

(19)



(11)

EP 4 539 066 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.04.2025 Bulletin 2025/16

(21) Application number: **23203573.3**

(22) Date of filing: **13.10.2023**

(51) International Patent Classification (IPC):
H01F 27/32 (2006.01) **H01F 41/12** (2006.01)
H01F 5/06 (2006.01) **H01F 5/02** (2006.01)
H01F 27/02 (2006.01) **H01F 27/28** (2006.01)
H01F 27/36 (2006.01)

(52) Cooperative Patent Classification (CPC):
H01F 5/06; H01F 5/02; H01F 27/02; H01F 27/2823;
H01F 27/2828; H01F 27/2885; H01F 27/2895;
H01F 27/323; H01F 27/363; H01F 41/122

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA
 Designated Validation States:
KH MA MD TN

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(54) **METHOD OF WINDING A COIL, COIL SUITABLE FOR BEING USED IN TRANSFORMERS AND TRANSFORMER**

(57) The present disclosure relates to structure of a coil, a method of winding a coil and a transformer. The present invention also relates to a method for production of the medium voltage instrument transformer primary coils insulation.

A method of winding a coil comprising steps of winding a layer of a wire on an insulation other than epoxy resins such that the layer of the wire pushes an excess adhesive towards an edge of the coil and placing the layer of insulation on the layer of the wire, wherein steps a) and b) are performed at least once.

A coil suitable for being used in transformers comprising at least one layer of a wire, wherein the wire ends with a terminal on each end, wherein the terminal is placed such that it may be connected to, at least two layers of an insulation, wherein the layer of the wire is placed between two of the at least two layers of the insulation, wherein the layer of insulation is a tape with one or both sides coated with an adhesive comprising a carrier, preferably a film, even more preferably made of PET, PVC, PP, PEN, paper or paper composite, adhesive layers, preferably acrylic, silicone or rubber, or the insulation is thermally activated adhesive tape, or the layer of insulation is an adhesive tape.

A transformer comprising a first coil, a second coil and a core placed inside of the at least two coils, wherein the first coil is the coil according to the present invention, and preferably the second coil is also the coil according to the present invention.

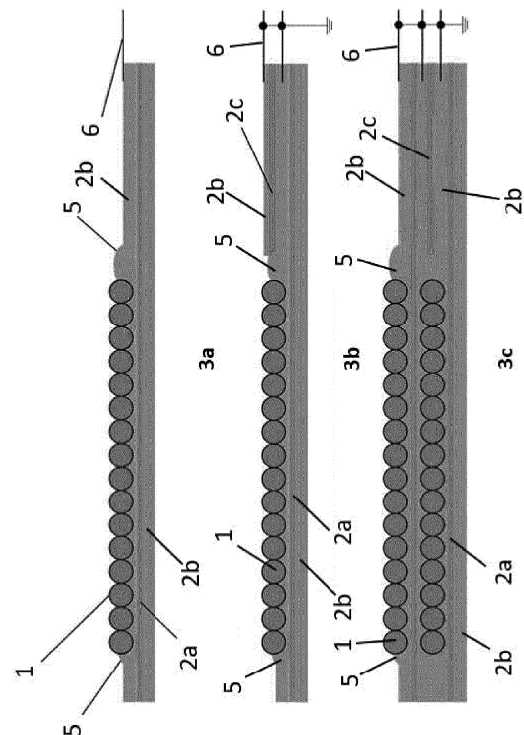


Fig. 3

Description

TECHNICAL FIELD

[0001] The present disclosure relates to structure of a coil, a method of winding a coil and a transformer. The present invention also relates to a method for production of the medium voltage instrument transformer primary coils insulation.

BACKGROUND

[0002] Standard medium voltage transformers are insulated with a PET film or PET laminates e.g. Mylar, DPF or Trivoltan. After a primary coil is wound, it is assembled in a mold with other parts of the voltage transformer and subsequently overcast with a silica-filled epoxy in an automatic pressure gelation process. This method causes some issues. A scrap rate can be quite high because formation of voids and defects between the PET film insulation is inevitable. This is particularly critical for higher voltage ratings, e.g., 36 kV. What is more the automatic pressure gelation is a high temperature process, characterized by considerable energy consumption. A production line requires many heavy and expensive molds, and the epoxy resin is irritating to the personnel.

[0003] Document EP3968345A1 discloses a primary coil suitable to use in a transformer and a method for manufacturing a primary coil suitable to use in a transformer. A primary coil suitable to use in a transformer comprising a primary winding bobbin on which a layer of a primary winding and at least one layer, preferably a fixed number of 1 to 3 layers, of an interlayer insulation material are wound alternately, wherein the interlayer insulation material and the primary winding are impregnated with an epoxy, wherein the interlayer insulation material is a nonwoven material or a crepe paper.

[0004] In the prior art, a standard structure of the coil for the medium voltage instrument transformers consists of number of layers of windings and an insulation material which are assembled in an alternate manner. Manufacturing of such coil starts with wrapping of few layers of the insulation material around a cylindrical core. The insulation material has porous structure, and it is usually made form crepe paper. Next a layer of the winding made of a thin wire is wrapped over the insulation layer. Subsequently several insulation and winding layers are wound one over another. Finally, a certain number of insulation material alone and a semiconductive screen is wrapped. Such prepared coil is later impregnated with the epoxy resin under vacuum conditions. Such coil is cured at elevated temperature which results in creation of a solid composite material consisting of the impregnated porous material and winding wire.

[0005] Such technique of a coil manufacturing has number of disadvantages. It requires application of the epoxy resins which contain compounds having negative

impact on the human health (e.g. anhydrites). The resin impregnation and curing process requires significant effort and consumes a lot of energy. Before impregnation, all the coils need to be assembled in molds which must be clean. The impregnation process must be performed very carefully otherwise remaining voids in the composite will become the source of partial discharges and finally the product will be scrapped. Subsequent curing process demands energy, and it is time consuming. The coil made of thermosetting material is very difficult to recycle.

SUMMARY OF THE DISCLOSURE

[0006] The object of the invention is to eliminate epoxy from the transformers production process.

[0007] According to a first aspect of the present invention there is provided a method of winding a coil comprising steps of:

- a) Winding a layer of a wire on an insulation other than epoxy resins such that the layer of the wire immerses in an adhesive and pushes an excess adhesive towards both sides of the wire;
- b) Placing the layer of insulation on the layer of the wire;

wherein steps a) and b) are performed at least once.

