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(54) **Three-phase high performance dry-type transformer with epoxy-insulated coils and method for manufacturing of same**

(57) The invention relates to a three-phase high performance dry-type transformer with epoxy insulated coils having a triangular core formed by three core legs which are positioned at the corners of a triangle, whereas the upper ends of each core leg are linked together by an upper yoke and the lower ends of each core leg by a lower yoke, whereas each coil is being wound around its own core leg, and whereas each coil has been provided with reinforcing fibres and cast resin. Furthermore it relates to a method for manufacturing same where a lower yoke is being connected with core legs at the corners of

the triangular core, where each core leg is provided with a winding of copper wire, where each winding is laminated with reinforcing fibres or with rovings or with prepreps being made thereof, where in each winding a tube like body is being fitted in order to form a channel provided for discharging heat losses generated during operation, and where each coil is being provided with cast resin, where each coil manufactured according to the aforementioned steps is being shifted on the respective core leg, where the upper yoke is connected to the core legs, and where the electrical installation of the conductors of each coil is finalized.

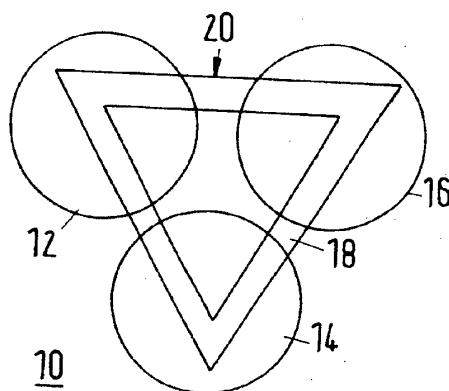


Fig.1

Description

Description

[0001] The invention relates to a three-phase high performance dry-type transformer with epoxy insulated coils having a triangular core, whereas the core consists of three sub-cores each being arranged at an angle of preferably 120 degrees to the other sub-cores and whereas each long side of each single-phase core forms a core leg joint with that of the adjacent single-phase core and to a method for manufacturing of a three-phase high performance dry-type transformer mentioned before.

[0002] Triangular cores are known since a long time, where the oldest publications are dating back about 100 years or more. Three-phase high performance transformers having a triangular core are known since a long time, too.

[0003] In GB 575564 a three-phase magnetic core has been published which comprises three V-shaped members formed of layers of magnetic material bonded together by insulating material and bent across the width of the strips, the two ends of each member being so shaped that they form butt joints with the ends of the other members at the axis of the core from which the three members radiate in directions mutually displaced by 120 degrees. A strip of magnetic material may be continuously wound to form the rectangular loop, the laminations being separated and bonded by a plastic insulating material. Cuts inclined at an angle of 120 degrees at the top and bottom of the coil make two V-shaped cores with surfaces at the ends so shaped that three cores may be placed together to form a three-phase structure, round the three legs on which windings may be placed. The surfaces forming the butt joints between core members extending between the central axis and the outer edges may be machined and then etched to remove burrs. The core members are held together by straps which hook into a triangular member at the bottom and are held by adjustable screw connections in a triangular member at the upper end.

[0004] Alternatively each core member is divided centrally by a conducting strip to prevent cross flux, insulated from the laminations and lying in a plane containing the central axis. As a further modification, core members of cruciform section are described which are made similarly to those previously described but from a strip which is wider at its middle portion. Preformed coils may be placed on the cores which are first cut across the legs and then joined by a butt joint, or the low voltage winding may be wound on the core and the high voltage winding slipped over it.

[0005] In principle today there are mainly two concepts, one is the Delta type which terms refer to the respective cross-section and the other is the Hexaformer type. Both types have been commercialized, and are available as liquid-cooled and as dry-type transformers.

[0006] A transformer core according to the Delta con-

cept has a three-dimensional iron core which structure is formed by three frame form iron cores which have the same size being provided with oblique D-shaped sections. The iron cores consist of magnetic conductive strip material. The three frame form iron cores are arranged in that way that they mutually include angles of 60 degrees to form the three-dimensional iron core.

[0007] A transformer according to the Hexaformer concept (W02008/108704) is a three-phase transformer with a specially shaped core, arranged in a triangular shape. In particular the hexaformer core comprises at least one leg and at least one yoke part, wherein the cross section of the leg or the legs is regularly multi-edged with more than four edges.

