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- **Gustafsson, Andreas**
SE-771 34 Ludvika (SE)
- **Hajek, Jan**
SE-771 31 Ludvika (SE)
- **Kranenborg, Jurjen**
SE-756 53 Uppsala (SE)
- **Bel Fdhila, Rebei**
724 76 Västerås (SE)

(71) Applicant: **ABB Technology Ltd**
8050 Zürich (CH)

(74) Representative: **Savela, Reino Aleks**
ABB AB
Intellectual Property
Ingenjör Bääths Gata 11
721 83 Västerås (SE)

(72) Inventors:
• **Laneryd, Tor**
SE-722 18 Västerås (SE)

(54) **Static electric induction system**

(57) The invention relates to a static electric induction system comprising cooling fluid, an outer shell (12) and an inner shell (14), a coil assembly (6) comprising a plurality of coil units (16), stacked on top of one another and positioned in between the outer and inner shells (12, 14), and a plurality of coil unit spacers (20) configured to form a plurality of intermediate fluid ducts (32) between the coil units (16). The static electric induction system further comprises a first and an adjacent second sector (2, 2'), each sector (2, 2') comprising a fluid guide arrangement (A, B) having a plurality of fluid guides (24, 26), whereby the vertical distance, as counted in coil units (16), between one pair of two subsequent fluid guides (24, 26) of a sector (2, 2') differs from a vertical distance, as counted in coil units (16), between another pair of two subsequent fluid guides (24, 26) of the same sector (2, 2') and wherein the first fluid guide arrangement (A) of the first sector (2) differs from the second fluid guide arrangement (B) of the second sector (2').

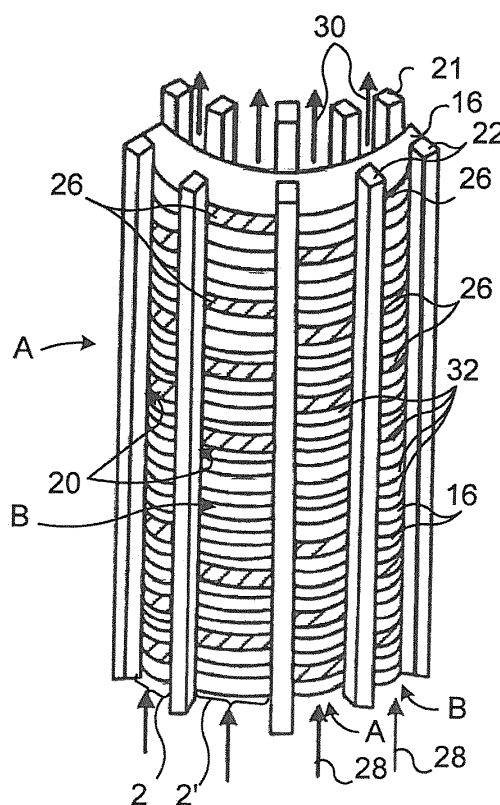


Fig. 4

Description

TECHNICAL FIELD

[0001] The invention relates to a static electric induction system, such as a transformer system, which is normally cooled by a fluid.

BACKGROUND

[0002] Known static electric inductions systems, such as core-type transformers, consist of a tank that contains an active part consisting of a core with a number of current-carrying windings wound around them. The electrical windings or coils are arranged in between electrically insulating cylinders. The electrical windings may be embedded or shaped as discs, which are arranged on top of one another. The electric windings may also be helically shaped. When the transformer is in use the discs generate heat, which needs to be dissipated by a cooling fluid, such as for example oil or ester based liquids. The heat decreases life expectancy of the transformer system and it is therefore generally required to cool transformer systems by using an efficient and robust cooling system. The discs are usually spaced apart in the vertical direction by spacers to form horizontal fluid ducts for the cooling liquid in between two discs or in between two turns of the helical winding. Vertical fluid ducts are usually formed in between the outer cylinder and the stacked discs and in between the inner cylinder and the stacked discs. In most cases the vertical fluid ducts are limited or defined in a horizontal or circumferential direction by spacer ribs, which are used to hold the insulating cylinders in position.

[0003] The cooling system of known transformers may comprise a plurality of fluid guides or flow control members that force the liquid to flow in certain directions, in order to enhance the efficiency of the transformer cooling system. The fluid guides are normally arranged in between two neighbouring spacer ribs next to the inner and/or the outer cylinder so that the fluid, which is flowing upwards in the vertical fluid ducts is forced to flow into the horizontal fluid ducts located below the fluid guides in a zigzag flow pattern. In general the fluid guides are arranged in a symmetrical pattern along the circumference of the housing next to an inside periphery and next to an outside periphery of the stacked discs. Symmetrical means that the fluid guides are arranged in a repeating or periodical pattern on the inside periphery and on the outside periphery of the stacked discs, with minor deviations related to manufacturing considerations.

[0004] US 4'245'206 A discloses a transformer comprising an outer insulation cylinder and an inner insulation cylinder with coil units arranged in between the outer and inner cylinders. Horizontal and vertical spacer members are used to position the coil units between the outer and inner cylinder and to arrange the coil units distant from one another to form horizontal and vertical passages for the cooling liquid. Flow control members are arranged in

between the vertical spacer members in order to guide and control the fluid flow by reducing the cross sections of the vertical ducts. The flow control members are arranged circumferentially and vertically symmetrical and periodically with a constant pitch over the entire height of the transformer. The flow control members arranged in a sectional area are always arranged symmetrical and in some cases shifted in a vertical direction, as illustrated in figure 17 of US 4'245'206 A. Due to the symmetrical arrangement of flow control members, hot spots can occur, especially in a circumferential direction of the coil units 16, and the peak temperature region cannot be effectively cooled.

[0005] Due to the generation of losses in the windings a hotspot occurs which affects the aging rate of the insulation and thereby the lifetime of the transformer.

