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# (54) A DISCONNECTING SYSTEM FOR CURRENT INTERRUPTION IN A TRANSFORMER


(57) The present invention relates to a disconnecting system (1;1') for current interruption in a transformer which transformer has vacuum interrupter (7) as current interrupting element placed inside the tank (2) of the transformer filled with the insulation medium (3).The vacuum interrupter (7) is equipped with a fixed contact (7b) and a movable contact (7a) and the movable contact (7a) of the vacuum interrupter (7) is connected mechanically with an elastic membrane (9) closing the compartment (10) of a bi-stable actuating device (8; 8') and the membrane (9) is in contact with a compressible medium (11) filling the compartment (10) and being in contact with the insulation medium (3) of the transformer.


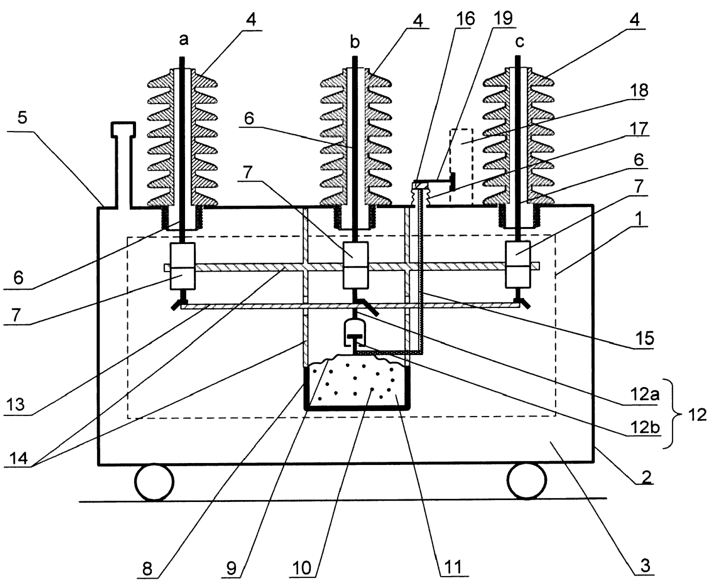


Fig.1

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## Description

**[0001]** The present invention relates to a disconnecting system for current interruption in a transformer which transformer is equipped with vacuum interrupters as current interrupting elements. In more details the disconnecting system can be used as an autonomous protection system for an oil filled transformer.

**[0002]** In electrical power networks many thousands of oil filled distribution transformers, rated most commonly at between 50 and 1000 kVA, are installed. While the transformer is considered one of the most reliable components in a network, still transformer failures may happen resulting in electricity shortage. One of the least probable, however still possible events is an internal arc in the transformer. This type of internal fault may lead to very fast catastrophic damage as the internal pressure builds up very rapidly. Under such conditions the transformer should be immediately disconnected from the network to minimize the damage and allow for maintaining of operation of the network. In particular relatively small, usually 50 to 300 kVA, pole mounted transformers are in some cases internally protected by a system comprising fuses and a load break switch. Such transformers are known as Totally Protected Transformers (TPC) and are equipped with MV fuses. Tripping at least one of the fuses, as a consequence of a single-phase internal fault activates a 3-phase disconnector. With such a TPC protection system a more reliable protection for the electrical system is achieved.

**[0003]** Fuses are simple, very mature products and their biggest advantage is that the reaction to the SC (Short Circuit) current is very fast as they start limiting the SC current before the prospective first current peak develops. The use of fuses however, has a certain number of drawbacks/shortcomings. Firstly, the fuses are single-use devices. Tripping of the internal fuse always require factory service. If the reason of the trip is an internal fault, the factory service or entire transformer replacement is needed anyway. However, fuse tripping may also be accidental due to temporary overcurrent, not necessary resulting in damaging transformer itself. In this solution, fuse tripping is also a result of oil leak, activating an internal short-circuiting mechanism. Secondly, fuses generate heat while conducting load currents. This limits the nominal current ratings of the fuses and limits the coverage of the transformer power ranges. In practice this solution is applicable to small transformers only, characterized by power of up to several hundreds of kVA.

**[0004]** This limitation is overcame by the use of vacuum interrupters, as described in PCT patent application WO01/91151. The known solution presents the electrical transformer device comprising at least one electrical transformer winding and at least one interrupting device coupled to this windings. The interrupting device includes a vacuum circuit breaker. The movable electrical contact of the circuit breaker is actuated by a magnetic actuator causing the contacts of the circuit breaker to move from closed position to open position and vice versa. The magnetic actuator is activated by an input signal, which may be an electrical current or voltage. The actuation of vacuum interrupters by means of magnetic actuators and use electronic controller has limitations regarding the speed of operation of such a system. Under the internal fault conditions, protection against the transformer tank rapture as a result of an internal pressure built-up should disconnect the transformer within several milliseconds from the occurrence of the fault. This requirement is hard or impossible to achieve by the system described. Moreover, use of the magnetic actuators, a dedicated control unit and measuring devices results in a high size and cost of such a system.

