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- (54) Title:** TRANSFORMER COMPRISING A HEAT PIPE

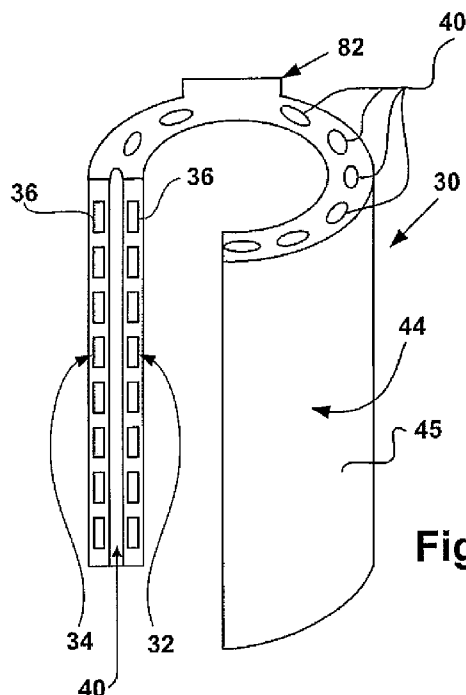


Fig. 2

- (57) Abstract:** The present invention relates to a transformer comprising a primary coil designated to be connected with a source of voltage and a secondary coil designated to be connected with a load. At least one of the coils comprises a first conductor layer comprising one or more disc windings arranged in an axial direction of the coil, said one or more disc windings comprising a conductor wound into a plurality of concentric turns; a second conductor layer disposed over the first conductor layer, the second conductor layer comprising one or more disc windings arranged in an axial direction of the coil, said one or more disc windings comprising a conductor wound into a plurality of concentric turns; and at least one heat pipe for dissipating heat energy from the coil, said heat pipe comprising at least one heat pipe evaporator. The transformer comprises at least one heat pipe evaporator which is positioned between the first conductor layer and the second conductor layer of the coil in which it is comprised.

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Transformer comprising a heat pipe

The present invention relates to a transformer according to the preamble of claim 1, and to a process for preparing the transformer according to claim 14.

5 Transformers are well known in the art to convert electricity at one voltage to electricity at another voltage, either of higher or lower value. This voltage conversion is achieved by an effect called mutual induction using a primary coil and a secondary coil, each
10 of which is wound on a ferromagnetic core and comprises a number of turns of an electrical conductor. The primary coil is connected to a source of voltage and the secondary coil is connected to a load. A current in the primary coil creates a magnetic field in the magnetic core, said
15 magnetic field inducing a voltage in the secondary coil.

In the past years, the performance of conventional transformers has been continuously increased. This increase in the performance has been accompanied by an ongoing development in the cooling of the transformer and
20 its components. The issue of an efficient cooling is of particular relevance in dry transformers, in which the windings are usually cast in a dielectric resin, such as an epoxy resin.

In this connection, US patent application publication No.
25 US 2006/0200971 discloses a dry-type, resin-encapsulated transformer comprising a coil, a plurality of integrated cooling ducts, and a resin encapsulating the coil.

Further, German publication No. DE 102 33 947 discloses a wind energy convertor comprising a generator, said
30 generator comprising a closed cycle cooling system. As in

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the transformer according to US 2006/0200971, cooling is thereby achieved by natural convection of air.

Alternatively, US patent No. 4,009,417 discloses a distribution transformer using heat pipe cooling. Thereby,
5 the transformer is provided with a cover in the form of a heat pipe with an evaporator section extending from the cover into the dielectric fluid of the transformer.

Heat pipe cooling is further referred to in US patent No. 5,656,984, which discloses a solid insulation transformer
10 having a core covered with a compressible closed-cell foam, said transformer comprising heat pipes placed between the inner coil and the core to extract heat before temperature builds up.

Also, non-published European patent application No. 09161988 of the applicant of the present invention
15 discloses a transformer coil comprising a heat pipe for dissipating heat energy, said heat pipe comprising an evaporator forming a laminar evaporator segment extending in circumferential direction of the windings. In order to
20 allow for an optimal heat transmission in the transformer, the heat pipe is thereby preferably annular. According to the embodiment given in the figures, the heat pipe is arranged between the primary and secondary winding.

Although the use of a heat pipe allows the heat generated
25 by the Ohmic losses in the conductor to be more efficiently removed than by mere convection of air, the preparation of known transformers using a heat pipe is relatively complex. In addition, such transformers are often prone to problems regarding the electrical isolation
30 of the electrical active parts, if no appropriate technical measures are taken. At low ambient temperatures, for example, the pressure in the interior of the heat pipe

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is low, meaning that also the dielectric performance is generally low. Given the low dielectric performance, the electrical field in the interior of the heat pipe is often too high to allow for a safe operation of the transformer
5 at low ambient temperatures.

The problem of the present invention is thus to provide a transformer which allows for an efficient cooling and at the same time for an efficient electrical isolation of its electrical active parts over a wide temperature range and
10 in particular also at low ambient temperatures.

The problem is solved by the transformer according to claim 1. Preferred embodiments of the invention are given in the dependent claims.

