(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 987 171 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
11.01.2017 Bulletin 2017/02

(21) Application number: **14717149.0**

(22) Date of filing: **14.04.2014**

(51) Int Cl.:
H01B 3/20 *(2006.01)* ***B01D 15/00*** *(2006.01)*
H01B 7/288 *(2006.01)* ***H01F 27/23*** *(2006.01)*
H02P 13/06 *(2006.01)*

(86) International application number:
PCT/EP2014/057514

(87) International publication number:
WO 2014/170263 (23.10.2014 Gazette 2014/43)

(54) MOISTURE ABSORBER IN ELECTRICAL EQUIPMENT

FEUCHTIGKEITSABSORBER IN ELEKTRISCHEN GERÄTEN

ABSORBEUR D'HUMIDITÉ DANS UN ÉQUIPEMENT ÉLECTRIQUE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **17.04.2013 EP 13164089**

(43) Date of publication of application:
24.02.2016 Bulletin 2016/08

(73) Proprietor: **ABB Schweiz AG**
5400 Baden (CH)

(72) Inventors:
- **LARSSON, Tommy**
  S-771 90 Ludvika (SE)
- **ANDERSSON, Gunnar**
  S-770 14 Nyhammar (SE)
- **STENESTAM, Bengt-Olof**
  S-771 42 Ludvika (SE)
- **SUNDQVIST, Pontus**
  S-784 50 Borlänge (SE)

(74) Representative: **Savela, Reino Aleksi**
ABB AB
Intellectual Property
Forskargränd 7
721 78 Västerås (SE)

(56) References cited:
EP-A1- 0 481 239 **US-A- 5 766 464**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 2 987 171 B1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an electrical equipment comprising a moisture absorbing element.

BACKGROUND

[0002] Liquid or gaseous electrically insulating fluids are used in electrical apparatuses such as transformers, capacitors, switchgear, bushings, etc., and have a multitude of functions. Insulating, dielectric, fluids typically act as an electrically insulating medium separating parts having different potentials within the apparatus and function as a cooling medium to transfer the heat generated in the current-carrying conductors and other parts of the apparatus. Additionally, analysis of the fluids provides a means to monitoring the health of an electrical equipment during operation.

[0003] In addition to the above mentioned basic functions, the insulating fluid should also comply with other necessary and desired requirements. The fluid when used in electrical equipment should contribute to a high efficiency, long operational life time, and minimal environmental impact. Further, the fluid has to be compatible with the materials used in the electrical equipment and it should not constitute a hazard for the health and safety of personnel. In practice, insulating fluids should exhibit various physical, electrical, and chemical properties. Most of these properties are regulated through standards and specifications that stipulate requirements for each one.

[0004] Traditionally, petroleum-based oils have been used as the insulating fluid in fluid-filled transformers mainly because of the advantageous properties relating to low viscosity, low pour point, high dielectric strength, easy availability and low cost. Lately, ester liquids are becoming an alternative to mineral oils. Esters are advantageous due to their high biodegradability and high fire/flash points (> 300°C).

[0005] Electrically insulating fluids are consequently also used in on-load tap changers (OLTC) in electrical power transformers. A tap changer is used in an electrical power transformer to choose the voltage by switching between different taps of the winding, thus changing the ratio between windings.

[0006] An OLTC will for different temperatures, expand and contract its oil volume. This is done via an oil expansion vessel, normally breathing through a silica gel breather to avoid moisture ingress in the oil volume.

[0007] It has been shown that the OL TC over time anyhow can accumulate moisture in the oil, and thus drying or replacement of the oil is needed at regular intervals. The time period, until the moisture content will be too high in the oil, depends on several factors such as the surrounding climate, the installation of the OL TC and the silica gel breather, the maintenance performed on the silica gel and the temperature variations inside the OL TC oil volume depending on the operation conditions.

[0008] If it would be possible to prolong this time period before the oil contains too much moisture, this would be very beneficial.

[0009] Moisture will enter the OL TC oil volume in different ways over time during operation or during maintenance. A high moisture content harms the insulation properties of the insulating oil and the used insulating polymers, e.g. polyester- or epoxy-composites, in the OLTC. To combat the entering of moisture into the oil, the silica gel breather and its maintenance is targeted in the art.

[0010] By adding a piece of moisture absorbing material, such as cellulose/paper, capable of absorbing moisture in a suitable range, the oil can be kept dry for a longer time. More water can thus enter the system before the water content in the oil is too high, e.g. above 35 ppm water, or being close to saturated level. The equilibrium between water in oil and paper is well known from so called Piper curves.

[0011] The OL TC is usually delivered without oil, and is then filled with the oil before it is tested or made operational.

[0012] EP 0 481 239 discloses an oil filter, especially for oil filled tap changers of tapped power transformers, as a component of a separate filter circuit, the oil filter having two concentrically arranged filter chambers, e.g. in labyrinth form. In this case, the outer filter chamber is used for filtering out solid impurities, e.g. by means of filter paper or glass wool, and the inner filter chamber is filled with moisture-absorbing material, e.g. zeolite, and is used for extraction of the water that is in the oil.

[0013] US 5,766,464 discloses an oil filtration system for an oil-filled electrical apparatus. A pump is used for pumping the oil through a filtration conduit in which contaminants are filtered from the oil. If it is desired to remove moisture from the oil, the filter medium may be comprised of dry paper or an ion exchange resin such as Dowex™ or an other desiccant material.

[0014] CN 202134324 (utility model) discloses an oil storage cabinet of an on-load voltage regulating switch. The switch comprises a moisture absorber which is connected to the storage cabinet via a connecting pipe.

[0015] JP 2007/221047 discloses a power transformer capable of surely removing moisture from a fluid insulator and maintaining and managing the fluid insulator over a long period of time, by providing an absorbent capable of continuously demonstrating excellent dehumidification capability. A freely detachable absorbent case is used to provide the continuous dehumidification.

SUMMARY

[0016] It is an objective of the present invention to provide an improved moisture absorbing system for electrical equipment.

