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

(11) **EP 3 196 901 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.07.2017 Bulletin 2017/30

(51) Int Cl.:
H01F 27/04 *(2006.01)* ***H01B 17/28*** *(2006.01)*

(21) Application number: **16152621.5**

(22) Date of filing: **25.01.2016**

(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
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(54) HIGH VOLTAGE ASSEMBLY

(57) A high voltage assembly (2), especially a high voltage transformer or a high voltage reactor, is proposed comprising: a metal enclosure (4) containing an active component and being connected to ground potential (3), a high voltage bushing (50) comprising a high voltage conductor (52), the high voltage bushing (50) passing through an opening (6) of the metal enclosure (4). A field forming jacket (8) is arranged inside the metal enclosure (4) to receive at least partly the high voltage bushing (50). The field forming jacket (8) is configured to provide an insulation gap (22) between an inner surface (14) of the field forming jacket (8) and an outer surface (58) of the high voltage bushing (50). The field forming jacket (8) comprises a field forming layer (18) with a first electrical connection (34) to the ground potential (3) and a second electrical connection (40) to a high voltage potential of the high voltage conductor (52).

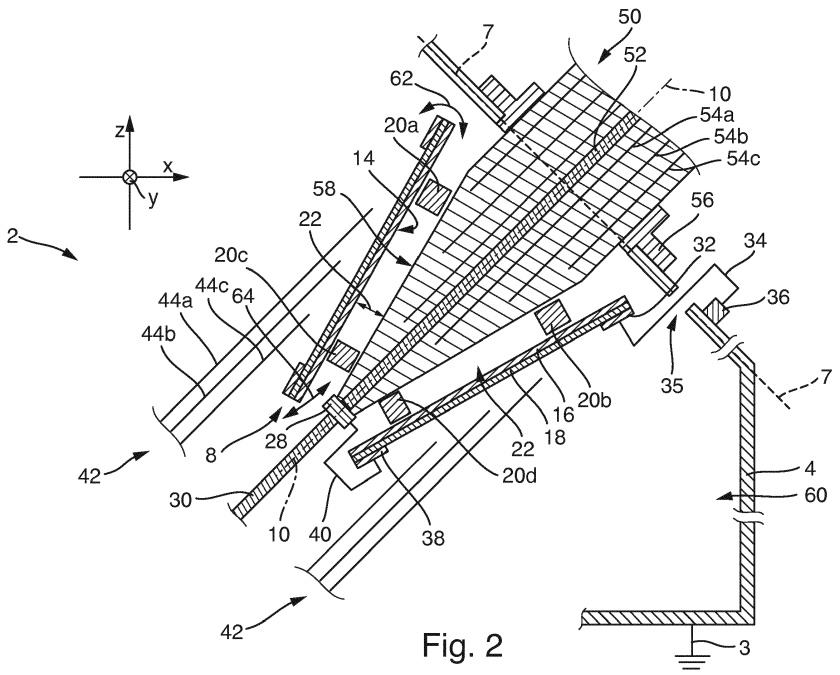

Fig. 2

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Description

Field of the invention

[0001] The present invention relates to a high voltage assembly according to the preamble of claim 1.

Background

[0002] Known high voltage assemblies comprise a high voltage bushing with a bushing body surrounding a high voltage conductor and containing a paper insulation. An outer side of the bushing body is coated at least in a region with a coating forming a coating layer. The coating layer has a greater electrical conductivity than the bushing body. For example US 2013/0240249 A1 shows such a high voltage bushing.

[0003] Moreover, sophisticated barrier systems which are arranged inside a high voltage assembly are known to reduce space between elements of the high voltage assembly by controlling the electrostatic field. These barrier systems comprise several layers of transformerboard barriers.

Summary

[0004] In view of the prior art, it is an object of the present disclosure to improve the arrangement of a high voltage bushing at high voltage assembly.

[0005] Therefore it is proposed a high voltage assembly which comprises a metal enclosure containing an active component and being connected to ground potential, a high voltage bushing comprising a high voltage conductor, the high voltage bushing passing through an opening of the metal enclosure. A field forming jacket is arranged inside the metal enclosure to receive at least partly the high voltage bushing. The field forming jacket is configured to provide an insulation gap between an inner surface of the field forming jacket and an outer surface of the high voltage bushing. The field forming jacket comprises a field forming layer with a first electrical connection to the ground potential and a second electrical connection to a high voltage potential of the high voltage conductor.

