US 20250259784A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0259784 A1
(43) Pub. Date: Aug. 14, 2025
Sahu et al.

(54) A WINDING, A TRANSFORMER AND A TRANSFORMER ARRANGEMENT

(71) Applicant: **Hitachi Energy Ltd**, Zürich (CH)

(72) Inventors: **Kiran Chandra Sahu**, Västerås (SE); **Anders Daneryd**, Västerås (SE)

(21) Appl. No.: **18/995,405**

(22) PCT Filed: **Aug. 3, 2023**

(86) PCT No.: **PCT/EP2023/071508**

§ 371 (c)(1),
(2) Date: **Jan. 16, 2025**

(30) **Foreign Application Priority Data**

Aug. 12, 2022 (EP) 22190287.7

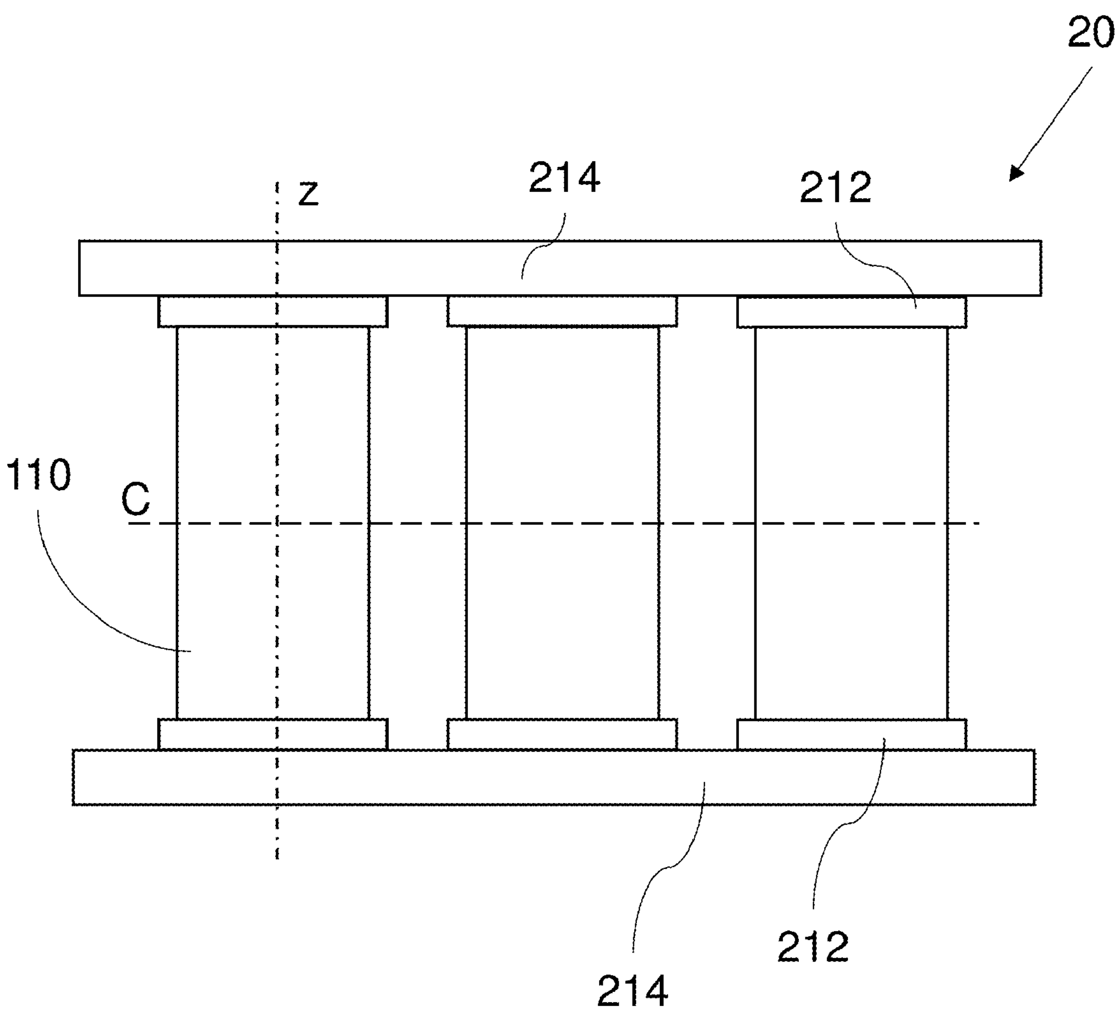
Publication Classification

(51) **Int. Cl.**
H01F 27/32 (2006.01)
H01F 27/33 (2006.01)

(52) **U.S. Cl.**
CPC ***H01F 27/323*** (2013.01); ***H01F 27/321*** (2013.01); ***H01F 27/33*** (2013.01)

(57) **ABSTRACT**

The disclosure relates to a winding for a phase winding of a transformer. The winding includes a plurality of winding portions arranged along a coil axis. The plurality of winding portions include a first winding portion arranged at a first end of the winding and a second winding portion arranged at a second end of the winding. The winding further includes at least a third winding portion arranged along the coil axis between the first winding portion and the second winding portion. The first winding portion and the second winding portion have a first winding portion stiffness as seen along the coil axis and the at least third winding portion has a second winding portion stiffness as seen along said coil axis. The second winding portion stiffness is greater than the first winding portion stiffness. The third portion has a third portion center point on the coil axis, equidistantly spaced at a distance from the first winding portion and from the second winding portion, which third portion center point is located closer to the first end of the winding than the winding center point.



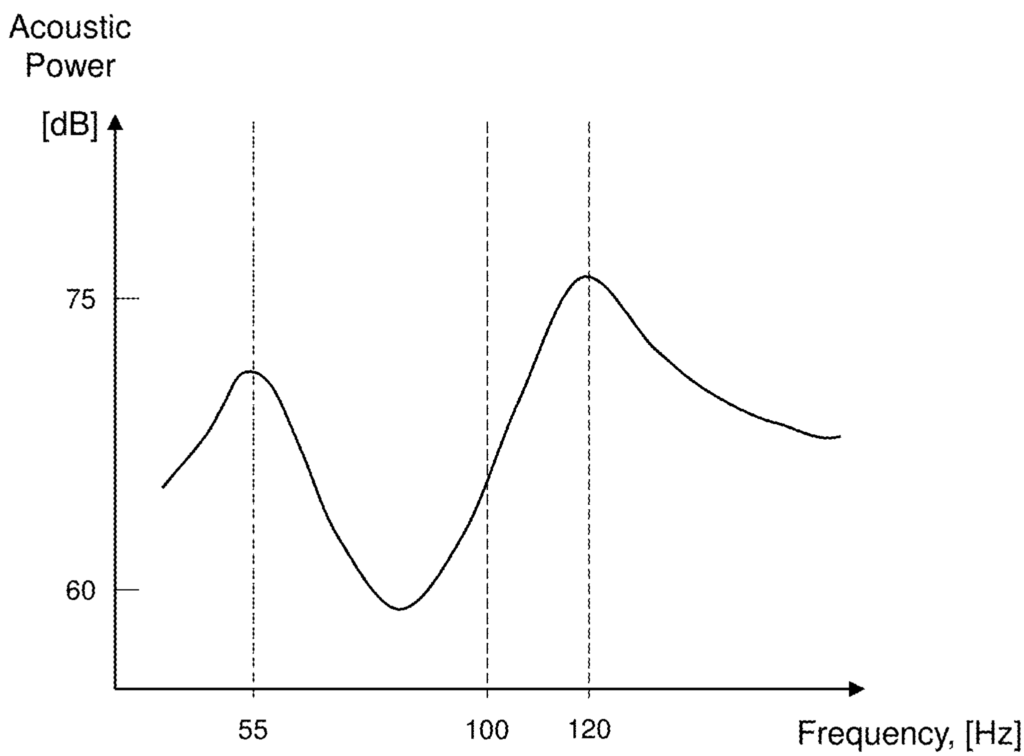


Fig. 1
(prior art)