[0008] Usually the core consists of a certain number of rolls of laminated steel bands, e.g. nine rolls, and the core legs have a cross sectional shape of a hexagonal, whereby good electrical respectively magnetic properties are achieved. Transformers built according to this concept are distinguished by higher energy efficiency, lower weight and volume, lower vibrations and noise level, lower electromagnetic stray field, lower inrush current and lack of third harmonic.

[0009] Compared to a conventional transformer, a triangular core transformer needs less core steel and has lower core losses. It is therefore economically and ecologically beneficial.

[0010] In addition, compared to the traditional technology of power transformer production that involves a large amount of manual labour, the new technology allows automating the production process to a large extent.

[0011] From DE 2051883 B2 it is known to have transformer coils being produced from wire turns impregnated with non-cured epoxy resin and wound in layers on a coil former with intermediate layer of resin impregnated fiber winding. The wound coil is coated by an insulating layer and the epoxy resin is cured after finished winding. First, the coil is coated with a primary insulation of resin impregnated fiber layer preferably of laminated glass etc., this layer being in the form of a gel during the winding process, in which at least one layer of wire with resin impregnation is deposited, with a following coating of a second resin impregnated fiber layer. Preferably the assembly forms an axially supported annular body.

[0012] With dry type transformers having these features usually their coils are arranged in a line whereas each coil is wound around its own core leg i.e. one adjacent to the next and the iron cores of each coil are being joint together by yokes which confine the transformer.

[0013] On one hand a transformer according to this traditional design is easy to manufacture on the other hand the required space for installation of such transformer is higher. Furthermore the demand for core steel is definitely higher as well as the core losses compared to triangular core transformers

[0014] Hence, it is an object of this invention to design a transformer of aforementioned kind with lower demand of space and highly effective operation data both con-

cerning power and insulation stability while incurring low manufacturing efforts.

[0015] This object is achieved by a three-phase high performance dry-type transformer with fiber reinforced epoxy insulated coils having a triangular core formed by three core legs which are positioned at the corners of a triangle, whereas the upper ends of each core leg are linked together by an upper yoke and the lower ends of each core leg by a lower yoke, whereas each coil is being wound around its own core leg, and whereas each coil has been provided with reinforcing fibres and cast resin.

[0016] According to a preferred embodiment of the invention the reinforcing fibres are being provided as glass fibres, as aramid fibers, as PET fibers, as other polymeric fibers, as ceramic fibers, or as a combination thereof.

[0017] According to further improvements of the invention the reinforcing fibres are being provided as rovings or as pre-pregs. A roving is a long and narrow bundle of fibers which is drawn. Pre-preg is a term for "pre-impregnated" composite fibres. These usually have the form of a weave or fabric or are uni-directional. They already contain an amount of the matrix material used to bond them together and to other components during manufacture. The pre-preg are mostly stored in cooled areas since activation is most commonly done by heat. Hence, composite structures built of prepregs will mostly require an oven or autoclave to cure the material.

[0018] Preferably the transformer according to this invention is characterized in that the windings of each coil are laminated with the reinforcing fibers and/or rovings and/or pre-pregs whereas the lamination of the windings with reinforcing fibers and/or rovings and/or pre-pregs is being provided as enhancement of the mechanical stability of the coils.

[0019] According to a further preferred embodiment of the invention each coil is provided with channels for cooling media whereas the channels are being aligned in parallel to the core axis. Preferably there are at least three channels being provided in each coil.

[0020] Furthermore it might be advantageous to have the cooling channels in different depth of the coil in order to give sufficient protection from overheating due to possible losses caused by eddy current loss or the like.

[0021] According to a preferred embodiment of the transformer according to the invention each channel for cooling media in the coils is being provided as a tube-like body which is fitted in the winding while manufacturing the coil.

[0022] A preferred embodiment of the transformer according to the invention is characterized in that at least one of the yokes, either the upper or the lower yoke, of each core part is removably connected to the respective core leg. Preferably each of the yokes is manufactured as a bar being part of a triangle whereas the bars are forming the contour of a triangle.

[0023] Advantageously with the transformer according to the invention each core as well as the yokes are made of low-loss iron alloy of chrytalline or amorphous struc-

ture.

[0024] Furthermore the object of this invention is to disclose a method how to manufacture a transformer as being described before. Accordingly a method for manufacturing a transformer according to the invention comprises different steps which are listed in the following.