[0017] According to an aspect of the present invention,

there is provided an electrical equipment configured for comprising an electrically insulating fluid, said electrical equipment comprising a water absorbing element protected by a water resistant material which inhibits the water absorbing element from absorbing water from its surroundings, said water resistant material being at least partly dissolvable by the electrically insulating fluid. Thus, the water resistant material protects the water absorbing element until it is immersed in said electrically insulating fluid.

[0018] According to another aspect of the present disclosure, there is provided a method of removing moisture and particles from an electrically insulating fluid in a tap changer for an electrical power transformer, the method comprising: heating a part of the electrically insulating fluid with heat generated by an electrical switch in the tap changer, whereby an upward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; cooling the upward flow, whereby a downward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; and trapping at least some particles carried by the upward flow and/or the downward flow in a water absorbing element in the tap changer, through which water absorbing element at least a part of the flow passes as a result of the natural circulation, thereby removing said particles (as well as moisture) from the electrically insulating fluid.

[0019] By the water absorbing element being protected by means of a water resistant material, the water absorbing element is protected from becoming partly saturated with moisture from e.g. the air before the insulating fluid is added into the electrical equipment. Of course, this would be a problem in itself if the water absorbing element was then also prevented from absorbing moisture from the insulating fluid which is the point of using a water absorbing element, or if the barrier of the protecting water resistant material e.g. has to be removed by hand (which would also mean that the water absorbing element would need to be readily accessible). However, this is not a problem with the present invention since the water resistant material is dissolvable by/in the electrically insulating fluid. Thus, the water absorbing element is released from the water resistant material when it is no longer needed, allowing the water absorbing element to perform its function of absorbing moisture from the electrically insulating fluid.

[0020] In some embodiments, the water absorbing element is impregnated with the water resistant material. In some other embodiments, wherein the water absorbing element is encased in a packaging or film made from the water resistant material. In yet some other embodiments, the water resistant material is adhered to surfaces of the water absorbing element. In some embodiments, the water absorbing element is encased in a water resistant casing which is held in place (e.g. glued together around the water absorbing element) by means of the water resistant material, whereby the casing will be opened up when the water resistant material is dissolved by the insulating fluid. This could be advantageous to reduce the amount of water resistant material dissolved in the insulating fluid, reducing its effect on the properties of the insulating fluid. It is conceivable that some or all of these different ways of protecting the water absorbing element by means of the water resistant material may in some cases be combined. Which way to use may e.g. depend on the properties of the water resistant material and/or of the water absorbing element, and possibly on the ease with which the water resistant material is dissolvable by the electrically insulating fluid. In some embodiments, the water absorbing element is positioned in a dedicated chamber therefor, e.g. a metal chamber, for avoiding that non-dissolvable casing parts or not yet fully dissolved water resistant material interferes with the electrical equipment.

[0021] In some embodiments, the water resistant material is completely dissolvable by the electrically insulating fluid within a week under regular operating conditions of the electrical equipment, such as within 48 or 24 hours. Conveniently, the water resistant material is not too easily dissolved since this may result in the water resistant material being at least partly removed prematurely. In view of the operating time of e.g. a power transformer, dissolution within a week may be sufficient. The time period for fully dissolving the water resistant material may be controlled e.g. by the choice of water resistant material and/or by the amount/thickness of the water resistant material.

[0022] In some embodiments, the water resistant material does not substantially alter the electrically insulating properties of the electrically insulating fluid when dissolved therein. Examples of such properties include e.g. Dielectric strength, dielectric dissipation factor, viscosity, acidity, etc. it is e.g. not desirable to reduce the resistance to electricity or heat of the insulating fluid by dissolving the water resistant material therein.

[0023] In some embodiments, the water resistant material is not corrosive to metals when dissolved in the electrically insulating fluid under operating conditions of the electrical equipment. Since, the electrical equipment may be made at least partly of metal, e.g. iron or copper, it is not desirable that the electrically insulating fluid increases in corrosivity when the water resistant material is dissolved therein.

[0024] In some embodiments, the water resistant material is a wax or lipid, such as Vaseline™, or a synthetic or natural polymer, or a mineral oil or ester based material. Such materials may conveniently be used with the present invention. The skilled person may, based on the present disclosure, find other materials which may also be suitable, depending on e.g. the properties of the water absorbing element, the properties of the electrically insulating fluid and/or the operating conditions of the electrical equipment. Generally, The water resistant material should be chosen such that it is dissolvable in the insulating fluid (e.g. a mineral oil or ester-based liquid) while

being resistant to (low solubility in) water. There are many materials, e.g. Vaseline which is given as a specific example herein, which are known to be dissolvable in e.g. oil but not dissolvable in water. The skilled person would thus not have any problems finding such materials. Also, a skilled person could find a suitable water resistant material by routine experimentation, e.g. by testing the solubility of some known water resistant materials in the insulation fluid used.

[0025] In some embodiments, the electrical equipment is part of a system with a system voltage of at least 1 kilovolt or at least 1.5 kilovolts. It may be in high voltage applications where it is most harmful when the insulating properties of the insulating fluid are compromised by a high moisture content. In some embodiments, the system voltage is up to 800 kilovolts, e.g. between 2 or 3 kilovolts and 500 or 800 kilovolts.

[0026] In some embodiments, the electrical equipment is an electrical power transformer or an electrical motor. These are examples of fluid insulated electrical equipment where the present invention may suitably be employed.

[0027] In some embodiments, the electrical equipment is an on-load tap changer for an electrical power transformer. A tap changer is a specific example where it is envisioned that the present invention may be especially beneficial. The tap changer of a power transformer is often placed partly or completely in a separate vessel which interior fluid is not in contact with or affected by the cellulose insulation of the power transformer. This is a reason for using the water absorbing element in particular in a tap changer since a moisture absorber in a transformer tank may not be as effective when it is working together or against several (e.g. hundreds or thousands of) kilos of cellulose (paper). The cellulose insulation of the power transformer may then control the moisture balance. Inside the tap changer, there may often not be any cellulose (paper) since it may not be a suitable insulation therein since it may produce abrasion products from the mechanical movements of the tap changer, and the relatively high risk of moisture in cellulose in a tap changer may be very bad in a tap changer. Since, the tap changer usually does not contain paper, the fluid volume therein is relatively easily affected by even a little moisture, which is why it may be especially beneficial to be able to introduce dry cellulose or other water absorbing material within the tap changer in accordance with the present invention. Thus it may be advantageous to be able to use e.g. cellulose in equipment such as a tap changer where the water absorbing material does not have to have dielectric insulation properties, but can instead be used predominantly for moisture absorption.