[0006] The field forming layer provides that the electric potential distribution is homogenized already in the insulation gap and beyond.

[0007] Moreover, a barrier system arranged in the metal enclosure is mechanically protected when connecting the high voltage bushing to the high voltage assembly. As the barrier system is protected from being damaged loosening of cellulose material is prevented. Therefore the probability of a respective malfunction of the high voltage assembly is reduced.

[0008] The field forming jacket therefore simplifies the construction of a barrier system and simultaneously improves the assembly of the high voltage bushing at construction site. Moreover, the proposed field forming jacket may replace a barrier system. By reducing the complexity of or even replacing the barrier system the production costs for the whole high voltage assembly are reduced.

[0009] The high voltage assembly is therefore suitable for high voltage direct current, HVDC, applications. But even in a test environment with alternating current or lightning impulse voltages the proposed field forming jacket enables the high voltage assembly to resist the resulting electrical stresses.

[0010] In an advantageous embodiment the first electrical connection between the field forming layer and ground potential comprises a disconnecting device for disconnecting the field forming layer from ground potential. This enables to establish a diagnosis, especially tangent delta measurements of the high voltage bushing, without the influence of the field forming jacket. Therefore the health of the insulation material inside the high voltage bushing can be evaluated.

[0011] In an advantageous embodiment the field forming jacket comprises a support layer on which the field forming layer is arranged, wherein the support layer is made of a non-hygroscopic material. The support layer therefore simplifies handling and processing. This means, that there is no need to dry the material like it would be necessary with hygroscopic material like cellulose.

[0012] In an advantageous embodiment electrically insulating spacer elements are arranged between the high voltage bushing and the field forming jacket. The spacer elements advantageously provide the insulation gap and simultaneously provide a protection against a mechanical damage when mounting the high voltage bushing.

[0013] In an advantageous embodiment the field forming layer is arranged on an outer surface of the field forming jacket. A mechanical damage of the field forming layer when mounting the high voltage bushing is therefore prevented.

[0014] In an advantageous embodiment the field forming layer is arranged on the inner surface of the field forming jacket.

[0015] In an advantageous embodiment the insulation gap is connected to an interior space of the metal enclosure for an exchange of an insulation fluid.

[0016] In an advantageous embodiment the insulation fluid is arranged in the insulation gap, wherein an electrical conductivity of the field forming layer is greater than an electrical conductivity of the insulation fluid.

[0017] In an advantageous embodiment the electrical conductivity of the field forming layer is greater than an electrical conductivity of the outer surface of the high voltage bushing.

Brief description of the figures

[0018]

Figures 1 to 3 show a schematic sectional view of a high voltage assembly, respectively.

Description of the embodiments

[0019] Figure 1 shows a schematic sectional view of a high voltage assembly 2. The high voltage assembly 2 may be a high voltage transformer or a high voltage reactor like a series reactor, a shunt reactor or a smoothing reactor. The high voltage assembly 2 comprises an active component not shown, wherein the active component comprises for example a transformer core and transformer windings. The high voltage assembly 2 comprises a metal enclosure 4 which is filled with an insulation fluid like transformer oil in an operational state of the high voltage assembly 2. The metal enclosure 4 is connected to ground potential 3. In figure 1 it is shown the high voltage assembly 2 in a state during assembly without a high voltage bushing received in an opening 6 of the metal enclosure 4.

[0020] A conically-shaped field forming jacket 8 extends along a central axis 10 and is essentially rotationally symmetric to the central axis 10. An inner surface 14 is arranged with respect to the opening 6 such that it is formed a receiving chamber 12 for receiving at least a part of the high voltage bushing. The field forming jacket 8 comprises a support layer 16 preferably of insulating, non-hygroscopic material and a field forming layer 18. Both the support layer 16 as also the field forming layer 18 extend along the conically tapering form of the field forming jacket 8. The support layer 16 may be made of fiber reinforced epoxy resin or other suitable non-hygroscopic material.

