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(54) **The insulating casing of a high-voltage winding**

(57) The invention relates to the insulating casing of a high-voltage winding applicable in high-voltage electric power equipment in which metal conducting elements are embedded in resin insulation, and in particular it relates to the casing of a dry transformer winding. The insulating casing according to the invention is characterized in that it comprises a side strip (2) situated longitudinally on the circumference of a thick-walled cylinder (1), which strip has recesses (5) situated on the external surface of the side strip (2) between phase connection surfaces (3) and a tap connection surface (4). The recesses (5) can have transverse convexities (7) or longitudinal convexities (8) situated on the surface of the side strip (2) in the location of the recesses (5).

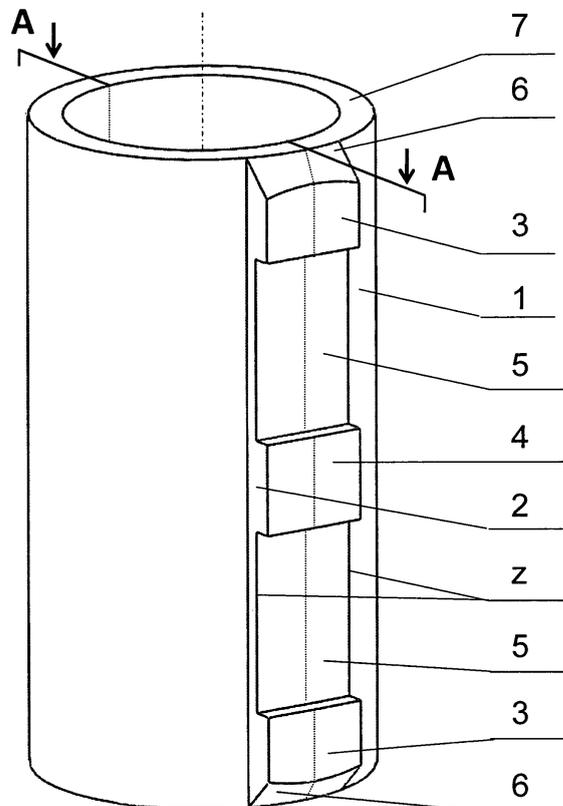


Fig. 1

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Description

[0001] The invention relates to the insulating casing of a high-voltage winding, applicable in high-voltage electric power equipment in which metal conducting elements are embedded in resin insulation, and in particular it relates to the casing of a dry transformer winding.

[0002] High-voltage electric power equipment comprising high-voltage conducting elements embedded in resin insulation require insulation which is durable and resistant to variable external stresses. Internal mechanical stresses which cause cracks in insulation can be the effect of both variable temperatures associated with the insulation pouring and curing processes and of temperature differences occurring during the operation of the piece of equipment. Temperature differences inside resin insulation arising during the operation of equipment result from heating-up of metal conducting elements caused by the flow of current. At the same time, resin insulation directly adjacent to those elements is heated up, while its other parts are cooled by ambient air. Unequal temperature distribution can result in the occurrence of great stresses and in deformation of material, which in consequence can lead to cracks which disqualify the product from further operation. In the operation of high-voltage equipment with resin insulation, especially dangerous are low temperatures reaching minus 50 degrees Celsius. Switching the flow of current on in a piece of equipment with resin insulation that has been cooled down to such low temperatures can result in the occurrence of particularly large temperature gradients and, in consequence, internal stresses. A proper design of the shape of resin insulation can improve both the distribution of temperatures inside equipment and the mechanical resistance of insulation.

[0003] Insulating casings of the windings of dry high-voltage resin transformers are made in the form of thick-walled cylinders which are provided with a side strip situated longitudinally on the external surface of the cylinder. This strip is made of the same material as the cylinder and it is formed by the thickened wall of the cylinder. On the strip there are fitted the main incoming connections connected with the winding situated inside the casing, and a tap changer used to change the operating range of the transformer. The thicker layer of resin insulation on the strip is necessary to insulate metal elements which form the high-voltage electric connection between the winding and the terminals of the main connections and of the tap connections. The use of a thicker resin layer around the whole circumference of the winding would allow to keep a cylindrical shape of the casing, however, it would require the use of a larger quantity of material and, due to the poor thermal conductivity of resin insulation, it would hamper heat conduction from the winding during its normal operation. That is why the insulating casing of the high-voltage winding of dry resin transformers in the form of thick-walled cylinders provided with side strips which are situated longitudinally on the exter-

nal surface and which are a thickened wall of the cylinder permit material savings and offer improvement in heat conductance from the winding at the cost of resignation from keeping the ideal cylindrical shape of the winding insulation.