[0006] The actual position and magnitude of the hotspot temperature depends on the actual distribution of the oil flow guides. An important design goal is to keep the maximal hotspot temperature as low as possible.

[0007] Therefore, the distribution or arrangement of flow guides in the transformer thus requires careful consideration and a proper analysis.

SUMMARY

[0008] In view of the above it is an object of the present invention to provide an improved static electric induction system, which is robust, efficient and durable. The static electric induction system may be a power transformer or a reactor.

[0009] Another object of the present invention is to provide a static electric induction system that works continuous and steady even under high load.

[0010] Disclosed herein is a static electric induction system comprising cooling fluid, an outer shell and an inner shell, a coil assembly comprising a plurality of coil units, stacked on top of one another and positioned in between the outer and inner shells, and a plurality of coil unit spacers configured to form a plurality of intermediate fluid ducts in between the coil units. The static electric induction system further comprises a first and an adjacent second sector, each of the first and second sector comprising a fluid guide arrangement having a plurality of fluid guides, whereby the vertical distance, as counted in coil units, between one pair of two subsequent fluid guides of a sector differs from a vertical distance, as counted in coil units, between another pair of two subsequent fluid guides of the same sector and whereby the first fluid guide arrangement of the first sector differs from the second fluid guide arrangement of the second sector.

[0011] The fluid guide arrangement of the first sector may differ from the fluid guide arrangement of the second sector not only in that it is vertically shifted.

[0012] The static electrical induction system further may comprise a plurality of vertical inner and outer coil unit spacer ribs uniformly arranged around an inner periphery and around an outer periphery of the coil assem-

bly, whereby respective two neighbouring vertical inner coil unit spacer ribs and two corresponding neighbouring vertical outer coil unit spacer ribs confine a first sector of the coil unit assembly.

[0013] The outer shell and the inner shell may form part of a housing that is configured to receive the coil assembly comprising the coil units and other potential electrical components.

[0014] The build up of the first and second fluid guide arrangements of the above described static electric induction system ensures that the magnitude of hot spots is reduced through heat transfer in the coil units and in the cooling fluid or conduction in the circumferential direction of the coil units.

[0015] In case an unexpected hot spot occurs, the static electric induction system according to the invention is capable to even out hot spots especially in the circumferential direction of the coil units around which hot spots normally spread, even unexpected hot spots. Even in case a hot spot occurs during unusual loading conditions or overloading, it is possible to even out or dissipate the heat energy from that hot spot by using a configuration as described above.

[0016] When a thermal analysis of the static electric induction system is conducted, hot spots and regions with increased temperatures become visible. Computational fluid dynamics (CFD) or thermohydrodynamic network modelling methods may be used to conduct the thermal analysis. Direct temperature measuring methods using fibre optic sensors may also be used to analyse temperature distribution in the static electric induction system. According to such a thermal analysis the fluid guides may be distributed within the static electrical induction system.

[0017] Advantageously the first and second fluid guide arrangements comprise inner fluid guides arranged next to the inner shell and outer fluid guides arranged next to the outer shell.

[0018] The fluid guides may ensure that the cooling fluid flow is changed from a vertical flow direction to a horizontal flow direction and back so that cooling fluid may enter the intermediate ducts.

[0019] The vertical distance, as counted in coil units, between one pair of two subsequent inner or outer fluid guides of a sector may differ from a vertical distance, as counted in coil units, between another pair of two subsequent inner or outer fluid guides of the same sector.

[0020] Thus the vertical distance between two subsequent outer fluid guides may vary and the vertical distance between two subsequent inner fluid guides may vary as seen over the height of the coil assembly.

[0021] This measure increases the efficiency of the cooling of hot spots.

[0022] In a preferred embodiment the inner and outer fluid guides are arranged in a non-periodical manner across at least two sectors.

[0023] The inner fluid guides are basically arranged on a surface defined by the inner periphery of the coil units or the coil assembly and the outer fluid guides are ar-

ranged on a surface defined by the outer periphery of the coil units or coil assembly. These surfaces are divided into sectors and when at least two sectors are analysed next to one another, the fluid guides are not periodically distributed.

[0024] It is even possible to have the inner and outer fluid guides not periodically distributed over three or more sectors. Thus it is theoretically possible to have the fluid guides distributed in a very random fashion over the entire inner and outer periphery of the coil assembly of the static electric induction system.

[0025] Preferably the static electric induction system comprises inner vertical fluid ducts and outer vertical fluid ducts.

[0026] The vertical fluid ducts are configured to provide a vertical passage for the cooling fluid.

[0027] In an embodiment the inner and outer fluid guides are configured to more or less completely block a vertical cooling fluid flow in the inner and outer vertical fluid ducts, respectively.

[0028] Such a blockage ensures that a comparatively large amount of cooling fluid is directed into the intermediate fluid ducts so that the coil units are cooled effectively along their horizontal surfaces.

[0029] Advantageously, the first fluid guide arrangement of the first sector is not congruent with the second fluid guide arrangement of the second sector.

[0030] Such a design enhances the cooling of the coil units in a horizontal direction and further reduces the spreading of hot spots along the horizontal or circumferential direction of the coil units.

[0031] A coil unit comprising a hot spot in the first sector is thus cooled more efficiently in an adjacent, second sector.

[0032] Preferably the cooling fluid follows a fluid flow pattern, which is generated by the different fluid guide arrangements, whereby the different fluid guide arrangements result in different fluid flow patterns.

[0033] The fluid flow patterns are used to cool the coil units and they may further indicate the different flow velocities of the cooling fluid within the static electric induction system.

[0034] In another embodiment the static electric induction system, or transformer, may comprise inner and outer coil unit spacer ribs, whereby the coil unit spacers are arranged in between the inner and outer coil unit spacer ribs.

[0035] The vertical inner and outer coil unit spacer ribs may be configured to receive coil unit spacers at any height and the coil unit spacers may be suitably connected to the inner and outer coil unit spacer ribs.