[0008] In one of the embodiments of the invention after step a) a step c) is performed during which the rest, toward the at least one edge of the coil, of the layer of insulation on which the layer of wire is wound is filled such that the height of the coil, after step c), is approximately even, preferably it is filled with an additional insulation or by winding a dielectric string with a diameter which matches the diameter of the wire.

[0009] In one embodiment before step b) a step d) is performed during which thin sheet of a semiconductive tape or a conductive, preferably metallic, tape or a wire is placed on the layer of insulation, on the at least one edge of the coil, such that the at least part of the semiconductor tape extends beyond the edge of the coil, wherein preferably the semiconductive tape is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire.

[0010] In yet another embodiment the layer of insulation (2) is a tape with one or both sides coated with an adhesive comprising

a carrier, preferably a film, even more preferably made of PET, PVC, PP, PEN, paper or paper composite,

adhesive layers, preferably acrylic, silicone or rubber, or

the layer of insulation is a thermally activated adhesive tape and during placing of the insulation a heat is applied to the insulation before step b), after step b)

or both, or

the layer of insulation is an adhesive tape.

[0011] In one embodiment the layer of insulation is placed during step b) such that it forms a layer structure, a brick wall structure or an overlapped structure.

[0012] In one of the embodiments before step a) a step e) is performed during which the layer of insulation is placed on a bobbin.

[0013] In yet another embodiment every next step a) is performed such that the layer of wire is shorter than the layer of wire wound during previous step a).

[0014] According to a second aspect of the present invention there is provided a coil suitable for being used in transformers comprising:

at least one layer of a wire, wherein the wire ends with a terminal on each end, wherein the terminal is placed such that it may be connected to,

at least two layers of an insulation, wherein the layer of the wire is placed between two of the at least two layers of the insulation,

wherein the layer of insulation is a tape with one or both sides coated with an adhesive comprising

a carrier, preferably a film, even more preferably made of PET, PVC, PP, PEN, paper or paper composite,

adhesive layers, preferably acrylic, silicone or rubber, or

the layer of insulation is thermally activated adhesive tape, or

the layer of insulation is an adhesive tape.

[0015] In one embodiment a thickness of the layer of the insulation is 10-300 μm .

[0016] In one of the preferred embodiments a distance between the layers of the wire is 20-300 μm .

[0017] The layer of insulation on which the layer of the wire is wound is filled toward the at least one edge of the coil such that the height of the layer of the wire is approximately even, preferably it is filled on the at least one edge with an additional insulation or with a layer of a dielectric string with a diameter which matches the diameter of the wire.

[0018] In one embodiment a thin sheet of a semiconductive tape or a conductive, preferably metallic, tape or a wire is placed on the at least one layer of the insulation, on the at least one edge of the coil, such that the at least part of the semiconductor tape extends beyond the edge of the coil, wherein preferably the semiconductive tape is a semiconductive crepe paper or a semiconductive syn-

thetic tape.

[0019] In one of the embodiments comprises a bobbin near the portion of the coil which is closest to the center of the coil.

[0020] According to a third aspect of the present invention there is provided a transformer comprising a first coil, a second coil and a core placed inside of the at least two coils, wherein the first coil is the coil according to the present invention, and preferably the second coil is also the coil according to the present invention.

[0021] In one embodiment the transformer the core and the at least two coils, the first coil and the second coil, are placed within a dielectric shell, preferably made from SMC, BMC or thermoplastic material.

[0022] In one of the preferred embodiments comprising an additional dielectric material layer to protect from a flashover between the terminal and the screen surrounding the coil formed from at least one thin sheet of a semiconductive tape placed on the at least one layer of the insulation, on the at least one edge of the coil.

[0023] In one embodiment the transformer is placed within a conductive shell, preferably made of metal.

[0024] In one of the embodiments comprises a bushing.

ADVANTAGES OF THE INVENTION

[0025] According to a present invention a production of transformers is much easier, faster, less expensive, sustainable and safe. Production doesn't require molds, resulting in more storage space. Eliminating casting improves production safety and reduces energy consumption of the production process. Heat processes are limited or completely eliminated. Eliminating the epoxy from a product improves sustainability and makes the product eco-friendly and safe for the production line operators.

[0026] The present invention improves a partial discharge performance, resulting in enhanced lifetime and reliability. Winding the one layer of insulation results in better control over the quality of its performance than when the entire coil is impregnated. The occurrence of partial discharges which can lead to insulation degradation is reduced. Modular construction makes the assembly easy. Most of the parts can be directly reused, and copper (in the case of the layer of wire made from copper) can be easily extracted what makes this invention recyclable. The majority of elements produced from eco-friendly, recyclable materials such as thermoplastics. New technology causes reduction of the weight.

[0027] Replacing the porous insulation material and the epoxy resin by the double-sided or single-sided adhesive tape eliminates the complex impregnation and curing processes. The adhesive tapes are solids and do not procure any health and safety hazards typical for liquid chemicals. They are usually made of thermoplastics materials which can be recycled. Elimination of impregnation and curing process would also significantly shorten the manufacturing process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The disclosure will now be discussed with reference to the figures, in which:

Figure 1 depicts a schematic cross-section view of a medium voltage instrument transformer coil as known in the prior art,

Figure 2 depicts possible adhesive tape winding patterns,

Figure 3 depicts schematics of a winding process, with adhesive movement filling a void space at the layer edge side, filling with adhesive tape,

Figure 4 depicts schematics of the winding process, with adhesive movement filling the void space at the layer edge side, filling with dielectric string,

Figure 5 depicts a winding where an adhesive has not reached a top area between wires,

Figure 6 depicts a winding where an adhesive has reached a top area between wires,

Figure 7 depicts a medium voltage transformer arrangement with a wrapped adhesive tape insulated primary coil module is presented, fitted with a dielectric shell,

Figure 8 depicts a medium voltage transformer arrangement with a wrapped adhesive tape insulated primary coil module is presented, fitted with a conductive shell.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0029] For a proper understanding of the disclosure, in the detailed description below corresponding elements or parts of the disclosure will be denoted with identical reference numerals in the drawings.

[0030] The present invention discloses a method of winding a coil comprising steps of:

- a) winding a layer of a wire 1 on an insulation 2 other than epoxy resins such that the layer of the wire 1 immerses in an adhesive and pushes an excess 5 adhesive towards both sides of the wire 1,
- b) placing the layer of insulation 2 on the layer of the wire 1,

wherein steps a) and b) are performed at least once.

[0031] In the present embodiment the layer of insulation 2 is a tape with one or both sides coated with an adhesive comprising a carrier and adhesive layers. The carrier 2a is preferably a film, even more preferably is made of PET, PVC, PP, PEN, paper or paper composite.