[0028] In some embodiments, the electrically insulating fluid is or comprises an oil, such as a mineral oil or an ester oil. In some embodiments, an ester-based fluid, typically an ester-based liquid such as an ester oil, may be preferred by virtue of its higher heat resistance. The electrically insulating fluid may be a conventional insulation liquid (e.g. oil) which is used for liquid-filled transformers or other electrical equipment. As is also mentioned above, in the background section, insulating dielectric fluids such as petroleum-based oils and ester liquids are known for use as electrically insulating fluids. Thus, a person skilled in the art would not have any problem choosing a suitable electrically insulating fluid, depending on the type of electrical equipment and its operating conditions, e.g. operating temperature.

[0029] In some embodiments, the water absorbing element comprises a water absorbing polymer material, such as a cellulose-based (e.g. paper or paper board), polyacrylamide-based or silica-based (silica gel/beads) water absorbing material, or cotton or a clay. These are examples of moisture absorbing materials which may be used. In some embodiments of the present invention, the water absorbing element is also arranged for removing/trapping particles from the electrically insulating fluid. Cellulose is an example of a water absorbing material which also traps particles. Water absorbing materials are well-known in the field, e.g. from the documents referred to in the background section above. Suitable properties of the water absorbing element, such as cellulose type, molecular weight, particle size etc., are known from commercially available water absorbing products, also known as desiccants. The skilled person may, based on the present disclosure, find other materials which may also be suitable, depending on e.g. the properties of the water resistant material, the properties of the electrically insulating fluid and/or the operating conditions of the electrical equipment. Generally, the water absorbing element may comprise a material that at all operational temperatures of the electrical equipment has a substantially higher affinity for water than the insulating fluid has. The amount of water absorbing material in in the water absorbing element depends on e.g. the space available in the electrical equipment. The more water absorbing material is used, the longer time the water absorbing element can be used for absorbing moisture in the electrical equipment before it e.g. needs to be exchanged. Typically, the same amount of water absorbing material may be used as for regular water absorbing elements used in electrical equipment today, possibly even a bit less since by means of the present invention, the water absorbing element is not already partially saturated with water before contacting the insulating fluid. As an example, an amount of water absorbing material corresponding to from 0.5% to 5% of the volume of the electrically insulating fluid in the electrical equipment may be used. In some embodiments, the water absorbing element can absorb between 0.01-1, such as between 0.1-1, litres of water per cubic metre of the electrically insulating fluid. This implies that the water absorbing element is present in such an amount/size that so much moisture can be absorbed under the operating conditions of the electrical equipment. Of course, a plurality of discrete water absorbing elements may be present in the same equipment.

[0030] Generally, all terms used in the claims are to be

interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. The use of "first", "second" etc. for different features/components of the present disclosure are only intended to distinguish the features/components from other similar features/components and not to impart any order or hierarchy to the features/components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Embodiments will be described, by way of example, with reference to the accompanying drawings, in which:

Fig 1 is a schematic block diagram of an embodiment of an electrical power transformer in accordance with the present invention.

Fig 2 is a schematic diagram of an embodiment of a tap changer in accordance with the present invention.

DETAILED DESCRIPTION

[0032] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments are shown. However, other embodiments in many different forms are possible within the scope of the present disclosure. Rather, the following embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout the description.

[0033] Electrical equipment is here defined as any equipment configured for being connectable to/conducting electrical current.

[0034] Figure 1 is a schematic illustration of an embodiment of an electrical equipment of the present invention, here in the form of an electrical power transformer 1. The power transformer 1 has housing 2 containing the electrical parts of the power transformer immersed in an insulating fluid 3. The electrically insulating fluid 3 is in accordance with any embodiment thereof discussed herein, e.g. a mineral oil or an ester-based liquid. At the top of the power transformer 1, a gas, e.g. air, phase 6 may be present within the housing and above a top surface of a liquid fluid 3. The electrical parts of the power transformer 1 comprises a metal core 4 surrounded by coils/windings 5 of electrical conductors 8 and 10. A tap changer (schematically shown at 13) can be used to tap into different positions in the windings 5 for adjusting the voltage of the power transformer 1. The tap changer 13 includes a compartment which separates the insulating fluid within the tap changer from the rest of the insulating fluid 3 in the transformer 1. In the very simplified illustration of the figure, an incoming electrical conductor 8 enters within the housing 2 via a bushing 7, and an outgoing electrical conductor 10 exits the housing 2 via a bushing 10. The transformer 1, or other electrical equipment in which such fluid 3 is used, may e.g. be a high temperature or high voltage power transformer, or a high voltage electrical motor or other high voltage equipment, arranged to operate at a temperature which is higher than the normal operating temperature for a mineral oil derived insulating fluid, e.g. an operating temperature of above, 160°C, 180°C or above 200°C.

[0035] In the transformer 1, in contact with the electrically insulating fluid 3, a water absorbing element 11 is located. The water absorbing element 11 (could also be called e.g. a moisture absorber) may be located anywhere within the electrical equipment 1 where it can conveniently absorb moisture without being in the way of the normal operation of the equipment 1. In accordance with some embodiments of the present invention, the water absorbing element may also function as filter or particle trap for trapping and thus removing particles from the insulating fluid 3. By also removing particles, the wear of the equipment may be reduced since particles may get stuck in moving parts of the equipment and cause abrasion. Both removal of moisture and removal of particles may extend the time before the insulating fluid 3 may have to be exchanged. As an example, the water absorbing element 11 may be located inside a tap changer of the power transformer 1, in order to keep the fluid 3 therein dry for an extended period of time. As is also noted above, the electrical equipment 1 may not always be filled with the insulating fluid 3. Rather, it may be delivered without the fluid, whereby the fluid may be added later when the equipment is put into operational use. Thus, there may be a long time from the manufacture or maintenance of the equipment 1, when the water absorbing element may be added or dried, before the fluid, e.g. oil, 3 is added into the equipment 1. During this time, there is a risk that the water absorbing element 11 absorbs moisture (i.e. water) from e.g. the air surrounding it, thus reducing the capacity of the water absorbing element 11 for its intended use of absorbing moisture from the insulating fluid 3.