**[0005]** A disconnecting system for current interruption in a transformer has a vacuum interrupter as current interrupting element which is placed inside the tank of the transformer filled with the insulation medium. The vacuum interrupter is equipped with a fixed and with a moveable contact. The movable contact of the vacuum interrupter is connected mechanically with an elastic membrane closing the compartment of a bi-stable actuating device. The membrane is in contact with a compressible medium filling the compartment and being in contact with the insulation medium of the transformer.

**[0006]** Preferably the membrane is connected with the vacuum interrupters trough a coupling member.

**[0007]** Preferably the coupling member has a first coupling element which is connected with the movable contact of the vacuum interrupter and a second coupling element which is connected with the membrane.

**[0008]** Preferably the coupling member is connected with the movable contact of the vacuum interrupter which vacuum interrupter is positioned vertically in the transformer tank.

**[0009]** Alternatively the coupling member has a first coupling element in the form of a pivoting lever which is connected with the movable contact of the vacuum interrupter and the second coupling element is connected with the membrane and with the pivoting lever.

**[0010]** Preferably the coupling member is connected with the movable contact of the vacuum interrupter positioned horizontally in the transformer tank.

**[0011]** Preferably the second coupling element is connected with a float element through a coupling bar pivotally connected with the cover of the tank.

**[0012]** Preferably the second coupling element is connected with a position indicator placed on the cover of the tank or on the bi-stable actuating device.

**[0013]** Preferably the second coupling element is connected with an external motor drive unit placed on the cover of the tank.

**[0014]** Preferably the disconnecting system is adapted for a three phase transformer.

**[0015]** Preferably the movable contacts of the three vacuum interrupters are rigidly connected with a dielectric bar.

**[0016]** The system according to the present invention, comprising pressure-activated bi-stable actuator and vacuum interrupters solves the problems mentioned above in a simple and cost-efficient way. The system according to the present invention is capable of autonomous, fast reaction to internal arc as it is activated by internal pressure build-up inside the transformer tank. Due to very low contact resistance of typical vacuum interrupters the system could be applied to protecting transformers of several MVA power ratings. Elimination of fuses, as current interrupting elements makes it possible to re-set the disconnecting system on site in case of accidental tripping. Therefore the present disconnecting system solves the shortcomings of the systems and devices known from the prior art as it immediately reacts to the overpressure inside the transformer tank and breaks short-circuit current disconnecting the faulty transformer from the network. The reaction is autonomous, without the time consuming process of measuring the operating parameters of the transformer, processing the electrical signals, and tripping the conventional actuating system. Accidental tripping of the device, as opposed to the known solution comprising fuses, does not require factory service of the transformer as the disconnecting system re-setting can be performed on site.

**[0017]** The system according to the invention is presented in the exemplary embodiments on the drawing, where:

Fig.1 shows a disconnecting system in a first embodiment of the invention, which is in installed in a three phase transformer, in the schematic face view of the three phase transformer,

Fig.2 shows details of the disconnecting system from the fig.1 in a closed position for the one phase,

Fig.3 shows details of the disconnecting system from the fig.1 in an open position for the one phase,

Fig.4 shows a graph of a mechanical displacement of an actuating device of the disconnecting system as a function of the force applied on the actuator,

Fig.5 shows a part of the disconnecting system in a first variant of a second embodiment of the invention, which is installed in the transformer, which is shown partially in a schematic side view of the transformer,

Fig.6 shows a part of disconnecting system in a second variant of a second embodiment of the invention, which is in installed in the transformer, which is shown partially as in a schematic side view of the transformer.

Technical description

**[0018]** The disconnecting system 1 according to the first embodiment of the present invention is placed in the three phase transformer tank 2 filled with an insulation medium, preferably oil 3. No single phase transformer is presented in the exemplary embodiment but the invention relates also to such a transformer. The three bushings 4 for the current supply phase a,b,c are mounted in a cover 5 of the tank 2. Each bushing 4 has a conductor 6 and the conductor 6 is connected with a vacuum interrupter 7. The vacuum interrupters 7. are placed vertically in the tank 2. The vacuum interrupter 7 is provided with a movable contact 7a and a fixed contact 7b. The moveable contact 7a is connected mechanically to a bi-stable actuating device 8 comprising an elastic membrane 9 closing a compartment 10 filled with a compressible medium 11, preferable gas, through a coupling member 12, comprising: a first element 12a and a second element 12b. The first coupling element 12a is connected with the movable contact 7a of the vacuum interrupters 7 through a dielectric bar 13, mechanically linking the moveable contacts 7a of the three vacuum interrupters 7 in there phases of the transformer. The second coupling element 12b is connected with the membrane 9. The membrane 9 is in contact with the oil 3 filling the tank 2. The coupling elements 12a and 12b assure a free movement of the bi-stable actuating device 8 until the threshold indicated as $F_T$ triggering a flip-over position of the membrane 9, what is explained in fig. 4 showing the mechanical displacement "d" of the membrane central point from the force F applied to the membrane. When the force threshold value $F_T$ is reached, the mechanical displacement "d" reaches the point $d_T$ at which the membrane flips to the opposite position and thus the movement of the membrane 9 by the distance "D" from the threshold displacement $d_T$ is fast and autonomous. The movement of the membrane 9 of the actuating device 8 when the threshold force $F_T$ is passed pulls the coupling member 12 which mechanically engages the actuating device 8 to the moveable contact of 7a of the vacuum interrupter 7. The coupling elements 12a and 12b are mutually sliding elements. In order to assure a simultaneous, three-phase operation of the three vacuum interrupters 7, the moveable contacts 7a of the three vacuum interrupters 7 are mechanically connected together by a dielectric bar 13. All vacuum interrupters 7 and bi-stable actuating device 8 are mechanically fixed together to a common frame 14 attached to the transformer cover 5. The membrane 9 is mechanically linked with a mechanical position change-over element 15 partially protruding above the transformer cover 5 and connected with a position indicator 16. The protruding part of the rod is placed inside a bellow 17 attached to the cover 5. The mechanical position change-over element 15 can either be used for manually changing the position of the bi-stable actuator 8 or for connecting an external motor-drive unit 18, located on the cover 5, what is schematically indicated on a drawing by dashed line. The system comprising the external motor-drive unit 18 attached to the mechanical position change-over element 15 additionally allows one for multiple operations of the disconnecting device 1 to connect and disconnect the transformer from the network under normal operating conditions. The change-over element 15 is connected with the motor-drive 18 by a connecting element 19.