[0021] The field forming layer 18 provides an electrical conductivity greater than an electrical conductivity of the insulation fluid surrounding the field forming jacket 8 and could be a slightly conducting varnish. Moreover, the field forming layer 18 provides the electrical conductivity greater than an electrical conductivity of an outer surface of the high voltage bushing. The electric resistivity of the field forming layer 18 is equal to or smaller than $1*10^{10}$ Ohm * m. Moreover, the field forming layer 18 provides the electrical conductivity greater than an electrical conductivity of the support layer 16.

[0022] The field forming jacket 8 comprises insulating spacer elements 20 arranged at the inner surface 14 of the field forming jacket 20. The spacer elements 20 are schematically shown and provide an insulation gap 22. The spacer elements 20 are arranged in two planes 24, 26, each perpendicular to the central axis 10 and being spaced apart to receive at least a part of an outer surface of the high voltage bushing. In a preferred embodiment there are arranged three spacer elements 20 in one of the planes 24, 26.

[0023] At an inner end of the field forming jacket 8 a contact element 28 is arranged to electrically contact a high voltage conductor of the high voltage bushing. The contact element 28 is electrically contacted to a high voltage conductor 30 which is electrically connected to the active component of the high voltage assembly 2. The contact element 28 is preferably configured to provide a detachable electrical connection. The connector element 28 is arranged inside the field forming jacket 8.

[0024] A first ring-shaped conducting layer 32 is arranged at a first end of the jacket 8 and is electrically connected to the field forming layer 18, wherein the first end is arranged in the direction of the opening 6. The first ring-shaped conducting layer 32 is electrically connected via a first connection 34 to ground potential 3. This connection to ground potential 3 can be established by connecting the first connection 34 to the inner surface of the metal enclosure 4.

[0025] Preferably, the first connection 34 to ground potential 3 can be opened for a diagnosis of the high voltage bushing via a disconnecting device 36. The disconnecting device 36 may be implemented as a screw plug for electrically connecting and disconnecting the first connection 34 to the metal enclosure 4 and therefore to ground potential 3. The disconnecting device 36 is placed outside the metal enclosure 4, wherein the first connection 34 is guided through an insulated and closed opening 35.

[0026] A second ring-shaped conducting layer 38 is arranged at a second end of the jacket 8 and is electrically connected to the field forming layer 18, wherein the second end is arranged remote from the opening 6. The second ring-shaped conducting layer 38 is electrically connected via a second connection 40 to the contact element 28.

[0027] The conducting layers 32 and 24 may comprise a conducting paint like a silverpaint or a carbon paint. In a further embodiment the conductive layers 32 and 34 comprise a conductive foil like a metal foil or carbonized paper.

[0028] Therefore the field forming jacket 8 comprises the field forming layer 8 with the first connection 34 to the ground potential 3 and the second connection 40 to a high voltage potential of the high voltage conductor of the high voltage bushing.

[0029] The field forming layer 18 is shown to be arranged at an outer surface of the field forming jacket 8. Of course the field forming layer 18 can be also arranged at the inner surface 14 of the jacket 8 or even inside two support layers. In a further embodiment the field forming jacket comprises a first field forming layer 18 on the inner surface 14 of the jacket 8 and a second field forming layer 18 on the outer surface of the jacket 8.

[0030] The field forming jacket 8 is surrounded by a barrier system 42 comprising single barrier elements 44 extending rotationally symmetric to the central axis 10. Of course the barrier elements 44 may be arranged in another way. The barrier system 42 serves to build channels for the insulation fluid and helps to reduce distances between the components of the high voltage assembly 2 by reducing leakage inductances. The field forming jacket 8 helps to reduce the complexity of the barrier system 42 and may supersede a respective barrier system 42.

[0031] The opening 6 is arranged in a plane 7, wherein

the plane 7 is inclined with respect to a horizontal xy-plane and with respect to a vertical yz-plane. Therefore the high voltage bushing has to be guided along the central axis 10 to be arranged inside the receiving chamber 12. Especially for large transformers the high voltage bushing is mounted on site. On site cranes are able to essentially move the high voltage bushing along a vertical axis or in a horizontal plane. This implies that mounting the high voltage bushing along the central axis 10 becomes difficult. The proposed field forming jacket 18 protects further elements inside the high voltage assembly 2 from being damaged. Of course the opening 6 can be also arranged in an essentially horizontal xy-plane or an essentially vertical yz-plane or xy-plane.