According to claim 1, the transformer of the present
15 invention comprises a primary coil designated to be connected with a source of voltage and a secondary coil designated to be connected with a load.

Of these coils, at least one comprises a first conductor layer and a second conductor layer disposed over the first
20 conductor layer. Both the first and the second conductor layer comprises one or more disc windings arranged in axial direction of the coil, said one or more disc windings comprising a conductor wound into a plurality of concentric turns.

25 The coil comprising the first conductor layer and the second conductor layer further comprises at least one heat pipe for dissipating heat energy from the coil, said heat pipe comprising at least one heat pipe evaporator.

In the present invention, furthermore, the at least one
30 heat pipe evaporator is positioned between the first

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conductor layer and the second conductor layer of the coil in which it is comprised.

Thus, if on the one hand the heat pipe evaporator is comprised in the primary coil, it is positioned between
5 the first conductor layer and the second conductor layer of the primary coil. If on the other hand the heat pipe evaporator is comprised in the secondary coil, it is positioned between the first conductor layer and the second conductor layer of the secondary coil.

10 As the voltage drop and thus the dielectric stress between the first conductor layer and the second conductor layer of the coil is relatively low, a relatively low dielectric performance of the medium between the layers is acceptable for providing a sufficient insulation. Thus, even though
15 the pressure in the interior of the heat pipe can be relatively low, the insulation performance achieved by the working medium of the heat pipe and by the material surrounding the heat pipe is sufficient to allow for a safe operation of the transformer.

20 Due to the specific positioning of the heat pipe evaporator, the present invention thus combines the advantages of the cooling by a heat pipe, i.e. a much more efficient removal of the heat generated in the conductor, with the advantages of casting the electrical active parts
25 in a material having a high insulative performance, i.e. a small clearance or gap or insulating distance is sufficient. Consequently, the present invention allows either the use of a conductor having a smaller cross-section (by keeping the current fixed) or more current to
30 flow through the conductor. Therefore, a transformer having a higher power density can be achieved according to the present invention, which is of particular interest for applications where the available space is limited.

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Preferably, the number of disc windings in the first conductor layer is the same as in the second conductor layer. Specifically, the disc windings of the first conductor layer are in general coaxially disposed inside
5 the disc windings of the second conductor layer, respectively, so as to form a plurality of coaxial pairs of disc windings.

The term "heat pipe" as used in connection with the present invention is to be interpreted broadly and
10 encompasses any closed system in which the thermal cycle of a heat pipe can be achieved. Apart from the heat pipe evaporator, which is in contact with the device to be cooled, a heat pipe generally further comprises a heat pipe condenser, in which the fluid condenses, and a
15 connecting channel, which connects the heat pipe evaporator and the heat pipe condenser and in which vapour and liquid travel upwards and downwards, respectively. Typically, a heat pipe comprises a sealed pipe or tube defining the heat pipe interior, as for example the tube
20 of the type described in WO 03/107364, the disclosure of which is herewith incorporated by reference. In general, the heat pipe is evacuated before filling it with a working medium, which is chosen to match the operating temperature.

25 During operation, thermal energy generated within the coil of the transformer is absorbed by the working medium in the heat pipe evaporator, whereby the working medium evaporates. The working medium vapour migrates to the heat pipe condenser where it condenses due to the lower
30 temperature present. The condensed working medium flows back to the heat pipe evaporator, where it again evaporates etc.

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Thus, cooling of the coil is achieved due to the absorption of thermal energy by the working medium in the heat pipe evaporator.

According to a further preferred embodiment, the at least
5 one heat pipe evaporator extends in axial direction of the coil. Thus, a simple and straightforward design of the transformer can be achieved.

In general, the heat pipe condenser, i.e. the part of the heat pipe where the absorbed thermal energy is released,
10 is arranged outside the coil. The cooling of the heat pipe condenser can, for example, be achieved by natural convection of air. Alternatively, a cooling means, such as a fan, can be attributed to the cooling section.

Preferably, the heat pipe condenser is positioned such
15 that during operation of the transformer it is above the heat pipe evaporator. Thus, the condensed working medium flows back to the heat pipe evaporator by gravitation, allowing for a very simple construction of the heat pipe.

In other embodiments of the invention, in which the heat
20 pipe condenser is not positioned such that it is above the heat pipe evaporator during operation, the interior of the heat pipe can comprise a wick capable of exerting capillary pressure on the condensed working medium.

The heat pipe evaporator can basically have any form which
25 allows it to achieve its function. In particular, the heat pipe evaporator can have a circular or rectangular cross-section. A heat pipe evaporator having an at least approximately elliptical cross-section, with spaced-apart, generally planar front and rear walls joined together by a
30 pair of spaced-apart curved side walls, has been found to be particularly well suited.

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According to a further preferred embodiment of the present invention, a spacer layer is disposed between the first conductor layer and the second conductor layer, the spacer layer comprising at least one spacer arranged so as to
5 form at least one passage between the first conductor layer and the second conductor layer, and the at least one heat pipe evaporator is formed by or disposed inside the at least one passage.

If the heat pipe evaporator is disposed inside the at
10 least one passage, for example by sliding a heat pipe evaporator duct into the respective passage, the spacer preferably has a cross-section approximately corresponding to the cross-section of the heat pipe (but with slightly bigger dimensions).