[0036] Having the coil unit spacers in line with vertical inner and outer coil unit spacer ribs has the advantage of having intermediate fluid ducts that have no disruptions in between the vertical inner and outer coil unit spacer ribs.

[0037] In an embodiment the static electrical induction system may comprise a third sector adjacent the second

sector, wherein the third sector comprises a third fluid guide arrangement that is different from the first and second fluid guide arrangements of the first and second sector.

[0038] Thus also the fluid flow pattern of the first, second and third sector may be different from one another.

[0039] Advantageously a density of inner and outer fluid guides is higher in a top region of the coil assembly than in a bottom region of the coil assembly.

[0040] Towards the top region there may be more fluid guides positioned than towards the bottom region.

[0041] The amount of intermediate fluid ducts in between two subsequent inner or outer fluid guides highly affects the cooling fluid flow in the intermediate fluid ducts.

[0042] As an example, the fluid flow in the intermediate fluid ducts increases by about 50% when the distance is reduced from six coil units to four coil units. Thus the placement of the fluid guides is a very effective to cool the static electric induction system.

[0043] The static electric induction system or transformer may be driven by natural convection.

[0044] Alternatively, the static electric induction system may comprise a pump drive configured to drive the cooling fluid in the static electric induction system or transformer.

[0045] Thus the above described configuration may be used in oil directed (OD) cooled transformers or in oil forced (OF) cooled transformers.

[0046] In another embodiment the amount of inner and outer fluid guides in a fluid guide arrangement differs from the amount of inner and outer fluid guides in another fluid guide arrangement.

[0047] Thus the amount of fluid guides do not have to be necessarily the same in the first, second or third sector. They may vary in each sector, given that the cooling is optimized by using less or more oil guides in one sector than in an adjacent sector.

[0048] The herein described further concerns a method of arranging fluid guides in a static electric induction system comprising the steps of:

- conducting a thermal analysis of the static electric induction system during use;
- identifying hot spots and regions with increased temperature in the thermal analysis;
- distributing and fixing the fluid guides based on the thermal analysis in order to reduce the hotspots and regions with increased temperature.

[0049] Such a method has the advantage, that the static electric induction system can be configured and equipped depending on material and construction characteristics of the specific transformer. The static electric induction system may in the end, after the thermal analysis, even comprise less fluid guides than a known trans-

former system comprising a symmetrical arrangement of fluid guides, since the thermal analysis may reveal that not that many fluid guides are necessary to efficiently cool the transformer.

[0050] Typical fluid guide arrangement patterns may comprise configurations where robustness versus lower maximum hot spots was taken into account or where different cooling modes (pump operating and not operating) has been taken into account. In addition fluid guide arrangement configurations may be chosen depending on different typical load cases of the transformer, different external conditions (desert, arctic conditions, weather and temperature) or different conditions of the transformer, such as for example during start-up phase or during steady-state phase. It may also be possible to invert the fluid guide patterns, such as arranging the outer fluid guides according to the inner pattern and the inner fluid guides according to the outer pattern.

[0051] All these configurations are within the scope of the present invention and they may accordingly influence the arrangement configuration and arrangement of the fluid guides.

[0052] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, system, apparatus, component, arrangement, pattern, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, system, apparatus, arrangement, pattern, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows an exemplary section of a transformer as it is known in the prior art;

Fig. 2 shows a schematic front view of a portion of the transformer as it is known in the prior art;

Fig. 3 shows a view onto a cross section of the embodiment of figure 2;

Fig. 4 illustrates a perspective view onto a portion of a static electric induction system or a transformer according to the invention;

Fig. 5 schematically illustrates a front view onto a portion of a static electric induction system or transformer according to the invention;

Fig. 5a schematically illustrates another embodi-

ment of the invention;

Fig. 6 schematically illustrates a view onto a cross section of a transformer according to the invention; and

Fig. 7 schematically illustrates a front view onto a portion of a transformer according to another embodiment of the invention.

DETAILED DESCRIPTION

[0054] The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the static electrical induction system are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments of the static electric induction system or transformer system are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0055] Referring to the figures 1 to 3, which illustrate the prior art, a section of a coil assembly 6 of a static electric induction system 1 is shown. The coil assembly 6 comprises a number of, in the present case six, coil units 16, which are disc-shaped and arranged on top of one another, spaced apart by coil unit spacers 20. The coil unit spacers 20 are arranged in between two consecutive coil units 16. The coil unit spacers 20 may be shaped as flat disc segments as shown in figure 1. Two consecutive, as seen along the circumference of the coil unit 16, coil unit spacers 20 arranged in the coil unit pitch 18 and two consecutive, as seen in a vertical direction of the coil assembly 6, coil units 16 define a horizontal intermediate fluid duct 32, which extends through the coil assembly 6 from an outer side or periphery 38 of the coil units 16 and coil assembly 6, respectively, to an inner side or periphery 40 of the coil units 16 and coil assembly 6, respectively.

[0056] The intermediate fluid ducts 32 are configured to let cooling fluid pass through, preferably dielectric fluid, which is normally a liquid, of a cooling system. The coil assembly 6 further comprises vertical inner and outer coil unit spacer ribs 21 22, which are configured to hold and position inner and outer shells 12, 14 the coil unit spacers 20, the coil assembly 6 and coil units 16, respectively, in position. The vertical inner and outer coil unit spacer ribs 21, 22 may, together with outer and inner electrical insulating shells (not shown in figure 1) define a plurality of vertical fluid ducts 28, 30 around the periphery of the coil units 16, as illustrated in figure 3, which also refers to the prior art.

[0057] Two neighbouring vertical inner spacer ribs 21 and two corresponding vertical outer spacer ribs 22 define a first sector 2, which comprises a corresponding

fluid guide arrangement A. The fluid guide arrangement A comprises inner and outer flow control members 24', 26'.

