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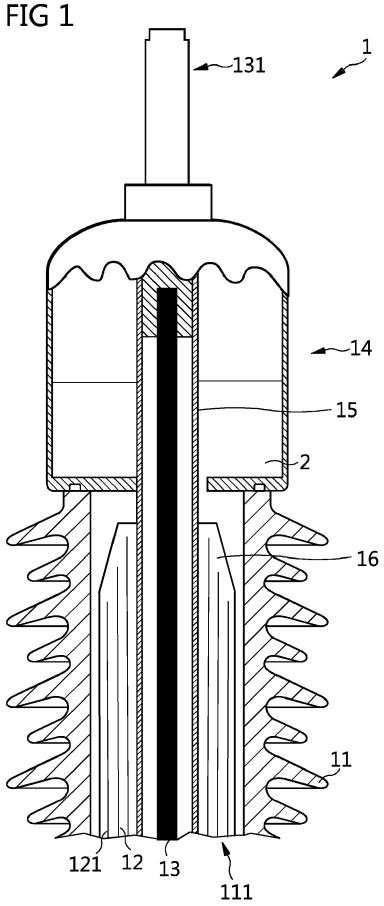
(54) **CAPACITIVE GRADED HIGH VOLTAGE BUSHING**

(57) The present invention concerns a capacitive graded bushing (1) for high electric voltage comprising:
- an insulator (11) comprising an insulator chamber (111) for receiving an electrical conductor (13) and insulating matter (12);
- the electrical conductor (13) located within the bushing (1) and extending through the insulator chamber (111);
- the insulating matter (12) surrounding the electrical conductor (13) and comprising several concentric (cylindrical) conductive layers (121) surrounding the electrical conductor (13) for forming a uniform core insulation called hereafter capacitive graded core (16);
characterized in that a dielectric insulation material (12) impregnated with an ester liquid is placed between two successive conductive layers (121).

FIG 1



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Description

[0001] The present invention relates generally to high voltage bushings and more particularly to insulation techniques for high voltage bushing for use in high environmental requirements.

[0002] Economic capacitive graded high voltage bushings in common oil impregnated paper (OIP) technology in general with insulating liquid of mineral oil are limited in their application temperature for technical reasons and based on respective standards. This limits also their application in case of increased ambient and/or service temperatures. In particular, the dielectric material used for insulation may present a high risk of inflammability. Especially the contained mineral oil may present a high risk of environmental pollution in case of leakage. The use of these high voltage bushings in applications with high environmental requirements (environmental protection areas, offshore, etc.) is therefore restricted or imposes special environmental protection precautions leading to high costs.

[0003] Prior art techniques have solved this problematic by developing high voltage bushings with solid dielectric technologies, e.g. wherein resin impregnated paper (RIP) or resin impregnated synthetic (RIS) are used. Such technologies can then be used for higher temperatures and are approved according to applicable standards. Depending upon the bushing design (e.g. dry type with foam as secondary insulation) the application in areas with high environmental requirements is possible. Indeed, such bushings are for instance free of any liquid leak of the insulating media in case of failure, avoiding therefore any polluting oil to bleed. Additionally, such type of bushing can also be used on environmentally friendly transformers with alternative insulating liquids. Unfortunately, the production of RIP and RIS high voltage bushings is extensive and the raw materials used are expensive.

[0004] An objective of the present invention is to propose a new concept of a bushing adapted to high environmental requirements, in particular to prevent oil pollution, and that enables additionally an easy and cost efficient manufacturing.

[0005] For achieving said objective, the present invention proposes notably a capacitive graded bushing for high electric voltage comprising an ester as impregnation agent within its capacitive graded core as disclosed by the object of the independent claim. Other advantages of the invention are presented in the dependent claims.

[0006] The present invention concerns therefore a capacitive graded bushing for high electric voltage comprising:

- an insulator comprising an insulator chamber for receiving an electrical conductor and insulating matter;
- the electrical conductor located within the bushing and extending through the insulator chamber;
- the insulating matter surrounding the electrical conductor and comprising several concentric, for instance cylindrical, conductive layers surrounding the electrical conductor for forming a uniform core insulation called hereafter capacitive graded core;

characterized in that a dielectric insulation material, for instance paper or synthetic material, impregnated with an ester liquid is placed between two successive conductive layers. The ester liquid is in particular partly or completely filling the insulator chamber and is part of said insulating matter.

[0007] Further aspects of the present invention will be better understood through the following drawings:

Figure 1 schematic illustration of a bushing according to the invention.