[0025] Beginning with the positioning of a lower yoke which is connected with core legs being positioned at the corners of the triangular core. Then each core leg is provided with a winding of copper or aluminum wire or foil, where each winding is laminated with reinforcing fibers or with rovings or with prepregs being made thereof.

[0026] The next step is characterized in that in each winding a tube like body is being fitted in order to form a channel provided for discharging heat losses generated during operation. Now, when the winding has been finalized each coil is being provided with cast resin.

[0027] Subsequently each coil manufactured according to the aforementioned steps is being shifted on the respective core leg and then the upper yoke is put on the core legs and connected to the core legs whereas each coil is held in position. Finally the electrical installation of the conductors of each coil is executed.

[0028] According to another method for manufacturing a transformer according to the invention comprises different steps which are listed in the following.

1) The first step is the positioning of the rectangular frames so that two long sides of any frame being aligned in parallel to each adjacent frame form the corner of a triangle. The short sides of each frame form the upper and the lower yoke.

2) Then the winding of the coils will be executed whereas each core leg will receive a winding for the primary voltage and one winding for the secondary voltage.

3) The coils according to this method are manufactured locally i.e. each core leg is subject to a separate winding procedure whereas the assembling of more than one winding on more than one core leg at the same time is possible. The winding of each coil is effected manually or mechanically by means of a winding machine.

4) According to a preferred feature of the invention in each winding at least one tube like body is being fitted in order each to form a channel provided for discharging heat losses generated during operation of the transformer.

5) According to a preferred step of the claimed method for manufacturing a transformer the position of each of the cooling channels is being checked.

6) Furthermore the coils according to this invention are provided with at least one layer, preferably more

than one layer of resin impregnated fiber windings in order to gain mechanical stability of the coils and to support the structure of the coils,

7) Advantageously the resin may be a polyester resin or according to a preferred embodiment of the invention it is an epoxy resin.

8) Furthermore advantageously the cast resin is cured by heat treatment of the total transformer in order to enhance the mechanical stability of the coils.

9) According to a further improvement of this method the conductors of each coil are connected to an interface.

10) Finally the transformer according to this invention is being tested as to its electrical properties.

[0029] Dry type transformers with these features offer a flexible, reliable and environmentally safe design for a wide range of applications beyond just distribution duty, and can withstand heavy loads and extreme temperatures. Their design provides a safe, reliable transformer, conforming to most worldwide standards, for a wide range of applications. Accordingly these transformers are capable of meeting performance requirements, whilst providing a non-flammable environmentally safe, maintenance-free product.

[0030] The transformers are made of resin reinforced with glass-fiber rovings, a material of enormous strength that enables them to withstand extreme mechanical stresses and thermal shocks from severe climates, regular cyclic loading and short circuit forces, or any equivalent fiber material. Besides that the reinforcement of the coils can be achieved by using pre-pregs which are used for laminating the windings.

[0031] Accordingly these materials are designed and tested to function at ambient temperatures as low as -60°C (-76°F), or beyond 50°C (122°F). Furthermore these transformers are non-explosive, non-toxic, self extinguishing and are 100 percent moisture-proof, unaffected by freezing conditions or chemicals.

[0032] A special advantage is that these transformers are produced without the use of moulds. Instead, their coils are manufactured on numerically controlled winding machines, so they can be customized to meet exact customer specifications and requirements including losses, impedances or dimensions. In particular, this design flexibility can be used to produce a transformer to just the right size, e.g., be able to pass through a restricted access hatch or doorway without the need to dismantle it, or to function in an area of restricted height. Typically these transformers are used indoors and outdoors, with enclosures available to suit most worldwide demands, and require no vaults or containment dikes, sprinklers or other costly fire suppression systems

[0033] The transformers according to this invention

can be used in variable frequency drives (VFD) and traction applications, where sudden cyclic loads and harmonics are applied and multiple windings solutions are required.

5 **[0034]** These and further advantageous embodiments and improvements of the invention are subject matter of the dependent claims.

[0035] By means of examples of various preferred embodiments of the invention which are shown in the attached drawing the invention, advantageous embodiments and improvements of the invention as well as special advantages of the invention shall be illustrated and described in more detail.