Adhesive layers 2b are preferably acrylic, silicone or rubber. In another embodiment the layer of insulation 2 is thermally activated adhesive tape. In this case during placing the insulation 2, a heat is applied to the insulation 2 before step b), after step b) or in different example of the invention - both. In another embodiment of the invention, the layer of insulation 2 is an adhesive tape which consists only of the adhesive layer. In this embodiment the layer of insulation 2 is a type of a transfer tape.

[0032] Winding the layer of the wire on the insulation results in immersing wire 1 in the above-mentioned adhesive. The excess of adhesive is pushed towards both sides of the wire 1. In the case of winding a first layer of the wire 1, the excess adhesive is pushed towards both sides of the wire 1, where a first side is directed into an edge of the coil. In the case of multiply layers of the wire 1, the excess adhesive is also pushed towards another layer of the wire 1. The adhesive layer 2b should completely fill any voids found between the layer of the insulation 2 and the wire 1. That is of particular importance when considering the edge of the layers of the wire 1 - it is an area of high electric field and must be free of defects.

[0033] In different embodiment of the invention, after step a) a step c) is performed during which the rest, toward the at least one edge of the coil, of the layer of insulation 2 on which the layer of wire 1 is wound is filled such that the height of the coil, after step c), is approximately even. Preferably it is filled with an additional insulation 2c or by winding a dielectric string 7 with a diameter which matches the diameter of the wire 1. As the layer of the wire 1 is wound the excess 5 adhesive forms a movement-a "wave", that travels in front of the layer of the wire 1. This movement, excess 5 adhesive, finally fills the potentially void space at the layer of the wire 1 edge, as it is shown in Fig. 3 and 4. The adhesive makes the winding process very easy, since it fixes the layer of the wire 1 turns and prevents any sliding or misalignments. This excess 5 adhesive can be in different embodiments any thermoplastic material.

[0034] There are several adhesive layers 2b winding patterns possible, as shown in the Fig. 2. In other embodiment of the invention the layer of insulation 2 is placed during step b) such that it forms a layer structure - 2a on the Fig. 2, a brick wall structure - 2b on the Fig. 2, or an overlapped structure - 2c on the Fig. 3. For the simplicity of this disclosure all examples show the layer structure.

[0035] In different embodiment of the invention, before step b) a step d) is performed during which thin sheet of a semiconductive tape 6 or a conductive, preferably metallic, tape or a wire is placed on the layer of insulation 2, on the at least one edge of the coil, such that the at least part of the semiconductor tape 6 extends beyond the edge of the coil, wherein preferably the semiconductive tape 6 is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire. The parts of the semiconductive tape 6 that extend beyond the edge of the coil can be connected galvanically together and grounded as it is shown in Fig. 3

and 4. In this manner a grounded screen 4 is formed around the coil, which can be used as a separate module.

[0036] In other embodiment of the invention wherein every next step a) is performed such that the layer of wire 1 is shorter than the layer of wire 1 wound during previous step a). The quality and dielectric strength of an adhesive interface between the edge of the layer of the wire 1 and the edge of the grounded tape forming the grounded screen 4 is critical. Essentially, the bottom layers of the wire 1 are at lower potential than the top layers. Winding the coil in a trapezoidal fashion, with longer bottom layers with edges closer to the grounded screen 4 and shorter top layers with edges further from the grounded screen, as shown in Fig. 7 and Fig. 8 can yield best results.

[0037] It is important that the adhesive film layers 2b are wound evenly, without any wrinkling where air could be trapped. To achieve this once a layer of the wire 1 is finished, the rest of the adhesive layer 2b towards the edge should somehow be filled. It can be done by means of adding an additional insulation 2c in the form of thin strip of adhesive layer 2b as it is shown in Fig. 3, or by means of adding a dielectric string 7, the diameter of which matches the diameter of the wire 1 as it is shown in Fig. 4.

[0038] In other embodiment of the invention before step a) a step e) is performed during which the layer of insulation 2 is placed on a bobbin 8 as it is seen on Fig 6 and 7.

[0039] This invention also discloses a coil suitable for being used in transformers. It is needed that the layers of the insulation 2 which come to the contact with a layer of a wire 1 will ensure that all voids around the wires 1 are filled. This coil comprises at least one layer of the wire 1 and at least two layers of the insulation 2. The wire 1 ends with a terminal on each end, wherein the terminal is placed such that it may be connected to, and the layer of the wire 1 is placed between two of the at least two layers of the insulation 2. The layer of the wire 1 is typically made from a copper, but it is known that the wire 1 can be made from any metal and alloys or that the wire 1 can be replaced with any conductor suitable for winding.

[0040] In the prior art, seen on Fig. 1, it is known to create coils consisting of layers of a wire PA2 and an insulation PA3. Firstly, the layers of the insulation PA3 are wrapped and then the layers of the wire PA2 are wrapped over the layer of the insulation PA3. The insulation PA3 is made from porous structure material. At the final stage, the coil is impregnated with epoxy resin PA1. Such coil also comprises a screen PA4 and a core PA5. The present invention's coil doesn't require use of the epoxy resin which very often contains compounds having negative impact on the human health and environment and eliminates time consuming process of impregnation and curing.

[0041] In one of the embodiments the layer of insulation 2 is a tape with one or both sides coated with an adhesive comprising a carrier 2a and adhesive layers 2b.

The carrier 2a is preferably a film and even more preferably made of PET, PVC, PP, PEN, paper or paper composite. Adhesive layers 2b are preferably acrylic, silicone or rubber, or the insulation is thermally activated adhesive tape. The tape film must be ensured by high, defect free quality, ensuring high dielectric withstand. The thickness of the tape can be typically between 10 - 200 μm . A distance between the layers of the wire 1 is preferably 20-300 μm . In another embodiment of the invention, the layer of insulation 2 is an adhesive tape which consists only of the adhesive layer. In this embodiment the layer of insulation 2 is a type of a transfer tape.

[0042] The adhesive thickness is in one of the embodiments between 10 - 150 μm , and it is best selected in such a way that it is optimized with regard to the diameter of the coil wire. In the best solution, the adhesive layer 2b should completely fill any voids found between the layer of the insulation 2 and the wire 1. That is of particular importance when considering the edge of the layers of the wire 1. In other embodiment of the invention the layer of insulation 2 on which the layer of the wire 1 is wound is filled toward the at least one edge of the coil such that the height of the layer of the wire is approximately even, preferably it is filled on the at least one edge with the additional insulation 2c or with the layer of the dielectric string 7 with the diameter which matches the diameter of the wire 1.