15 It is further preferred that the at least one heat pipe evaporator is arranged in closer proximity to the inner wall of the coil comprising the heat pipe evaporator than to its outer wall.

As mentioned above, it is furthermore preferable that the
20 heat pipe evaporator is formed by the passage itself, which is closed on top and bottom. Thus, no additional means, such as a heat pipe evaporator duct, is required.

According to a further preferred embodiment, the transformer comprises a plurality of heat pipe
25 evaporators, the interior of said heat pipe evaporators being interconnected with each other.

In this regard, it can be preferable that each heat pipe evaporator leads with its bottom end into a receptacle for collecting the heat pipe working medium. The thus
30 collected liquid working medium can be re-introduced or recirculated to the plurality of heat pipe evaporators.

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Alternatively or additionally, it is further preferred that each heat pipe evaporator leads with its upper end into a joint heat pipe condenser, in particular via a connecting channel. Thus, the condensed working medium is collected and can evenly be distributed to the heat pipe evaporators.

According to a further preferred embodiment, the heat pipe evaporator is made of an electrically insulating material. Preferably, said material has at the same time a sufficient thermal conductivity to allow for an efficient heat transfer from the coil to the interior of the heat pipe evaporator. In particular, the material of the heat pipe evaporator can be a glass reinforced epoxy resin.

As to the working medium of the heat pipe, a material fulfilling at least one the following requirements is preferably used:

In particular, it is preferred that the working medium has good thermal properties, in particular a great latent heat of evaporation and a high thermal capacity, as well as a low viscosity.

Since for a safe operation, the pressure in the system needs to be maintained within a specific range, the boiling point of the working medium is preferably in a range around the normal operation temperature of the transformer. Thus, a significant under- or overpressure in the heat pipe is avoided.

In addition, the solidification point of the working medium is preferably lower than the ambient temperature, i.e. the temperature of the transformer's surrounding. Thus, freezing of the working medium is prevented also during shut-down periods of the transformer.

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Also, the working medium is preferably environmentally friendly and fulfils safety requirements, such as non-flammability and low toxicity, in order to comply with the relatively strict requirements imposed on these media.

- 5 In order to prevent electrical discharge in the heat pipe, it is further highly preferred that the working medium is dielectrically insulating. Thus, the heat pipe preferably comprises a dielectric fluid as a working medium.

10 The applicability of electrically insulating working media is however limited due to their relatively low environmental friendliness. In particular, their Global Warming Potential (GWP) is in some cases very high.

In this context, a fluorinated hydrocarbon, preferably a fluoroether and/or a fluoroketone, has now been found to
15 be particularly preferred.

In particular, a fluoroketone having from 4 to 12 carbon atoms, preferably 6 carbon atoms, has been found to be very well suited for the present invention. Most preferably, the fluoroketone is dodecafluoro-2-
20 methylpentan-3-one.

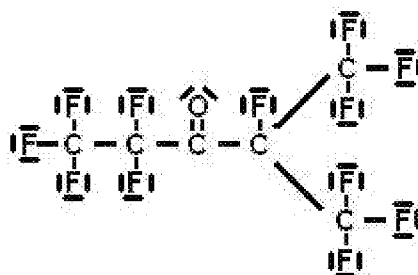
Among the most preferred fluoroketones having 6 carbon atoms, dodecafluoro-2-methylpentan-3-one has been found to be particularly preferred for its high insulating properties and its extremely low GWP.

- 25 Dodecafluoro-2-methylpentan-3-one (also named 1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)-3-pentanone, perfluoro-2-methyl-3-pentanone or $\text{CF}_3\text{CF}_2\text{C}(\text{O})\text{CF}(\text{CF}_3)_2$) has previously only been considered useful for completely different applications, namely the
30 processing of molten reactive metals (as referred to in WO 2004/090177), for the cleaning of a vapour reactor (as

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referred to in WO 02/086191) and in fire extinction systems, or in liquid form for cooling of electronic systems, or for the Rankine-process in small power plants (as referred to in EP-A-1764487).

- 5 Dodecafluoro-2-methylpentan-3-one is clear, colorless and almost odourless. Its structural formula is given in the following:



Dodecafluoro-2-methylpentan-3-one has an average lifetime
 10 in the atmosphere of about 5 days and its GWP is only about 1. In addition, its ozone depletion potential (ODP) is zero. Thus, the environmental load is much lower than the one of conventional insulation fluids.

In addition, dodecafluoro-2-methylpentan-3-one is non-
 15 toxic and offers outstanding margins of human safety.

The high cooling efficiency achieved by using a heat pipe according to the present invention is of particular interest in a high voltage coil. It is thus preferred that the coil comprising the at least one heat pipe is a high
 20 voltage coil. Of course, the present invention also relates to embodiments in which the at least one heat pipe is comprised in a low voltage coil or both a high voltage and a low voltage coil.

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As mentioned above, the transformer is preferably a dry transformer.

In general, the transformer of the present invention is a distribution transformer and may have an exemplary kVA
5 rating in a range of from about 112.5 kVA to about 15,000 kVA. The voltage of the high voltage coil may be, e.g., in a range of from about 600 V to about 35 kV and the voltage of the low voltage coil may be, e.g., in a range of from about 120 V to about 15 kV.