10 **[0036]** It is shown in

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Fig. 1 a top view on a schematic drawing of an arrangement of a triangular transformer core equipped with coils and yokes;

20 Fig. 2 a side elevation of a core frame consisting of a closed loop;

Fig. 3 a top view on a triangular core;

25 Fig. 4 a side elevation of a triangular core formed by three core frames whereas each long side of each frame is joint to a long side of the adjacent frame and thus being fitted to a triangle;

30 Fig. 5 a top view on a triangular core according to Fig. 3 provided with a winding and

Fig. 6 a side elevation of the triangular core according to Fig. 4 provided with a winding.

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[0037] Fig. 1 shows a top view on a schematic drawing of an arrangement of a triangular transformer 10 equipped with coils 12, 14, 16 and a yoke 18. The coils 12, 14, 16 are wound each around a core leg (not shown in this view) and form a three phase high power transformer 10 with a triangular core 20.

[0038] The yoke 18 is put on the top ends of each core leg and connected thereto thus it forms a closed magnetic circuit.

40 **[0039]** In Fig. 2 a closed frame 22 is shown consisting of two long sides 24 each interlinked with the other by means of a bow-shaped connection piece 26. Each long side 24 being adjacent to the long side 24 of a neighboring frame 22 serves as core leg 25 for the coils 12, 14, 16 while the bow-shaped connection piece 26 forms the yoke 18. Hence each core leg 25 for the coils 12, 14, 16 is formed by two long sides 24 of two frames 22 which are aligned together and thus form a triangle as can be seen from Fig. 3.

45 **[0040]** Fig. 3 shows a top view on a triangular core 20 formed by three closed frames 22, whereas the long sides 24 of each frame 22 extend perpendicular to the plane of projection. At the corners of this triangle the adjacent

said long sides 24 of two neighboured frames 22 are aligned with one another, while the bow-shaped connection pieces 26 at the ends of said long sides 24 form the yoke 18.

[0041] In Fig. 4 a side elevation of a triangular core 20 is being shown which is formed by three core frames 22 whereas each long side 24 of each frame 22 is linked to a long side 24 of the adjacent frame 22 and thus being fitted to a triangle core 20 for a transformer 10 according to the invention. As mentioned before two aligned long sides 24 form a core leg 25 where a winding is wound around.

[0042] In Fig. 5 a top view on a triangular core 20 according to Fig. 3 is shown which is provided with a winding base 28 and a winding 12, 14, 16 thereon.

[0043] The winding base 28 serves as a carrier for the winding or coil 12, 14, 16 and is initially rotatable around the respective core leg 25. This rotatability allows that the winding can be easily manufactured in a professional manner i.e. exactly turn by turn and layer by layer.

[0044] Finally Fig. 6 shows a side elevation of the triangular core 20 according to Fig. 4 whereas each core leg 25 is being provided with a winding base 28 and a coil 12, 14 has been applied thereon. The third coil is being masked in this drawing.

[0045] As for the manufacturing of such winding when the triangle core is made of closed frames 22, i.e. when both ends of each core leg 25 are connected with a triangular yoke 18 so that it is not possible to shift a readily wound coil on the respective core leg 25, according to one embodiment of the invention each core leg 25 is equipped with a cylindrical winding base 28 for the winding of the respective coil.

[0046] This tube-like winding base 28 which on one hand is rather narrow i.e. it surrounds the respective core leg 25 at close distance, while on the other hand the space between the core leg 25 and the winding base 28 is big enough so that the winding base 28 is allowed to rotate around the core leg 25. Accordingly the aluminium or copper wire which has been provided for the winding is wound steadily around the winding base 28 which preferably is made of a low-loss iron alloy of crystalline or amorphous structure as the core leg 25 is, too.

[0047] In order to provide the respective core leg 25 with a coil automatically or semit-automatically the winding base 28 is mechanically rotated by means of a belt drive, or a chain drive, or a gearwheel drive or the like, which can be removed after finishing the winding procedure, whereas the winding wire is spooled turn by turn and layer by layer. Hence the local manufacturing of coils at each of the core legs 25 can easily be performed without opening the closed frame 22 of the triangular core 20.

[0048] When the winding of the conductor is being performed preferably at least one tube per coil for discharging waste heat during operation is positioned at the right circular angle and at the defined radius within the winding area. Accordingly these tube-like cooling ducts are fastened to the winding by means of fibers respectively pre-

pregs made thereof and laminated with e.g., epoxy resin before further proceeding with manufacture of the coils.