[0058] The inner and outer flow control members 24', 26' are positioned in a symmetrical manner in the fluid ducts 28, 30 and in the fluid guide arrangement A, A' in order to guide fluid into the intermediate fluid ducts 32, as illustrated in figure 1 and 3.

[0059] The fluid guide arrangement A, A' and the intermediate fluid ducts 32 result in a fluid flow pattern 10 of the cooling fluid as illustrated in figure 3 (static electric induction system in use). In the prior art the fluid flow patterns 10 and the fluid guide arrangements A, A' are the same and/or they are congruent with each other.

[0060] Referring now to figure 2 which illustrates fluid guide arrangements A, A' comprising the inner and outer flow control members 24', 26', a first fluid guide arrangement A is vertically and centrally shifted from a second fluid guide arrangement A'. The flow control members 24', 26', in figure 2 exemplify the outer flow control members 26' of the first fluid guide arrangement A, are arranged with a constant vertical distance as counted in coil units 16, namely every three coil units 16. The outer flow control members 26' of the adjacent second fluid guide arrangement A' are arranged vertically shifted but shifted in that the outer fluid guide 26 of the second fluid guide arrangement A' is arranged centrally in between two subsequent outer flow control members 26' of the first fluid guide arrangement A, as seen in a vertical direction. The arrangement of the flow control members 26' and thus the fluid guide arrangements A, A' are symmetrical, since the patterns are repeating and since the first and second fluid guide arrangements A, A' are not different from one another but only vertically and centrally shifted.

[0061] The flow control members 24', 26' shown in the prior art are not configured to substantially block the vertical fluid ducts 28, 30. They are only configured to partially block the vertical fluid ducts 28, 30 and to let a certain amount of cooling fluid pass by without forcing it into the intermediate fluid ducts 32.

[0062] When a fluid guide arrangement A, A' as shown in figures 1 to 3 is used, a hot spot may usually always occur at the same position, whereas when different or non periodical or only partially periodical fluid guide arrangements are installed or used, the hot spots can not occur at the same position and they are therefore reduced or even eliminated.

[0063] In a transformer design only the absolute maximum temperature is relevant to define the hottest spot. Thus it is rather important to reduce the temperature of the hottest or "maximal" hot spots and to prohibit the spreading of hot spots.

[0064] Referring now to figures 4 to 7, which exemplary illustrate embodiments of the present invention, the fluid guide arrangements A, B vary and they are different from one another.

[0065] Figure 4 illustrates a portion of the transformer or static electric induction system 1, in which a first sector

2 and an adjacent second sector 2' are illustrated. The first and second sectors 2, 2' are defined or limited by a pair of vertical inner - and a pair of corresponding vertical outer spacer ribs 21, 22. Each of the first and second sector 2, 2' comprises a different fluid guide arrangement A, B. The first sector 2 comprises a first fluid guide arrangement A and the second sector 2' comprises a second fluid guide arrangement B. The inner and outer fluid guides 24, 26 of one fluid guide arrangement A, B are always arranged depending on each other, which becomes clear when figure 6 is considered. Figure 6 illustrates the cooling fluid flow pattern 10 within the static electric induction system 1. The inner fluid guides 24 and the outer fluid guides 26 of each fluid guide arrangement A, B are arranged in order to create a fluid flow pattern 10, 10' that ensures an efficient cooling of the transformer or static electric induction system 1. An outer and an inner fluid guide 24, 26 may thus not be arranged on the same level or height in a fluid guide arrangement A, B since this would block the fluid flow in the transformer.

[0066] The inner fluid guides 24 and the outer fluid guides 26 are configured to almost completely or substantially block the vertical fluid ducts 28, 30. The flow control members 24' and 26' in the prior art are only slightly obstructing the vertical fluid ducts.

[0067] In figure 4 four sectors 2, 2' are illustrated, whereby the first sector 2 and the second sector 2' are arranged in an alternating manner. The fluid guide arrangement A of the first sector 2 comprises in total six outer fluid guides 26 arranged in a non periodical manner over the height of the transformer 1. The vertical distances as counted in coil units 16 between two subsequent outer fluid guides 26 vary and these distances are not constant over the height. This provides a more effective cooling of potential hot spots since the risk of the hot spots spreading, especially in horizontal direction is substantially reduced as compared to the prior art.

[0068] The sectors 2, 2' have all the same size, since the vertical inner and outer coil unit spacer ribs 21, 22 are uniformly distributed and arranged around the inner and outer periphery 38, 40 of the coil assembly 6.

[0069] As mentioned in the introduction, the vertical positioning and the amount of coil units 16 in between two subsequent inner and/or outer fluid guides 24, 26 has a substantial influence on the fluid that passes in the intermediate fluid ducts 32 and thus a substantial influence on the cooling performance.

[0070] The inner and outer fluid guides 24, 26 are arranged in between the vertical inner and or outer coil unit spacer ribs 21, 22 and between the inner periphery 38 and the inner shell 14 and between the outer periphery 40 and the outer shell 40, respectively. The inner and outer fluid guides 24, 26 are preferably ring-segment shaped and connected to respective two consecutive vertical inner and outer coil unit spacer ribs 21, 22, respectively. The vertical coil unit spacer ribs 21, 22 are configured to receive the fluid guides 24, 26 at any height. The fluid guides 24, 26 may be connected to the vertical

coil unit spacer ribs 21, 22 by a groove/rib mechanism.

[0071] The inner and outer shells 12, 14 may be electrically insulating or they may not be electrically insulating. The inner and outer shells are preferably cylindrically formed.