[0008] A preferred embodiment of a capacitive graded bushing according to the invention is presented in Figure 1, which shows a part of a high electric voltage capacitive graded bushing 1 for a transformer or a high voltage device. The bushing 1 comprises an insulator 11 having a chamber 111 for receiving an electrical conductor 13 and insulating matter 12 that surrounds the electrical conductor 13. The electrical conductor 13 can be a solid or rope conductor. According to a first preferred embodiment, the electrical conductor 13 might be placed within a tube 15. According to other embodiments, the electrical conductor might be a conductive tube. The electrical conductor 13 comprises a first extremity 131 located at the top of the bushing 1 and configured for being electrically connected to a first device and a second extremity (not shown) configured for being connected to another device, for instance a transformer. The electrical conductor 13 typically extends from the top of the bushing 1 to its bottom through the insulator chamber 111, clamping means and gaskets ensuring the different parts of the bushing 1 being hermetically held together.

[0009] The bushing 1 further comprises concentric conductive layers 121 (e.g. aluminum foils) which are isolated against another and serve as a built-in capacitor for equalizing and controlling the electrical stress on the insulation and maximizing the electrical field uniformity. The insulating matter 12 suitable for high voltage fills then the space between successive concentric conductive layers 121. The concentric conductive layers 121 arranged concentrically around the electrical conductor 13 and spaced apart by said insulating matter 12 form the capacitive graded core 16 of the bushing 1. The capacitive graded core 16 is typically placed within the chamber 111 and preferentially surrounded by insulating matter, e.g. insulating liquid 2. According to the present invention, the insulating liquid is an ester liquid that preferentially fills a space between the capacitive graded core 16 and a wall of the insulator chamber 111.

[0010] The present invention proposes to use a dielectric insulation material impregnated with an ester liquid as insulating material placed between the successive

conductive layers 121. Preferentially, the insulator 11 might be surmounted by an expansion chamber 14 communicating with the chamber 111 of the insulator 11 in order to have the ester liquid 2 filling the chamber 111 and extending upwardly into the liquid expansion chamber 14. In particular, the ester liquid may partly fill the expansion chamber 14. The chamber 111 is further configured for having the ester liquid 2 extending upwardly into the liquid expansion chamber 14 in case of a volume change of the ester liquid 2 due to temperature variations.

[0011] Preferentially, the dielectric insulation material forms a layer between each successive conductive layers 121, wherein the layers formed by the dielectric insulation material and the successive conductive layers 121 are each wound around the electrical conductor 13. In particular, said layers formed by the dielectric insulation material and the successive conductive layers can be directly or indirectly wound around the electrical conductor 13. For instance, the electrical conductor could be a conductive tube serving as winding support for the previously mentioned layers. According to other embodiments, the electrical conductor could be placed within a tube 15 serving as winding support for said previously mentioned layers.

[0012] According to a preferred embodiment, the dielectric insulation material is a plastic mixed dielectric impregnated with the ester liquid, which comprises for instance a plastic foil and a non-woven fabric. Preferably, the plastic foil and the non-woven fabric have a sandwich structure between two successive conductive layers 121.

[0013] According to another preferred embodiment, the dielectric insulation material is a paper impregnated with the ester liquid.

[0014] The present invention proposes therefore to satisfy the high environmental requirements for a bushing by using as insulating matter a special combination of a dielectric and an ester liquid as impregnation agent within the capacitive graded core of the bushing. The ester liquid according to the invention can be synthetic and/or natural ester liquid. The preferred embodiments result in a capacitive graded high voltage bushing type EIS (ester impregnated synthetic) or in a capacitive graded high voltage bushing type EIP (ester impregnated paper). According to the latter, common paper used in OIP technology is used instead of the plastic mixed dielectric.

[0015] The present invention has many different advantages over existing solutions, which makes the bushing according to the invention a very attractive product.

[0016] Indeed, an advantage of the EIP bushing is that for a manufacturer of established OIP bushing only small adaptions in the production process are required. Furthermore, the EIP and EIS bushings provide more security by using ester liquid which is less inflammable compared to the common used mineral oil.

[0017] Additionally, the combination between plastic mixed dielectric or paper dielectric with a special impregnation agent that is natural or synthetic ester provides new application ranges for economic liquid insulated high voltage bushings. Additionally, the bushings according to the invention provide the following advantages compared to prior art bushings:

- a cost-efficient production;
- a significant reduction or omission of the cost and time expensive drying process (in case of EIS);
- a higher permitted ambient and/or service temperatures (in case of EIS);
- they are applicable on environmentally friendly transformers with ester liquids;
- they enable applications in areas with extremely high environmental requirements.

[0018] In conclusion, the proposed EIS or EIP technologies are an economical alternative compared to the more expensive solid material technology. Further for EIP technology the same production equipment almost free of adaptation can be used (for instance the winding machine for producing the capacitive graded core of the bushing).