[0032] Figure 2 shows a schematic sectional view of the high voltage assembly 2 with the high voltage bushing 50 received in the high voltage assembly 2. The high voltage conductor 52 is electrically connected to the contact 28. A flange 56 establishes the mechanical connection of the high voltage bushing 50 to the metal enclosure 4.

[0033] The high voltage bushing 50 comprises the high voltage conductor 52 which extends along the central axis 10. The high voltage conductor 52 is surrounded by field guiding elements 54, wherein the field guiding elements 54 are arranged in an insulating material. Therefore the high voltage bushing 50 can be referred to as a condenser bushing.

[0034] The insulating gap 22 is arranged between the inner surface 14 and the outer surface 58 of the high voltage bushing 50. The spacer elements 20 are circumferentially spaced apart to establish an exchange of insulation fluid in the insulation gap 22. According to the embodiment shown an exchange of insulation fluid is possible between an interior space 60 of the metal enclosure 4 and the insulation gap 22. The arrows 62 and 64 indicate this insulation fluid exchange.

[0035] In an embodiment not shown the insulating gap 22 is hermetically separated from the interior space 60 of the metal enclosure 4 and is filled with a further insulation fluid.

[0036] The field forming jacket 8 is shown with a conical shape and an essentially constant distance to the outer surface 58 of the high voltage bushing 50. Of course, the field forming jacket 8 does not have to follow this constraint and may be of cylindrical or other tubular shape with a varying distance between the outer surface 58 and the inner surface 14.

[0037] Figure 3 shows a schematic sectional view of the high voltage assembly 2 with the high voltage bushing 50 received in the high voltage assembly 2. The lines 66 of the electric potential are influenced by the field forming layer 18 of the field forming jacket 8 such that the electric potential according to the lines 66 is homogenized. This homogenization of the electric field results in a better utilization of the insulation material and thus the possibility to reduce required space and volume. Additionally, if barriers are required in the field space, complexity of those barriers can be largely reduced. The toroidal structure 68 is connected to high voltage for an experimental setup.

Claims

1. A high voltage assembly (2), especially a high voltage transformer or a high voltage reactor, comprising:

   - a metal enclosure (4) containing an active component and being connected to ground potential (3),
   - a high voltage bushing (50) comprising a high voltage conductor (52), the high voltage bushing (50) passing through an opening (6) of the metal enclosure (4),

   the high voltage assembly (2) being **characterized in**

   - **that** a field forming jacket (8) is arranged inside the metal enclosure (4) to receive at least partly the high voltage bushing (50),
   - **that** the field forming jacket (8) is configured to provide an insulation gap (22) between an inner surface (14) of the field forming jacket (8) and an outer surface (58) of the high voltage bushing (50), and
   - **that** the field forming jacket (8) comprises a field forming layer (18) with a first electrical connection (34) to the ground potential (3) and a second electrical connection (40) to a high voltage potential of the high voltage conductor (52).

2. The high voltage assembly (2) according to claim 1, wherein the first electrical connection (34) between the field forming layer (18) and ground potential (3) comprises a disconnecting device (36) for disconnecting the field forming layer (18) from ground potential (3).

3. The high voltage assembly (2) according to claim 1 or 2, wherein the field forming jacket (18) comprises a support layer (16) on which the field forming layer (18) is arranged, and wherein the support layer (16) is made of a non-hygroscopic material.

4. The high voltage assembly (2) according to one of the preceding claims, wherein electrically insulating spacer elements (20) are arranged between the high voltage bushing (50) and the field forming jacket (8).

5. The high voltage assembly (2) according to one of the preceding claims, wherein the field forming layer (18) is arranged on an outer surface of the field forming jacket (8).

6. The high voltage assembly (2) according to one of the claims 1 to 4, wherein the field forming layer (18) is arranged on the inner surface (14) of the field forming jacket (8).

7. The high voltage assembly (2) according to one of the preceding claims, wherein the insulation gap (22) is connected to an interior space (60) of the metal enclosure (4) for an exchange of an insulation fluid.