**[0019]** In the first version of the second embodiment of the disconnecting system 1' the bi-stable actuating device 8' is not immersed into the oil 3 filling the tank 2 but it is attached to the cover 5 of the tank 2 in an inverted position what means that the compartment 10 with the medium 11 is placed above the cover 5 and the membrane 9 is in contact with the oil 3. Each of the vacuum interrupters 7 is positioned horizontally in the tank 2. In order to assure a simultaneous, three-phase operation of the three vacuum interrupters 7, the moveable contacts 7a of the three vacuum interrupters 7 are mechanically connected together by a dielectric bar 13'. All vacuum interrupters 7 are mechanically fixed together to a common frame 14' attached to the transformer cover 5. The dielectric bar 13' is in mechanical contact with a coupling member 12', comprising elements 12'a and 12'b, the first having a form of a pivoting lever 12'a fixed to the cover 5 of the tank 2 and a second coupling element 12'b connected with the membrane 9 and with the pivoting lever 12'a. The both coupling elements 12'a and 12'b are connected in such way that the vertical movement of the bi-stable actuating device 8' is converted to a horizontal movement of the moveable contacts 7a of the horizontally positioned vacuum interrupters 7 when the threshold value of the force $F_T$ is exceeded.

**[0020]** In the second version of the second embodiment of the disconnecting system 1' a float element 20 is located inside the transformer tank 2 and attached to the pivoting bar 21 mechanically coupled to the bi-stable actuating element 8'. The float element 20 inside the tank 2, the pivoting bar 21 acts on the sliding element 12'b connected to the bi-stable actuator 8 when the oil level in the tank 2 drops, lowering the vertical position of the float element 20. The membrane 9' is mechanically linked with a mechanical position change-over element 15' having a form of a rigid rod, located centrally in the bi-stable actuator 8' partially protruding above its housing and connected with a position indicator 16'. The protruding part of the mechanical position change-over element 15' is placed inside a bellow 17' attached to the housing of the bi-stable actuator 8', mounted on the top of the transformer cover 5. The mechanical position change-over element 15' can either be used for manually changing the position of the bi-stable actuator 8' or for connecting an external motor-drive unit 18, located on the cover 5, what is schematically indicated on a drawing by dashed line. As in the first embodiment, the system comprising the external motor-drive unit 18 attached to the mechanical position change-over element 15' additionally allows one for multiple operations of the disconnecting device 1 to connect and disconnect the transformer from the network under normal operating conditions. The change-over element 15' is connected with the motor-drive 18 by a connecting element 19.

**[0021]** In the both embodiments of the invention the oil pressure inside the transformer tank 2 acts on a membrane 9 of the bi-stable actuating device 8 or 8'. Since the opposite side of the membrane 9 encloses a compartment 10 filled with a compressible medium 11, preferable gas, the oil pressure built-up results in the net force F acting on the membrane 9. When the force reaches the threshold value $F_T$, the flip-over of the bi-stable actuating device 8, 8' takes place. Mechanical linkage between the bi stable actuating device 8, 8' and the moveable contact 7a of the vacuum interrupters 7 is not mechanically engaged until the membrane displacement $d_T$ is reached, thanks to a backlash between the two coupling elements 12a and 12b, or 12'a and 12'b. Therefore the contacts 7a and 7b of the vacuum interrupter 7 remain closed until the displacement point $d_T$ of the bi-stable element 8, 8' flip-over is reached. At the time instance of passing the flip-over displacement point $d_T$, the coupling elements 12a and 12b, or 12'a and 12'b are engaged and the movement of the coupling element 12b, 12'b results in linking the bi-stable actuator 8 to the moving contact 7a of the vacuum interrupter 7 which becomes accelerated by the bi-stable actuator 8 or 8'. The bi-stable actuator 8 or 8' can thus be activated by internal oil pressure increase both under a fast internal oil pressure build-up resulting from internal arc and under the gradual internal pressure built-up. In both cases exceeding the predefined pressure threshold $F_T$ level results in acceleration of the moving contacts 7a from the close to the open position. In all embodiments and variants of the invention the moving contacts 7a of the three vacuum interrupters 7 are mechanically fixed to the dielectric bar 13 or 13' ensuring a simultaneous operation of the vacuum interrupters 7 in all three phases.