[0043] In one embodiment of the invention, instead of the last layer of the wire 1, a conductive/semiconductive screen is placed.

[0044] In different embodiment of the invention a thin sheet of a semiconductive tape 6 or a conductive, preferably metallic, tape or a wire is placed on the at least one layer of the insulation 2, on the at least one edge of the coil, such that the at least part of the semiconductor tape 6 extends beyond the edge of the coil, wherein preferably the semiconductive tape 6 is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire.

[0045] As it is seen in Fig. 3 and 4, layers of the wire 1 wrapped on the surface of the adhesive layer 2b with sufficient tension will push out the underlaying adhesive layer 2b to the free space between them. This results in immersion of the wires 1 in the adhesive layer 2b (glue) and elimination of voids between them. Then next adhesive layer 2b covering the wires 1 from top (also applied with certain pressure) fills the remaining voids and finally the completely free structure consisting of the polymeric film wires - carriers 2a, and adhesive layer 2b is achieved.

[0046] It should be noted that in reality there is some free space between wires 1 as shown in Fig. 5 and 6. During a winding process the adhesive is pushed toward edges as the excess adhesive 5 of the current winding layer and toward adjacent wires 1. Usually also only the bottom area 1' between the wires 1 is filled with the adhesive however it is possible, due to the greater force used during the winding process or by means of greater

amount of the adhesive used, that the adhesive will also fill the top area 1" between the wires 1. In such cases it will be sufficient that the carrier 2a will have only one adhesive layer 2b since the adhesive will be able to insulate adjacent wires 1.

[0047] In other embodiment of the invention the coil comprises a bobbin 8 near the portion of the coil which is closest to the center of the coil.

[0048] This invention also discloses a transformer 10 comprising at least two coils and a core 3 placed inside of the at least two coils, where those coils are a first coil 14 and a second coil 15. The first coil 14 and the second coil 15 are the coils according to the presented invention.

[0049] In different embodiment of the invention the core 3 and the at least two coils, the first coil 14 and the second coil 15, are placed within a dielectric shell 9 as it is shown in Fig. 7. The shell 9 is preferably made from SMC, BMC or thermoplastic material. Material should have sufficient dielectric strength.

[0050] The transformer 10 in different embodiment has a medium voltage screen 17 and a baseplate 16.

[0051] In different embodiment of the invention, having a dielectric shell 9 requires adding an additional dielectric material layer 11 to protect from a flashover between the terminal and the screen 4 surrounding the coil formed from at least one thin sheet of a semiconductive tape placed on the at least one layer of the insulation 2, on the at least one edge of the coil. Additional dielectric material layer 11 is to prevent an internal breakdown from the medium voltage lead to the grounded screen 4. The additional dielectric material layer 11 can be room temperature cured silicone gel, polyurethane, or even silica filled epoxy.

[0052] The transformer 10 is preferably placed, in one of the embodiments, within a conductive shell 13, preferably made of metal as it is shown in Fig. 7. A conductive shell 13 renders the voltage transformer 10 touch proof - no electric field is present on the surface of the apparatus. Such solutions are commonly used in GIS switchgears. The shell 13 can be made from any conductive material, such as metal sheets. It can also be made from a dielectric material, coated with conductive paint or a layer of metallization. If the conductive shell 13 arrangement is considered, no additional secondary dielectric insulation is required. However, in other embodiment of the invention, the transformer comprises a bushing 12. The bushing 12 is needed to feed the medium voltage lead through the grounded shell.

[0053] Legend:

1- wire

1' - bottom area between wires

1" - top area between wires

2 - insulation

2a - carrier

2b - adhesive layer

2c - additional insulation

3 - core

4 - screen

5 - excess adhesive

6 - semiconductive tape

7 - string

8 - bobbin

9 - dielectric shell

10 - transformer

11 - additional dielectric material layer

12 - bushing

13 - conductive shell

14 - first coil

15 - second coil

16 - baseplate

17 - medium voltage screen

Claims

1. A method of winding a coil comprising steps of:

- a) Winding a layer of a wire (1) on an insulation (2) other than epoxy resins such that the layer of the wire (1) immerses in an adhesive and pushes an excess (5) adhesive towards both sides of the wire (1);
- b) Placing the layer of insulation (2) on the layer of the wire (1);

wherein steps a) and b) are performed at least once.

2. The method of winding a coil according to claim 1, **wherein** after step a) a step c) is performed during which the rest, toward the at least one edge of the coil, of the layer of insulation (2) on which the layer of wire (1) is wound is filled such that the height of the coil, after step c), is approximately even, preferably it is filled with an additional insulation (2c) or by winding

a dielectric string (7) with a diameter which matches the diameter of the wire (1).

3. The method of winding a coil according to claim 1 or 2, **wherein** before step b) a step d) is performed during which thin sheet of a semiconductive tape (6) or a conductive, preferably metallic, tape or a wire is placed on the layer of insulation (2), on the at least one edge of the coil, such that the at least part of the semiconductor tape (6) extends beyond the edge of the coil, wherein preferably the semiconductive tape (6) is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire.

4. The method of winding a coil according to anyone of claim 1-3, **wherein** the layer of insulation (2) is a tape with one or both sides coated with an adhesive comprising

a carrier (2a), preferably a film, even more preferably made of PET, PVC, PP, PEN, paper or paper composite,

adhesive layers (2b), preferably acrylic, silicone or rubber, or

the layer of insulation (2) is a thermally activated adhesive tape and during placing of the insulation (2) a heat is applied to the insulation (2) before step b), after step b) or both, or the layer of insulation (2) is an adhesive tape.

5. The method of winding a coil according to anyone of claims 1-4, **wherein** the layer of insulation (2) is placed during step b) such that it forms a layer structure, a brick wall structure or an overlapped structure.

6. A coil suitable for being used in transformers (10) comprising:

at least one layer of a wire (1), wherein the wire (1) ends with a terminal on each end, wherein the terminal is placed such that it may be connected to,

at least two layers of an insulation (2), wherein the layer of the wire (1) is placed between two of the at least two layers of the insulation (2), wherein the layer of insulation (2) is a tape with one or both sides coated with an adhesive comprising

a carrier (2a), preferably a film, even more preferably made of PET, PVC, PP, PEN, paper or paper composite, adhesive layers (2b), preferably acrylic, silicone or rubber, or

the layer of insulation (2) is thermally activated

adhesive tape, or

the layer of insulation (2) is an adhesive tape.