8. The high voltage assembly (2) according to one of the preceding claims, wherein the insulation fluid is arranged in the insulation gap (22), and wherein an electrical conductivity of the field forming layer (18) is greater than an electrical conductivity of the insulation fluid.

9. The high voltage assembly (2) according to one of the preceding claims, wherein the electrical conductivity of the field forming layer (18) is greater than an electrical conductivity of the outer surface (58) of the high voltage bushing (50).

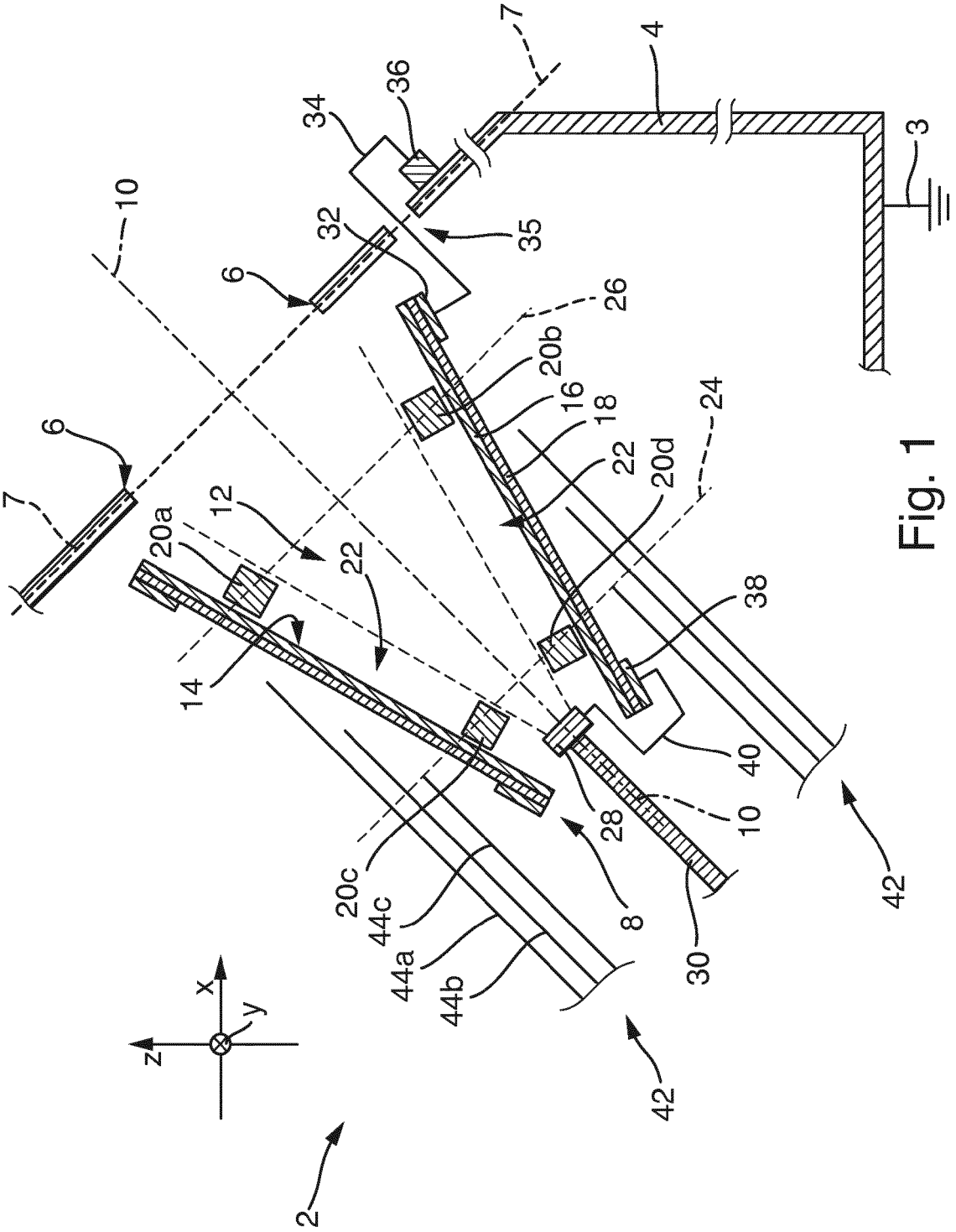
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Fig. 1