[0004] From patent description US6445269 there is known a casing of the high-voltage winding of a dry transformer of a design similar to that of the above described casings. The high-voltage winding of a dry transformer is embedded in a thermoplastic resin material forming a thick-walled cylinder which is fitted with a side strip. The strip has hollowed-out blind holes situated along the strip and offering places for fixing the winding connections and for installing the tap changer. An inconvenience of the presented casing made of thermoplastic material is the lack of an efficient solution to the problem of cracking of the casings caused by abrupt changes in temperatures occurring inside the insulating casings when high-voltage conductors are sometimes heated to a temperature of 140 degrees Celsius while the temperature outside is very low, sometimes as low as minus 50 degrees Celsius. In such situation, a considerable temperature difference can be reached between the cylindrical part of insulation containing the winding, which together with the winding will quickly increase its temperature, and the longitudinal strip containing the main connections and the tap connections, whose temperature will be much lower. The temperature difference can result in cracks in the casing around the strip in the longitudinal direction of the cylinder and on the strip in the transverse direction of the cylinder. Therefore there is a need to make a high-voltage winding casing of epoxy resin which will be relatively cheap in production, whose thickness will be relatively small, and whose durability will be high due to the reduced possibility of occurrence of internal mechanical stresses caused by a temperature shock during the operation of equipment comprising an insulating casing of high-voltage windings. If the transformer is located in a place which is exposed to large seasonal temperature changes, then the casing may crack on the outside as a result of thermal stresses. Especially adverse condition occur if after a period of shutdown at low temperature (e.g. -50°C) the transformer is switched on. The temperature gradient that occurs between the internal part of the casing, which reaches temperatures in excess of 140°C as a result of heating up of the winding, and the external part causes the occurrence of stresses. Due to the fact that resin has low thermal conductivity, large temperature gradients linger in the thickest places as a result of poor heat conduction for a time long enough to considerably increase the risk of cracking of the casing. In order to reinforce casing elements which are the most exposed to cracking, internal elements are covered with a glass fiber mesh which is poured over with resin and functions as an internal reinforcement increasing the mechanical strength of the component.

[0005] The essence of the insulating casing of a high-voltage winding comprising a thick-walled cylinder of a

resin material in which the high-voltage winding is embedded, fitted with a side strip situated longitudinally on the external surface of the thick-walled cylinder with phase connection surfaces, with places for installing electrical connections connected to the winding, and with the tap connection surface, with a place for installing the tap changer, is that the side strip has recesses which are situated on the external surface of the side strip between the phase connection surfaces and the tap connection surface.

[0006] Preferably, the phase connection surfaces with places for installing electrical connections connected to the winding, from the front sides of the thick-walled cylinder have at least one external cut-off whose plane is situated at an acute angle " α " in relation to the front plane of the thick-walled cylinder.

[0007] Preferably, the side strip in the place where the cut-off is situated, in the cross-section of thick-walled cylinder, has a shape approximate to a rectangle, a trapezoid, a triangle or an oval, and the cut-offs of the side strip in the longitudinal section of the thick-walled cylinder have the shape approximate to a rectangle, a trapezoid, a triangle or an oval.

[0008] Preferably, on the surface constituting the bottom of the cut-off there is situated at least one row of transverse convexities and/or longitudinal convexities.

[0009] Preferably, the longitudinal convexities are situated longitudinally or askew in relation to the axis of the thick-walled cylinder in a location remote from the edge "z" of the side strip, and in cross-section they have a shape approximate to a rectangle, a trapezoid, a triangle or an oval.