[0036] In accordance with the present invention, the water absorbing element 11 is associated with a water resistant material 12 which inhibits/prevents the water absorbing element from absorbing water from its surroundings. The water absorbing element 11 may e.g. be coated by the water resistant material 12, or otherwise enclosed in the water resistant material 12, or it may be impregnated with the water resistant material 12. The manner of association between the water resistant material 12 and the water absorbing element 11 may be

chosen based on the properties of the water resistant material 12 chosen. A polymeric/plastic water resistant material 12 may e.g. be made into a packaging or a film within which the water absorbing element 11 can be enclosed. A wax or lipid may e.g. suitable be coated onto surfaces of the water absorbing element 11 or impregnated into the water absorbing element 11 (if the water absorbing element 11 is of a porous material suitable for being impregnated, e.g. a cellulose material such as paper or paper board). In accordance with the present invention, the water resistant material 12 is dissolvable in the insulating fluid 3 which the equipment 1 is configured to be filled with. This implies that once the equipment is filled with the fluid 3, and the fluid 3 contacts the water absorbing element 11 protected by the water resistant material 12, the water resistant material 12 starts to dissolve in the insulating fluid, eventually no longer inhibiting/preventing the water absorbing element 11 from absorbing water from its surrounding medium (now comprising or consisting of the insulating fluid). Typically, the water absorbing element 11 is then fully immersed in the insulating fluid 3, but in some embodiments it may be only partly immersed therein. The water absorbing element 11 is then freed to perform its intended function of absorbing moisture from the insulating fluid, and can do so for a longer time than if it had already partly been saturated with moisture from e.g. air.

[0037] Figure 2 schematically illustrates an embodiment of a tap changer 13 of the present disclosure. The tap changer is configured for use in an electrical power transformer 1 for switching between different taps in the winding of the transformer. The tap changer 13 comprises a housing 22 enclosing the tap changer, forming the outer surface of the tap changer, however still allowing parts of the tap changer e.g. parts of a switch 23 to extend outside of the housing 22. The housing 22 of the tap changer 13 is filled with the electrically insulating liquid fluid 3 e.g. a mineral or ester oil. The tap changer is configured to be positioned in the transformer such that a switch 23 of the tap changer 13 is arranged at the bottom region of the tap changer, at least partly within the housing 22, whereby insulation fluid 3 can be heated by the electrical components of e.g. the switch and rise upwards within the housing 22. By the fluid 3 being heated and thus rising within the housing 2, a natural circulation of the fluid is achieved within the housing of the tap changer. This natural circulation gives rise to an upward flow 25 of the fluid 3, as well as an adjacent downward flow 27. In the embodiment of figure 2, the upward flow 25 is created at the centre along a central longitudinal axis of the housing 22, while the downward flow 27 is more peripherally located within the housing 22, if the housing approximates a cylinder in shape. A water absorbing element 11 which may also act as a particle trap is positioned inside the housing 22 such that it intercepts a flow of the fluid 3, allows at least a part of the flow to pass through the water absorbing element 11. In accordance with the present invention, the water absorbing element 11 is prior to immersing it in the insulating fluid 3 protected by a water resistant material 12 which is then dissolved by the fluid 3 whereby the fluid is allowed to come into contact with the water absorbing material of the water absorbing element 11. The water absorbing element/particle trap 11 may intercept an upward flow 25 and/or a downward flow 27 of the fluid 3. The water absorbing element/particle trap does not have to intercept the whole flow 25 or 27, although it may be desirable to intercept as much as possible in order to achieve efficient moisture and/or particle removal. Even if only a part, possibly a minor part, of the upward or downward fluid flows pass through the water absorbing element/particle trap 11, that may be enough to sufficiently remove moisture/particles from the fluid 3 since the natural circulation and thus the flowing through the water absorbing element/particle trap is continuous or reoccurs with every tap change. The water absorbing element 11 may be a passive particle trap which allows the fluid 3 flow to pass through it whereby particles are trapped/deposited within the water absorbing element. The water absorbing element 11 may e.g. comprise a filter which mechanically traps the particles and/or which electrostatically or otherwise binds or adsorbs the particles, depending on the material(s) used for the filter. Additionally or alternatively, the water absorbing element may comprise a labyrinth comprising a material which traps the particles e.g. electrostatically or otherwise binds adsorbs the particles. As mentioned above, the water absorbing material used in the water absorbing element 11 may also trap particles to at least some extent. Additional particle trapping material or functions may also be used in the water absorbing element 11 if convenient. The water absorbing element 11 may thus remove both moisture and particles from the fluid 3, further extending the life of the insulating fluid 3 as well as of the tap changer 13. Since no pumps are used and the circulation is only, or at least predominantly, through natural circulation, larger particles may be allowed to sediment within the tap changer, where they may do no harm since they are not circulating with the fluid and are not deposited on the solid insulation material within the tap changer. Thus, the water absorbing element 11 may mainly be arranged to trap smaller particles which do not sediment. This also prolongs the life time of the water absorbing element since it takes longer for it to be clogged by the trapped particles if fewer large particles are trapped. A suitable material which can be used in the water absorbing element 11 for trapping both moisture and the particles is cellulose, but a person skilled in the art may also know of other suitable water absorbing materials which may also to at least some extent trap particles from the insulating fluid 3.

[0038] In the embodiment shown in figure 2, the fluid 3 is mainly heated by at least one transition resistor 28 during switching of the switch 23, causing the central upward flow 25 of the fluid. As the upward flow 25 travels upwards, the fluid therein is cooled down, creating the peripheral downward flow 27. Optionally, a heat ex-

changer (not shown) at the top of the tap changer 13 can be used to additionally cool the fluid 3.