7. The coil according to claim 6, **wherein** a thickness of the layer of the insulation (2) is 10-300 μm .

8. The coil according to claim 6 or 7, **wherein** a distance between the layers of the wire (1) is 20-300 μm .

9. The coil according to any one of claims 6-8 **wherein** the layer of insulation (2) on which the layer of the wire (1) is wound is filled toward the at least one edge of the coil such that the height of the layer of the wire (1) is approximately even, preferably it is filled on the at least one edge with an additional insulation (2c) or with a layer of a dielectric string (7) with a diameter which matches the diameter of the wire (1).

10. The coil according to any one of claims 6-9 **wherein** a thin sheet of a semiconductive tape (6) or a conductive, preferably metallic, tape or a wire is placed on the at least one layer of the insulation, on the at least one edge of the coil, such that the at least part of the semiconductor tape (6) extends beyond the edge of the coil, wherein preferably the semiconductive tape (6) is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire.

11. The coil according to any one of claims 6-10 **wherein** comprises a bobbin (8) near the portion of the coil which is closest to the center of the coil.

12. A transformer (10) comprising a first coil (14), a second coil (15) and a core (3) placed inside of the at least two coils, wherein the first coil (14) is the coil according to claims 8-13, and preferably the second coil (15) is also the coil according to claims 8-13.

13. The transformer (10) according to claim 12, **wherein** the core (3) and the at least two coils, the first coil (14) and the second coil (15), are placed within a dielectric shell (9), preferably made from SMC, BMC or thermoplastic material.

14. The transformer (10) according to claim 12 or 13, **wherein** comprising an additional dielectric material layer (11) to protect from a flashover between the terminal and the screen (4) surrounding the coil formed from at least one thin sheet of a semiconductive tape placed on the at least one layer of the insulation (2), on the at least one edge of the coil.

15. The transformer (10) according to any one of claims 12-14 **wherein** is placed within a conductive shell (13), preferably made of metal.