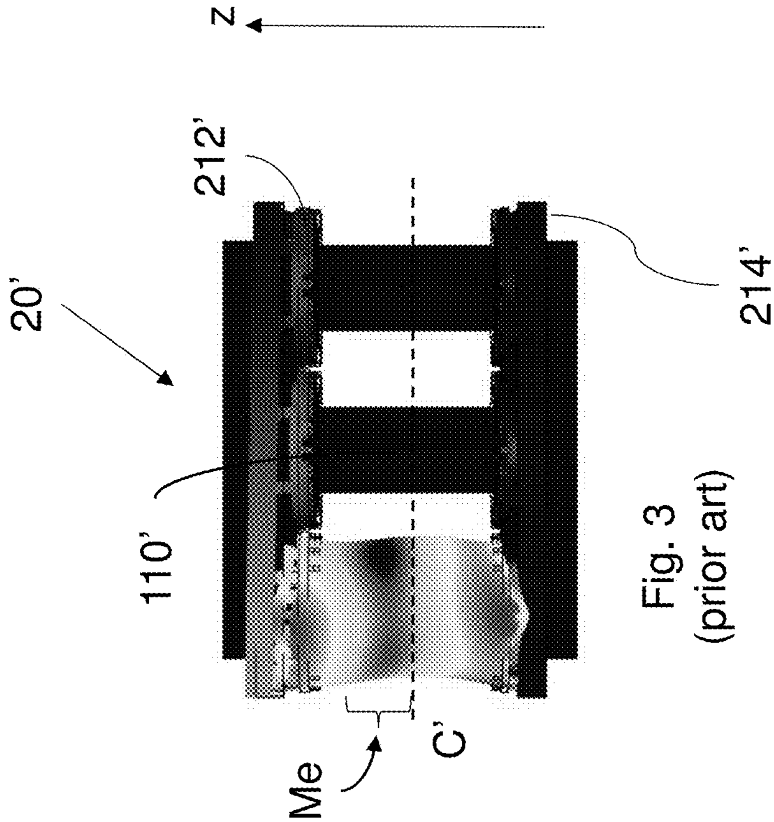


Fig. 3
(prior art)

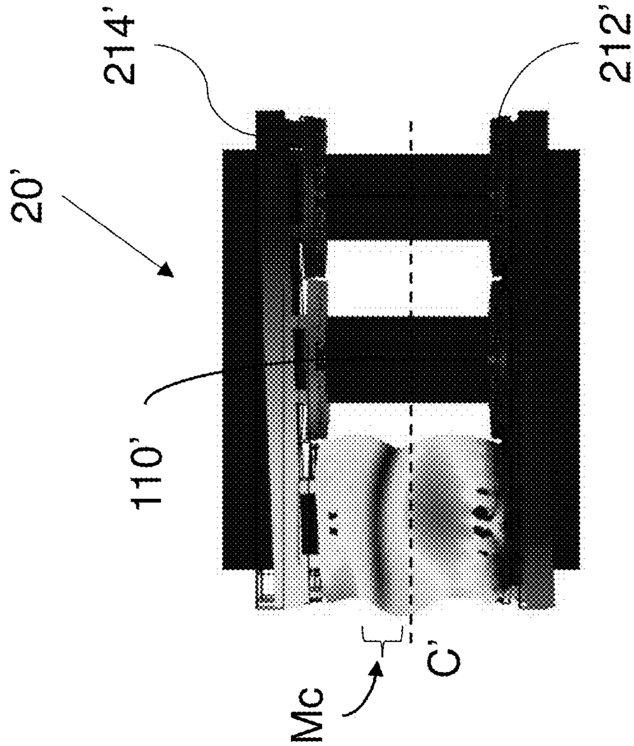


Fig. 2
(prior art)