[0010] Preferably, the transverse convexities are situated transversely in relation to the axis of the thick-walled cylinder, and in longitudinal section they have a shape approximate to a rectangle, a trapezoid, a triangle or an oval.

[0011] Preferably, the thick-walled cylinder is made of epoxy resin.

[0012] The insulating casing of a high-voltage winding according to claims 1-7 is applicable as a casing in a dry transformer.

[0013] The advantage of the insulating casing according to the invention is its simple design permitting a reduction or elimination of internal mechanical stresses inside the casing, which are the cause of cracks in the casing. Thanks to the cut-offs of a specific shape, situated on the side strip, the danger of transverse cracks in the casing has been eliminated. Thanks to the cut-offs made on the connection surfaces with places for fitting the winding connections, the danger of longitudinal cracks in the casing has been eliminated. Moreover, the casing according to the invention is made of epoxy resin whose quantity used for casting the casing is smaller compared to known casings with reinforcing strips, which reduces the weight of the casing and brings material savings.

[0014] The subject of the invention is presented as an embodiment in the drawing, where:

fig. 1 shows the insulating casing of a high-voltage winding in perspective view,

fig. 2 shows the insulating casing of a high-voltage winding in a longitudinal, A-A plane section,

fig. 3 shows a recess 5 having the shape of a rectangle, shown as a partial broken-out section "a" of the section A-A from fig. 2,

fig. 4, 5, 6 show the shape of the recess 5, for different embodiments of the invention, shown as partial broken-out sections "a" of the section A-A from fig. 2,

fig. 7 shows the recess 5 having the shape of a rectangle, with transverse convexities in the shape of a triangle, shown as a partial broken-out section "a" of the section A-A from fig. 2,

fig. 8, 9, 10, 11 show the shape of the transverse convexities, for different embodiments of the invention, shown as a partial broken-out section "b" from fig. 7,

fig. 12 shows the insulating casing of a high-voltage winding 3 in cross-section B-B from fig. 2,

fig. 13, 14, 15 show the shape of the section of the side strip, for different embodiments of the invention, shown as a partial broken-out section "c" from section B-B from fig. 12,

fig. 16 shows the section of the side strip of a rectangular shape with longitudinal convexities, shown as a partial broken-out section "c" from section B-B from fig. 12,

fig. 17, 18, 19, 20 show the shape of the longitudinal convexities, for different embodiments of the invention, shown as a partial broken-out section "d" from fig. 16.

[0015] The insulating casing according to the invention is the product of pouring a high-voltage winding placed in a mold with a suitable insulating material. After suitable curing of the cast, the insulating casing has the shape of a thick-walled cylinder 1 with a side strip 2 which is situated on the external surface of the cylinder, parallel to the axis of the cylinder. On both ends of the strip 2 there are phase connection surfaces 3 which are places for fitting the main connections of the winding. On the strip 2 there is also a tap connection surface 4 which is the place for fitting the tap changer and which is situated between the phase connection surfaces 3. On the external surface of the strip 2 there are situated recesses 5 which are arranged between the phase connection surfaces 3 and the tap connection surface 4. The phase connection surfaces 3 on the front sides of the thick-

walled cylinder 1 have at least one external cut-off 6 whose plane is situated at an acute angle " α " in relation to the front plane 7 of the thick-walled cylinder 1. A high-voltage winding 8 is embedded in the material of the thick-walled cylinder. The high-voltage winding is provided with conducting terminals which are lead outside the external surface of the cylinder 1, in the dedicated places, i.e. on the outside of the phase connection surfaces 3 and on the outside of the tap connection surface 4, which is not shown in the drawings.

[0016] The shapes of the recesses 5 in different embodiments of the invention are shown as broken-out sections "a" from the longitudinal section of the casing made by means of the longitudinal plane A-A crossing the axis of the cylinder 1. The recesses 5 have a shape approximate to a rectangle - fig. 3, or to a trapezoid - fig. 4, or to a triangle - fig. 5, or to an oval - fig. 6. The recesses 5 have a longitudinal edge "z" which is the edge of the bottom of the recess 5.