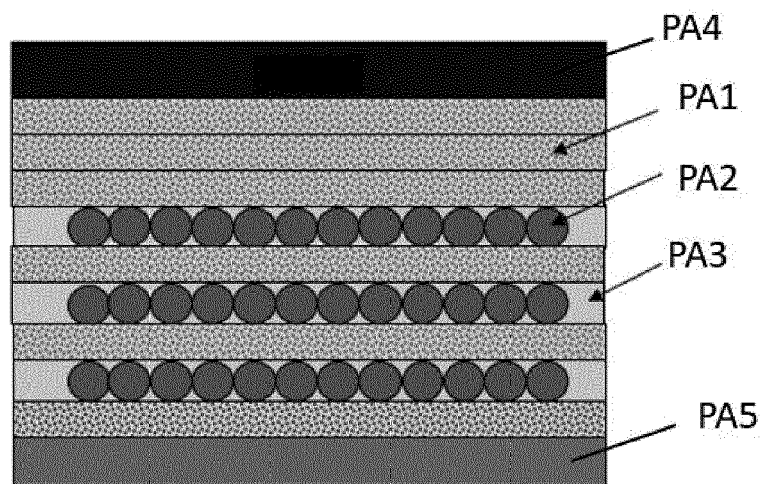


Fig. 1 - PRIOR ART

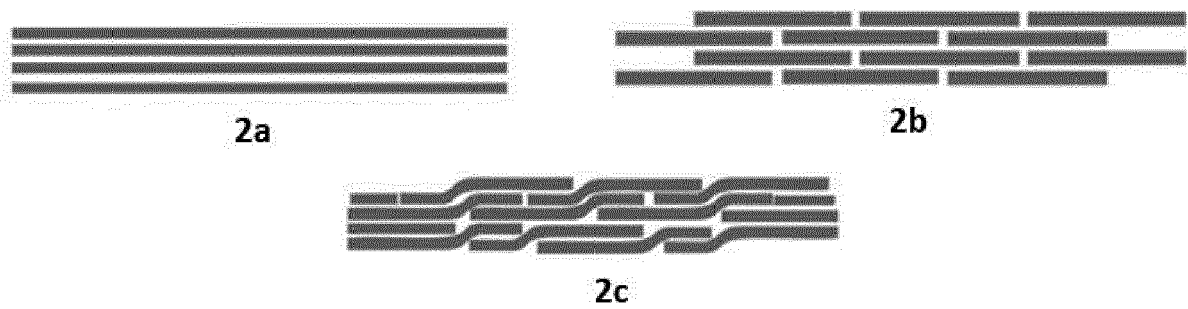


Fig. 2

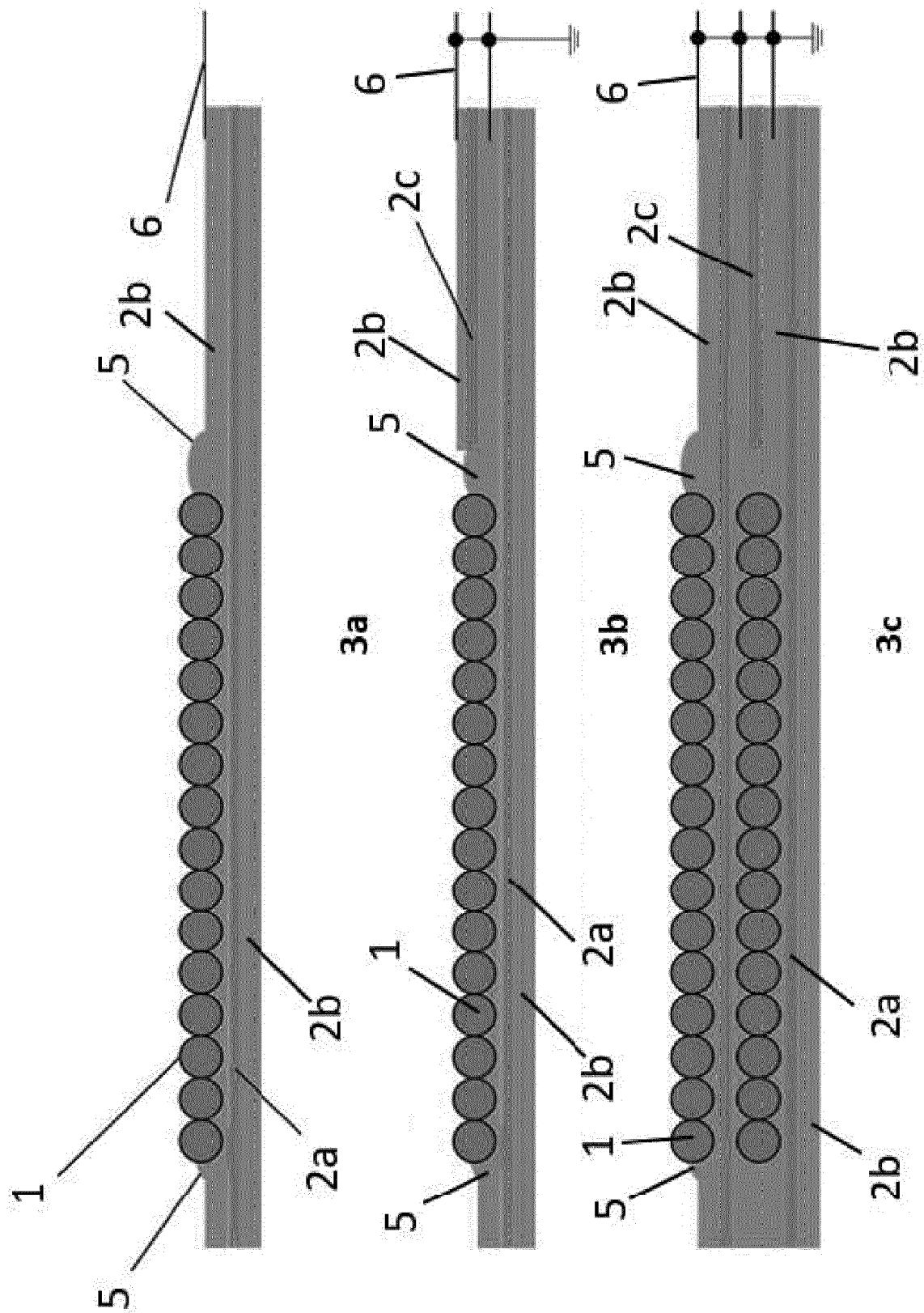


Fig. 3

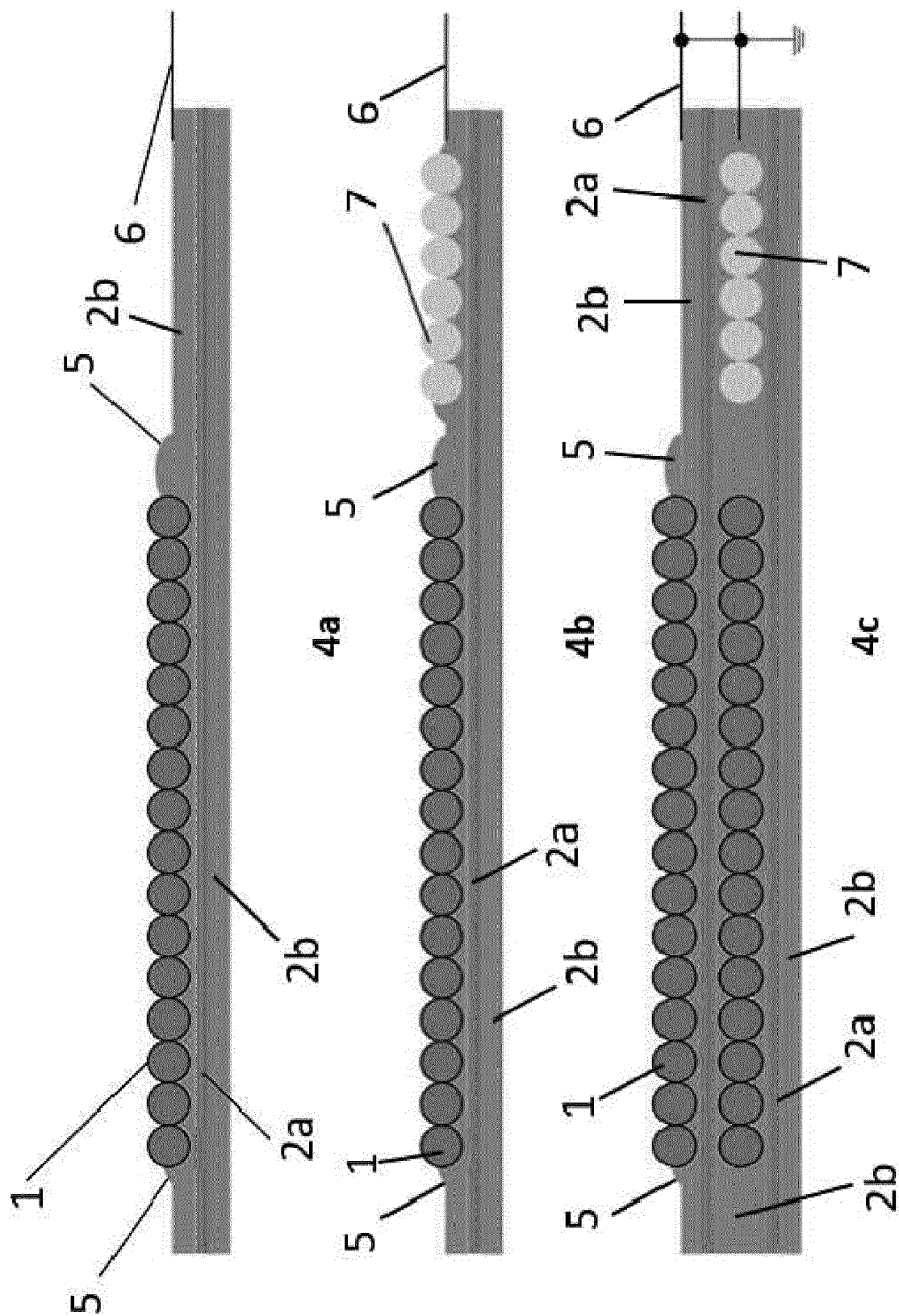


Fig. 4

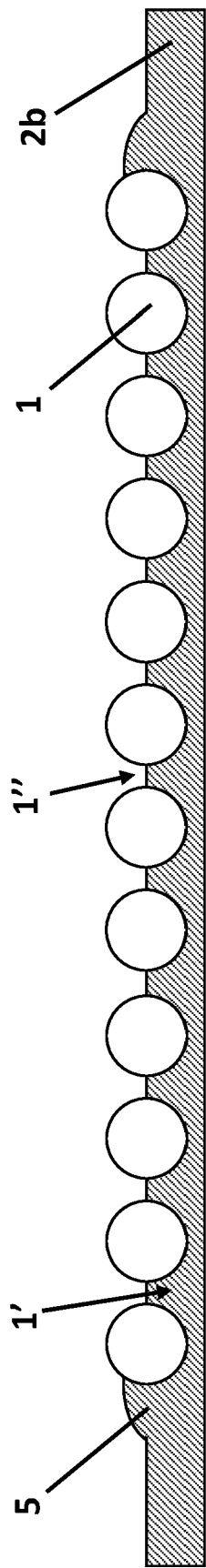


Fig. 5

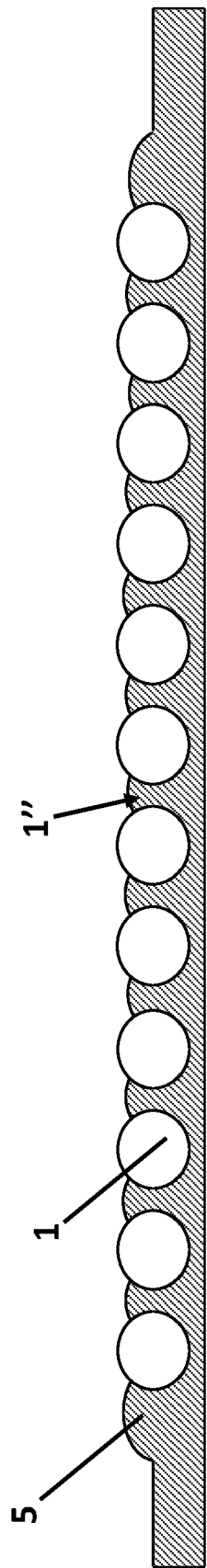


Fig. 6

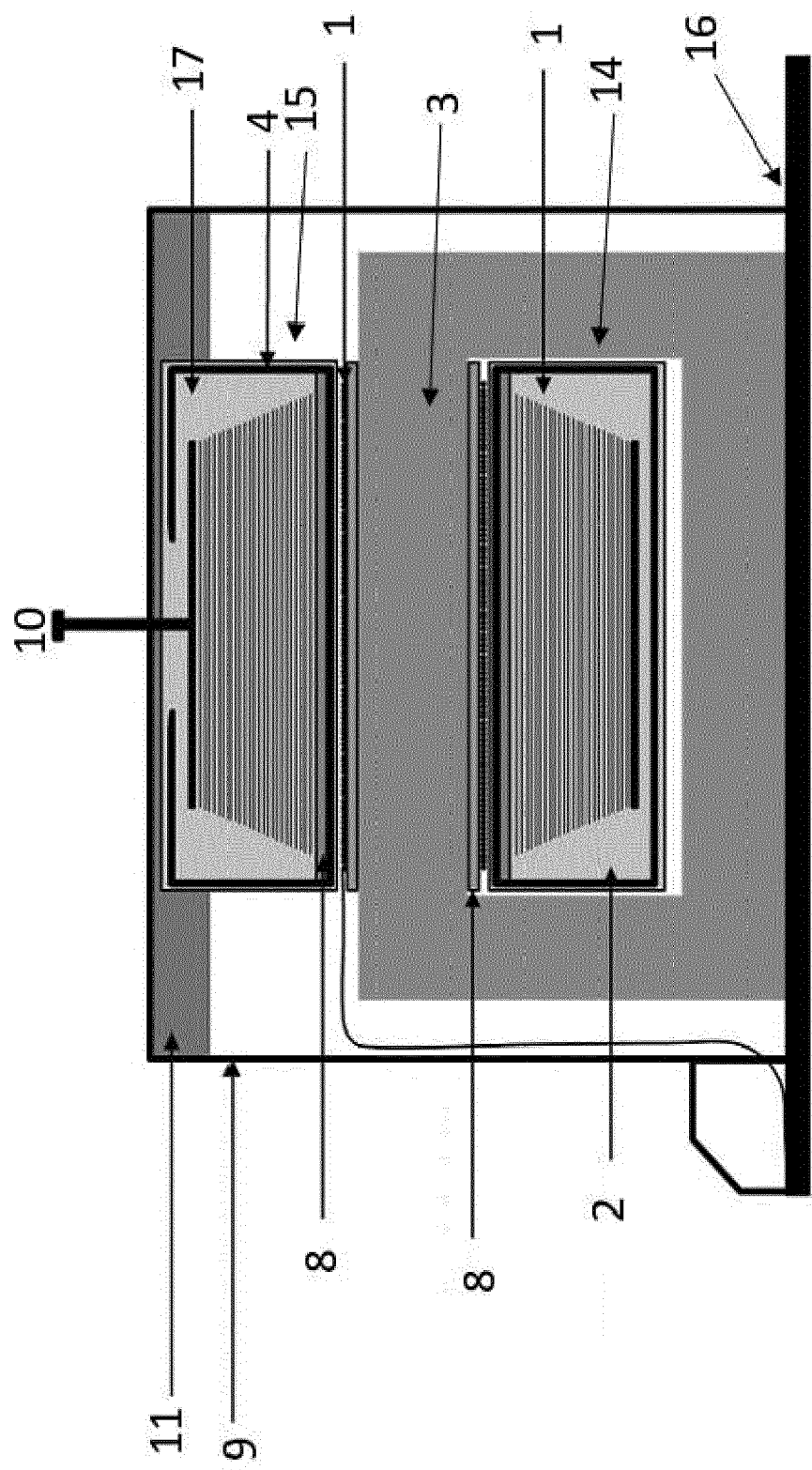


Fig. 7

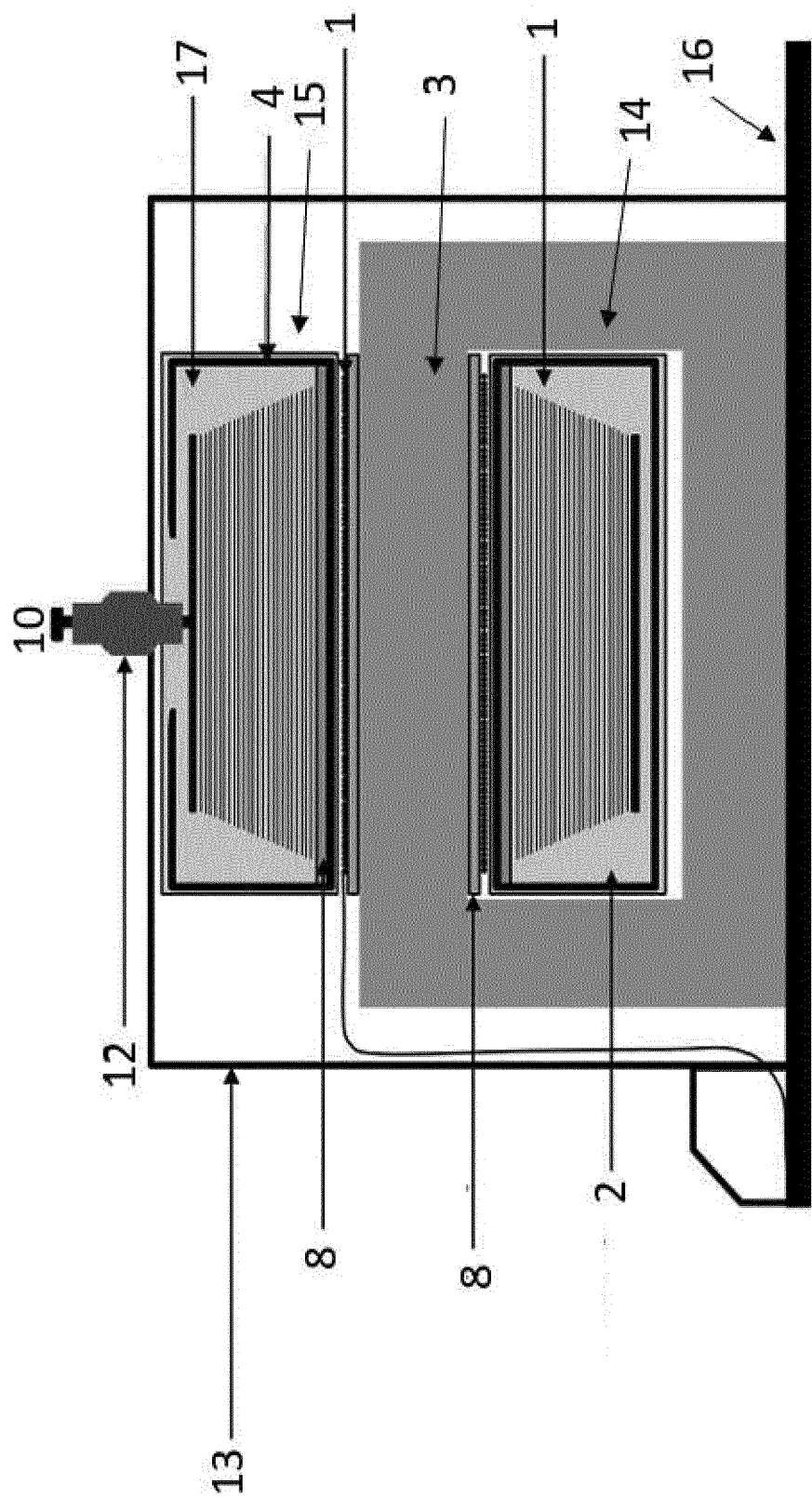


Fig. 8



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 3573

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 767 760 A (MOLLIE JEAN-PAUL [BE] ET AL) 16 June 1998 (1998-06-16)	1,4-8, 11,12	INV. H01F27/32
Y	* figures 2,3 * * corresponding description *	2,5,7-9	H01F41/12 H01F5/06 H01F5/02
X	JP H07 326525 A (SUMITOMO 3M LTD) 12 December 1995 (1995-12-12)	1,4-8, 11,12	H01F27/02 H01F27/28
Y	* figures 1,2 * * corresponding description *	2,5,7-9	H01F27/36
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Y	* figure 1 * * corresponding description *	2,5,7-9	
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Y	* figures 1,2 * * corresponding description *	2,5,7-9	
Y	EP 0 171 688 A1 (MESSWANDLER BAU AG [DE]) 19 February 1986 (1986-02-19)	2,5,9	TECHNICAL FIELDS SEARCHED (IPC) H01F
-The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 February 2024	Examiner Weisser, Wolfgang
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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Application Number

EP 23 20 3573

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1, 2, 6-9 (completely); 4, 5, 11, 12 (partially)

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



LACK OF UNITY OF INVENTION
SHEET B

Application Number