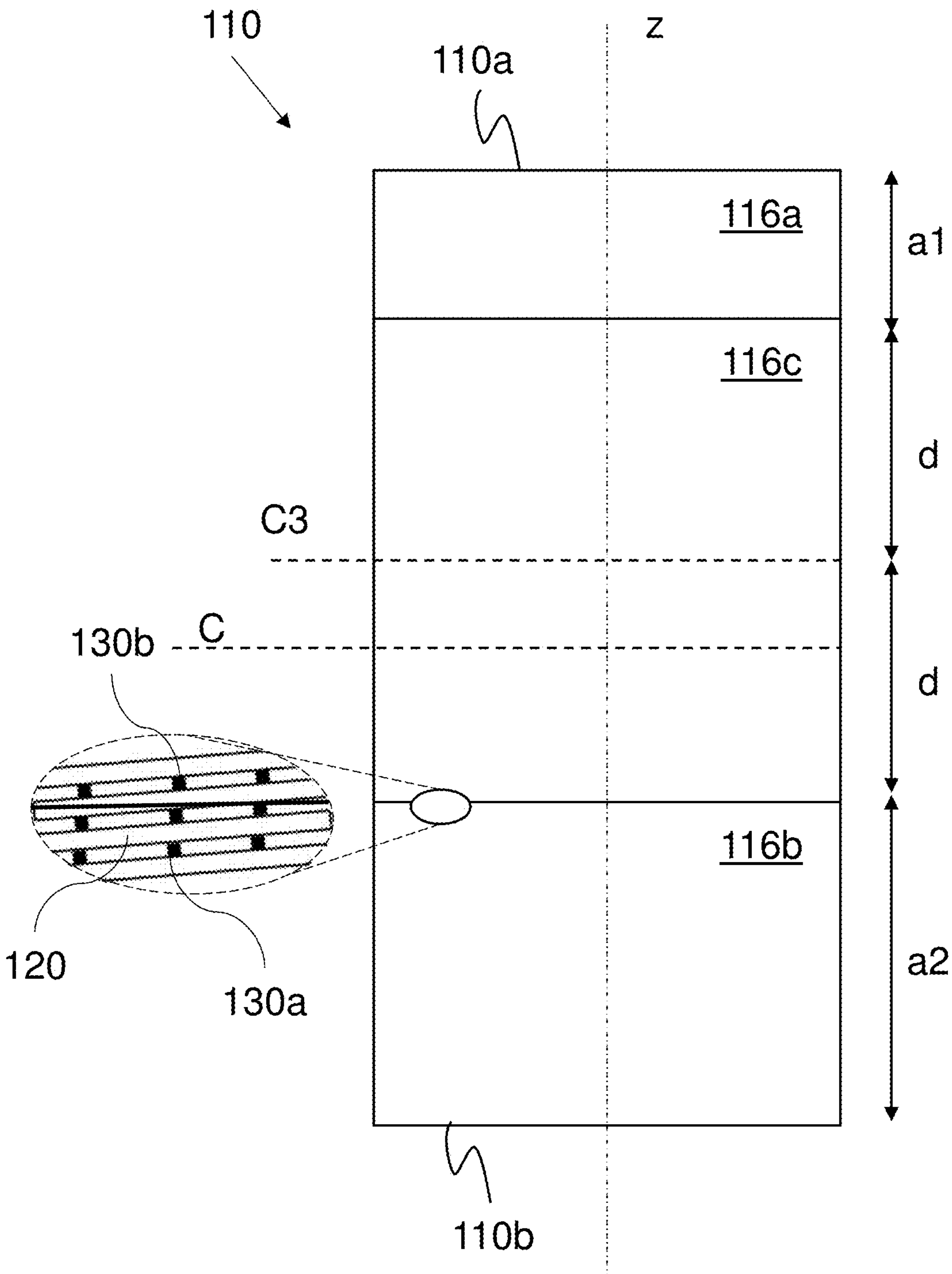


Fig. 4

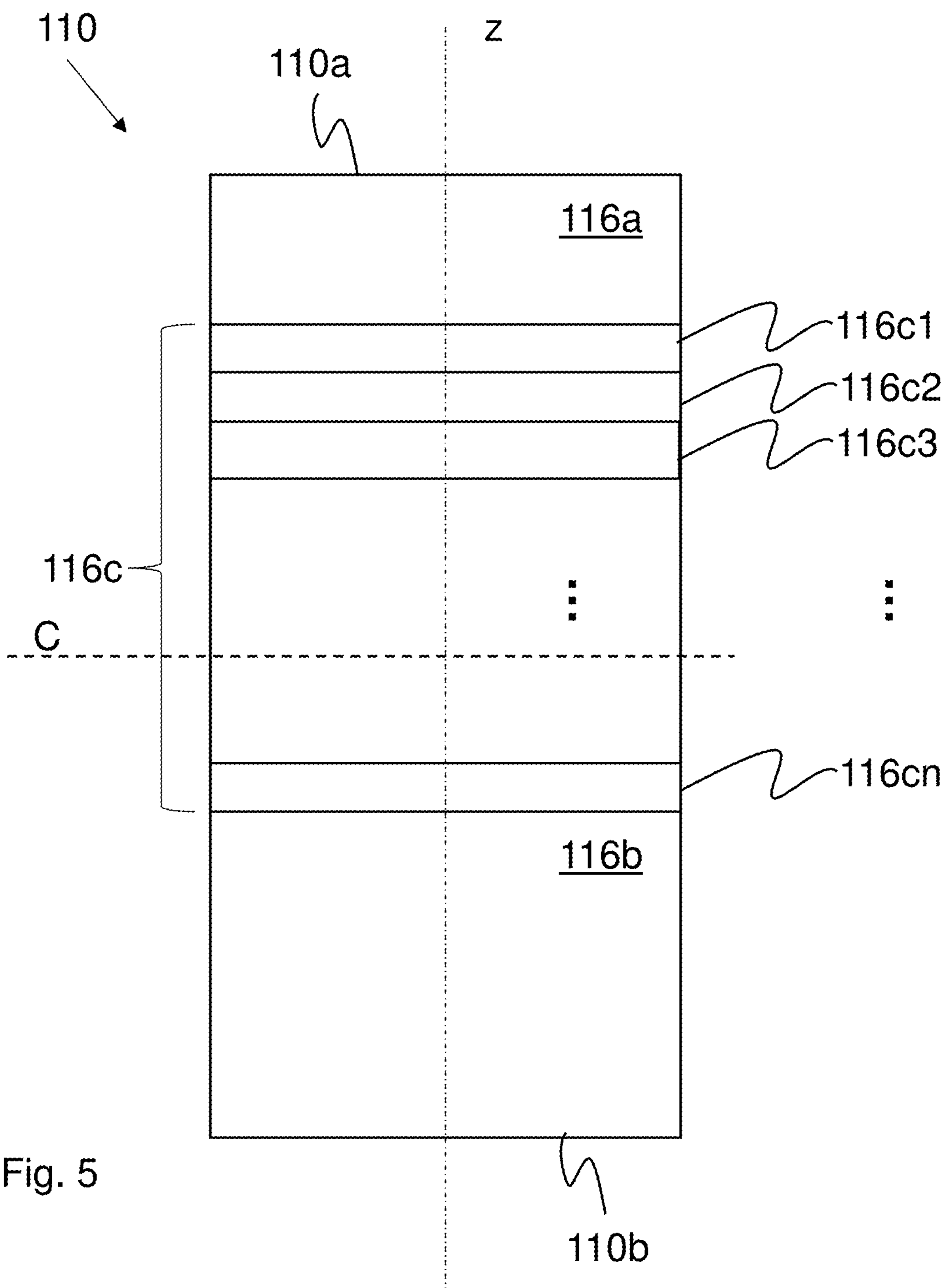


Fig. 5

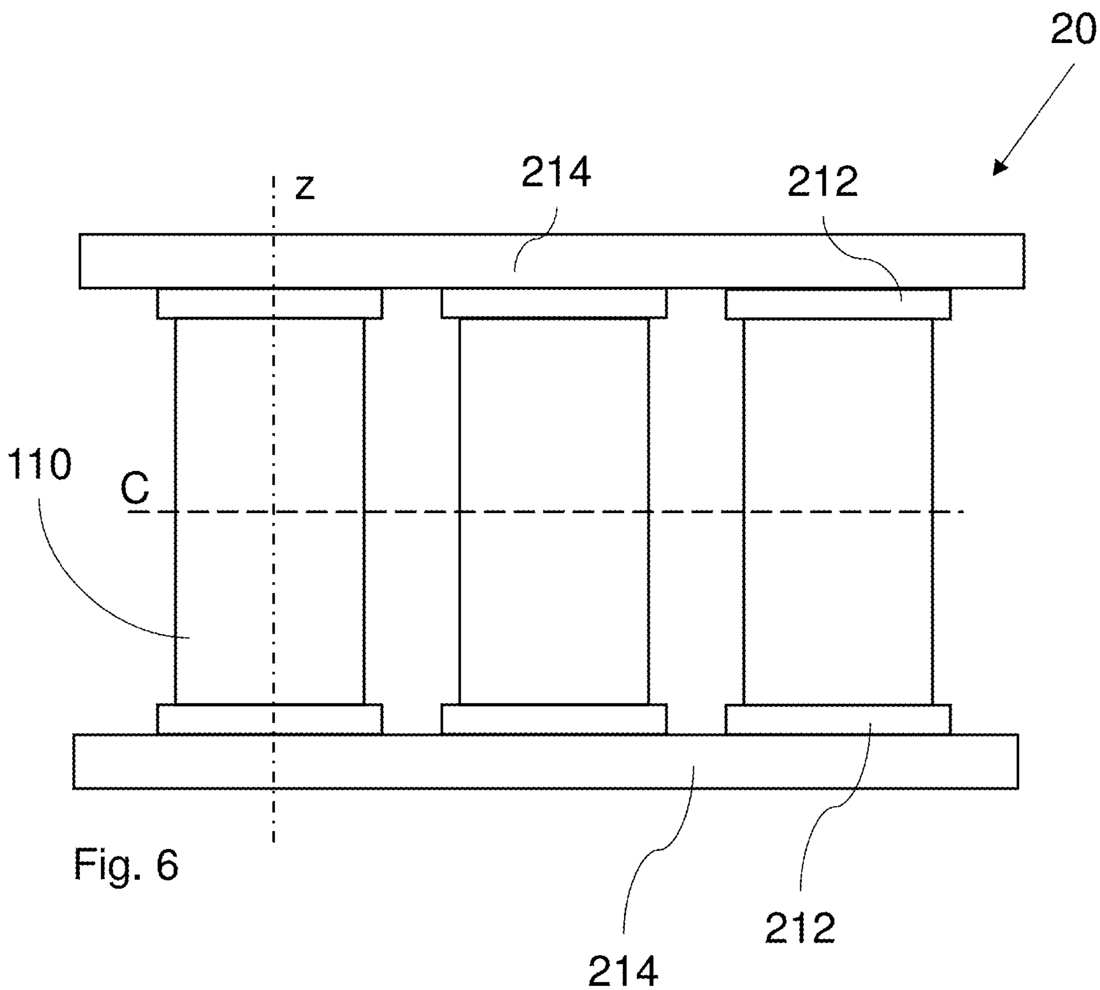


Fig. 6

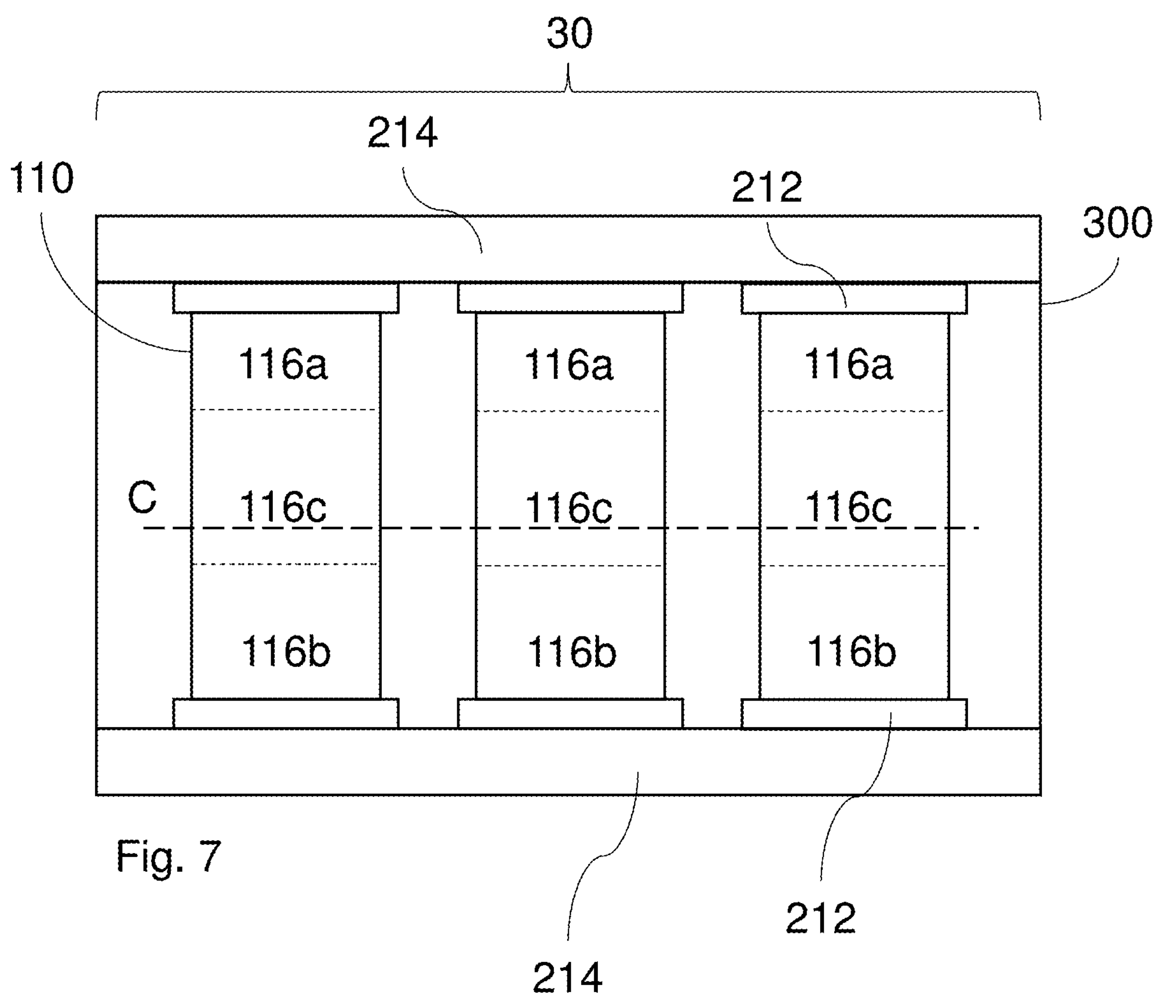

30
214
110
212
300
116a
116a
116a
C
116c
116c
116c
116b
116b
116b
214
212

Fig. 7

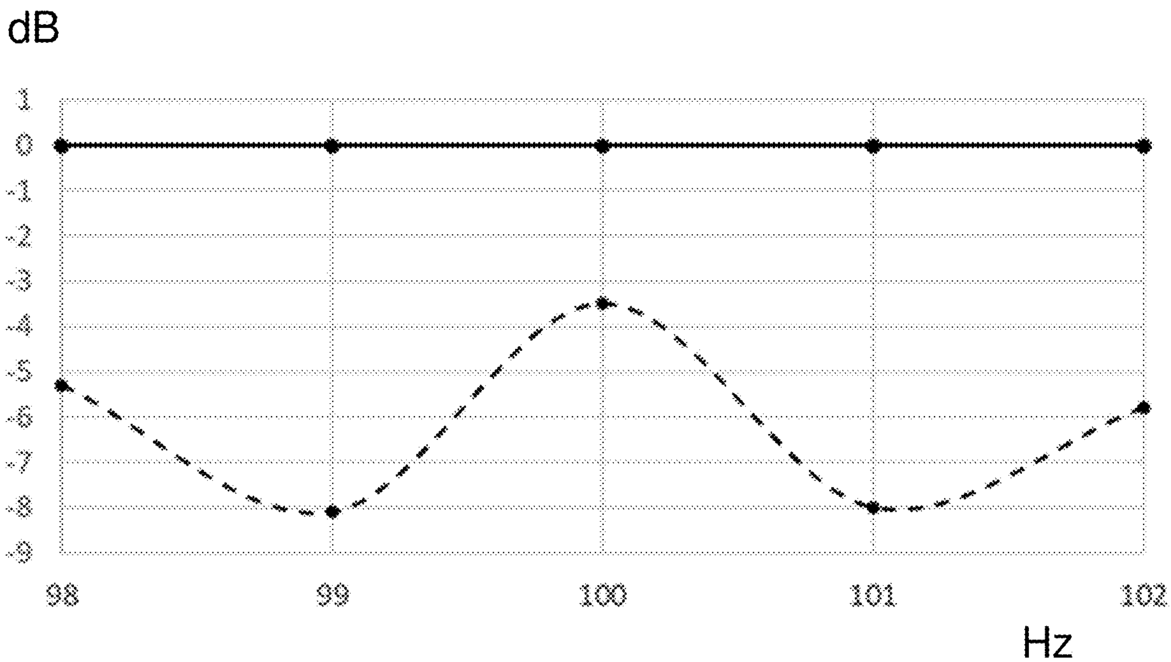


Fig. 8

A WINDING, A TRANSFORMER AND A TRANSFORMER ARRANGEMENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a 35 U.S.C. § 371 national stage application of PCT International Application No. PCT/EP2023/071508 filed on Aug. 3, 2023, which in turn claims priority to European Patent Application No. 22190287.7, filed on Aug. 12, 2022, the disclosures and content of which are incorporated by reference herein in their entireties.

TECHNICAL FIELD

[0002] The present disclosure relates to a winding for a transformer. The disclosure also relates to a transformer comprising such a winding, and to a transformer arrangement comprising such a transformer.

BACKGROUND

[0003] Transformers, as any other industrial products, must comply with various requirements on noise levels. Load noise is produced by electromagnetic forces in the windings of transformers. Transformers vibrate at 100 Hz or 120 Hz mechanical frequency due to electric operating frequencies at 50 Hz or 60 Hz, respectively. Asymmetric, and especially symmetric vibration modes, contribute to the generation of noise. Symmetric vibrations cause a piston-like movement of the windings, which in turn is transmitted via pressplates, support frame and transformer oil to the walls of a transformer tank, generating significant noise.

[0004] JPH04318905 A discloses a winding device having spacers made of pressboard and a central portion of the winding has spacers of a larger compressive elastic modulus, such as fiber board or a resin.

[0005] U.S. Pat. No. 3,815,068 A shows a winding having thicker spacers located in the axial middle portion of a low-voltage winding. The thicker spacers give the winding larger gaps between the coil turns, resulting on a reduced number of turns in the middle portion.

[0006] JP2013183151 A discloses that a mode shape of the winding may be changed by changing the material and thickness of spacers.

SUMMARY

[0007] Therefore, an object of the disclosure is to provide an improved winding for a transformer. More specifically, an object of the disclosure is to provide a winding having reduced noise emissions and which is cost-effective to build and assemble. Another object of the disclosure is to provide a transformer comprising such a winding and a transformer arrangement comprising such a transformer in a transformer tank.