[0039] In the embodiment shown in figure 2, a guide 29 is used to additionally guide the upward and/or downward flows 25 and 27 to the water absorbing element 11 and to control the natural circulation. The guide 29 may e.g. be essentially rotation symmetrical to form a funnel facing downward. In figure 2, the natural circulation with the upward flow 25 and the downward flow 27 is illustrated with arrows. As can be seen, the flows 25 and 27 are essentially parallel and adjacent to each other, but in opposite directions. However, the guide 29 can guide the upward flow 25 and/or the downward flow 27 e.g. by concentrating the upward flow 25 when it passes through a funnel-shaped guide 29, as illustrated by the upward flow 25 arrows within the funnel 29 in figure 2. As the upward flow 25 reaches the top of the housing 22, the naturally circulating fluid 3 is cooled down, possibly also assisted by a cooling heat exchanger at the top of the housing, and forms part of the downward flow 27. The downward flow 27 is more peripheral than the concentrated upward flow 25 and is thus intercepted and guided by the outside of the funnel-shaped guide 29. The guide 29 guides the downward flow 27 to the water absorbing element 11 which in the embodiment of figure 2 is attached to the outside of guide 29. Possibly the water absorbing element 11 is also essentially rotation symmetrical and attached along the circumference of the funnel 29.

[0040] In an example embodiment, the water absorbing element 11 (possibly also acting as a particle trap) in figure 2 is attached to the guide 29 which guides the downward flow 27 of the naturally circulating fluid 3. In this embodiment, the water absorbing element 11 is in the form of a labyrinth through which at least a part of the downward flow 27 passes. The labyrinth may comprise a material, such as cellulose, suitable for absorbing moisture and/or trapping particles, especially small particles such as metallic wear particles.

[0041] According to an aspect of the present invention there is provided a method. The method is performed in an embodiment of a tap changer 13 of the present disclosure. A part of the electrically insulating fluid 3 is heated by heat generated by a transition resistor 28 of an electrical switch 23 in the tap changer 13, whereby an upward flow 25 of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer. The upward flow 25 is intercepted and guided by an inside of a funnel-shaped guide 29 arranged facing downwards in the tap changer 13, whereby the upward flow is concentrated by passing through the funnel-shaped guide. The upward flow 25 is cooled above the funnel-shaped guide 29 in the tap changer 13, whereby a downward flow 27 of the electrically insulating fluid 3 is created through natural circulation of the electrically insulating fluid in the tap changer. The downward flow 27 is intercepted and guided by an outside of the funnel-shaped guide 29, whereby said downward flow is guided by the guide such that at least a part of the downward flow passes through a water absorbing element 11 in the tap changer 13. At least some particles as well as moisture carried by the downward flow 27 in the water absorbing element 11 may be are trapped, thereby removing said particles from the electrically insulating fluid 3.

[0042] In some embodiments of the present disclosure, the electrical switch 23 comprises at least one transition resistor 28, wherein the natural circulation, when the tap changer is in use, is caused at least partly by heat generated by said at least one resistor. A resistance is used in the switch in order to not short circuit the step of the winding in the transformer when changing from one tap to another tap. This resistance is called the transition resistance and generates heat at each tap change, thus resulting in the natural circulation discussed herein. Additionally or alternatively, a more continuous resistance may be used to give more continuous heating and natural circulation, but this requires higher energy use. In accordance with the present disclosure, the transition resistance is enough to give sufficient circulation, although additional heating, e.g. by means of heating elements at the bottom region of the tap changer, is also possible and may be used in some embodiments of the present disclosure.

[0043] In some embodiments of the present disclosure, a guide 29 is positioned inside the housing 22 and arranged for guiding the flow 25, 27 of the electrically insulating fluid 3 caused by natural circulation to the water absorbing element 11 (possibly also acting as a particle trap).

[0044] In some embodiments, the guide 29 is funnel-shaped. In some embodiments, the funnel-shaped guide 29 is arranged to collect and concentrate an upward flow 25 of the electrically insulating fluid which is then cooled and forms a downward flow 27 to the intercepting water absorbing element 11 positioned outside of the funnel-shaped guide. In some embodiments, the water absorbing element 11 is attached to the guide 29.

[0045] In some embodiments of the present disclosure, the water absorbing element 11 is in the form of a filter and/or of a labyrinth.

[0046] In some embodiments of the present disclosure, the water absorbing element 11 comprises cellulose for trapping moisture and/or particles.

[0047] In some embodiments of the present disclosure, the water absorbing element 11 is configured to trap small particles, not settling particles, having a typical particle size of less than 100 μm but most particles will be smaller than 10 μm or even 1 μm. But the size of the particles not settling depends on the used fluid viscosity and the actual particle density.

[0048] In some embodiments of the present disclosure, the tap changer 13 is configured for being used in an electrical power transformer having a system voltage of at least 1 kilovolt. Higher voltages will increase the dielectrical forces and the need for clean surfaces, therefore is the removal of the particles of higher importance.

[0049] Below follow some other aspects of the present disclosure.

[0050] According to an aspect of the present disclosure, there is provided a method of removing moisture and particles from an electrically insulating fluid 3 in a tap changer 13 for an electrical power transformer 1, the method comprising: heating a part of the electrically insulating fluid with heat generated by a resistor 28 of an electrical switch 23 in the tap changer, whereby an upward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; allowing said upward flow to be intercepted by an inside of a funnel-shaped guide 29 arranged facing downwards in the tap changer, whereby the upward flow is concentrated by passing through the funnel-shaped guide; cooling the upward flow above the funnel-shaped guide in the tap changer, whereby a downward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; allowing said downward flow to be intercepted by an outside of the funnel-shaped guide 29, whereby said downward flow is guided by the guide such that at least a part of the downward flow passes through a water absorbing element 11 in the tap changer; and trapping at least some particles carried by the downward flow in the water absorbing element 11, thereby removing said particles (as well as moisture) from the electrically insulating fluid.