[0049] Reference list

5	10	triangular transformer
	12	coil
	14	coil
10	16	coil
	18	yoke
15	20	triangular core
	22	closed frame
	24	long side
20	25	core leg
	26	bow-shaped connection piece
25	28	winding base

Claims

- 30 1. A three-phase high performance dry-type transformer (10) with resin insulated coils (12, 14, 16) having a triangular core (20) formed by three core legs (25) each being positioned at the corners of a triangle, whereas the upper ends of each core leg (25) are linked together by an upper yoke (18) and the lower ends of each core leg by a lower yoke (18), whereas each coil (12, 14, 16) is being wound around a core leg (25), and whereas each coil (12, 14, 16) has been provided with reinforcing fibres and cast resin.
- 35 2. A three-phase high performance dry-type transformer (10) with resin insulated coils (12, 14, 16) having a triangular core (20) formed by three closed frames (22) each having two long sides (24) each being aligned in parallel to the respective long side (24) of the adjacent frame (22) and thus forming in each case a core leg (25), whereas each coil (12, 14, 16) is being wound around one core leg (25), and whereas each coil (12, 14, 16) has been provided with reinforcing fibres and cast resin.
- 40 3. Transformer according to claim 1 or 2 whereas the reinforcing fibres are provided as glass fibers, as aramid fibers, as PET fibers, as other polymeric fibers, as ceramic fibers, or as a combination thereof.
- 45 4. Transformer according to claim 3 whereas the reinforcing fibers are provided as rovings.

5. Transformer according to at least one of the preceding claims where the windings are made of fibers having a length of about some hundred meters, at least having a length of one circumference of the coil.
6. Transformer according to one of the preceding claims where the reinforcing fibres are being preimpregnated with thermosetting resin or a thermoplastic polymer.
7. Transformer according to claim 6 where the thermosetting resin is an epoxy resin.
8. Transformer according to at least one of the preceding claims where the windings of each coil (12, 14, 16) are laminated with the reinforcing fibres and/or rovings and/or pre-pregs.
9. Transformer according to claim 7 where the reinforcing fibers respectively the lamination of the windings with reinforcing fibres and/or rovings and/or pre-pregs are being provided as enhancement of the mechanical stability of the coils (12, 14, 16).
10. Transformer according to one of the preceding claims where each coil (12, 14, 16) is provided with channels for cooling media whereas the channels are being aligned in parallel to the coil axis.
11. Transformer according to claim 10 where each channel for cooling media in the coils (12, 14, 16) is being provided as a tube-like body which is fitted in the winding while manufacturing the coil.
12. Transformer according to one of the preceding claims where at least one of the upper or the lower yoke (18) is removably connected to the respective core leg (25).
13. Transformer according to one of the preceding claims where each core as well as the yokes (18) are manufactured of a low-loss iron alloy of crystalline or amorphous structure.
14. Method for manufacturing a transformer according to one of the preceding claims whereas the core legs (25) are positioned at the corners of a triangular core (20) and each core leg (25) is being connected with a lower and an upper yoke (18), where each core leg (25) is provided with a coil (12, 14, 16) of copper or aluminum wire or foil, where each coil (12, 14, 16) is laminated with reinforcing fibres or with rovings respectively with pre-pregs being made thereof, whereas in each coil (12, 14, 16) at least one tube like body is being fitted in order to form a channel provided for discharging heat losses generated during operation, where each coil (12, 14, 16) is being provided with cast resin, and whereas the electrical

installation of the conductors of each coil is finalized.

15. Method for manufacturing a transformer according to claim 14 where the triangular core (20) is assembled from a lower yoke (18) being connected with core legs (25) at the corners of the triangular core (25) in one piece and an upper yoke (18), where each core leg (25) is provided with a coil (12, 14, 16) of copper or aluminum wire or foil, whereas each coil (12, 14, 16) manufactured according to the aforementioned steps is being shifted on the respective core leg (25), where the upper yoke (18) is connected to the core legs (25), and where the electrical installation of the conductors of each coil is finalized.