[0008] According to a first aspect of the disclosure the object is at least partly achieved by a winding according to claim **1**.

[0009] Hence, there is provided a winding for a phase winding of a transformer, said winding having coil turns around a coil axis. The winding has a first end and a second end and a winding center point on the coil axis between the first end and the second end. The winding comprises a plurality of winding portions arranged along the coil axis. The plurality of winding portions comprise a first winding portion arranged at the first end of the winding and a second winding portion arranged at the second end of the winding. The winding further comprises at least a third winding portion arranged along the coil axis between the first winding portion and the second winding portion. The first winding portion and the second winding portion have a first winding portion stiffness as seen along said coil axis, and the at least third winding portion has a second winding portion stiffness as seen along said coil axis. The second winding portion stiffness is greater than the first winding portion stiffness. The third portion has a third portion center point on the coil axis, equidistantly spaced at a distance from the first winding portion and from the second winding portion. The third portion center point is located closer to the first end of the winding than the winding center point.

[0010] The winding is a winding for a phase winding of a transformer. A phase winding may have a plurality of windings. For instance, a three-phase transformer has three phase windings, each of which has at least two windings, e.g., an inner winding and an outer winding wherein "inner" and "outer" refer to relative positions of the windings around the coil axis. A single-phase transformer has only one phase winding.

[0011] A winding portion is herein defined as a portion of the winding along the coil axis. The coil axis is a vertical axis when the winding is assembled with a phase winding of a transformer. The first winding portion and the second winding portion sandwich the third winding portion between them. Conventional windings only have a single winding portion.

[0012] It has been discovered that a middle part of the winding, wherein "middle" refers to a position along the coil axis, expands and contracts significantly more than other parts of the winding due to symmetric vibrations at the operating frequency. Therefore, arranging a third winding portion having a greater stiffness in the middle part of the winding reduces/dampens the movement of the winding and thereby reduces noise emissions.

[0013] A distance between the third portion center point and the first end of the winding is shorter than a distance between the winding center point and the first end of the winding.