10

Apart from the transformer described above, the present invention also relates to a process for producing the same. Said process comprises the steps of:

- a) forming a first conductor layer;
- 15 b) forming a spacer layer over the first conductor layer;
and
- c) forming a second conductor layer over the spacer layer, wherein the spacer layer is formed such that when the second conductor layer is formed, at least one axially
20 extending passage is formed between the first and second conductor layer, said at least one passage forming or comprising a heat pipe evaporator.

If the heat pipe evaporator is to be formed by the passage itself, i.e. without an additional means such as a heat
25 pipe evaporator duct, it is preferably closed on top and bottom, the interior thus formed being connected to the rest of the heat pipe.

According to a specific embodiment, the process further comprises after step c) the additional step of

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d) sliding at least one heat pipe evaporator duct into the at least one axially extending passage so as to be disposed between the first conductor layer and the second conductor layer.

- 5 The process can thus be carried out in analogy to the process described in unpublished US patent application No. 61/241,684, the disclosure of which is herewith incorporated by reference.

This allows the transformer of the present invention to be
10 prepared in a very simple and straightforward manner.

The present invention is further illustrated by way of the attached Figures, of which

Fig. 1 shows a schematic sectional view of a transformer according to the present invention;

- 15 Fig. 2 shows a perspective view of a coil of a transformer according to the present invention, with a segment of the coil cut away to show a cross section of a portion of the coil;

Fig. 3 shows an end view of the coil according to Fig. 2;

- 20 Fig. 4 shows a plurality of coaxial pairs of the disc windings of the coil;

Fig. 5 shows an end view of the coaxial pairs of the disc windings of the coil, and

- Fig. 6 shows a wiring schematic of the transformer of the
25 present invention.

The transformer 10 shown in Fig. 1 comprises three coil assemblies 12 (one for each phase) mounted to a core 18

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and enclosed within a ventilated outer housing 20. The core 18 is comprised of ferromagnetic metal and is generally rectangular in shape. The core 18 includes a pair of outer legs 22 extending between a pair of yokes 24. An inner leg 26 also extends between the yokes 24 and is disposed between and substantially evenly spaced from the outer legs 22. The coil assemblies 12 are mounted to and disposed around the outer legs 22 and the inner leg 26, respectively. Each coil assembly 12 comprises a high voltage coil and a low voltage coil, each of which is cylindrical in shape. If the transformer 10 is a step-down transformer, the high voltage coil is the primary coil and the low voltage coil is the secondary coil. Alternately, if the transformer 10 is a step-up transformer, the high voltage coil is the secondary coil and the low voltage coil is the primary coil. In each coil assembly 12, the high voltage coil 30 and the low voltage coil may be mounted concentrically, with the low voltage coil being disposed within and radially inward from the high voltage coil 30, as shown in Fig. 1. Alternatively, the high voltage coil 30 and the low voltage coil may be mounted so as to be axially separated, with the low voltage coil being mounted above or below the high voltage coil 30.

Although the transformer 10 is shown and described as being a three phase distribution transformer, it should be appreciated that the present invention is not limited to three phase transformers or distribution transformers. The present invention may also be utilized, e.g., in single phase transformers and transformers other than distribution transformers.

According to Figs. 2 and 3, the high voltage coil 30 has a plurality of conductor layers, which comprise at least an inner or first conductor layer 32 and an outer or second

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conductor layer 34. Each of the first and second conductor layers 32, 34 of the high voltage coil 30 comprises a plurality of disc windings 36. The disc windings 36 in the first conductor layer 32 may be coaxially disposed inside
5 the disc windings 36 in the second conductor layer 34, respectively, so as to form coaxial pairs 37 of disc windings 36 that are arranged along a longitudinal axis of the high voltage coil 30, as shown in Fig. 4. A plurality of heat pipe evaporators 40 are disposed around the
10 circumference of the high voltage coil 30 in a spaced-apart manner. The heat pipe evaporators 40 are positioned between the first conductor layer 32 and the second conductor layer 34 of the high voltage coil 30. They are substantially evenly spaced apart, except for an enlarged
15 spacing or gap, wherein a dome 82 is formed. The heat pipe evaporators 40 and the first and second conductor layers 32, 34 are encapsulated in an encasement 44 comprised of a solid dielectric insulating resin 45.

20 Referring to Figs. 4 and 5, each disc winding 36 comprises a plurality of concentric layers of a conductor 46. The conductor 46 is composed of a metal such as copper or aluminum and may be in the form of a wire with an elliptical or rectangular cross-section. Alternately, and
25 as shown, the conductor 46 may be in the form of a foil, wherein the conductor 46 is thin and rectangular, with a width as wide as the disc winding 36 it forms. In the embodiments shown and described, it has been found particularly useful to use foil conductors, more
30 specifically foil conductors having a width to thickness ratio of greater than 20:1, more particularly from about 250:1 to about 25:1, more particularly from about 200:1 to about 50:1, still more particularly about 150:1. In each disc winding 36, the turns of the conductor 46 are wound
35 in a radial direction, one on top of the other, i.e., one

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turn per layer. A layer of insulating material is disposed between each layer or turn of the conductor 46. In this manner, there are alternating layers of the conductor 46 and the insulating material. The insulating material may be comprised of a polyimide film, such as is sold under the trademark Nomex®; a polyamide film, such as is sold under the trademark Kapton®; or a polyester film, such as is sold under the trademark Mylar®.