[0017] The shapes of the strip 2 at the location of the recesses 5 in different embodiments of the invention, are shown as broken-out sections "c" from the casing cross-section B-B. In the presented embodiments, the shape of the strip 2 protruding above the external surface of the cylinder 1 is approximate to a rectangle - fig. 12, or to a trapezoid - fig. 13, or to a triangle - fig. 14, or to an oval - fig. 15.

[0018] In the presented embodiments of the invention, the surfaces of the recesses 5 are basically smooth i.e. they do not have above-average surface irregularities that could be seen with the unaided eye. In other embodiments of the invention, the surfaces of the recesses 5 has visible transverse convexities 9 which are arranged transversely to the axis of the cylinder 1 in one or in multiple rows. The transverse convexities 9 are shown in the drawing as broken-out sections "b" and in cross-section they have a shape approximate to a rectangle - fig. 7 and 8, or to a trapezoid - fig. 9, or to a triangle - fig. 10, or to an oval - fig. 11.

[0019] In still other variants of the embodiment, on the external surface of the strip 2, at the locations of the recesses 5 there are longitudinal convexities 10 which are arranged longitudinally in relation to the axis of the cylinder 1 in one or in multiple rows. The longitudinal convexities 10 are presented in the drawing as broken-out sections "d" and in cross-section they have a shape approximate to a rectangle - fig. 16 and 17, or to a trapezoid - fig. 18, or to a triangle - fig. 19, or to an oval - fig. 20.

[0020] In the casing according to the invention, applied as a high-voltage casing of a dry transformer, the shoulder on the thick-walled cylinder 1 appearing in known solutions along the whole length of the casing and defined as the side strip 2 is reduced on segments between the main connections and the taps. Such design to a large extent eliminates the occurrence of strong internal stresses associated with a great temperature gradient, which prevents internal transverse cracks. Also the application of an external cut-off on the phase connection surfaces

contributes to a reduction in internal stresses, which prevents internal longitudinal cracks. Due to the reduction in material the casing of a high-voltage winding has an approximately cylindrical shape, which results in a reduction in temperature gradients and ensures a homogenous distribution of internal stresses, which reduces the risk of cracking of the casing. The reduction in the level of internal stresses in the component makes it possible to eliminate the external reinforcing mesh, which constitutes an additional reduction in the cost of production.

Claims

1. An insulating casing of a high-voltage winding comprising a thick-walled cylinder (1) of a resin material in which the high-voltage winding (8) is embedded, fitted with a side strip (2) situated longitudinally on the external surface of the thick-walled cylinder (1), on which there are located phase connection surfaces (3) with places for installing electric connections connected with the winding (8) and a tap connection surface (4) with a place for installing the tap changer, **characterized in that** the side strip (2) has recesses (5) which are situated on the external surface of the side strip (2) between the phase connection surfaces (3) and the tap connection surface (4).
2. An insulating casing according to claim 1, **characterized in that** the phase connection surfaces (3) with places for installing electric connections connected with the winding (8), from the front sides of the thick-walled cylinder (1), have at least one external cut-off (6) whose plane is situated at an acute angle (α) to the front plane (7) of the thick-walled cylinder (1).
3. An insulating casing according to claims 1-2, **characterized in that** the side strip (2) in the recess (5) location, in the cross-section of the cylinder (1) has a shape approximate to a rectangle, a trapezoid, a triangle or an oval, and the recesses (5) in the longitudinal section of the cylinder (1) have a shape approximate to a rectangle, a trapezoid, a triangle or an oval.
4. An insulating casing according to claims 1-3, **characterized in that** at least one row of transverse convexities (9) and/or longitudinal convexities (10) is situated on the surface which is the bottom of the recess (5).
5. An insulating casing according to claim 4, **characterized in that** the longitudinal convexities (10) are situated longitudinally or askew in relation to the axis of the cylinder (1) at a location remote from the edge (z) of the side strip (2), and their cross-section has a shape approximate to a rectangle, a trapezoid, a

triangle or an oval.