[0014] It has been observed that the largest movements of the winding arise closer to the first end than to the second end, i.e., not exactly at the winding center point. It is therefore advantageous to make the winding stiffer in a portion closer to the first end than in the axial center of the winding. Accordingly, the third winding portion, which is stiffer than the first winding portion and the second winding portion, is arranged closer to the first end than to the second end. It follows that an extension along the coil axis of the first winding portion may be shorter than an extension along the coil axis of the second winding portion.

[0015] Optionally, the winding is provided with a plurality of spacers between the coil turns, wherein the first winding portion and the second winding portion is provided with at least one first type of spacers having at least one first modulus of elasticity and the third winding portion is provided with at least one second type of spacers having at least one second modulus of elasticity, and wherein each of the at least one second modulus of elasticity is greater than the first modulus of elasticity.

[0016] Spacers are used to keep the coil turns of the windings separated to avoid short-circuiting the coil turns. The elasticity/stiffness of the spacers affect the elasticity/

stiffness of the winding. The stiffness of a winding portion may thus be adapted and configured using spacers of different kinds. According to the present disclosure, a stiffer kind of spacer, having a significantly greater modulus of elasticity, is arranged between the coil turns of the third winding portion, as compared to the spacers of the first winding portion and of the second winding portion. Thereby, the second winding portion stiffness is greater than the first winding portion stiffness.

[0017] Optionally, the third winding portion comprises a plurality of sub-portions arranged along the coil axis. Each sub-portion having a sub-portion stiffness as seen along the coil axis. Each sub-portion comprises one second type of spacers and each sub-portion stiffness is greater than the first winding portion stiffness.

[0018] The second type of spacers are thus characterized in that they are all of greater stiffness than the first type of spacers. The second type of spacers may comprise different spacers, such that each sub-portion has spacers of a particular stiffness (modulus of elasticity). The second type of spacers may for instance comprise two kinds of spacers. Thereby, the third winding portion may have two different kinds of sub-portions which are arranged along the coil axis, for instance in an alternating configuration.