As shown in Fig. 5, the inner and outer disc windings 36 are separated by a spacer layer comprising a series of circumferentially arranged spaces 120 separated by spacers 112.

The disc windings 36 may be connected together in the manner shown in Fig. 6. As shown, the first conductor layer 32 comprises disc windings 36a-36h and the second conductor layer 34 comprises disc windings 36i-36p. In the first conductor layer 32, the disc windings 36a-36d are serially connected together and the disc windings 36e-36h are serially connected together. The disc winding 36d is not connected to the adjacent disc winding 36e. In this manner, the first conductor layer 32 has two groups of serially-connected disc windings 36, wherein the two groups are not directly connected together. In the second conductor layer 34, there are four groups of disc windings 36 that are not connected together, wherein each group consists of a pair of connected-together disc windings 36. The four pairs are: 36i and 36j, 36k and 36l, 36m and 36n and 36o and 36p. Main taps 50, 52 are connected to the disc windings 36i, 36p, respectively of the second conductor layer 34. Nominal taps 54 are connected to different disc windings 36, respectively. Connecting together different pairs of the nominal taps 54 changes the turns ratio of the transformer 10. For example,

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connecting together the nominal taps 54a and 54b serially connects together all of the disc windings 36 in both the first and second conductor layers 32, 34. The main taps 50, 52 are located toward ends of the high voltage coil 30, respectively, while the nominal taps are located toward the center of the high voltage coil 30. The main taps 50, 52 and nominal taps are located in the dome 82 of the high voltage coil 30.

Between the first conductor layer 32 and the second conductor layer 34 of the high voltage coil 30, a heat pipe evaporator 40 is positioned.

Due to the specific positioning of the heat pipe evaporator 40, the present invention allows a transformer having a higher power density to be achieved, which is of particular interest for applications where the available space is limited.

List of reference numerals

	10	transformer
	12	coil assembly
	18	core
5	20	outer housing
	22	outer leg
	24	yoke
	26	inner leg
	30	high voltage coil
10	32	first conductor layer
	34	second conductor layer
	36	disc winding
	37	coaxial pair of disc windings
	40	heat pipe evaporator
15	44	encasement
	45	insulating resin
	46	conductor
	50, 52	main taps
	54	nominal tap
20	82	dome
	112	spacer
	120	space separated by spacers

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Claims

1. A transformer (10) comprising a primary coil designated to be connected with a source of voltage and a secondary coil designated to be connected with a load, at least one of the coils comprising
5 a first conductor layer (32) comprising one or more disc windings (36) arranged in an axial direction of the coil, said one or more disc windings (36) comprising a conductor (46) wound into a plurality of
10 concentric turns;
a second conductor layer (34) disposed over the first conductor layer (32), the second conductor layer (34) comprising one or more disc windings (36) arranged in an axial direction of the coil, said one or more disc
15 windings (36) comprising a conductor (46) wound into a plurality of concentric turns; and
at least one heat pipe for dissipating heat energy from the coil, said heat pipe comprising at least one heat pipe evaporator (40), wherein
20 the at least one heat pipe evaporator (40) is positioned between the first conductor layer (32) and the second conductor layer (34) of the coil in which it is comprised.
2. The transformer (10) according to claim 1, wherein
25 the at least one heat pipe evaporator (40) extends in an axial direction of the coil.
3. The transformer (10) according to any of the preceding claims, wherein a spacer layer (120) is disposed between the first conductor layer (32) and

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the second conductor layer (34), the spacer layer (120) comprising at least one spacer (112) arranged so as to form at least one passage between the first conductor layer (32) and the second conductor layer (34), and the at least one heat pipe evaporator (40) is formed by or disposed inside the at least one passage.

4. The transformer (10) according to any of the preceding claims, wherein it comprises a plurality of heat pipe evaporators (40), the interior of said heat pipe evaporators (40) being interconnected with one another.

5. The transformer (10) according to claim 4, wherein each heat pipe evaporator (40) leads with its bottom end into a receptacle for collecting a heat pipe working medium.

6. The transformer (10) according to any of the claims 4-5, wherein each heat pipe evaporator (40) leads with its upper end into a joint heat pipe condenser, in particular via a connecting channel.

7. The transformer (10) according to any of the preceding claims, wherein the at least one heat pipe evaporator (40) is made of an electrically insulating material, in particular a glass reinforced epoxy resin.

8. The transformer (10) according to any of the preceding claims, wherein the coil comprising the first conductor layer (32) and the second conductor layer (34) is a high voltage coil (30).