[0072] Figure 5 schematically illustrates a front view of a portion of a static electric induction system 1 comprising outer fluid guides 26, vertical outer spacer ribs 22 and coil units 16 which form the coil assembly 6. The fluid guide arrangements A of the first sector 2 are vertically shifted but not centrally shifted, namely by one coil unit pitch 18 or by one coil unit 16 and the vertical distances as counted in coil units 16 between the subsequent out fluid guides 26, as seen from the bottom of the coil assembly 6 is first three coil units 16 and then two coil units 16. Thus the distances are not constant over the height of the coil assembly 6. Although figure 5 only illustrates the outer fluid guides 26, similar arrangements which are not congruent with the arrangement of the outer fluid guides 26, are used for the inner fluid guides 24. The arrangement of the inner fluid guides 24 and the arrangement of outer fluid guides 26 in one sector 2, 2' forms the fluid guide arrangement A, B.

[0073] The coil assembly 6 is cylindrically shaped as illustrated partially in figure 4 and thus figure 6 illustrates a cross section cut through a static electric induction system 1, illustrating the fluid guide arrangement A of a first sector 2 and the fluid guide arrangement B of a second sector 2'. The cross section illustrated in figure 6 is not related to the portion of the static electric induction system 1 shown in figure 5.

[0074] Figure 5a schematically illustrates another embodiment of the static electric induction system 1. The fluid guide arrangements A of the first sector 2 has a constant distance (same number of coil units) between fluid guides over the height of the coil assembly 6 and the fluid guide arrangements B of the second sector 2' has a not constant distance (different number of coil units) between fluid guides over the height of the coil assembly 6. The distances, in the vertical direction, between guides in arrangement B, is smaller in the top part than in bottom part. The fluid guide arrangements in fig 5a leads to that the fluid flow, and thus the cooling, in the top part of sector B is higher and thus a better cooling of the coil assembly 6, overall.

[0075] In figure 6, the inner and outer fluid guides 24, 26 are distributed non-periodically in order to improve the efficiency of the cooling of the coil units 16. In the shown embodiment the coil units 16 are coil discs 37. It is further illustrated in figure 6, that the inner and outer fluid guides 24, 26 are configured to substantially block the vertical fluid ducts 28, 30.

[0076] Figure 7 schematically illustrates another solution according to the invention comprising a first sector 2, a second 2' and a third sector 2'', whereby each sector comprises a different fluid guide arrangement A, B, C. The first sector 2 comprises a first fluid guide arrangement A, the second sector comprises a second fluid guide

arrangement B and the third sector 2" comprises a third fluid guide arrangement C. In figure 7 only the outer fluid guides 26 of the fluid guide arrangements A, B, C are shown. It is however clear that the inner fluid guides 24 are distributed and positioned dependent and the outer fluid guides 26 in order to create the fluid flow pattern 10, 10' without fluid flow blockages. The third fluid guide arrangement C results in a fluid flow pattern (not shown), which is different from the fluid flow patterns of the first and second fluid guide arrangements A, B of the first and second sector 2, 2'. As can be seen from figure 5 the amount of outer fluid guides 26 is four in the first and second fluid guide arrangements A, B of the first and second sectors 2, 2' and it is five in the third fluid guide arrangement C of the third sector 2". The amount of the corresponding inner fluid guides 24 may be the same as the amount of outer fluid guides 26 in the fluid guide arrangements A, B, C or not. The amount and distribution of the fluid guides 24, 26 depends on a thermal analysis of the static electric induction system. The thermal analysis reveals hot spots and regions with increased temperatures. According to the thermal analysis the fluid guides 24, 26 are distributed within the static electrical induction system.

[0077] As previously mentioned the density, thus the amount of fluid guides 24, 26 arranged in a top region of the static electric induction system 1 or coil assembly 6 may be higher than in a middle region or a lower region. A higher density of fluid guides 24, 26 increases the fluid flow in the intermediate ducts 32 significantly and it may thus improve the cooling in the top region of the transformer.

[0078] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A static electric induction system comprising:

- cooling fluid,
- an outer shell (12) and an inner shell (14),
- a coil assembly (6) comprising a plurality of coil units (16), stacked on top of one another and positioned in between the outer and inner shells (12, 14), and a plurality of coil unit spacers (20) configured to form a plurality of intermediate fluid ducts (32) between the coil units (16),
- a first and an adjacent second sector (2, 2'), each sector (2, 2') comprising a fluid guide arrangement (A, B) having a plurality of fluid guides (24, 26), wherein the vertical distance, as counted in coil units (16), between one pair of two subsequent fluid

guides (24, 26) of a sector (2, 2') differs from a vertical distance, as counted in coil units (16), between another pair of two subsequent fluid guides (24, 26) of the same sector (2, 2') and wherein the first fluid guide arrangement (A) of the first sector (2) differs from the second fluid guide arrangement (B) of the second sector (2').

2. The static electric induction system according to claim 1, wherein the first and second fluid guide arrangements (A, B) comprise inner fluid guides (24) arranged next to the inner shell (14) and outer fluid guides (26) arranged next to the outer shell (12).
3. The static electric induction system according to claim 1 or 2, wherein the vertical distance, as counted in coil units (16), between one pair of two subsequent inner or outer fluid guides (24, 26) of a sector (2, 2') differs from a vertical distance, as counted in coil units (16), between another pair of two subsequent inner or outer fluid guides (24, 26) of the same sector (2, 2').
4. The static electric induction system according to any of the previous claims, wherein the inner and outer fluid guides (24, 26) are arranged in a non-periodical manner across at least two sectors (2, 2').
5. The static electric induction system according to any of the previous claims, comprising inner vertical fluid ducts (28) and outer vertical fluid ducts (30).
6. The static electric induction system according to the previous claim, wherein the inner and outer fluid guides (24, 26) are configured to substantially block a vertical cooling fluid flow in the inner and outer vertical fluid ducts (30, 28), respectively.
7. The static electric induction system according to any of the previous claims, wherein the first fluid guide arrangement (A) of the first sector (2) is not congruent with the second fluid guide arrangement (B) of the second sector (2').
8. The static electric induction system according to the previous claim, wherein the cooling fluid defines a fluid flow pattern (10, 10', 10'') and wherein the different fluid guide arrangements (A, B, C) result in different fluid flow patterns (10, 10', 10'').
9. The static electric induction system according to any of the previous claims, comprising inner and outer coil unit spacer ribs (21, 22), wherein the coil unit spacers (20) are arranged in between the inner and outer coil unit spacer ribs (21, 22).
10. The static electric induction system according to any of the previous claims, comprising a third sector (2'')

adjacent the second sector (2'), wherein the third sector (2'') comprises a third fluid guide arrangement (C) that is different from the first and second fluid guide arrangements (A, B) of the first and second sector (2, 2').