[0019] Optionally, a distribution of the plurality of sub-portions forms an aggregate winding portion stiffness, wherein the plurality of sub-portions is configured such that the aggregate winding portion stiffness of the third winding portion located on a first side of the winding center point as seen along the coil axis is greater than an aggregate winding portion stiffness of the third winding portion located on a second side of the winding center point as seen along the coil axis.

[0020] An aggregate winding portion stiffness is to be understood as a collection of sub-portions stiffnesses that provide a winding portion with a stiffness that may vary along the axial extent of the winding portion. Since each sub-portion stiffness is stiffer than the at least first winding portion stiffness and the at least second winding portion stiffness, it is ensured that the third winding portion is stiffer than the first winding portion and the second winding portion along the whole axial extent of the third winding portion.

[0021] The stiffness of the third winding portion along the coil axis may thus be configured by arranging the sub-portions in a pre-determined manner. By arranging one or more sub-portions having a greater stiffness on the first side of the winding center point and arranging one or more sub-portions having a lower stiffness on the second side of the winding center point, it is ensured that the third winding portion is stiffer closer to the first end than to the second end. Thereby, the large movements of the winding may be dampened more efficiently.

[0022] Optionally, the first side of the winding center point is located closer to the first end than to the second end of the winding.

[0023] It should be understood the first side of the center point is the side closer the first end of the winding and the second side of the center point is the side closer the second end of the winding.

[0024] Optionally, the modulus of elasticity of the first type of spacers may be 0.1 GPa-3 GPa, preferably 0.5 GPa-1.5 GPa, and most preferably 0.9 GPa-1.1 GPa. The modulus of elasticity of the at least one second type of spacers may be more than 50 GPa, preferably more than 80 GPa, and most preferably more than 105 GPa. Further, a material of the first type of spacers may be a cellulose-based material such as pressboard and a material of the at least one second type of spacers may be a composite material such as steatite.

[0025] Conventional spacers are usually made of pressboard which has a modulus of elasticity of around 1 GPa. It can be seen that the stiffnesses (moduli of elasticity) suggested for the second type of spacers is much higher than the first type of spacers. Steatite, which has a modulus of elasticity of around 110 GPa, has been shown to have a particularly large damping effect on the noise generation.

[0026] Optionally, the first end is an upper end of the winding when installed in a transformer and the second end is a lower end of the winding when installed in a transformer.

[0027] Thus, the largest movements of the vibrating winding occur somewhat closer to the upper end of the winding than to the lower end.

[0028] Optionally, the first end is a lower end of the winding when installed in a transformer and the second end is an upper end of the winding when installed in a transformer.

[0029] Thus, the largest movements of the vibrating winding occur somewhat closer to the lower end of the winding than to the upper end.

[0030] It is foreseen that the largest movements of the vibrating winding occur offset from the center of the winding towards the upper end or towards the lower end of the winding. The offset depends on the construction of a transformer in which the winding is comprised.

[0031] According to a second aspect of the present disclosure, the object is at least partly achieved by a transformer according to claim **11**.

[0032] Thus, there is provided a transformer comprising at least one winding according to any one of the embodiments of the first aspect of the present disclosure.

[0033] Optionally, the transformer comprises at least one phase winding which has a winding according to any one of the embodiments of the first aspect of the present disclosure.

[0034] When the transformer comprises at least one winding according to the present disclosure, the acoustic power of each such winding may reduce the acoustic power of the transformer as a whole, such as when at least one winding of three phase windings is in accordance with the present disclosure. The winding according to the present disclosure may thus be an inner or outer winding of the phase winding. Expressed differently, the winding according to the present disclosure may be a high voltage winding or a low voltage winding of the phase winding.

[0035] According to a third aspect of the present disclosure, the object is at least partly achieved by a transformer arrangement according to claim **13**.

[0036] Thus, there is provided a transformer arrangement comprising a transformer according to any one of the embodiments of the second aspect of the present disclosure. The transformer may be immersed in an electrically insulating medium inside a transformer tank.

[0037] The transformer may be immersed in an electrically insulating medium, such as oil, in the transformer tank. By the provision of at least one winding according to the disclosure, the symmetric mode of the transformer may be modified to reduce vibration and noise of the transformer.

Consequently, such a transformer in a transformer tank will cause the transformer tank walls to generate less noise to the surroundings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] Further objects and advantages of, and features of the disclosure will be apparent from the following description of one or more embodiments, with reference to the appended drawings, where:

[0039] FIG. **1** shows the noise power generated by a prior art transformer at predetermined frequencies

[0040] FIG. **2** shows a prior art phase winding under maximum compression.

[0041] FIG. **3** shows a prior art phase winding under maximum expansion.

[0042] FIG. **4** shows a schematic representation of a winding according to an embodiment of the first aspect of the present disclosure.

[0043] FIG. **5** shows a schematic representation of a winding according to an embodiment of the first aspect of the present disclosure.

[0044] FIG. **6** shows a transformer according to the second aspect of the present disclosure.

[0045] FIG. **7** shows a transformer arrangement according to the third aspect of the present disclosure.

[0046] FIG. **8** shows a reduction in noise at various frequencies for a winding according to the first aspect of the present disclosure.

DETAILED DESCRIPTION

[0047] The present disclosure is developed in more detail below referring to the appended drawings which show examples of embodiments. The disclosure should not be viewed as limited to the described examples of embodiments; instead, it is defined by the appended patent claims. Like numbers refer to like elements throughout the description.

[0048] FIG. **1** shows how acoustic power of a prior art transformer **20'**, shown in FIGS. **2** and **3**, as a result of vibrations of windings **110'**, varies with frequency. The horizontal axis displays the mechanical vibration frequency. The curve represents a superposition of vibration modes of the structure of the transformer **20'** because of vibrations of the windings **110'**. The modes of interest of the transformer **20'** may be identified at the peak amplitudes, where the acoustic power is largest. The peak amplitude at around 120 Hz shows a symmetric vibration mode. It can be seen that it has a great influence on the acoustic power at 100 Hz and 120 Hz, i.e., at the operating electric frequencies of 50 Hz and 60 Hz, respectively.

[0049] Symmetric movements (piston-like displacements) of the transformer **20'** (FIGS. **2** and **3**), especially when installed in a transformer tank (not shown), radiate significant noise to the far field as compared to asymmetric movement because symmetric vibrations displace more air outside the transformer tank and thereby radiate sound more efficiently than asymmetric movements. Windings **110'** (see FIGS. **2** and **3**) under load usually vibrate at 100 Hz or 120 Hz mechanical main frequency (i.e., usually 50 Hz or 60 Hz predetermined electrical operating (excitation) frequency multiplied by two).

[0050] FIGS. **2** and **3** show simulated movement in an operating prior art transformer **20'** having three phase windings, each comprising windings **110'** having pressboard spacers between the coil turns. Only movement in one of the phase windings is shown for the sake of clarity. In normal operation all three phase windings would move similarly but with a phase difference between the oscillations. The phase windings are clamped between upper and lower pressplates **212'** and upper and lower support beams **214'**. When the winding **110'** vibrates, the vibrational movement is transferred to the pressplates **212'** and the support beams **214'**, as shown. If the transformer **20'** is enclosed in a transformer tank and immersed in an insulating medium, the movements would be further transferred via the insulating medium to the transformer tank walls.