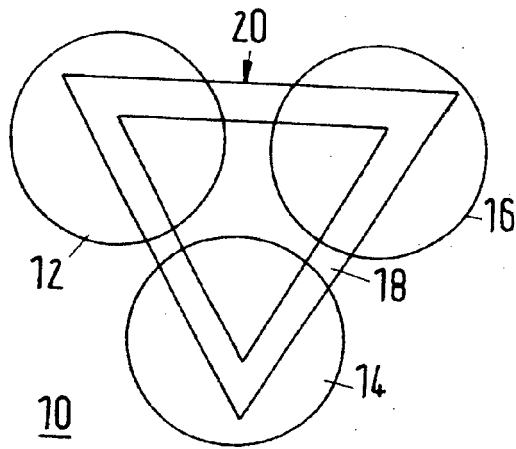


Fig.1

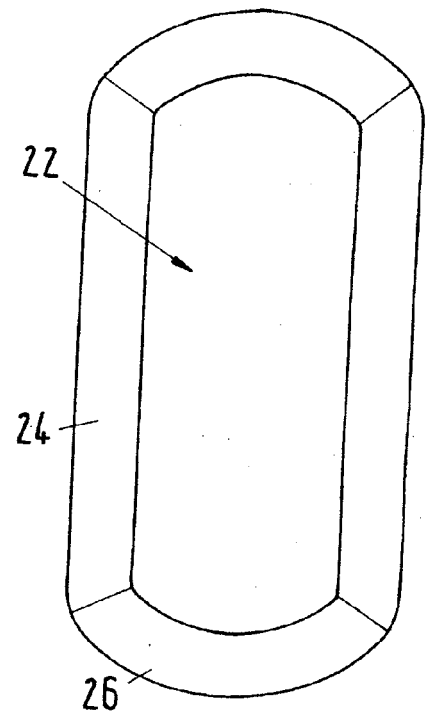


Fig.2

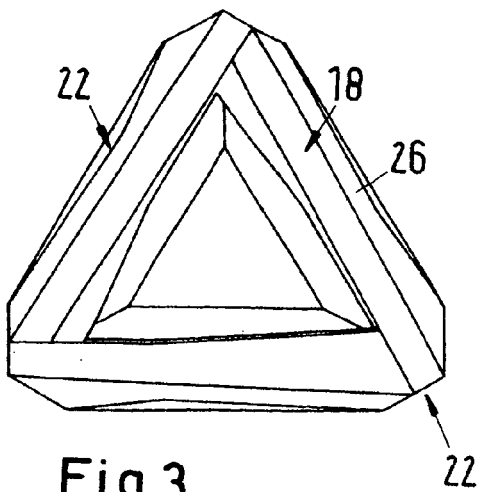


Fig.3

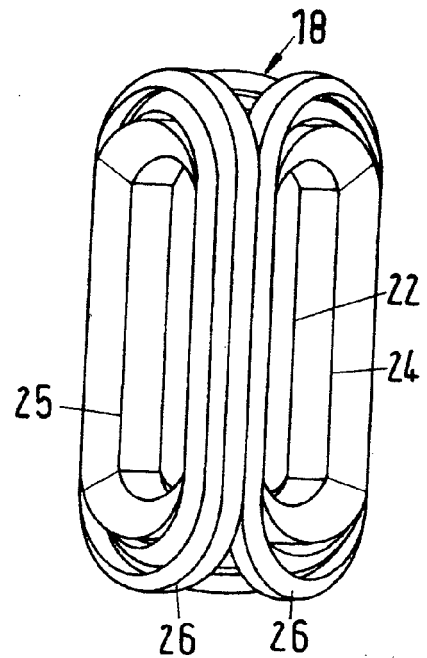


Fig.4

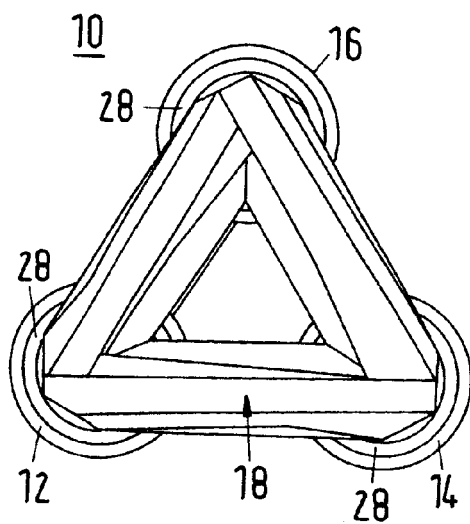


Fig. 5

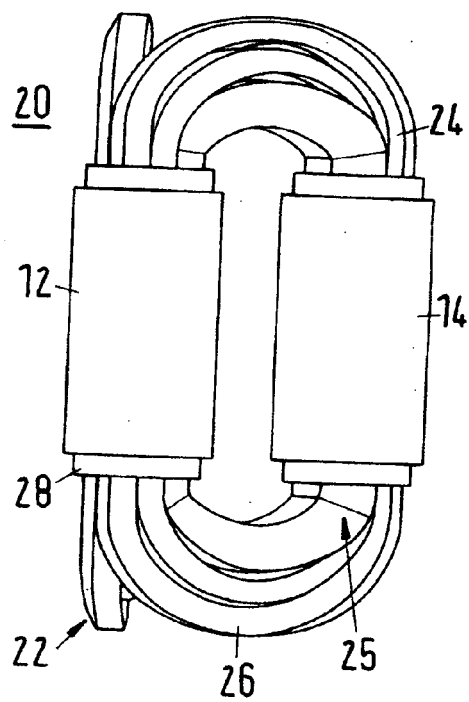


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 10 00 2974

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 00/25327 A1 (A T T ADVANCED TRANSFORMER TEC [IL]; BOLOTINSKY YURI [IL]; RUBSHEIN A) 4 May 2000 (2000-05-04) * page 9, lines 15-18 * * page 11, line 27 - page 12, line 7 * * page 14, lines 1-10 * * page 14, line 26 - page 15, line 2 * * page 16, lines 3-21; figures 1-3 *	1-15	INV. H01F30/12 H01F41/12 H01F27/32
X	DE 40 29 097 A1 (MESSWANDLER BAU AG [DE]) 19 March 1992 (1992-03-19) * column 2, lines 15-26,44-59; claim 2; figures 1,2 *	1-15	
X	WO 01/65572 A2 (HOEGLUND LENNART [SE]) 7 September 2001 (2001-09-07) * page 2, line 4 - page 3, line 5; figures 1,1a,1b * * page 25, lines 17-26 * * page 31, lines 3-9; figure 29 * * page 7, lines 19-26; figure 2 *	1-14	
X	US 5 202 664 A (POULSEN PEDER U [US]) 13 April 1993 (1993-04-13) * column 1, line 58 - column 2, line 20 * * column 3, lines 27-30 *	1-14	TECHNICAL FIELDS SEARCHED (IPC) H01F
A	US 2009/313812 A1 (PULNIKOV SERGEY [DE]) 24 December 2009 (2009-12-24) * paragraphs [0005], [0076] - [0080], [0087], [0088]; claim 1; figures 11-13,27 *	1,3-6, 8-11,14	
