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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Improvements in or relating to insulation components for hvdc converter transformers**

(57) In the field of single phase HVDC converter transformers there is a need to reduce the creep stress arising on the surface of an insulation assembly within the transformer without adversely impacting on the manufacture of the transformer.

An insulation component (50; 80), for a limb of a HVDC converter transformer, comprises a component body (52) which has first and second ends (54, 56). An inner surface, that in use faces the magnetic core (12) of a limb (14, 16) of a HVDC converter transformer, extends between the first and second ends (54, 56). An outer surface (58), which lies opposite the inner surface, also extends between the first and second ends (54, 56). The outer surface (58) has a surface profile (60; 82) which extends between the first and second ends (54, 56) and that includes at least one raised formation (64; 84).

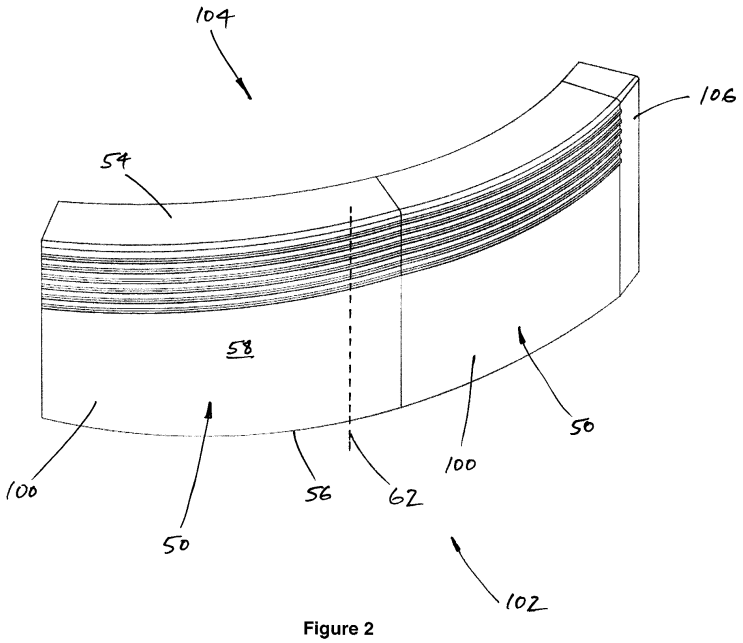

Figure 2

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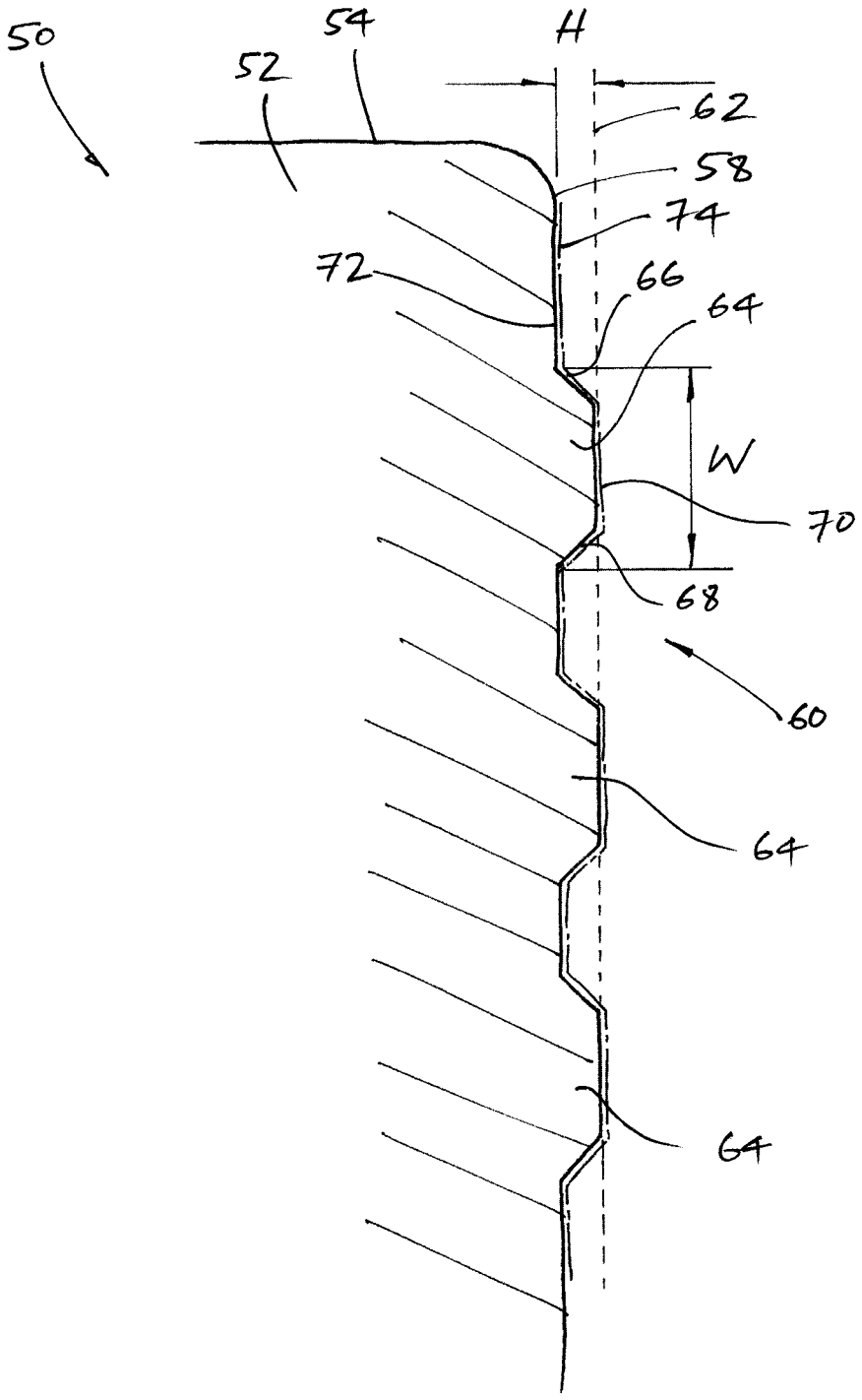