[0051] The piston-like movement of symmetric vibrations leads to an oscillating compression and expansion of the windings, especially along a coil axis z. FIG. **2** shows the moving phase winding under maximum compression Mc. FIG. **3** shows the moving phase winding under maximum expansion Me. The movement of the windings **110'** varies along the coil axis, but FIGS. **2** and **3** show that both compression and expansion have a maximum slightly offset from a winding center point C'. It is an object of the present disclosure to reduce and dampen the movement of windings of a transformer.

[0052] FIG. **4** shows a winding **110** for a phase winding of a transformer **20** according to the first aspect of the present disclosure. The winding **110** has coil turns **120** around a coil axis z. The winding **110** further has a first end **110*a*** and a second end **110*b*** and a winding center point C on the coil axis z between the first end **110*a*** and the second end **110*b***.

[0053] The winding **110** comprises a plurality of winding portions **116** arranged along the coil axis z. The plurality of winding portions **116** comprise a first winding portion **116*a*** arranged at the first end **110*a*** of the winding **110** and a second winding portion **116*b*** arranged at the second end **110*b*** of the winding **110**. The winding **110** further comprises at least a third winding portion **116*c*** arranged along the coil axis z between the first winding portion **116*a*** and the second winding portion **116*b***. The first winding portion **116*a*** and the second winding portion **116*b*** have a first winding portion stiffness as seen along the coil axis z and the at least third winding portion **116*c*** has a second winding portion stiffness as seen along the coil axis z. The second winding portion stiffness is greater than the first winding portion stiffness.

[0054] The first winding portion **116*a*** and the second winding portion **116*b*** sandwich the third winding portion **116*c*** between them. Conventional windings, such as illustrated in FIGS. **2** and **3**, only have a single winding portion.

[0055] Since it has been discovered that a middle part of the winding **110** expands and contracts significantly more than other parts of the winding **110** due to symmetric vibrations at the operating frequency, arranging the middle part of the winding **110** with a greater stiffness reduces/dampens the movement of the winding **110** and thereby reduces noise emissions. The greater stiffness of the middle part is achieved by the third winding portion **116*c*** which has the second winding portion stiffness, which is greater than the first winding portion stiffness of the first winding portion **116*a*** and the second winding portion **116*b***.

[0056] The third portion **116*c*** has a third portion center point C**3** on the coil axis z, equidistantly spaced at a distance d from the first winding portion **116*a*** and from the second winding portion **116*b***. The third portion center point C**3** may, as illustrated in FIG. **4**, be located closer to the first end

110*a* of the winding **110** than the winding center point C. It is also conceivable that the winding center point C and the third portion center point C**3** are the same, such as if the third winding portion **116***c* in located in the axial middle of the winding **110**.

[0057] Depending on the construction and design of a transformer and how phase windings are mounted and assembled with each other, the largest movements of the winding **110** may arise closer to the first end **110***a* than to the second end **110***b*, i.e., not exactly at the winding center point C. It is therefore advantageous to make the winding **110** stiffer in a portion closer to the first end **110***a* than in the axial center of the winding C. Accordingly, the third winding portion **116***c*, which is stiffer than the first winding portion **116***a* and the second winding portion **116***b*, is arranged closer to the first end **110***a* than to the second end **110***b*. It follows that an axial extension a**1** of the first winding portion **116***a* may be shorter than an axial extension a**2** of the second winding portion **116***b*, as exemplified in FIG. **4**.

[0058] It should herein be understood that the first end **110***a* may be an upper end of the winding **110** when installed in a transformer **100** and the second end **110***b* may be a lower end of the winding **110** when installed in a transformer **100**, or vice versa. Thus, in operation, the largest movements of the vibrating winding **110** occur somewhat closer to the upper end **110***a* of the winding **110** than to the lower end **110***b*. Alternatively, the largest movements of the vibrating winding **110** may occur somewhat closer to the lower end **110***a* of the winding **110** than to the upper end **110***b*. The illustrated exemplary embodiments show the first end **110***a* as the upper end and the second end **110***b* as the lower end.

[0059] The winding **110** is provided with a plurality of spacers **130** between the coil turns **120**. The first winding portion **116***a* and the second winding portion **116***b* are provided with at least one first type of spacers **130***a*, as exemplified by the detailed view in FIG. **4**, having at least one first modulus of elasticity. The third winding portion **116***c* is provided with at least one second type of spacers **130***b* (not shown) having at least one second modulus of elasticity. Each of the at least one second modulus of elasticity is greater than the at least one first modulus of elasticity.

[0060] The spacers **130** are conventionally distributed along the axial length of the winding **110**, between the coil turns **120**, so as to separate and electrically insulate the coil turns **120** of the winding **110** from each other. The elasticity/stiffness of the spacers **130** affect the elasticity/stiffness of the winding **110**. The stiffness of a winding portion **116** may thus be adapted and configured using spacers **130** of different kinds. According to the present disclosure, a stiffer second type of spacers **130***b*, having a greater modulus of elasticity, is arranged between the coil turns **120** of the third winding portion **116***c*, as compared to the first type of spacers **130***a* of the first winding portion **116***a* and of the second winding portion **116***b*. Thereby, the second winding portion stiffness is greater than the first winding portion stiffness.

[0061] In another embodiment, exemplified in FIG. **5**, the third winding portion **116***c* comprises a plurality of sub-portions **116***c***1**, . . . **116***cn* arranged along the coil axis z. Each sub-portion **116***c***1**, . . . **116***cn* has a sub-portion stiffness as seen along the coil axis z, and Each sub-portion **116***c***1**, . . . **116***cn* comprises one second type of spacers **130***b*. Each sub-portion stiffness is configured to be greater than the first winding portion stiffness.

[0062] The second type of spacers **130***b* are thus characterized in that they are all of greater stiffness than each of the at least one first type of spacers **130***a*. The second type of spacers **130***b* may comprise different spacers **130***b*, such that each sub-portion **116***c***1**, . . . **116***cn* has spacers **130***b* of a respective stiffness (modulus of elasticity). The second type of spacers **130***b* may for instance comprise two kinds of spacers **130***b*. Thereby, the third winding portion **116***c* may for instance have two different kinds of sub-portions **116***c***1**, **116***c***2** which are arranged along the coil axis, for instance arranging a plurality of a first sub-portion in an alternating configuration with a plurality of second sub-portions other. Using the example of two different sub-portions, it is also conceivable to arrange a first sub-portion **116***c***1** on a first side of the third portion center point C**3** and to arrange a second sub-portion **116***c***2** on a second side of the third portion center point C**3**.

[0063] It is also conceivable to configure the first winding portion **116***a* and the second winding portion **116***b* with first sub-portions and second sub-portions, respectively (not shown). Each first sub-portion and each second sub-portion would then comprise one first type of spacers **130***a*. Each first and second sub-portion stiffness would be configured to be lesser than each of the sub-portion portion stiffnesses of the third winding portion **116***c*. Stiffer first sub-portions and second sub-portions would then be arranged closer to the third winding portion **116***c* than less stiff sub-portions and second sub-portions, such that the first winding portion **116***a* and the second winding portion **116***b* exhibit a higher stiffness near the third winding portion **116***c* than farther away from the third winding portion **116***c*.