[0051] According to an aspect of the present disclosure, there is provided a tap changer 13 for an electrical power transformer 1, the tap changer comprising: means for heating a part of the electrically insulating fluid 3 with heat generated by an electrical switch 23 in the tap changer, whereby an upward flow 25 of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; means for cooling the upward flow 25, whereby a downward flow 27 of the electrically insulating fluid 3 is created through natural circulation of the electrically insulating fluid in the tap changer; and means for trapping at least some particles carried by the upward flow and/or the downward flow in a water absorbing element 11 in the tap changer, through which particle trap at least a part of the flow and/or passes as a result of the natural circulation, thereby removing said particles (as well as moisture) from the electrically insulating fluid.

[0052] According to an aspect of the present disclosure, there is provided a tap changer 13 for an electrical power transformer 1, the tap changer comprising: a housing 22 forming an outside of the tap changer, said housing being configured to be filled with an electrically insulating fluid 3; an electrical switch 23 positioned at least partly inside the housing and configured for switching between different taps of a transformer winding; a water absorbing element 11, positioned inside the housing such that it will intercept a flow of the electrically insulating fluid caused by natural circulation of said electrically insulating fluid when the tap changer is in use.

[0053] By means of embodiments of the present invention, a water absorbing element 11 may be used for removing not only moisture but also to at lest some degree for removing particles from the insulation fluid 3 in an electrical equipment e.g. a tap changer of a transformer. It is an advantage to also be able to remove particles from the electrically insulating fluid 3 (typically a liquid such as mineral oil or an ester oil) by using a natural circulation of the fluid within the tap changer 13. Thereby, no pump is needed for circulating the fluid through e.g. a particle filter, and neither is any circulation loop needed. Instead, in accordance with the present disclosure, the natural circulation creates a flow within the tap changer, which flow can be intercepted by, and pass though the water absorbing element 11 which is also able to trap particles e.g. a filter or a labyrinth comprising a particle trapping (e.g. adsorbing) material. Natural circulation implies that the circulation is achieved without pumping. Rather, the natural circulation is caused by temperature gradients in the fluid in combination with the act of gravity. As the fluid is heated, e.g. by heat loss from electrical components in the tap changer such as the transition resistors 28, the density of the fluid is reduced and the heated fluid will rise, thereby also allowing cooler fluid to descend within the tap changer. A fluid flow caused by the natural circulation can then be intercepted by and pass through the water absorbing element 11 in accordance with the present disclosure, and no extra pump and circulation loop is needed. The present disclosure has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the present disclosure, as defined by the appended patent claims.

Claims

1. An electrical equipment (1) configured for comprising an electrically insulating fluid (3), said electrical equipment comprising a water absorbing element (11) protected by a water resistant material (12) which inhibits the water absorbing element from absorbing water from its surroundings, said water resistant material being dissolvable by the electrically insulating fluid.

2. The electrical equipment of claim 1, wherein the water absorbing element (11) is impregnated with the water resistant material (12).

3. The electrical equipment of claim 1, wherein the water absorbing element (11) is encased in a packaging or film made from the water resistant material (12).

4. The electrical equipment of claim 1, wherein the water resistant material (12) is adhered to surfaces of

the water absorbing element (11).

5. The electrical equipment of claim 1, wherein the water absorbing element is encased in a water resistant casing which is held in place by means of the water resistant material.

6. The electrical equipment of any preceding claim, wherein a guide (29) is positioned inside the electrical equipment (1) and arranged for guiding a flow (25, 27) of the electrically insulating fluid (3) to the water absorbing element (11).

7. The electrical equipment of claim 6, wherein the guide (29) is arranged for guiding the flow (25, 27) as caused by natural circulation of the electrically insulating fluid (3).

8. The electrical equipment of claim 6 or 7, wherein the guide (29) is funnel-shaped.

9. The electrical equipment of claim 8, wherein the funnel-shaped guide (29) is arranged to collect and concentrate an upward flow (25) of the electrically insulating fluid (3) which is then cooled and forms a downward flow (27) to the intercepting water absorbing element (11) positioned outside of the funnel-shaped guide.

10. The electrical equipment of any claim 6-9, wherein the water absorbing element (11) is attached to said guide (29).

11. The electrical equipment of any preceding claim, wherein the water absorbing element (11) is configured to trap particles in the electrically insulating fluid (3) when immersed therein.

12. The electrical equipment of any preceding claim, wherein the water resistant material (12) is completely dissolvable by the electrically insulating fluid (3) within a week under regular operating conditions of the electrical equipment (1), such as within 48 or 24 hours.

13. The electrical equipment of any preceding claim, wherein the water resistant material (12) is a wax or lipid, such as Vaseline, or a synthetic or natural polymer, or a mineral oil or ester based material.

14. The electrical equipment of any claim 1-13, wherein the electrical equipment (1) is an on-load tap changer for an electrical power transformer.

15. The electrical equipment of any preceding claim, wherein the water absorbing element (11) comprises a water absorbing polymer material, such as a cellulose-based, polyacrylamide-based or silica-based water absorbing material, or cotton or a clay.

16. A method of removing moisture and particles from an electrically insulating fluid (3) in a tap changer (13) for an electrical power transformer (1), the method comprising:

heating a part of the electrically insulating fluid with heat generated by an electrical switch (23) in the tap changer, whereby an upward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer;
cooling the upward flow, whereby a downward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; and
trapping at least some particles carried by the upward flow and/or the downward flow in a water absorbing element (11) in the tap changer, through which water absorbing element at least a part of the flow passes as a result of the natural circulation, thereby removing said particles as well as moisture from the electrically insulating fluid.

Patentansprüche

1. Elektrische Anlage (1), die so konfiguriert ist, dass sie ein elektrisch isolierendes Fluid (3) enthält, wobei die elektrische Anlage ein wasserabsorbierendes Element (11) umfasst, das durch ein wasserfestes Material (12) geschützt wird, das verhindert, dass das wasserabsorbierende Element Wasser aus seiner Umgebung absorbiert, wobei das wasserfeste Material durch das elektrisch isolierende Fluid aufgelöst werden kann.

2. Elektrische Anlage nach Anspruch 1, wobei das wasserabsorbierende Element (11) mit dem wasserfesten Material (12) imprägniert ist.

3. Elektrische Anlage nach Anspruch 1, wobei das wasserabsorbierende Element (11) in einer Verpackung oder einer Beschichtung eingekapselt ist, die aus dem wasserfesten Material (12) hergestellt ist.