Figure 3

Description

[0001] This invention relates to an insulation component for a two limb high voltage direct current (HVDC) converter transformer, an insulation assembly including such an insulation component, and a method of manufacturing such an insulation component.

[0002] A typical single phase HVDC converter transformer 10 is illustrated schematically in Figure 1. The converter transformer 10 includes a magnetic core 12 which has first and second interconnected limbs 14, 16 around each of which is arranged a coil (not shown). Each limb 14, 16 and associated coil is surrounded by a corresponding insulation assembly 18, 20.

[0003] During operation of the transformer 10 each coil has an electromagnetic field associated with it and the respective electromagnetic fields interact with one another in an interaction region 22 which lies between the coils. Such interaction gives rise in use to a large electrical stress, i.e. a so-called "creep stress", on the outer surface 24 of each insulation assembly 18, 20 at the interaction region 22. Too high a creep stress can lead to tracking and subsequent failure of the corresponding insulation assembly 18, 20, which in turn means the associated transformer 10 will not meet one or more industry-standard acceptance criteria.

[0004] In an attempt to reduce the creep stress arising on the outer surface 24 of each insulation assembly 18, 20, and thereby reduce the likelihood of damage occurring to the insulation assemblies 18, 20, it is known to provide an earthing screen (not shown) in the interaction region 22 between the coils. Such a screen disrupts the interaction of the respective electromagnetic fields and so reduces the magnitude of the creep stress arising on the outer surface 24 of each insulation assembly 18, 20 at the interaction region 22.

[0005] However, including such an earthing screen may interfere with the running of electrical connections to each coil and additionally increases the size, and hence the cost, of the transformer 10.

[0006] There is a need, therefore, to reduce the creep stress arising on the surface of an insulation assembly of a single phase HVDC converter transformer without adversely impacting on the manufacture of the transformer, and in particular without adversely impacting on the running of electrical connections to each coil of the transformer or on the size of the transformer.

[0007] According to a first aspect of the invention there is provided an insulation component, for a limb of an HVDC converter transformer, comprising a component body having first and second ends between which extends an inner surface that in use faces the magnetic core of a limb of a HVDC converter transformer and an outer surface which lies opposite the inner surface, the outer surface having a surface profile extending between the first and second ends which includes at least one raised formation.

[0008] The provision of an insulation component, which has an outer surface with a surface profile extending between first and second ends thereof that includes at least one raised formation, results in the length of a path along the surface profile of such an insulation component being longer that the corresponding path along the surface profile of a conventional insulation component. The provision of a longer surface profile path means that any electrical stress, i.e. creep stress, which arises on the outer surface of the said insulation component is distributed over a greater length of outer surface and so the overall creep stress experienced by the given length of outer surface is reduced.

[0009] Moreover, achieving such a reduction by way of a modified insulation component obviates the need significantly to modify the structure of the associated insulation assembly or transformer as a whole, and so does not adversely impact on the running of electrical connections to each coil of the transformer.

[0010] Additionally, the insulation component of the invention provides such a reduction in creep stress within the overall envelope of a comparable conventional insulation assembly, and so does not necessitate an increase in size of the transformer.

[0011] Preferably at least one raised formation has first and second parallel sides. The inclusion of such first and second sides helps to provide a desired increase in length of the surface profile path for a given height of raised formation.

[0012] Optionally at least one raised formation has first and second sides which extend towards one another. Having first and second sides that extend towards one another similarly helps to provide a desired increase in length of the surface profile path for a given height of raised formation, while reducing the incidence of relatively sudden changes of direction in the surface profile which might otherwise lead to a concentration in creep stress.

[0013] In a preferred embodiment of the invention the first and second sides extend towards one another as they extend out of the component body. Such an arrangement helps to minimise creep stress concentrations in a manner that is readily manufacturable.

[0014] The at least one raised formation may have a third side extending between the first and second sides. Providing a third such side helps in maintaining the integrity of the or each raised formation during manufacture of the insulation component.

[0015] Preferably the third side lies parallel to the remainder of the surface profile of the outer surface. Such an arrangement is readily manufacturable without the need, e.g. for specially modified tooling.

[0016] In another preferred embodiment of the invention the surface profile extending between the first and second ends includes a plurality of raised formations.

[0017] The inclusion of a plurality of raised formations provides a further reduction in the overall creep stress experienced by a given length of outer surface of the insulation component, as may be required to meet a par-

ticular acceptance criteria, as well as permitting a tuning of the insulation characteristics of an associated insulation assembly to optimise its performance across a range of likely operating conditions.

