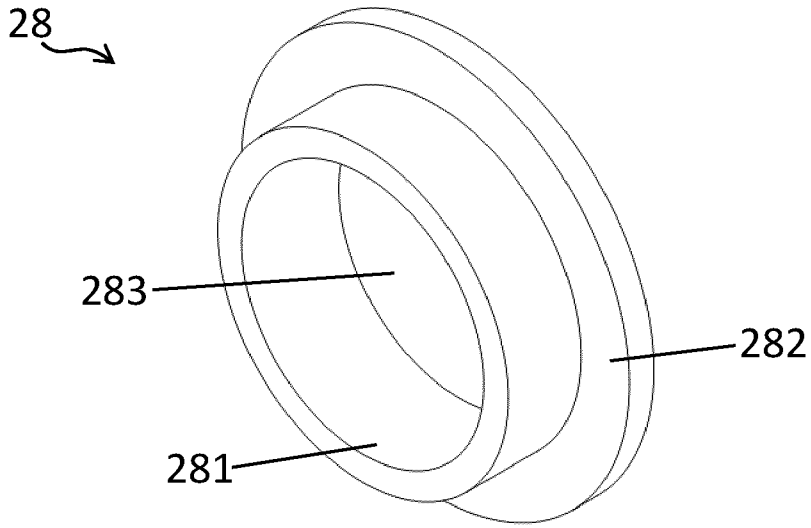


Fig. 14

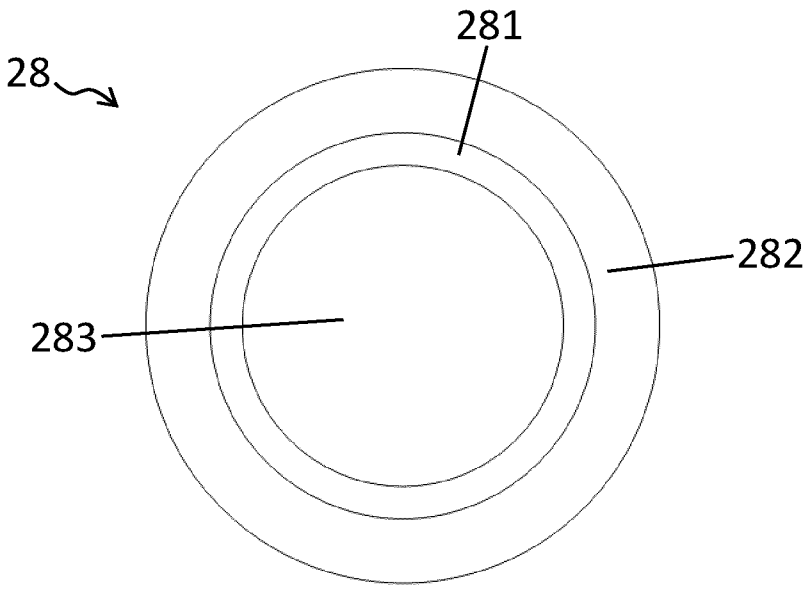


Fig. 15

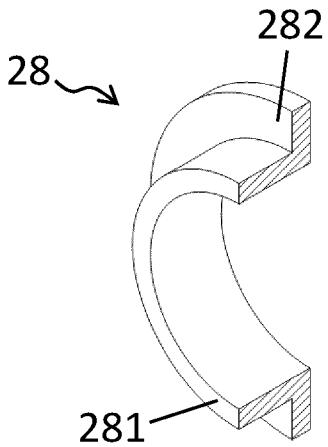


Fig. 16

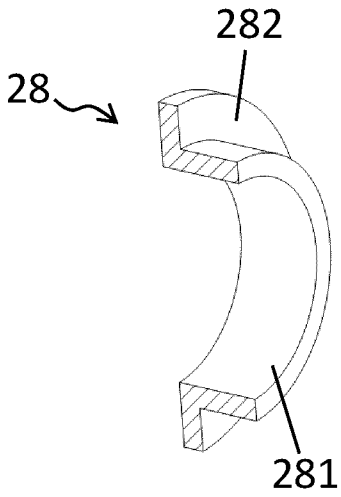
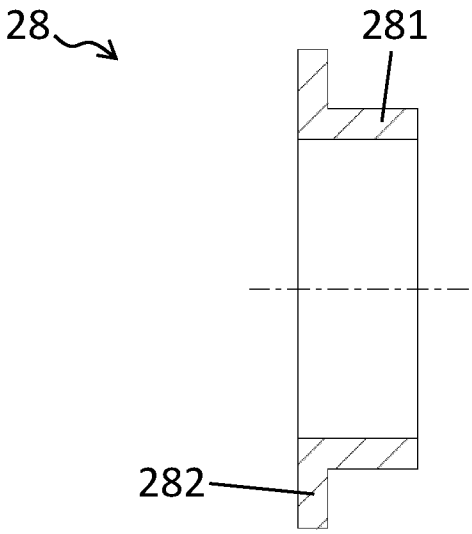


Fig. 17



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/073345

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01H3/60
ADD. H01H33/666

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 4 084 033 A1 (HITACHI ENERGY SWITZERLAND AG [CH]) 2 November 2022 (2022-11-02) paragraphs [0017], [0018]; figure 3	1-12
A	DE 10 2014 102929 A1 (ABB TECHNOLOGY AG [CH]) 10 September 2015 (2015-09-10) paragraphs [0051] - [0057]; figures 4,5A,5B	1-12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2024	29/02/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Arenz, Rainer

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/073345

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