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11. The static electric induction system according to any of the previous claims, wherein a density of inner and outer fluid guides (24, 26) is higher in a top region of the coil assembly (6) than in a bottom region of the coil assembly.
12. The static electric induction system according to any of the previous claims, wherein the cooling fluid is driven by natural convection.
13. The static electric induction system according to any of the previous claims, comprising a pump drive configured to drive the cooling fluid in the static electric induction system.
14. The static electric induction system according to any of the previous claims, wherein the amount of inner and outer fluid guides (24, 26) in the first or second fluid guide arrangement (A, B) differs from the amount of inner and outer fluid guides in the third fluid guide arrangement (C).

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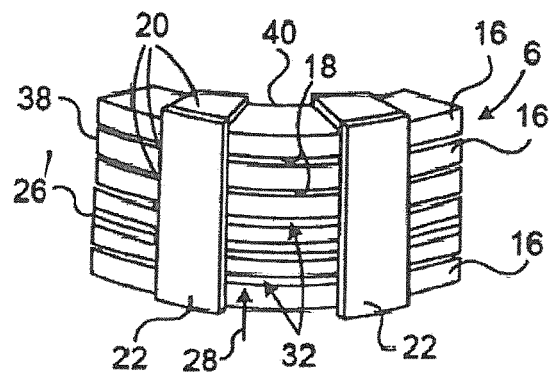
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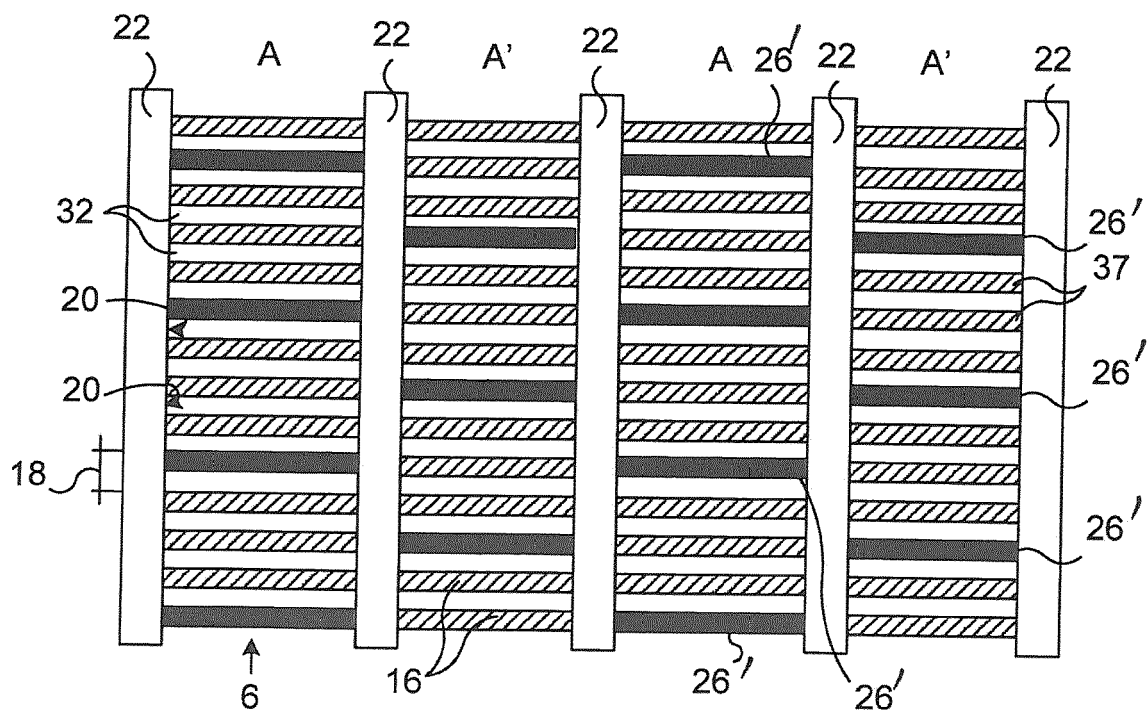
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Prior Art