9. The transformer (10) according to any of the preceding claims, wherein it is a dry transformer.

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10. The transformer (10) according to any of the preceding claims, wherein the heat pipe comprises a dielectric fluid as a working medium.
11. The transformer (10) according to claim 10, wherein
5 the dielectric fluid is a fluorinated hydrocarbon, preferably a fluoroether and/or a fluoroketone.
12. The transformer (10) according to claim 11, wherein the fluoroketone has from 4 to 12 carbon atoms, preferably 6 carbon atoms.
- 10 13. The transformer (10) according to claim 12, wherein the fluoroketone is dodecafluoro-2-methylpentan-3-one.
14. Process for preparation of a transformer (10) according to any of claims 3 to 13, comprising:
- 15 a) forming a first conductor layer (32);
- b) forming a spacer layer (120) over the first conductor layer (32); and
- c) forming a second conductor layer (34) over the spacer layer (120), wherein the spacer layer (120) is
20 formed such that when the second conductor layer (34) is formed, at least one axially extending passage is formed between the first conductor layer (32) and second conductor layer (34), said at least one passage forming or comprising a heat pipe evaporator (40).
- 25 15. Process according to claim 14, comprising after step c) the additional step of
- d) sliding at least one heat pipe evaporator duct into the at least one passage so as to be disposed between the first conductor layer (32) and the second
30 conductor layer (34).

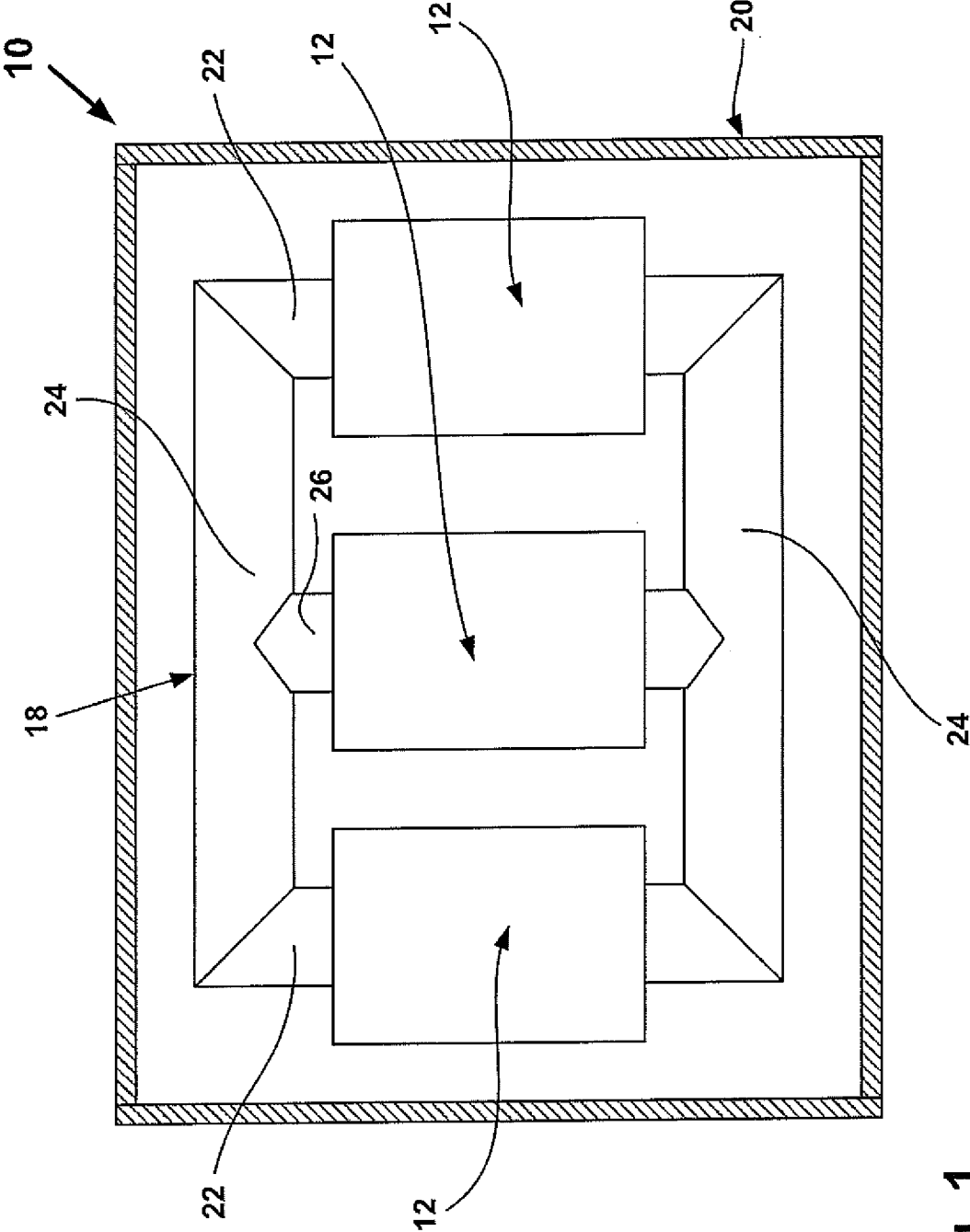
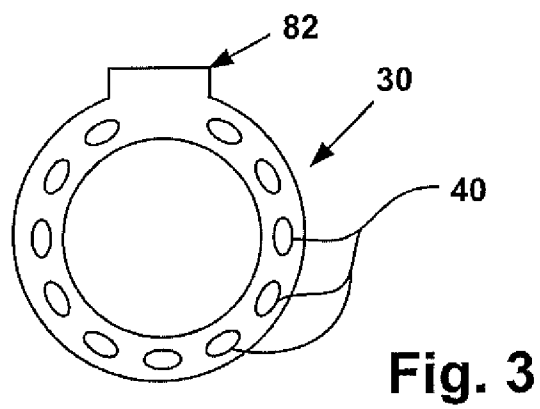
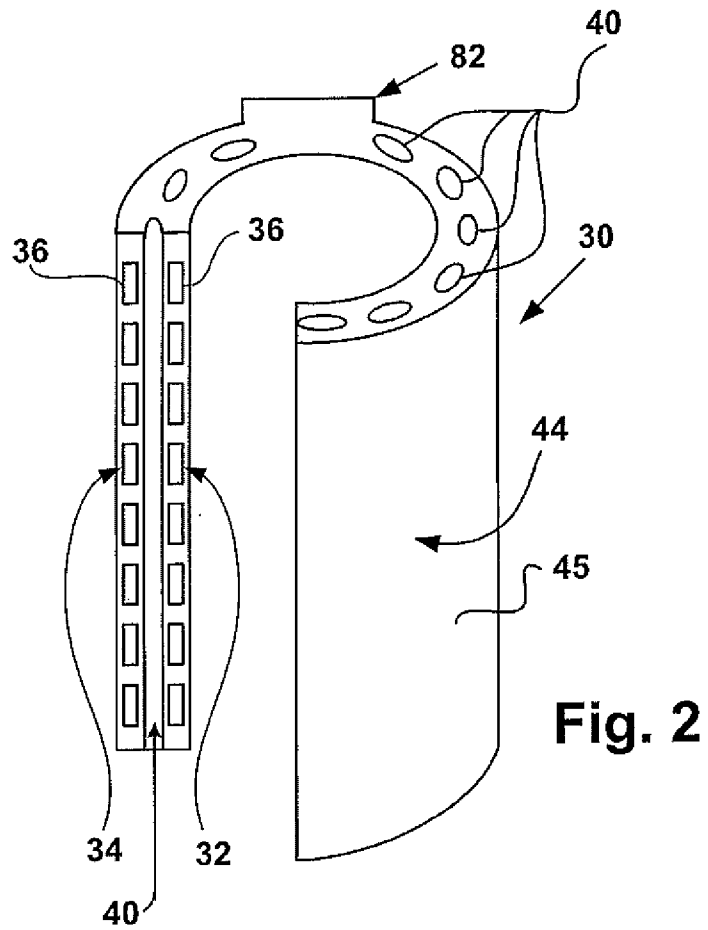