**[0022]** In the second variant of the second embodiment of the invention a float element 20 is provided, which is under normal operating conditions floating at the top of the transformer. If the level of the oil in the transformer tank 2 drops as a result of oil leak, the position of the float element 20 lowers. The float element 20 acts mechanically through the pivoting bar 21 on the bi-stable actuating device 8' through the coupling element 12'b with force resulting from the mass of the float. The parameters of the float element 20 and of the pivoting bar 21 are selected so that the force acting on the bi-stable actuating device 8' is larger than the threshold force level $F_T$. Under this condition lowering the oil level below a pre-defined level value results in mechanical displacement of the membrane 9, exceeding the flip-over point $d_T$. In this case the activation of the disconnecting system takes place in a similar was as in the case of the oil pressure built-up.

**[0023]** In both embodiments of invention the flip-over of the bi-stable actuating device 8, 8' can be also achieved by acting on the mechanical position change-over element 15, 15' extending above the transformer cover 5 or above the housing of the bi-stable actuator 8'. This element 15, 15' can either be used for manually changing the position of the bi-stable actuator 8, 8' or for connecting an external motor-drive unit 18 connected to the cover 5. This additionally allows for multiple operations of the disconnecting system 1, 1' to connect and disconnect the transformer from the network under normal operating conditions.

**[0024]** There are other possible embodiments of the present invention obvious to those skilled in the art not described in the present document. They can be constructed by combining or exchanging the features described in the above two embodiments.

Specification of the indications

**[0025]**

| | |
|---|---|
| 1, 1' - | disconnecting system |
| 2 - | tank of the transformer |
| 3 - | insulation medium |
| 4 - | bushing |
| 5 - | cover |
| 6 - | current conductor |
| 7 - | vacuum interrupter |
| 7a - | fixed contact |
| 7b - | movable contact |
| 8, 8' - | bi-stable actuator |
| 9 - | elastic membrane |
| 10 - | compartment |
| 11 - | compressible medium |
| 12, 12' - | coupling member |
| 12a - | first coupling element |
| 12b - | second coupling element |
| 12'a - | pivoting lever |
| 12'b - | second coupling element |
| 13, 13' - | dielectric bar |
| 14 - | frame |
| 15, 15' - | mechanical position change-over element |
| 16 - | position indicator |
| 17, 17' - | bellow |
| 18 - | external motor-drive unit |
| 19 - | connecting member |
| 20 - | float element |
| 21 - | pivoting bar |

## Claims

**1.** A disconnecting system for current interruption in a transformer having vacuum interrupter (7) as current interrupting element placed inside the tank (2) of the transformer filled with the insulation medium (3); the vacuum interrupter (7) is equipped with a fixed contact (7b) and a movable contact (7a), **characterized in that** the movable contact (7a) of the vacuum interrupter (7) is connected mechanically with an elastic membrane (9) closing the compartment (10) of a bi-stable actuating device (8; 8') and the membrane (9) is in contact with a compressible medium (11) filling the compartment (10) and being in contact with the insulation medium (3) of the transformer.

**2.** A disconnecting system according to the claim 1, **characterized in that** the membrane (9) is connected with the vacuum interrupters (7) trough a coupling member (12, 12').

**3.** A disconnecting system according to the claim 2, **characterized in that** the coupling member (12) has a first coupling element (12a) which is connected with the movable contact (7a) of the vacuum interrupter (7) and a second coupling element (12b) which is connected with the membrane (9).

**4.** A disconnecting system according to the claim 3, **characterized in that** the coupling member (12) is connected with the movable contact (7a) of the vacuum interrupter (7) which is positioned vertically in the transformer tank (2).

**5.** A disconnecting system according to the claim 2, **characterized in that** the coupling member (12') has a first coupling element (12'a) in the form of a pivoting angular lever which is connected with the movable contact (7a) of the vacuum interrupter (7) and the second coupling element (12'b) is connected rigidly with the membrane (9) and slidable with the pivoting lever (12'a).

**6.** A disconnecting system according to the claim 5, **characterized in that** the coupling member (12') is connected with the movable contact (7a) of the vacuum interrupter (7) positioned horizontally in the transformer tank (2).

**7.** A disconnecting system according to the claim 6, **characterized in that** the second coupling element (12b') is connected with a float element (20) through a coupling bar (21) pivotally connected with the cover (5) of the tank (2).