4. Elektrische Anlage nach Anspruch 1, wobei das wasserfeste Material (12) an Oberflächen des wasserabsorbierenden Elements (11) anhaftet.

5. Elektrische Anlage nach Anspruch 1, wobei das wasserabsorbierende Element in einem wasserfesten Gehäuse eingekapselt ist, das mittels des wasserfesten Materials an seinem Platz gehalten wird.

6. Elektrische Anlage nach einem der vorhergehenden

Ansprüche, wobei eine Führung (29) in der elektrischen Anlage (1) positioniert ist und eingerichtet ist, eine Strömung (25, 27) des elektrisch isolierenden Fluids (3) zu dem wasserabsorbierenden Element (11) zu lenken.

7. Elektrische Anlage nach Anspruch 6, wobei die Führung (29) eingerichtet ist, die Strömung (25, 27) so zu lenken, wie sie durch eine natürliche Zirkulation des elektrisch isolierenden Fluids (3) verursacht werden würde.

8. Elektrische Anlage nach Anspruch 6 oder 7, wobei die Führung (29) trichterförmig ist.

9. Elektrische Anlage nach Anspruch 8, wobei die trichterförmige Führung (29) so eingerichtet ist, dass sie eine Aufwärtsströmung (25) des elektrisch isolierenden Fluids (3) sammelt und konzentriert, die daraufhin gekühlt wird und eine Abwärtsströmung (27) zu dem auffangenden wasserabsorbierenden Element (11), das außerhalb der trichterförmigen Führung positioniert ist, bildet.

10. Elektrische Anlage nach einem der Ansprüche 6-9, wobei das wasserabsorbierende Element (11) an der Führung (29) befestigt ist.

11. Elektrische Anlage nach einem der vorhergehenden Ansprüche, wobei das wasserabsorbierende Element (11) konfiguriert ist, Partikel in dem elektrisch isolierenden Fluid (3) einzufangen, wenn es darin eingetaucht ist.

12. Elektrische Anlage nach einem der vorhergehenden Ansprüche, wobei das wasserfeste Material (12) durch das elektrisch isolierende Fluid (3) innerhalb einer Woche unter regulären Betriebsbedingungen der elektrischen Anlage (1), etwa innerhalb von 48 oder 24 Stunden, vollständig auflösbar ist.

13. Elektrische Anlage nach einem der vorhergehenden Ansprüche, wobei das wasserfeste Material (12) ein Wachs oder ein Lipid wie etwa Vaseline oder ein synthetisches oder natürliches Polymer oder ein Mineralöl oder ein Material auf Esterbasis ist.

14. Elektrische Anlage nach einem der Ansprüche 1-13, wobei die elektrische Anlage (1) ein Laststufenschalter für einen elektrischen Leistungstransformator ist.

15. Elektrische Anlage nach einem der vorhergehenden Ansprüche, wobei das wasserabsorbierende Element (11) ein wasserabsorbierendes Polymermaterial wie etwa ein wasserabsorbierendes Material auf Zellulosebasis, auf Polyacrylamidbasis oder auf Kieselsäurebasis, oder Baumwolle oder einen Ton umfasst.

16. Verfahren zum Entfernen von Feuchtigkeit und Partikeln aus einem elektrisch isolierenden Fluid (3) in einem Stufenschalter (13) für einen elektrischen Leistungstransformator (1), wobei das Verfahren die folgenden Schritte umfasst:

Erhitzen eines Teils des elektrisch isolierenden Fluids mit Wärme, die durch einen Elektroschalter (23) in dem Stufenschalter erzeugt wird, wodurch eine Aufwärtsströmung des elektrisch isolierenden Fluids durch eine natürliche Zirkulation des elektrisch isolierenden Fluids in dem Stufenschalter erzeugt wird;
Kühlen der Aufwärtsströmung, wodurch durch eine natürliche Zirkulation des elektrisch isolierenden Fluids in dem Stufenschalter eine Abwärtsströmung des elektrisch isolierenden Fluids erzeugt wird; und
Einfangen von wenigstens einigen Partikeln, die durch die Aufwärtsströmung bzw. die Abwärtsströmung in einem wasserabsorbierenden Element (11) in dem Stufenschalter getragen werden, wobei als ein Ergebnis der natürlichen Zirkulation wenigstens ein Teil der Strömung durch das wasserabsorbierende Element verläuft, wodurch die Partikel sowie Feuchtigkeit aus dem elektrisch isolierenden Fluid entfernt werden.

Revendications

1. Équipement électrique (1) configuré pour comporter un fluide électriquement isolant (3), ledit équipement électrique comportant un élément (11) absorbant l'eau protégé par un matériau (12) résistant à l'eau qui empêche l'élément absorbant l'eau d'absorber de l'eau à partir de son environnement, ledit matériau résistant à l'eau pouvant être dissous par le fluide électriquement isolant.

2. Équipement électrique selon la revendication 1, l'élément (11) absorbant l'eau étant imprégné du matériau (12) résistant à l'eau.

3. Équipement électrique selon la revendication 1, l'élément (11) absorbant l'eau étant enrobé dans un emballage ou un film constitué du matériau (12) résistant à l'eau.

4. Équipement électrique selon la revendication 1, le matériau (12) résistant à l'eau étant collé à des surfaces de l'élément (11) absorbant l'eau.

5. Équipement électrique selon la revendication 1, l'élément absorbant l'eau étant enrobé dans une enveloppe résistant à l'eau qui est maintenue en place au moyen du matériau résistant à l'eau.

6. Équipement électrique selon l'une quelconque des revendications précédentes, un guide (29) étant positionné à l'intérieur de l'équipement électrique (1) et agencé pour guider un écoulement (25, 27) du fluide électriquement isolant (3) jusqu'à l'élément (11) absorbant l'eau.

7. Équipement électrique selon la revendication 6, le guide (29) étant agencé pour guider l'écoulement (25, 27) qui est causé par la circulation naturelle du fluide électriquement isolant (3).

8. Équipement électrique selon la revendication 6 ou 7, le guide (29) présentant la forme d'un entonnoir.