Claims

1. Capacitive graded bushing (1) for high electric voltage comprising:

   - an insulator (11) comprising an insulator chamber (111) for receiving an electrical conductor (13) and insulating matter (12);
   - the electrical conductor (13) located within the bushing (1) and extending through the insulator chamber (111);
   - the insulating matter (12) surrounding the electrical conductor (13) and comprising several concentric conductive layers (121) surrounding the electrical conductor (13) for forming a uniform core insulation called hereafter capacitive graded core (16);

   characterized in that a dielectric insulation material impregnated with an ester liquid is placed between two successive conductive layers (121).

2. Capacitive graded bushing (1) according to claim 1, wherein the dielectric insulation material forms a layer between two successive conductive layers (121).

3. Capacitive graded bushing (1) according to claim 1 or 2, wherein the layer formed by the dielectric insulation material and the successive conductive layers (121) are each wound around the electrical conductor (13).

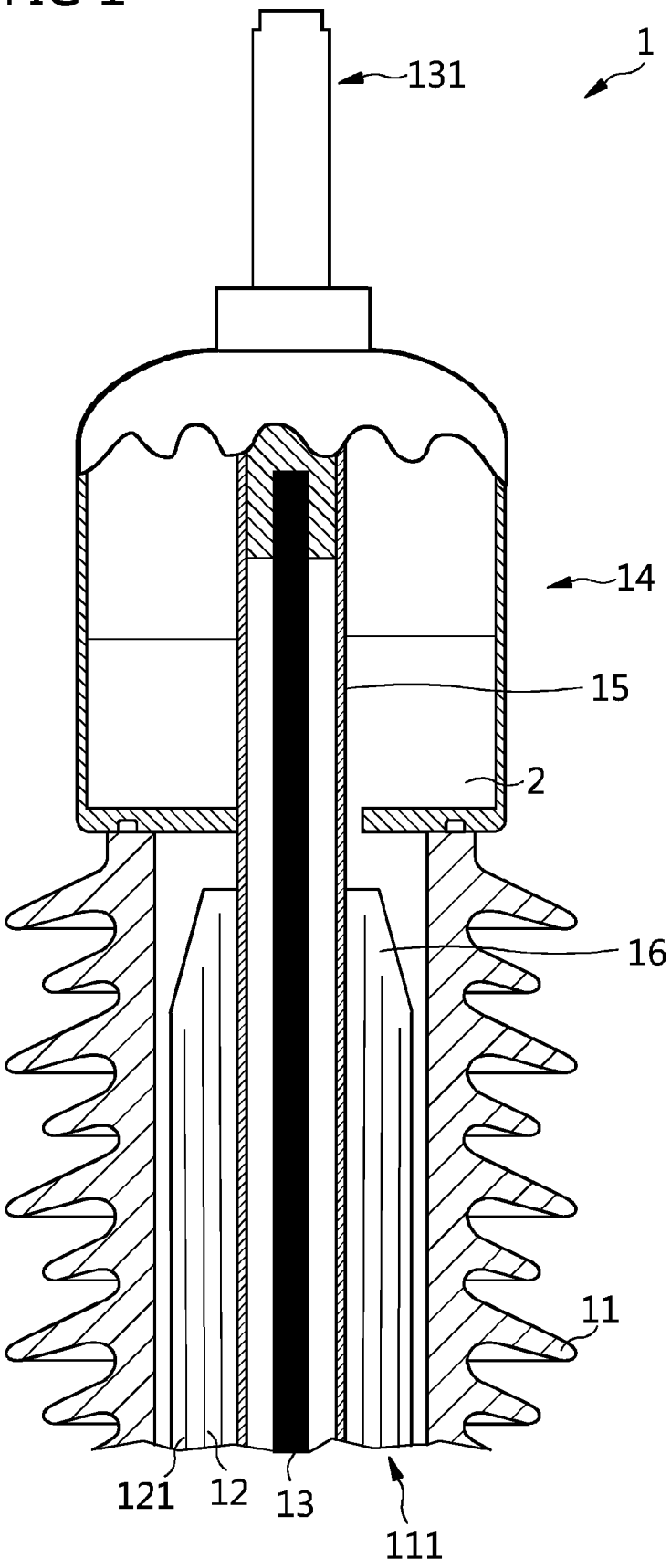
4. Capacitive graded bushing (1) according to one of the claims 1-3, wherein the dielectric insulation material is a plastic mixed dielectric.

5. Capacitive graded bushing (1) according to claim 4, wherein the plastic mixed dielectric comprises a plastic foil and a non-woven fabric.

6. Capacitive graded bushing (1) according to one of the claims 1 to 3, wherein the dielectric insulation material is a paper.

7. Capacitive graded bushing (1) according to one of the claims 1 to 6, wherein the ester liquid fills a space between the capacitive graded core (16) and a wall of the insulator chamber (111).

FIG 1



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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 5557

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 November 2018	Hillmayr, Heinrich

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 5557

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TECHNICAL FIELDS SEARCHED (IPC)

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