[0018] Optionally the plurality of raised formations are each identical to one another. Such an arrangement simplifies manufacture of the insulation component, as well as helping it to provide a uniform reduction in creep stress during operation.

[0019] An insulation component according to a further preferred embodiment of the invention defines an insulation component segment cooperable with one or more other segments to form an insulation assembly.

[0020] Having the insulation component define such an insulation component segment allows for the tailoring of the insulation characteristics of an associated insulation assembly, e.g. in a manner whereby an insulation portion which is adept at reducing the creep stress it experiences can be positioned within a transformer structure only where high creep stress might otherwise arise, e.g. at or around an interaction region.

[0021] The insulation component segment may be cooperable with at least one other identical insulation component segment to define a low creep stress insulation region of an insulation assembly. Such functionality further assists in tailoring the insulation characteristics of an associated insulation assembly.

[0022] Optionally the insulation component segment includes an interlock element cooperable with an interlock element of an adjacent segment to secure the said segments to one another. The inclusion of an interlock element ensures that the creep stress is reduced as required and the low creep stress insulation region is positioned as desired in the insulation assembly.

[0023] According to a second aspect of the invention there is provided an insulation assembly, for a HVDC converter transformer, comprising at least one insulation component segment as described hereinabove. Such an insulation assembly is highly tuneable from a creep stress reduction perspective.

[0024] According to a third aspect of the invention there is provided a method of manufacturing an insulation component, for a HVDC converter transformer, comprising the steps of:

(a) forming a component sub-body from a malleable fibrous insulation material, the component sub-body having first and second ends between which extends an inner surface that in use faces the magnetic core of a limb of a HVDC converter transformer and an outer sub-surface which lies opposite the inner surface;

(b) applying a surface profile layer of malleable fibrous insulating material to the outer sub-surface whereby fibres of the component sub-body and the surface profile layer interlink with one another to define a homogenous component body having an outer surface which lies opposite the said inner surface and which has a surface profile extending between the first and second ends; and

(c) forming at least one raised formation in the surface profile of the outer surface.

[0025] Such a method advantageously gives rise to the insulation component of the invention in a cost-effective and readily repeatable manner.

[0026] Preferably the step of forming at least one raised formation in the surface profile of the outer surface includes using a tool to mould the or each raised formation. Use of a tool helps to ensure that the resulting raised formation maintains its desired shape during subsequent processing of the insulation component.

[0027] Optionally moulding the or each raised formation occurs while at least the surface profile layer remains wet. Such scheduling of the moulding step helps to ensure ready and accurate creation of the raised formation.

[0028] There now follows a brief description of a preferred embodiment of the invention, by way of non-limiting example, with reference being made to the following figures in which:

Figure 1 shows a schematic view of a typical conventional single phase HVDC converter transformer;

Figure 2 shows a schematic view of an insulation assembly including a plurality of insulation components according to a first embodiment of the invention;

Figure 3 shows an enlarged schematic cross-sectional view of a portion of the surface profile of the outer surface of one of the insulation components shown in Figure 2;

Figure 4 shows an enlarged schematic cross-sectional view of a portion of the surface profile of the outer surface of an insulation component according to a second embodiment of the invention; and

Figure 5 illustrates schematically a method of manufacturing the insulation component shown in Figure 2.

[0029] An insulation component according to a first embodiment of the invention is designated generally by the reference numeral 50.

[0030] The insulation component 50 includes a component body 52 that has a first end 54 and a second end 56. An inner surface (not shown), which in use faces the magnetic core 12 of a limb 14, 16 of a converter transformer, extends between the first and second ends 54, 56. An outer surface 58 lies opposite the inner surface and extends similarly between the first and second ends 54, 56.

[0031] The outer surface 58 has a surface profile 60 (along a path 62 which extends between the first and second ends 54, 56 and in use lies substantially parallel to a corresponding limb 14, 16) that includes six raised formations 64.

[0032] In other embodiments of the invention (not

shown) the surface profile 60 may be considered from the perspective of a path that lies at a different angle to an associated limb 14, 16. In addition, the surface profile 60 in other embodiments of the invention may, irrespective of the angle relative to the associated limb 14, 16 at which it lies, include more than or fewer than six raised formations 64.

[0033] As illustrated partially in Figure 3, each raised formation 64 is identical and has first and second sides 66, 68 which extend towards one another, and more particularly extend towards one another as they extend out of the component body 52.

[0034] Each raised formation 64 also includes a third side 70 that extends between the first and second sides 66, 68, and additionally lies parallel to a remainder 72 of the surface profile 60.

[0035] In the embodiment shown, each raised formation 64 has a finished height H of approximately 6mm and a finished width W of approximately 20mm. In other embodiments of the invention one or more recess formations may have a different height and/or a different width.

[0036] Figure 4 shows a portion of an insulation component 80 according to a second embodiment of the invention. The second insulation component 80 includes an outer surface 58 that has a surface profile 82 in which four raised formations 84 are formed. Each raised formation 84 has first and second parallel sides 86, 88, as well as a third side 90 which is both parallel to the remainder 72 of the surface profile 82 and substantially perpendicular to each of the first and second sides 86, 88. Each raised formation 84 similarly has a height H of approximately 6mm and a width W of approximately 20mm, although other dimensions are also possible.

[0037] Still further embodiments of the invention (not shown) may have surface profiles that include one or more raised formations which differ in shape to those mentioned above, and indeed which differ in shape to one another within a given surface profile. All such further embodiments nevertheless have a surface profile which is greater in length than that of a conventional straight surface profile having no raised formations formed thereon.