Fig. 1



Prior Art

Fig. 2

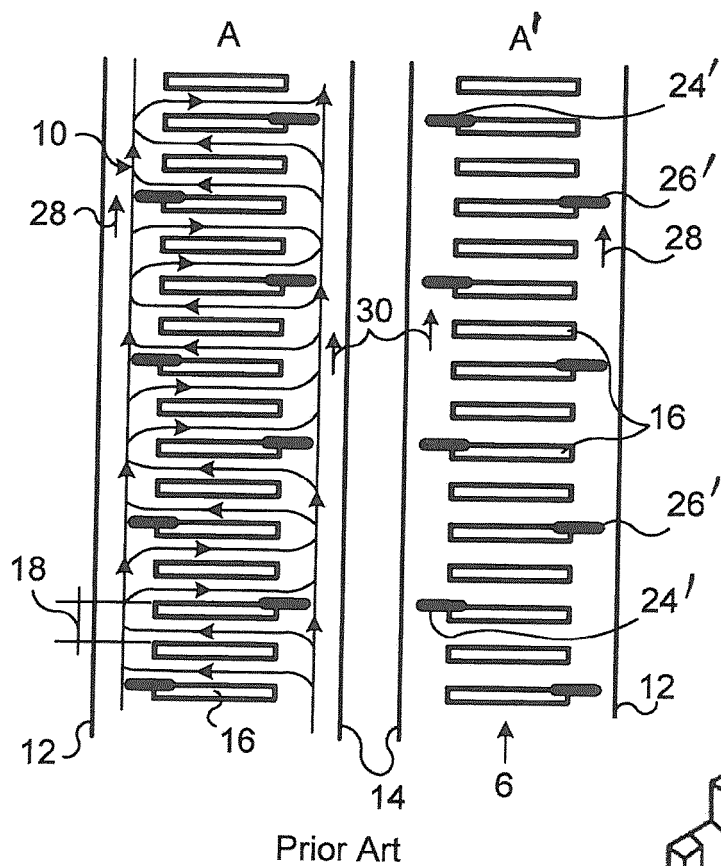


Fig. 3

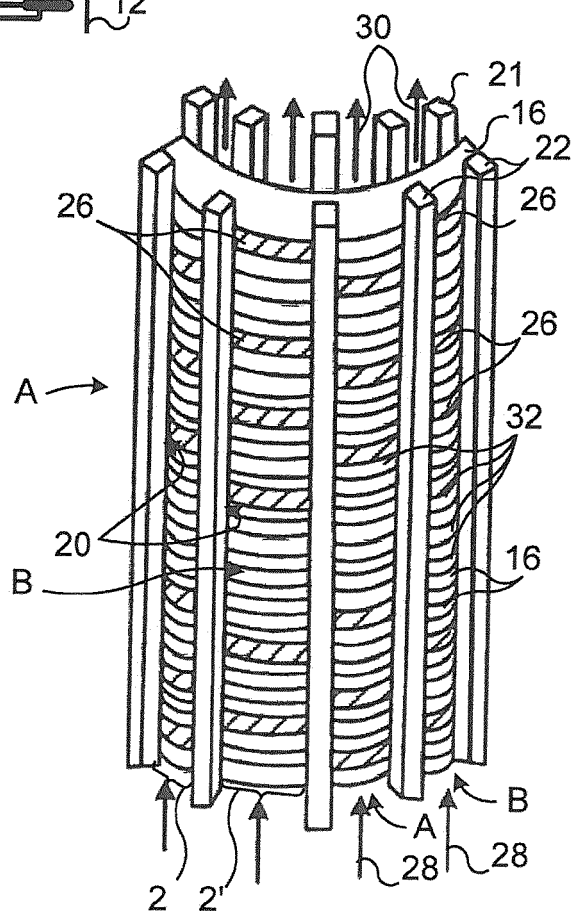


Fig. 4

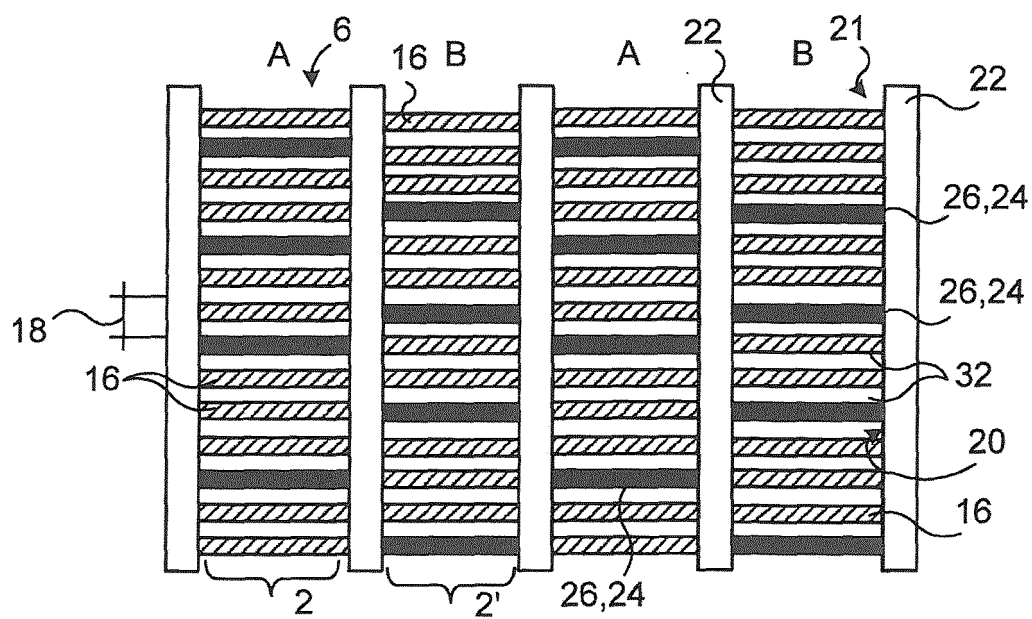


Fig. 5