A	US 2006/200971 A1 (LANOUE THOMAS J [US] ET AL LANOUE THOMAS J [US] ET AL) 14 September 2006 (2006-09-14) * paragraphs [0016], [0017], [0021] - [0025]; figures 1-6 *	1,3,4, 6-11,14	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 4 August 2010	Examiner Teske, Ekkehard
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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EPO FORM 1503 03.82 (P04C01)

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

EP 10 00 2974

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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04-08-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0025327	A1	04-05-2000	
		AU 6365199 A	15-05-2000
		CN 1328690 A	26-12-2001
		EP 1125308 A1	22-08-2001
		PL 348031 A1	06-05-2002
		RU 2237306 C2	27-09-2004
		US 6792666 B1	21-09-2004
		US 2003112111 A1	19-06-2003
DE 4029097	A1	19-03-1992	NONE
WO 0165572	A2	07-09-2001	
		AU 3960901 A	12-09-2001
		EP 1277217 A2	22-01-2003
US 5202664	A	13-04-1993	
		WO 9315515 A1	05-08-1993
US 2009313812	A1	24-12-2009	NONE
US 2006200971	A1	14-09-2006	
		AT 319171 T	15-03-2006
		AU 2002368017 A1	31-12-2003
		BR 0215491 A	02-08-2005
		CA 2471507 A1	24-12-2003
		CN 1615530 A	11-05-2005
		DE 60209574 T2	24-08-2006
		EP 1461814 A1	29-09-2004
		ES 2256595 T3	16-07-2006
		WO 03107364 A1	24-12-2003
		US 7023312 B1	04-04-2006

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 575564 A [0003]
- WO 2008108704 A [0007]
- DE 2051883 B2 [0011]