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1, 2, 6-9 (completely); 4, 5, 11, 12 (partially)

A method of winding a coil as defined in independent claim 1, further specifying that after step a) a step c) is performed during which the rest, toward the at least one edge of the coil, of the layer of insulation on which the layer of wire is wound is filled such that the height of the coil, after step c), is approximately even, preferably it is filled with an additional insulation or by winding a dielectric string with a diameter which matches the diameter of the wire. (claim 2)

A coil as defined in present claim 6, further specifying that the layer of insulation on which the layer of the wire is wound is filled toward the at least one edge of the coil such that the height of the coil is approximately even is approximately even, preferably it is filled on the at least one edge with an additional insulation or with a layer of a dielectric string with a diameter which matches the diameter of the wire. (claim 9)

Further, the features of claim 4 (composition of the insulation layer), claim 5 (structure of the insulation layer), claim 7 (thickness of the insulation layer), claim 8 (distance between the layers of the wire), 11 (bobbin), 12 (transformer) are also considered within the first invention.

2. claims: 3, 10, 14 (completely); 4, 5, 11, 12 (partially)

A method of winding a coil as defined in independent claim 1, further specifying that before step b) a step d) is performed during which thin sheet of a semiconductive tape or a conductive, preferably metallic, tape or a wire is placed on the layer of insulation, on the at least one edge of the coil, such that the at least part of the semiconductor tape extends beyond the edge of the coil, wherein preferably the semiconductive tape is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire. (claim 3)

A coil as defined in present claim 6, further specifying that a thin sheet of a semiconductive tape or a conductive, preferably metallic, tape or a wire is placed on the at least one layer of the insulation, on the at least one edge of the coil, such that the at least part of the semiconductor tape extends beyond the edge of the coil, wherein preferably the semiconductive tape is a semiconductive crepe paper or a semiconductive synthetic tape or a conductive, preferably metallic, tape or a wire. (claim 10)

A coil as defined in present claim 6, further specifying



LACK OF UNITY OF INVENTION **SHEET B**

Application Number

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

that an additional dielectric material layer to protect from a flashover between the terminal and the screen surrounding the coil formed from at least one thin sheet of a semiconductive tape placed on the at least one layer of the insulation, on the at least one edge of the coil. (claim 14)

3. claims: 13, 15

A coil as defined in present claim 6, further specifying that

- the core and the at least two coils, the first coil and the second coil, are placed within a dielectric shell, preferably made from SMC, BMC or thermoplastic material (claim 13)

- (the core and the at least two coils (?)) are placed within a conductive shell, preferably made of metal (claim 15).

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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