[0038] Returning to Figure 2, each first insulation component 50 defines an insulation component segment 100 that cooperates with an identical adjacent insulation component segment 100 to define a low creep stress insulation region 102 of an insulation assembly 104 (only a portion of which is shown in Figure 2).

[0039] The or each insulation component segment 100 may also cooperate with one or more other insulation segments 106 that have a straight surface profile, i.e. a surface profile which has no raised formations formed therein, in order that together the various segments form an insulation assembly that completely encloses an associated limb and coil.

[0040] Moreover, in still further embodiments of the invention (not shown), the insulation component may instead itself define an insulation assembly, e.g. the insulation component may define an annular ring which in use extends completely around an associated limb and coil.

[0041] In each case the resulting insulation assembly also need not be annular, and instead may adopt any other shape capable of completely encompassing the associated limb and coil.

[0042] Each insulation component segment 100 includes an interlock element (not shown) that cooperates in use with the interlock element of an adjacent segment to secure the insulation component segment 100 and the adjacent segment to one another.

[0043] The interlock element may take the form of a mutually engageable interlock formation or member, or other mutually cooperable locking component.

[0044] In use the low creep stress insulation region 102 of the portion of insulation assembly 104 shown schematically in Figure 2 is positioned to lie in the interaction region 22 between the first and second limbs 14, 16 of a single phase HVDC converter transformer.

[0045] The inclusion of raised formations 64 in the surface profile 60 of the outer surface 58 of each insulation component segment 100 results in a longer surface profile path 74 which, in turn, distributes the electrical stress, i.e. creep stress, arising on the outer surface 58 of the insulation component segment 100 over a greater length of outer surface 58, such that the overall creep stress experienced by the given length of outer surface 58 is reduced.

[0046] Figure 5 illustrates schematically a method of manufacturing each of the insulation component segments 100 mentioned above.

[0047] More particularly Figure 5 shows a component sub-body 110 formed from a malleable fibrous insulation material, such as paper or pressboard. The component sub-body has first and second ends 54, 56 between which extends an inner surface 112 (that in use faces the magnetic core 12 of a limb 14, 16 of a HVDC converter transformer) and an outer sub-surface 114 which lies opposite the inner surface 112.

[0048] Figure 5 also illustrates a surface profile layer 116 of the malleable fibrous insulation material which has been applied to the outer sub-surface 114 of the component sub-body 110. As shown, the surface profile layer 116 may also be applied to the first end 54 of the component sub-body 110. In each instance the fibres of the component sub-body 110 and the surface profile layer 116 are interlinked with one another to define a homogenous component body 52 which has an outer surface 58 that lies opposite the aforementioned inner surface112, and which has a surface profile 60 that extends along a path 62 between the first and second ends 54, 56.

[0049] Furthermore, Figure 5 shows the formation of a first raised formation 64a on the surface profile 60 of the outer surface 58, and the intention subsequently to form second and third raised formations 64b, 64c in the same surface profile 60.

[0050] Although not illustrated in Figure 5, a tool is used to mould each raised formation 64 on the outer surface 58, and such moulding takes places while at least the surface profile layer 116 remains wet.

Claims

1. An insulation component, for a limb of a HVDC converter transformer, comprising a component body having first and second ends between which extends an inner surface that in use faces the magnetic core of a limb of a HVDC converter transformer and an outer surface which lies opposite the inner surface, the outer surface having a surface profile extending between the first and second ends which includes at least one raised formation.

2. An insulation component according to Claim 1 wherein at least one raised formation has first and second parallel sides.

3. An insulation component according to Claim 1 wherein at least one raised formation has first and second sides which extend towards one another.

4. An insulation component according to Claim 3 wherein the first and second sides extend towards one another as they extend out of the component body.

5. An insulation component according to any of Claims 2 to 4 wherein the at least one raised formation has a third side extending between the first and second sides.

6. An insulation component according to Claim 5 wherein the third side lies parallel to the remainder of the surface profile of the outer surface.

7. An insulation component according to any preceding claim wherein the surface profile extending between the first and second ends includes a plurality of raised formations.

8. An insulation component according to Claim 7 wherein the plurality of raised formations are each identical to one another.

9. An insulation component according to any preceding claim that defines an insulation component segment cooperable with one or more other segments to form an insulation assembly.

10. An insulation component according to Claim 9 wherein the insulation component segment is cooperable with at least one other identical insulation component segment to define a low creep stress insulation region of an insulation assembly.

11. An insulation component according to Claim 10 wherein the insulation component segment includes an interlock element cooperable with an interlock element of an adjacent segment to secure the said segments to one another.

12. An insulation assembly, for a HVDC converter transformer, comprising at least one insulation component segment according to any one of Claims 9 to 11.

13. A method of manufacturing an insulation component, for a HVDC converter transformer, comprising the steps of:

    (a) forming a component sub-body from a malleable fibrous insulation material, the component sub-body having first and second ends between which extends an inner surface that in use faces the magnetic core of a limb of a HVDC converter transformer and an outer sub-surface which lies opposite the inner surface;
    (b) applying a surface profile layer of malleable fibrous insulating material to the outer sub-surface whereby fibres of the component sub-body and the surface profile layer interlink with one another to define a homogenous component body having an outer surface which lies opposite the said inner surface and which has a surface profile extending between the first and second ends; and
    (c) forming at least one raised formation in the surface profile of the outer surface.