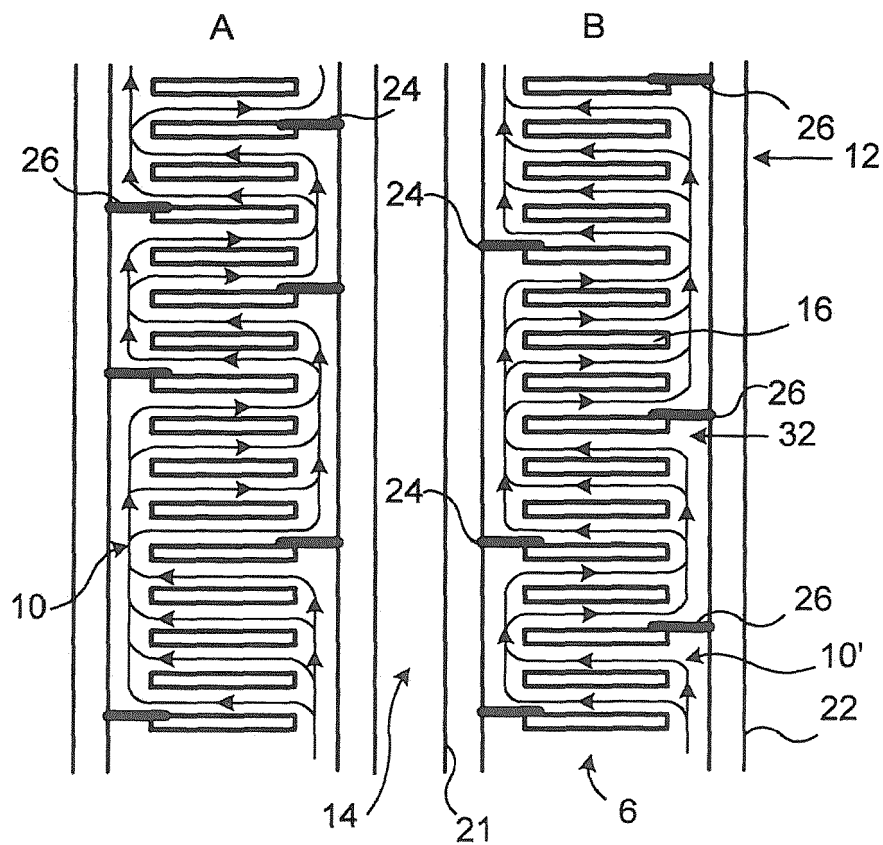


Fig. 6

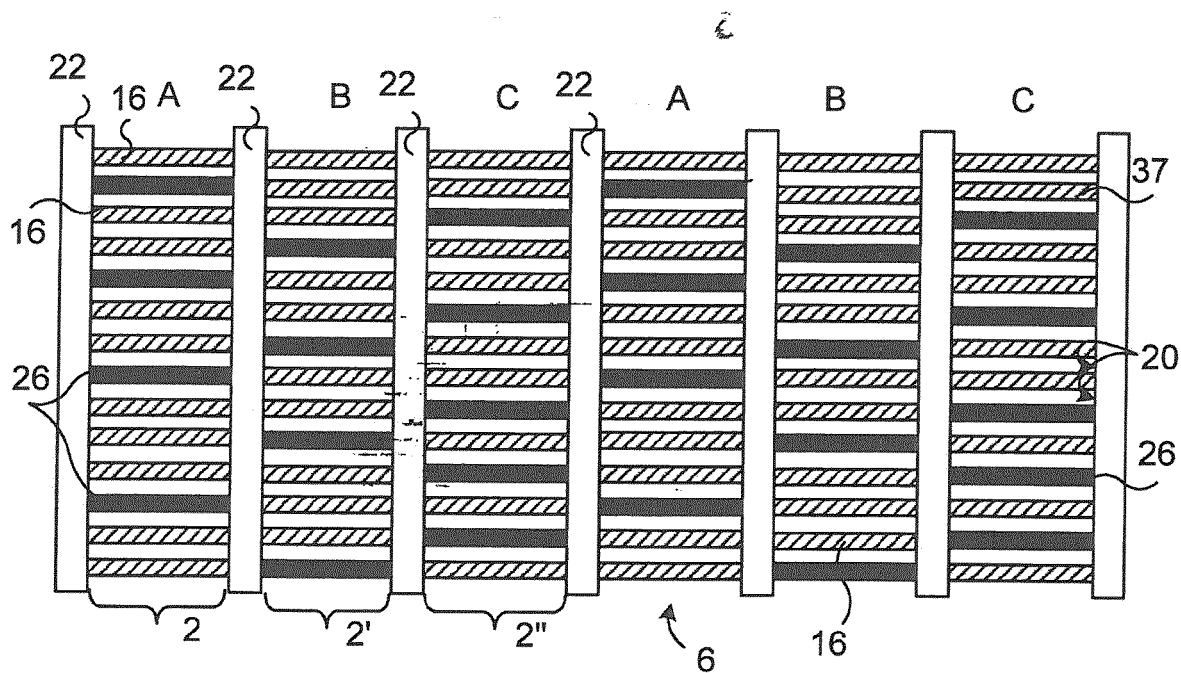


Fig. 7

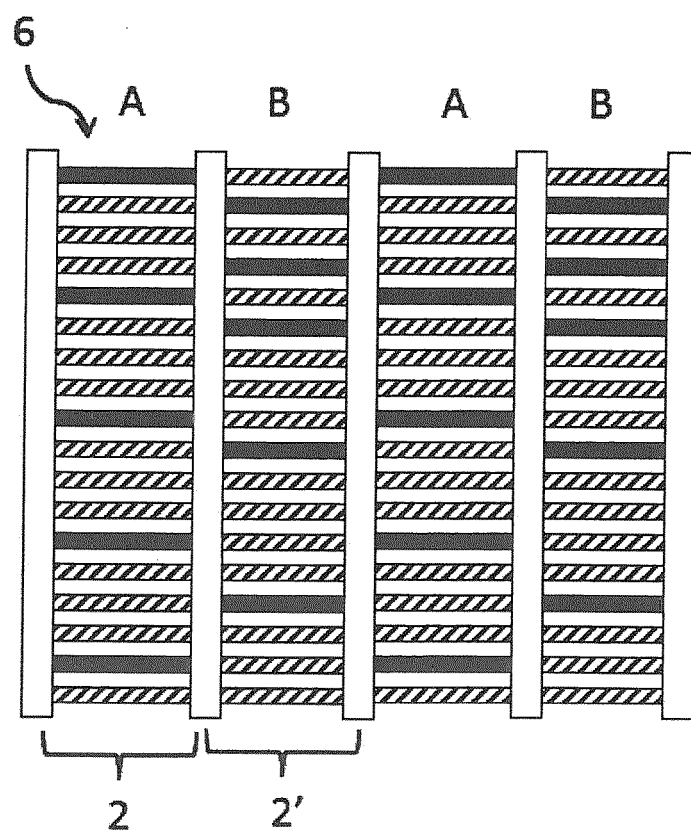


Fig 5a



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