[0064] A distribution of the plurality of sub-portions **116***c***1**, . . . **116***cn* of the third winding portion **116***c* forms an aggregate winding portion stiffness of the third winding portion **116***c*. The plurality of sub-portions **116***c***1**, . . . **116***cn* may be configured such that the aggregate winding portion stiffness of the third winding portion **116***c*, located on a first side of the winding center point C as seen along the coil axis z, is greater than an aggregate winding portion stiffness of the third winding portion **116***c* located on a second side of the winding center point C as seen along the coil axis z.

[0065] The aggregate stiffness of the third winding portion **116***c* along the coil axis may thus be configured by arranging the sub-portions **116***c***1**, . . . **116***cn* in a pre-determined manner. By arranging one or more sub-portions **116***c***1**, . . . **116***cn* having a greater stiffness on the first side of the winding center point C and arranging one or more sub-portions **116***c***1**, . . . **116***cn* having a lower stiffness on the second side of the winding center point C it is ensured that the third winding portion **116***c* is stiffer closer to the first end **110***a* than to the second end **110***b*. Thereby, the large movements of the winding **110** may be dampened more efficiently.

[0066] It should herein be understood that the first side of the winding center point C is located closer to the first end **110***a* than to the second end **110***b* of the winding **110**.

[0067] The spacers **130** may be selected such that the modulus of elasticity of the first type of spacers **130***a* is 0.1 GPa-3 GPa, preferably 0.5 GPa-1.5 GPa, and most preferably 0.9 GPa-1.1 GPa. The modulus of elasticity of the at least one second type of spacers **130***b* may be selected to be more than 50 GPa, preferably more than 80 GPa, and most preferably more than 105 GPa. In one example, the material of the first type of spacers **130***a* may be selected to be pressboard and a material of the at least one second type of spacers **130***b* may be selected to be steatite.

[0068] Conventional spacers **130** are usually made of pressboard which has a modulus of elasticity of around 1 GPa. It can be seen that the stiffnesses (moduli of elasticity) suggested for the second type of spacers **130***b* is much higher than the first type of spacers **130***a*. Steatite, which has a modulus of elasticity of around 110 GPa, has been shown to have a particularly large damping effect on the noise generation in combination with the first winding portion **116***a* and the second winding portion **116***b* being provided with conventional pressboard spacers.

[0069] FIG. **6** exemplifies a transformer **20** according to the second aspect of the present disclosure. The transformer **20** comprises at least one winding **110** according to any one of the embodiments of the first aspect of the present disclosure. The transformer **20** may further comprise upper and lower pressplates **212** and upper and lower support beams **214**. The windings **110** are clamped between the support beams **214** and the pressplates **212**. At least one winding **110** of the transformer **20** may be a winding **110** according to the first aspect of the present disclosure, as described herein above. The winding **110** may thus be an inner winding and/or an outer winding of a phase winding of the transformer **20**.

[0070] FIG. **7** shows a transformer arrangement **30** according to the third aspect of the present disclosure. The transformer arrangement **30** comprises a transformer **20** according to any one of the embodiments of the second aspect of the present disclosure. The transformer may be immersed in an electrically insulating medium, such as oil, inside a transformer tank **300**. By the provision of at least one winding **110** according to the disclosure, the symmetric mode of the transformer **20** may be modified to reduce vibration and noise of the transformer. Consequently, such a transformer **20** in a transformer tank **300** will cause the transformer tank walls to generate less noise to the surroundings.

[0071] FIG. **8** shows a diagram of simulated results at different mechanical frequencies of a winding **110**. The horizontal line at 0 dB represents a reference conventional (prior art) winding **110'**. The dashed line represents a winding according to the present disclosure, having the first winding portion **116***a*, the second winding portion **116***b* and the third winding portion **116***c*, where the third winding portion **116***c* is provided with stiffer spacers than the first winding portion **116***a* and the second winding portion **116***b*. It can be seen that noise reduction is at least −3.5 dB at 100 Hz, which is a significant and noticeable reduction in noise.

1. A winding for a phase winding of a transformer, said winding having coil turns around a coil axis, the winding having a first end and a second end and a winding center point on the coil axis between the first end and the second end,

wherein the winding comprises a plurality of winding portions arranged along the coil axis said plurality of winding portions comprising a first winding portion arranged at the first end of the winding and a second winding portion arranged at the second end of the winding, the winding further comprising at least a third winding portion arranged along the coil axis between the first winding portion and the second winding portion, wherein the first winding portion and the second winding portion have a first winding portion stiffness as seen along said coil axis and the at least third winding portion has a second winding portion stiffness as seen along said coil axis, and wherein the second winding portion stiffness is greater than the first winding portion stiffness, and

wherein the third portion has a third portion center point on the coil axis, equidistantly spaced at a distance from the first winding portion and from the second winding portion, which third portion center point is located closer to the first end of the winding than the winding center point.

2. The winding according to claim **1**, wherein the winding is provided with a plurality of spacers between the coil turns, and wherein the first winding portion and the second winding portion are provided with at least one first type of spacers having at least one first modulus of elasticity and the third winding portion is provided with at least one second type of spacers having at least one second modulus of elasticity, and wherein each of the at least one second modulus of elasticity is greater than each of the at least one first modulus of elasticity.

3. The winding according to claim **1**, wherein the third winding portion comprises a plurality of sub-portions arranged along the coil axis, each sub-portion having a sub-portion stiffness as seen along the coil axis, wherein each sub-portion comprises one second type of spacers and wherein each sub-portion stiffness is greater than the first winding portion stiffness.

4. The winding according to claim **3**, wherein a distribution of the plurality of sub-portions forms an aggregate winding portion stiffness, and wherein the plurality of sub-portions is configured such that the aggregate winding portion stiffness of the third winding portion located on a first side of the winding center point as seen along the coil axis is greater than an aggregate winding portion stiffness of the third winding portion located on a second side of the winding center point as seen along the coil axis.

5. The winding according to claim **4**, wherein the first side of the winding center point is located closer to the first end than to the second end of the winding.

6. The winding according to claim **2**, wherein the modulus of elasticity of the first type of spacers is 0.1 GPa-3 GPa, and wherein the modulus of elasticity of the at least one second type of spacers is more than 50 GPa.

7. The winding according to claim **6**, wherein a material of the first type of spacers is pressboard and wherein a material of the at least one second type of spacers is steatite.

8. The winding according to claim **1**, wherein the first end is an upper end of the winding when installed in a transformer and the second end is a lower end of the winding when installed in a transformer.

9. The winding according to claim **1**, wherein the first end is a lower end of the winding when installed in a transformer and the second end is an upper end of the winding when installed in a transformer.

10. A transformer comprising at least one winding according to claim **1**.

11. The transformer according to claim **10**, comprising at least one phase winding having the at least one winding.

12. A transformer arrangement comprising a transformer according to claim **10**, the transformer being immersed in an electrically insulating medium inside a transformer tank.

* * * * *