9. Équipement électrique selon la revendication 8, le guide (29) en forme d'entonnoir étant agencé pour recueillir et concentrer un écoulement ascendant (25) du fluide électriquement isolant (3), qui est ensuite refroidi et forme un écoulement descendant (27) jusqu'à l'élément (11) absorbant l'eau qui l'intercepte et est positionné à l'extérieur du guide en forme d'entonnoir.

10. Équipement électrique selon l'une quelconque des revendications 6 à 9, l'élément (11) absorbant l'eau étant fixé audit guide (29).

11. Équipement électrique selon l'une quelconque des revendications précédentes, l'élément (11) absorbant l'eau étant configuré pour piéger des particules présentes dans le fluide électriquement isolant (3) lorsqu'il est immergé dans celui-ci.

12. Équipement électrique selon l'une quelconque des revendications précédentes, le matériau (12) résistant à l'eau pouvant être entièrement dissous par le fluide électriquement isolant (3) dans un délai d'une semaine sous des conditions ordinaires de fonctionnement de l'équipement électrique (1), par exemple dans un délai de 48 ou de 24 heures.

13. Équipement électrique selon l'une quelconque des revendications précédentes, le matériau (12) résistant à l'eau étant une cire ou un lipide, comme de la vaseline, ou un polymère synthétique ou naturel, ou un matériau à base d'huile minérale ou d'ester.

14. Équipement électrique selon l'une quelconque des revendications 1 à 13, l'équipement électrique (1) étant un changeur de prises en charge pour transformateur électrique de puissance.

15. Équipement électrique selon l'une quelconque des revendications précédentes, l'élément (11) absorbant l'eau comportant un matériau polymère absorbant l'eau, tel qu'un matériau absorbant l'eau à base de cellulose, à base de polyacrylamide ou à base de silice, ou du coton ou une argile.

16. Procédé d'élimination d'humidité et de particules d'un fluide électriquement isolant (3) dans un changeur (13) de prises pour transformateur électrique de puissance (1), le procédé comportant les étapes consistant à :

chauffer une partie du fluide électriquement isolant avec de la chaleur générée par un commutateur électrique (23) dans le changeur de prises, un écoulement ascendant du fluide électriquement isolant étant ainsi créé par circulation naturelle du fluide électriquement isolant dans le changeur de prises ;
refroidir l'écoulement ascendant, un écoulement descendant du fluide électriquement isolant étant ainsi créé par circulation naturelle du fluide électriquement isolant dans le changeur de prises ; et
piéger au moins certaines particules transportées par l'écoulement ascendant et / ou l'écoulement descendant dans un élément (11) absorbant l'eau dans le changeur de prises, au moins une partie de l'écoulement passant à travers ledit élément absorbant l'eau du fait de la circulation naturelle, éliminant ainsi lesdites particules ainsi que l'humidité du fluide électriquement isolant.

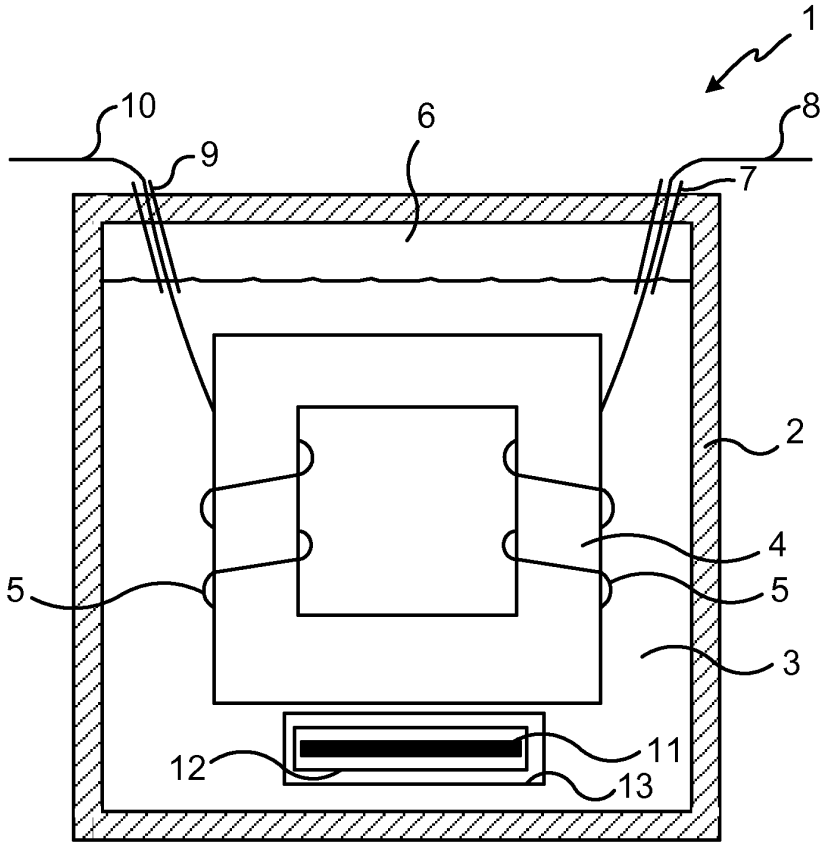


Fig. 1

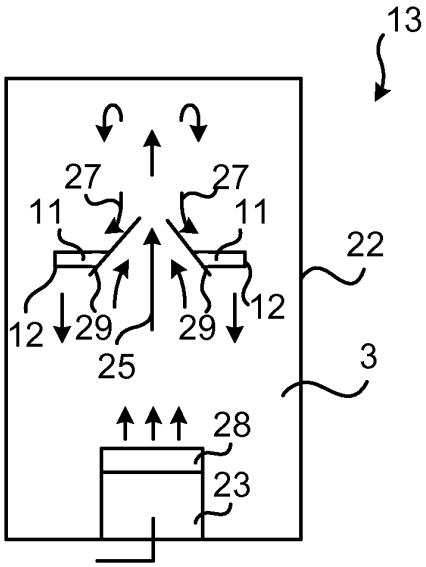


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0481239 A **[0012]**
- US 5766464 A **[0013]**
- CN 202134324 **[0014]**
- JP 2007221047 A **[0015]**