Fig. 1



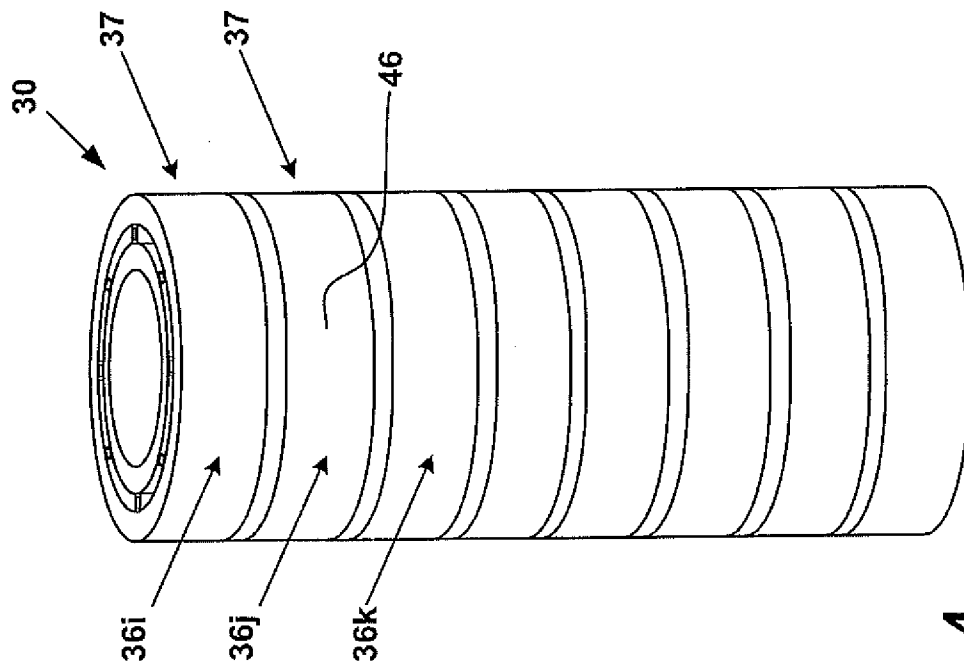


Fig. 4

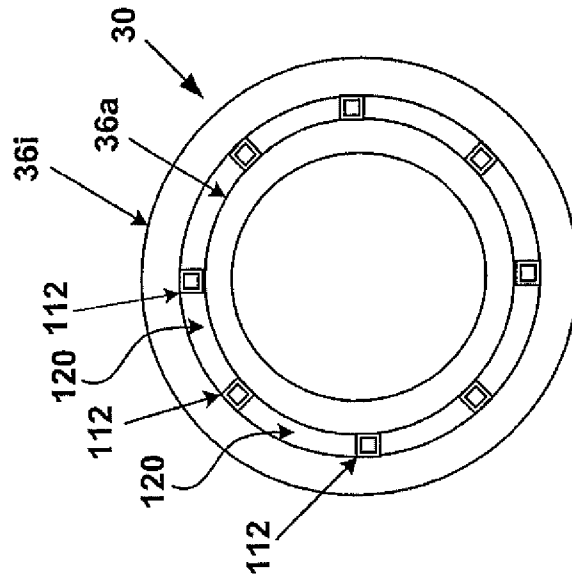


Fig. 5

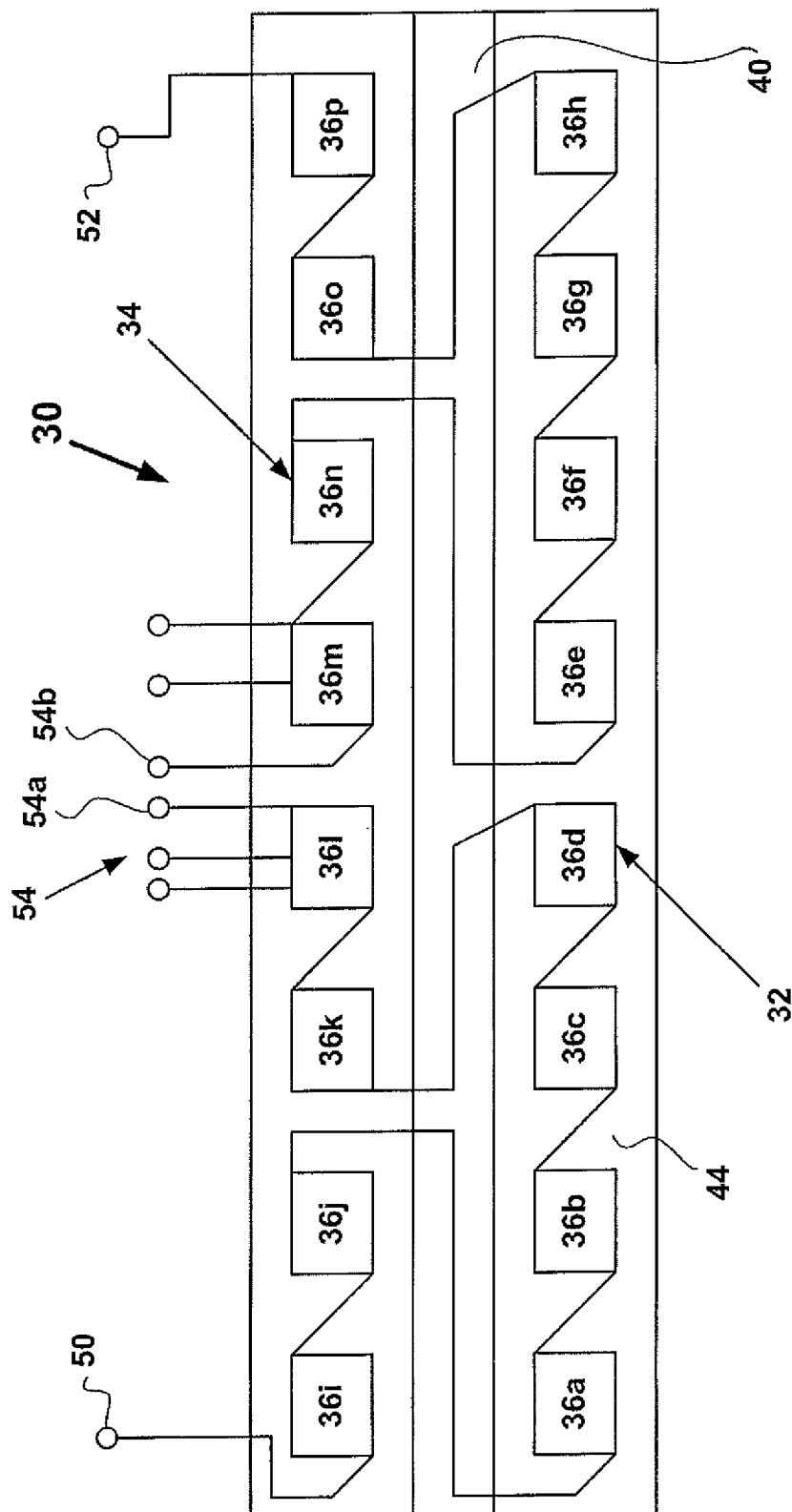


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/066570

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01F27/08

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00/39819 A1 (SQUARE D CO [US]) 6 July 2000 (2000-07-06) page 3, line 20 - page 3, line 32; figures 1,2,3 page 6, line 17 - page 7, line 16 page 5, line 6 - page 5, line 7	1-15
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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10 May 2010

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/066570

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No

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