**8.** A disconnecting system according to any of the previous claims, **characterized in that** the second coupling element (12b; 12'b) is connected with a position indicator (16) placed on the cover (5) of the tank (2) or on the bi-stable actuating device (8').

**9.** A disconnecting system according to any of the previous claims, **characterized in that** the second coupling element (12b; 12'b) is connected with an external motor drive unit (18) placed on the cover (5) of the tank (2).

**10.** A disconnecting system according to any of the previous claims, **characterized in that** the system (1, 1') is adapted for three phase transformer.

**11.** A disconnecting system according to the claim 10, **characterized in that** the movable contacts (7a) of the three vacuum interrupters (7) are rigidly connected with a dielectric bar (13; 13').

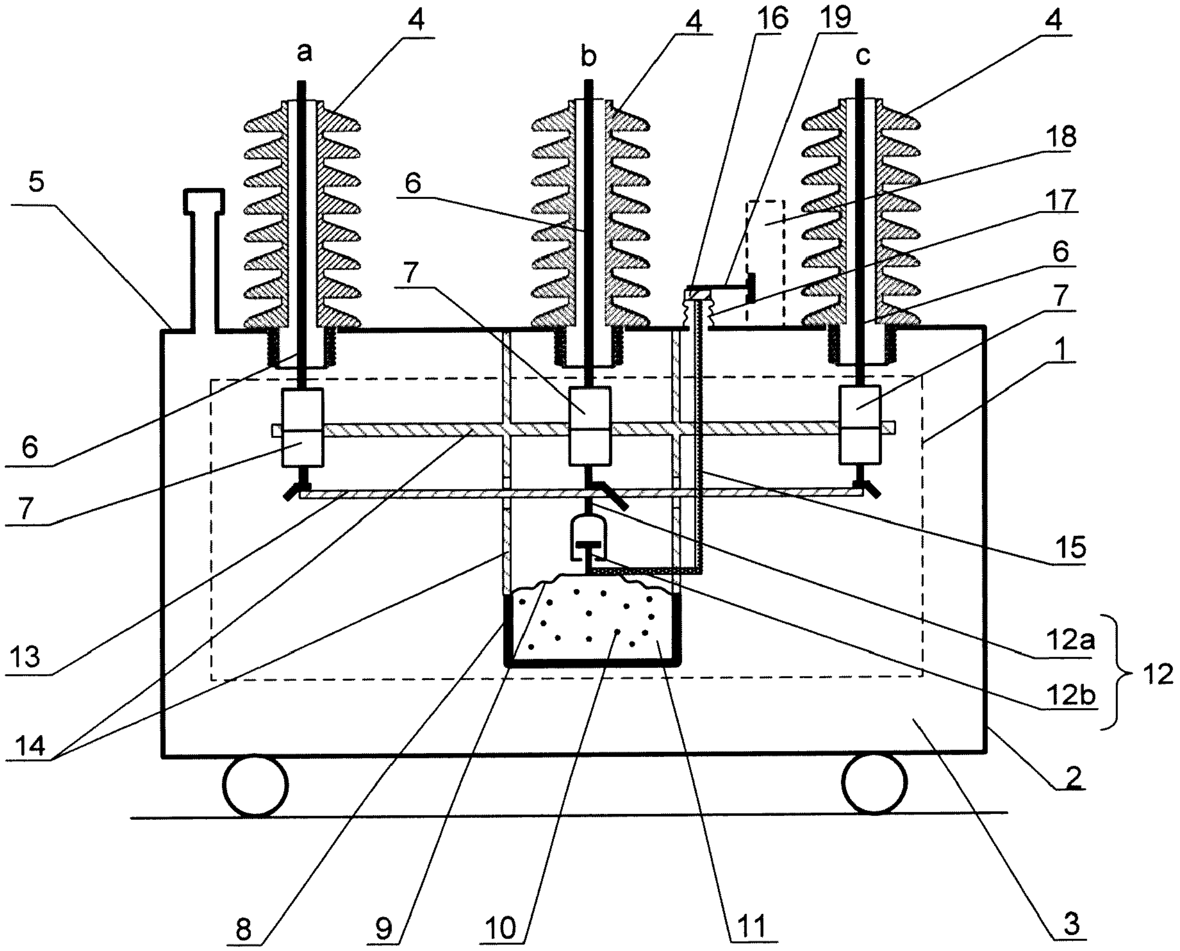


Fig.1

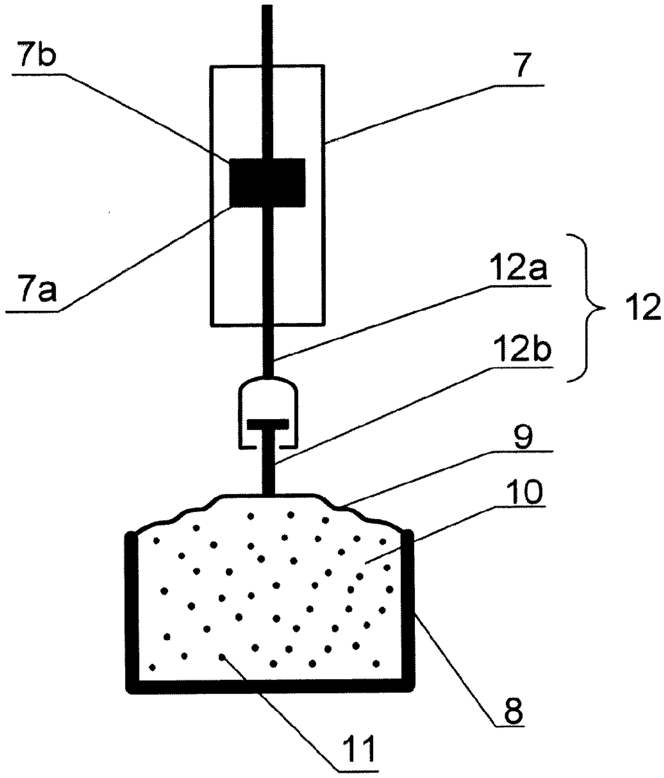


Fig.2

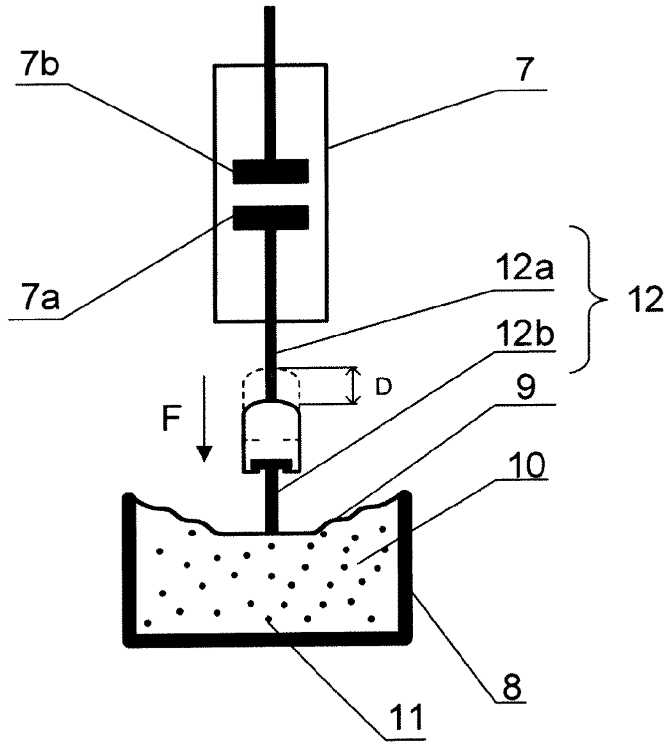


Fig.3

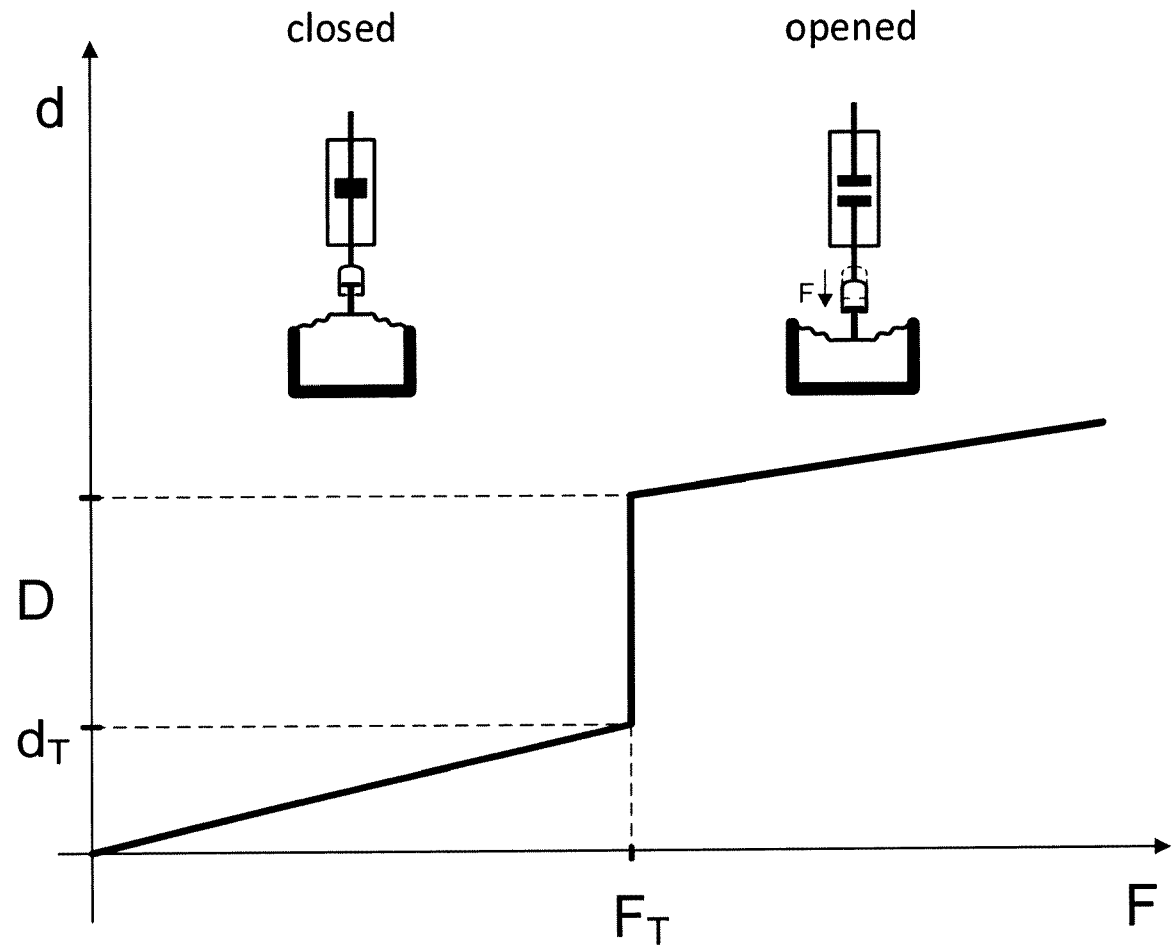


Fig.4

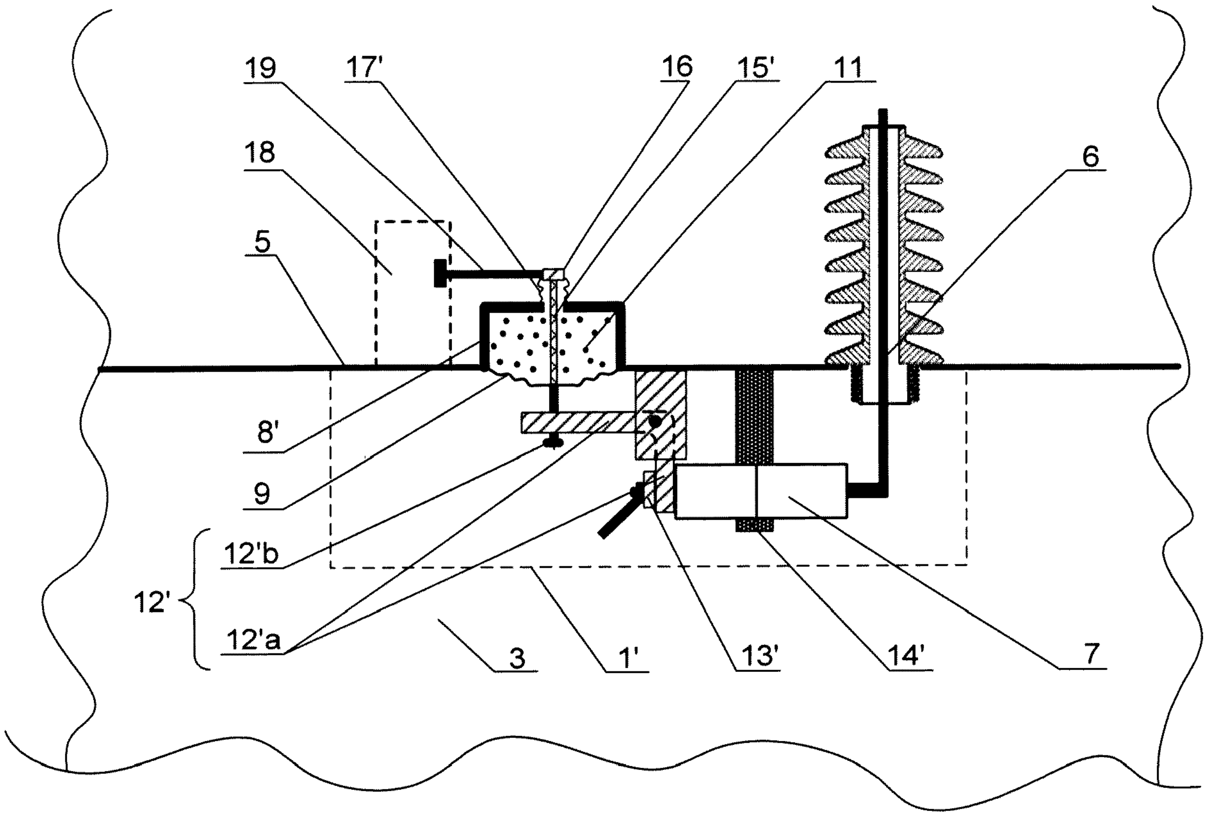


Fig.5

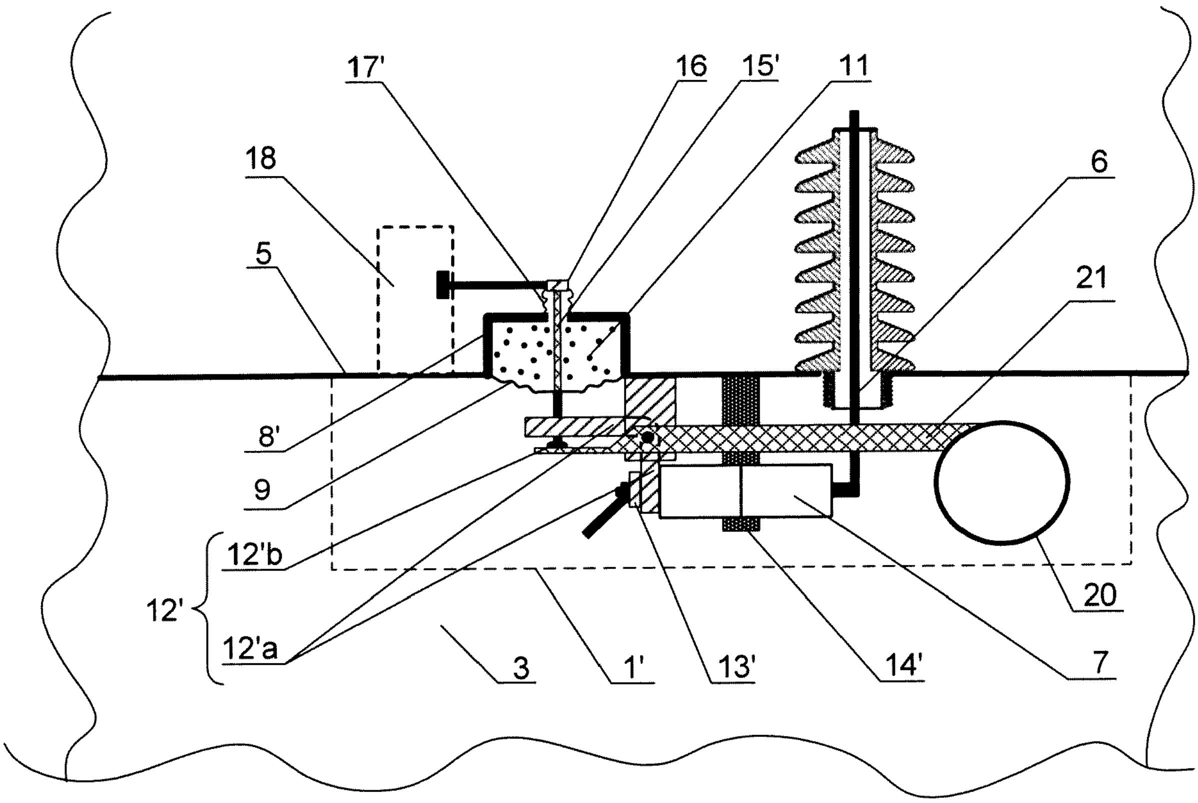


**Fig.6**

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# EUROPEAN SEARCH REPORT

Application Number
EP 17 46 0015

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| A,D | WO 01/91151 A1 (ABB POWER T & D CO [US]) 29 November 2001 (2001-11-29) * page 1, lines 4-8 * * page 1, line 17 - page 2, line 12 * * page 3, line 13 - page 7, line 30; figures 1-4B * ----- | 1-11 | INV. H01H35/34 H01H33/666 H01F27/40 H01H33/55 |