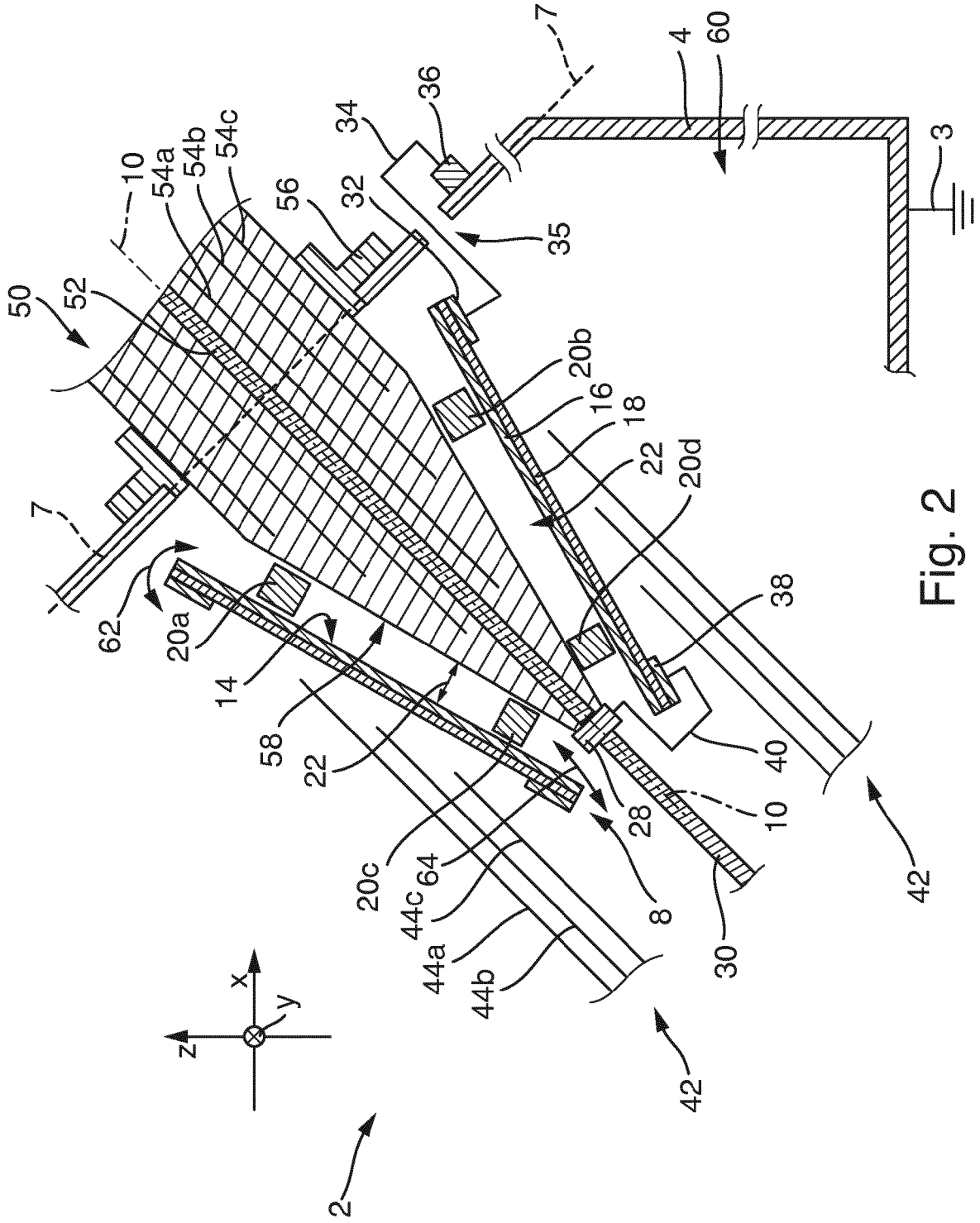
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Fig. 2