14. A method of manufacturing an insulation component according to Claim 13 wherein the step of forming at least one raised formation in the surface profile of the outer surface includes using a tool to mould the or each raised formation.

15. A method of manufacturing an insulation component according to Claim 14 wherein moulding the or each raised formation occurs while at least the surface profile layer remains wet.

Amended claims in accordance with Rule 137(2) EPC.

1. A method of manufacturing an insulation component, for a HVDC converter transformer (10), comprising the steps of:

    (a) forming a component sub-body (110) from a malleable fibrous insulation material, the component sub-body (110) having first and second ends (54, 56) between which extends an inner

surface (112) that in use faces the magnetic core of a limb of a HVDC converter transformer and an outer sub-surface (114) which lies opposite the inner surface;

(b) applying a surface profile layer (116) of malleable fibrous insulating material to the outer sub-surface (114) whereby fibres of the component sub-body (110) and the surface profile layer (116) interlink with one another to define a homogenous component body having an outer surface which lies opposite the said inner surface and which has a surface profile extending between the first and second ends; and

(c) forming at least one raised formation (64a) in the surface profile of the outer surface.

2. A method of manufacturing an insulation component according to Claim 1 wherein the step of forming at least one raised formation (64a) in the surface profile (60) of the outer surface includes using a tool to mould the or each raised formation.

3. A method of manufacturing an insulation component according to Claim 2 wherein moulding the or each raised formation (64a) occurs while at least the surface profile layer remains wet.