| A | GB 737 280 A (GRAVINER MANUFACTURING CO; ANDERS MATHISEN; WILKINSON SWORD CO LTD) 21 September 1955 (1955-09-21) * page 1, lines 19-37 * * page 1, line 93 - page 3, line 3; figures 1-4 * ----- | 1-11 | |
| A | FR 811 100 A (SIEMENS AG) 6 April 1937 (1937-04-06) * page 1, lines 1-12 * * page 2, lines 4-10, 41-56; figure 1 * ----- | 1-11 | |
| A | DE 11 17 735 B (LICENTIA GMBH) 23 November 1961 (1961-11-23) * column 2, line 38 - column 4, line 11; figure 1 * ----- | 1-11 | TECHNICAL FIELDS SEARCHED (IPC) H01F H01H |

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 22 August 2017 | Meyer, Jan |

CATEGORY OF CITED DOCUMENTS

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22-08-2017

| Patent document cited in search report | | Publication date | Patent family member(s) | | | Publication date |
|---|---|---|---|---|---|---|
| WO 0191151 | A1 | 29-11-2001 | AU | 6874601 | A | 03-12-2001 |
| | | | BR | 0111026 | A | 17-06-2003 |
| | | | CA | 2410703 | A1 | 29-11-2001 |
| | | | CN | 1439165 | A | 27-08-2003 |
| | | | DE | 10291282 | T5 | 29-04-2004 |
| | | | MX | PA02011566 | A | 06-06-2003 |
| | | | WO | 0191151 | A1 | 29-11-2001 |
| GB 737280 | A | 21-09-1955 | NONE | | | |
| FR 811100 | A | 06-04-1937 | NONE | | | |
| DE 1117735 | B | 23-11-1961 | NONE | | | |

EPO FORM P0459

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

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- WO 0191151 A **[0004]**