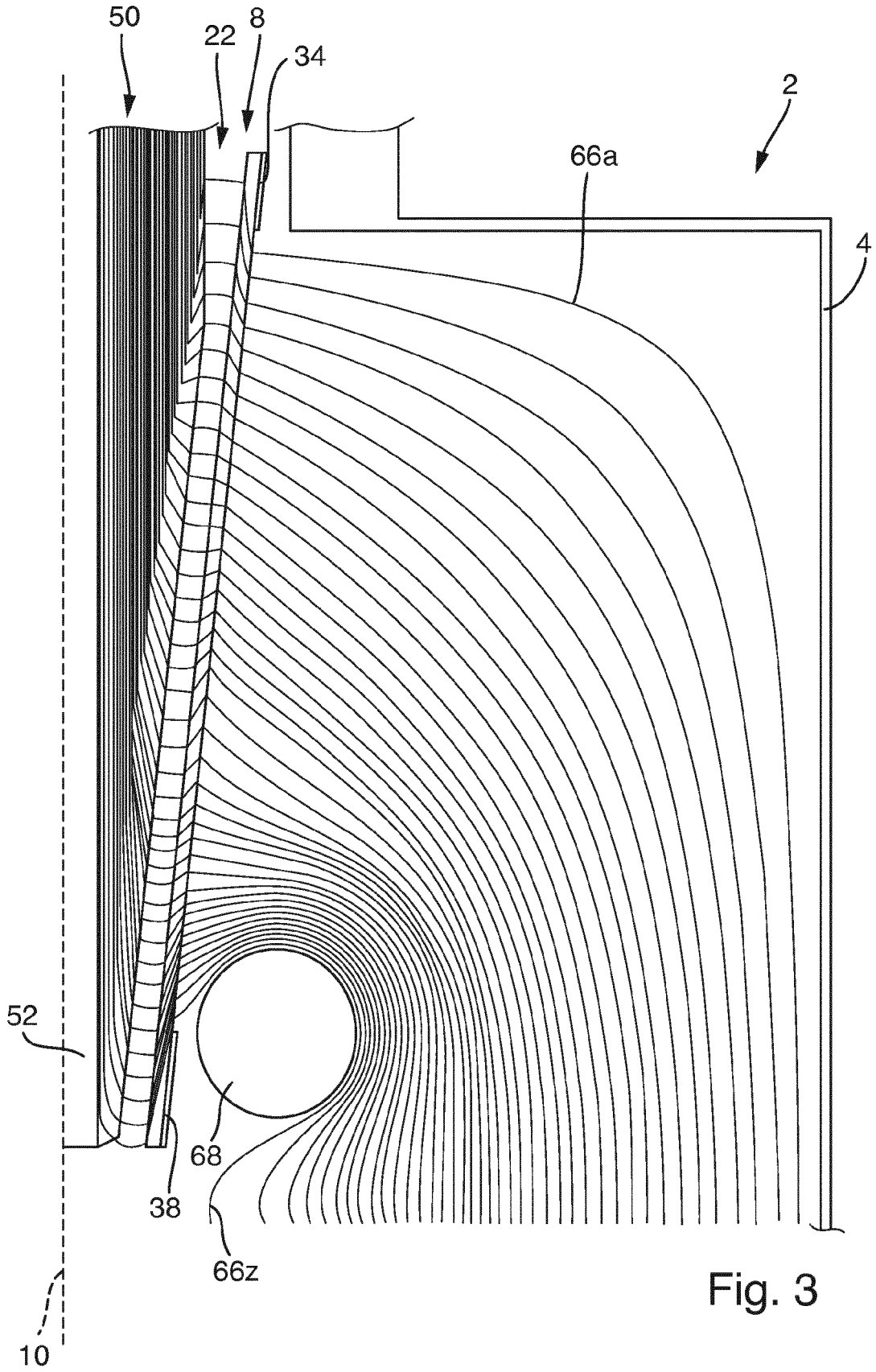

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 2621

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	US 5 227 584 A (HOLMSTROEM LARS [SE] ET AL) 13 July 1993 (1993-07-13) * abstract * -----	1	INV. H01F27/04 H01B17/28
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TECHNICAL FIELDS SEARCHED (IPC)

H01F
H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 May 2016	Salm, Robert

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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