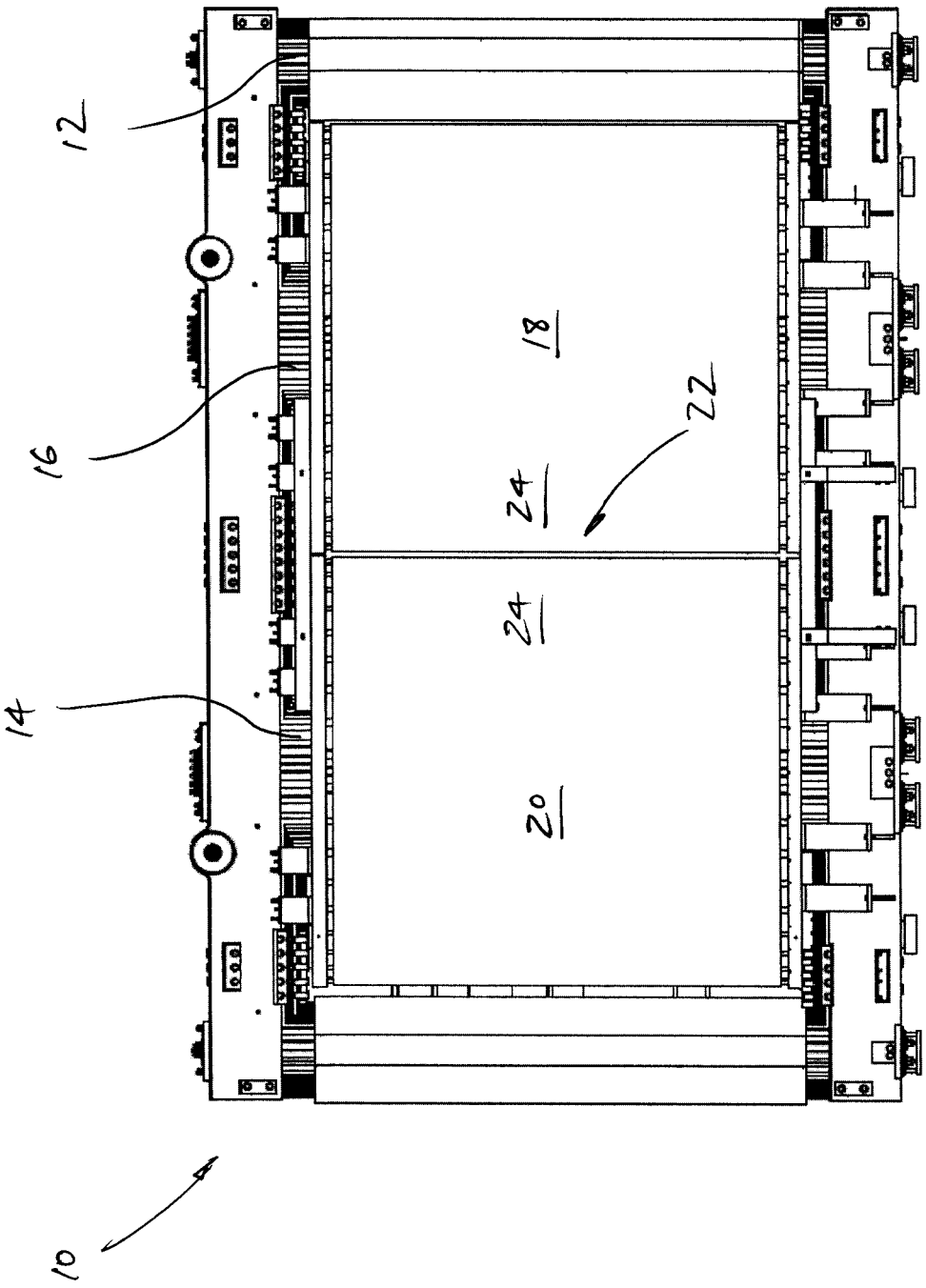

Figure 1

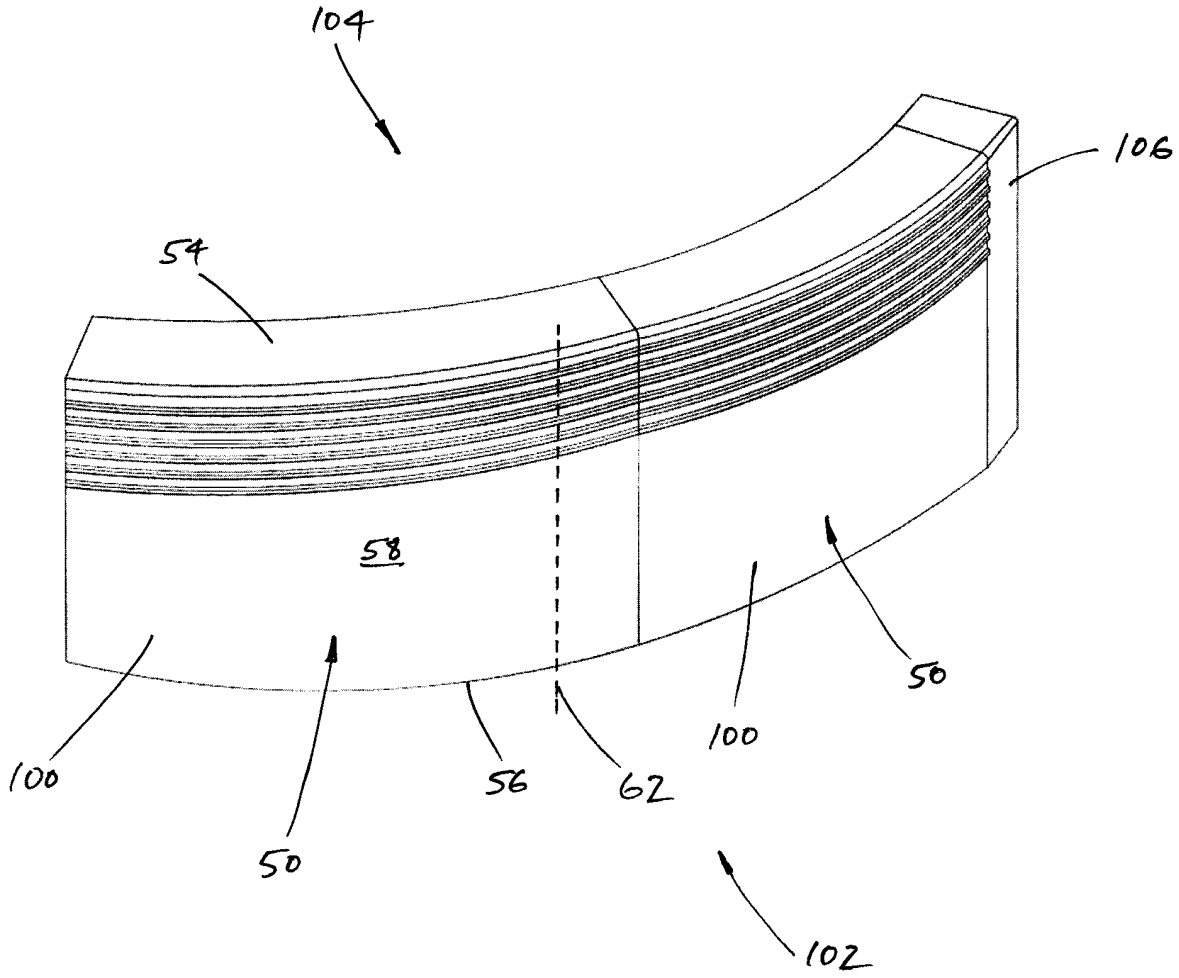

Figure 2

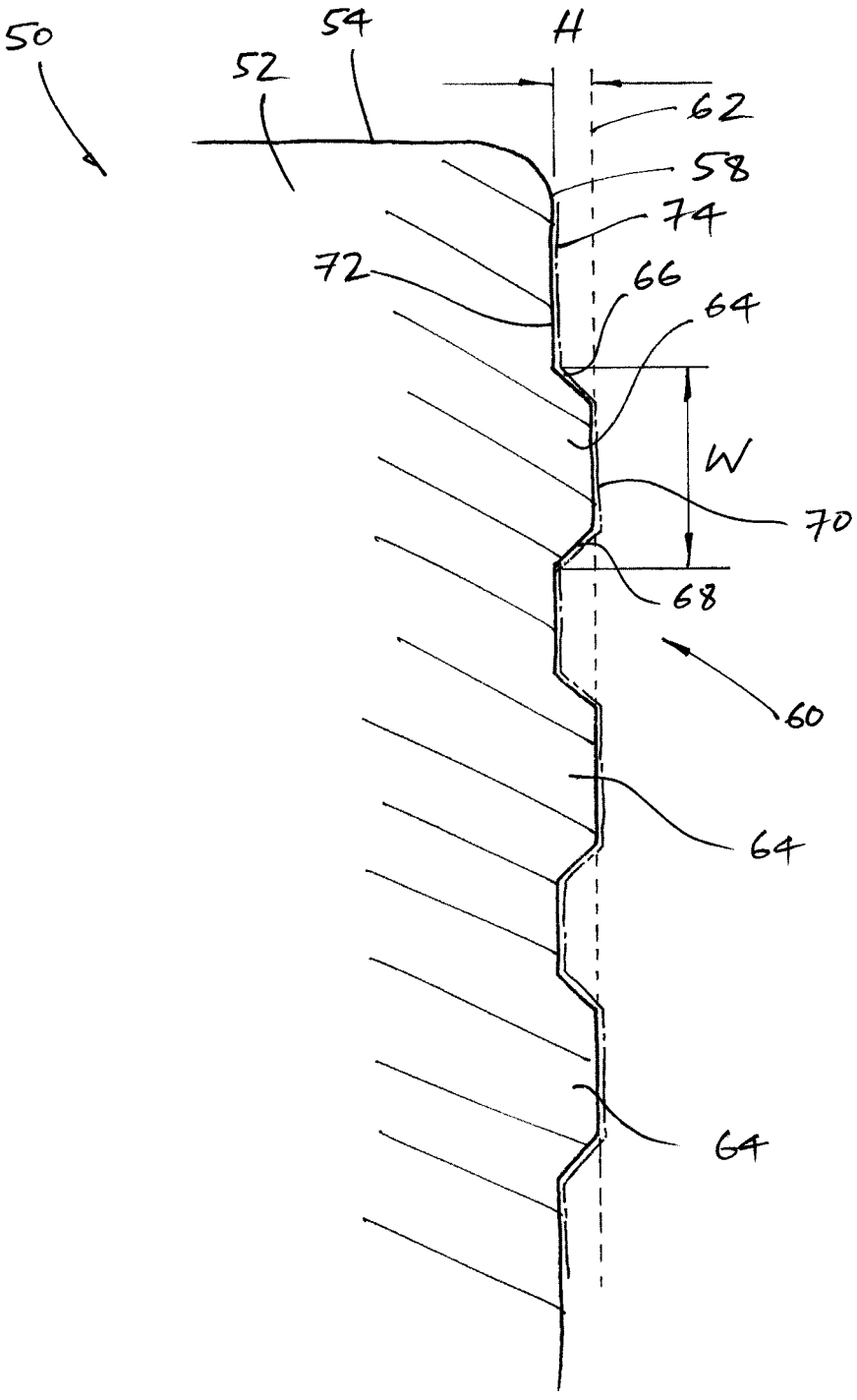

Figure 3

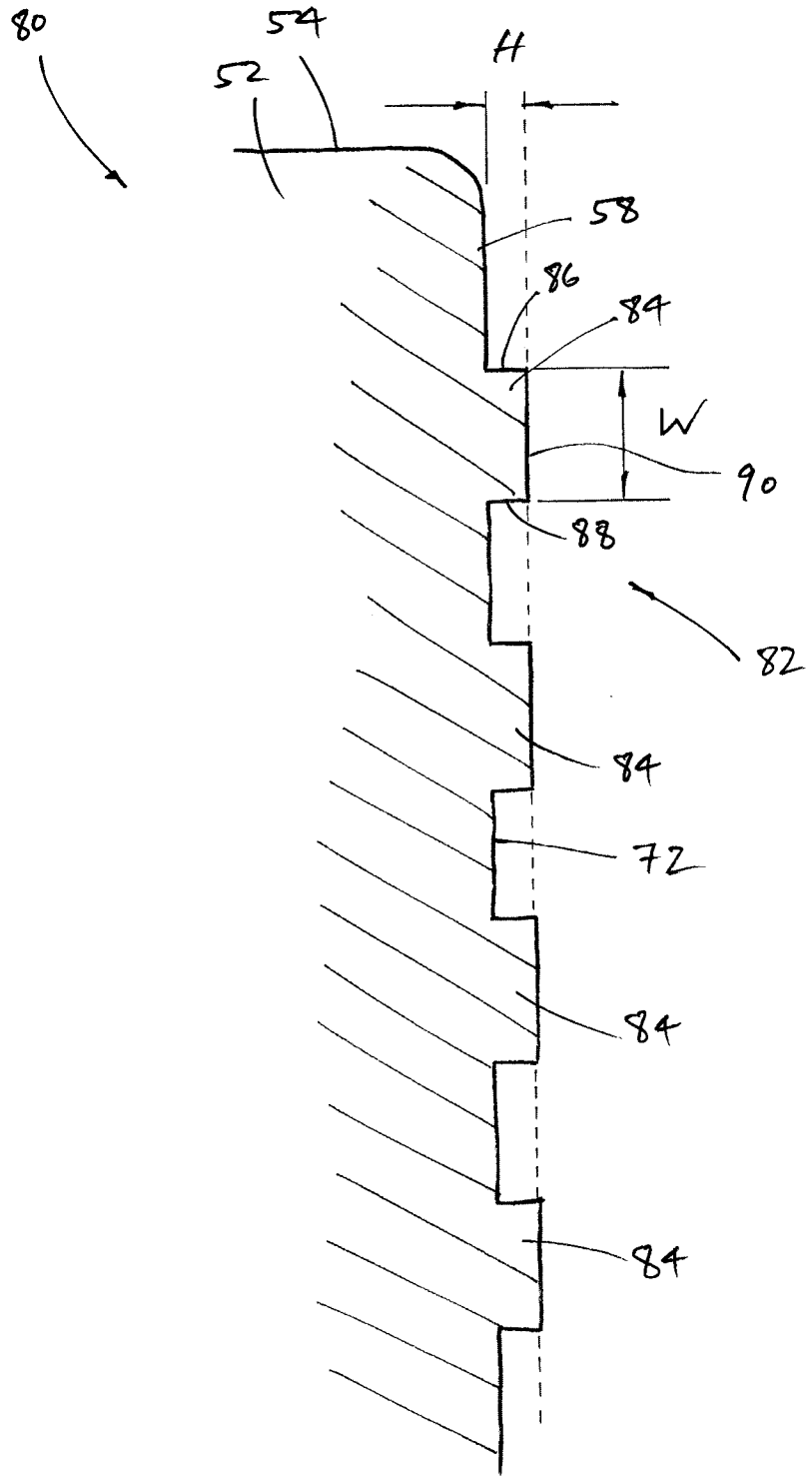

Figure 4

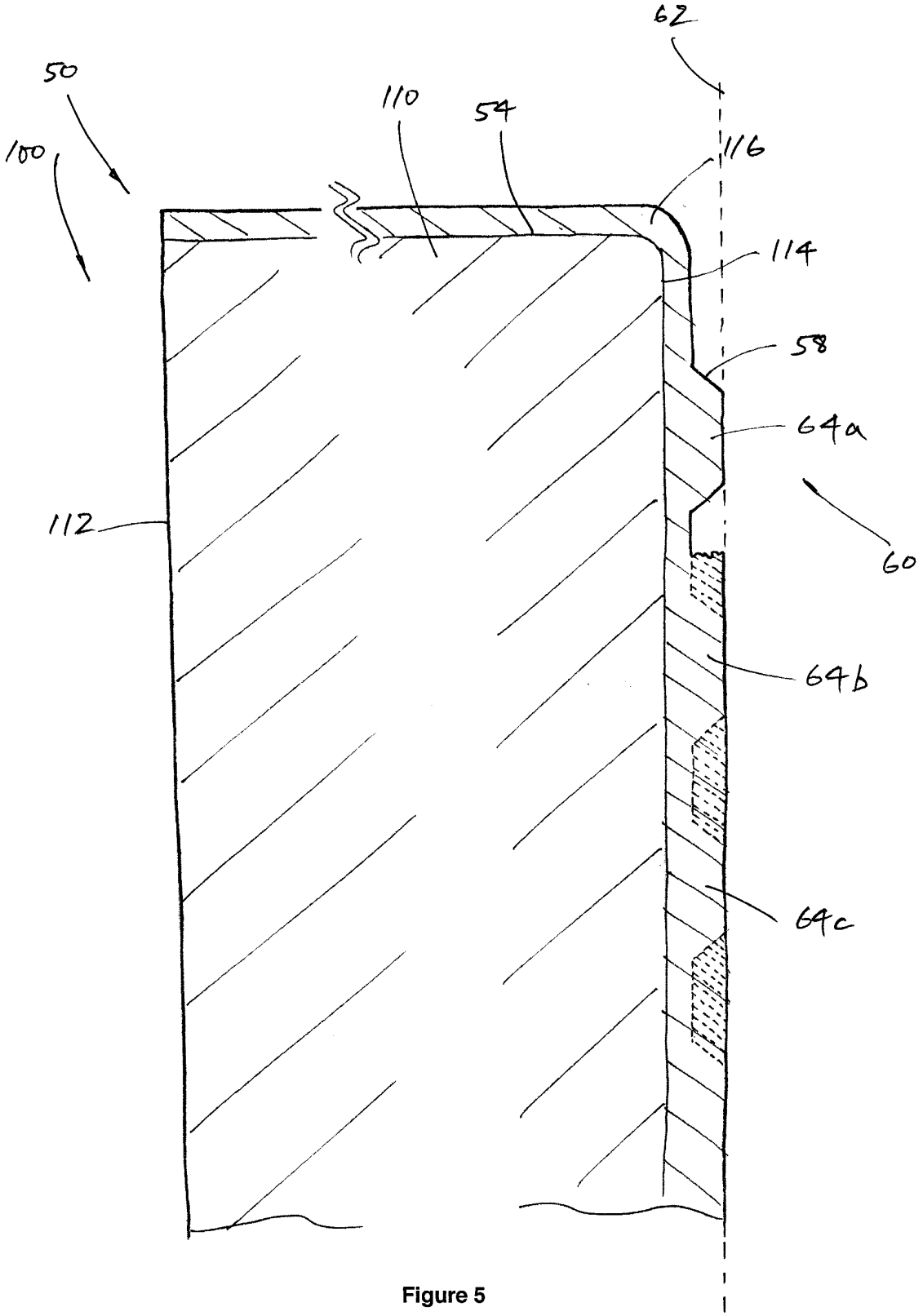

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 13 27 5037

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	DE 603 240 C (PAUL REICHERT) 26 September 1934 (1934-09-26) * page 1, lines 1-11; figures 2,4 * * page 2, lines 35-60, 108-122 *	1,2, 7-10,12	INV. H01F27/32 H01B3/48 H01F41/12
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A	* page 2, left-hand column, paragraph 11-19; figures 5-7 *	13	
A	US 2004/150498 A1 (MARUSINEC RICHARD M [US] ET AL) 5 August 2004 (2004-08-05) * paragraphs [0005] - [0008], [0033] - [0047]; figure 3.5 *	1	

TECHNICAL FIELDS SEARCHED (IPC)

H01F
H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 August 2013	Reder, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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02-08-2013

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