6. An insulating casing according to claim 4, **characterized in that** the transverse convexities (9) are situated transversely in relation to the axis of the cylinder (1), and their longitudinal section has a shape approximate to a rectangle, a trapezoid, a triangle or an oval. 5
7. An insulating casing according to any of the previous claims, **characterized in that** the thick-walled cylinder is made of epoxy resin. 10
8. Application of the insulating casing of a high-voltage winding according to claims 1-7 as the casing in a dry transformer. 15

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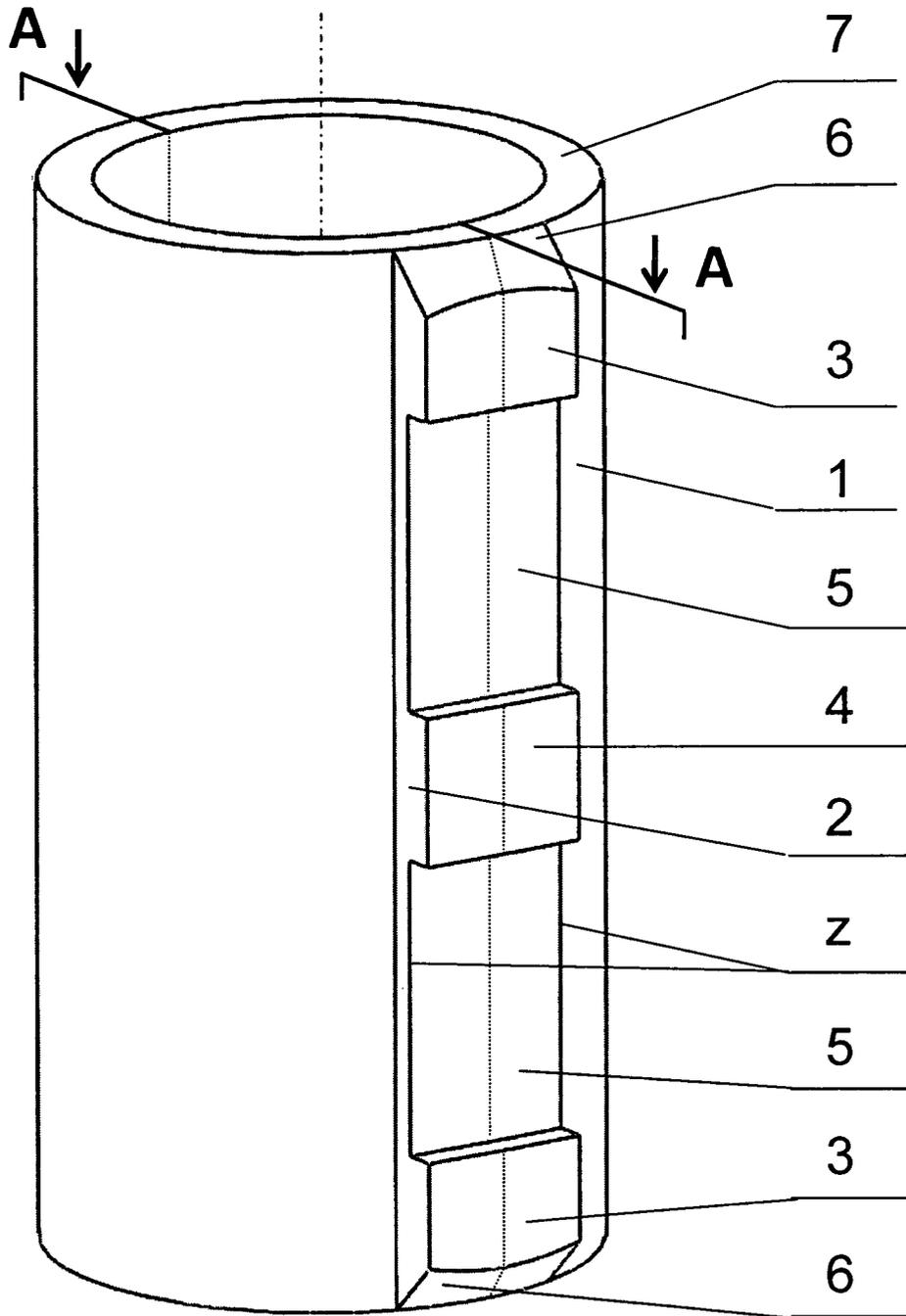


Fig. 1

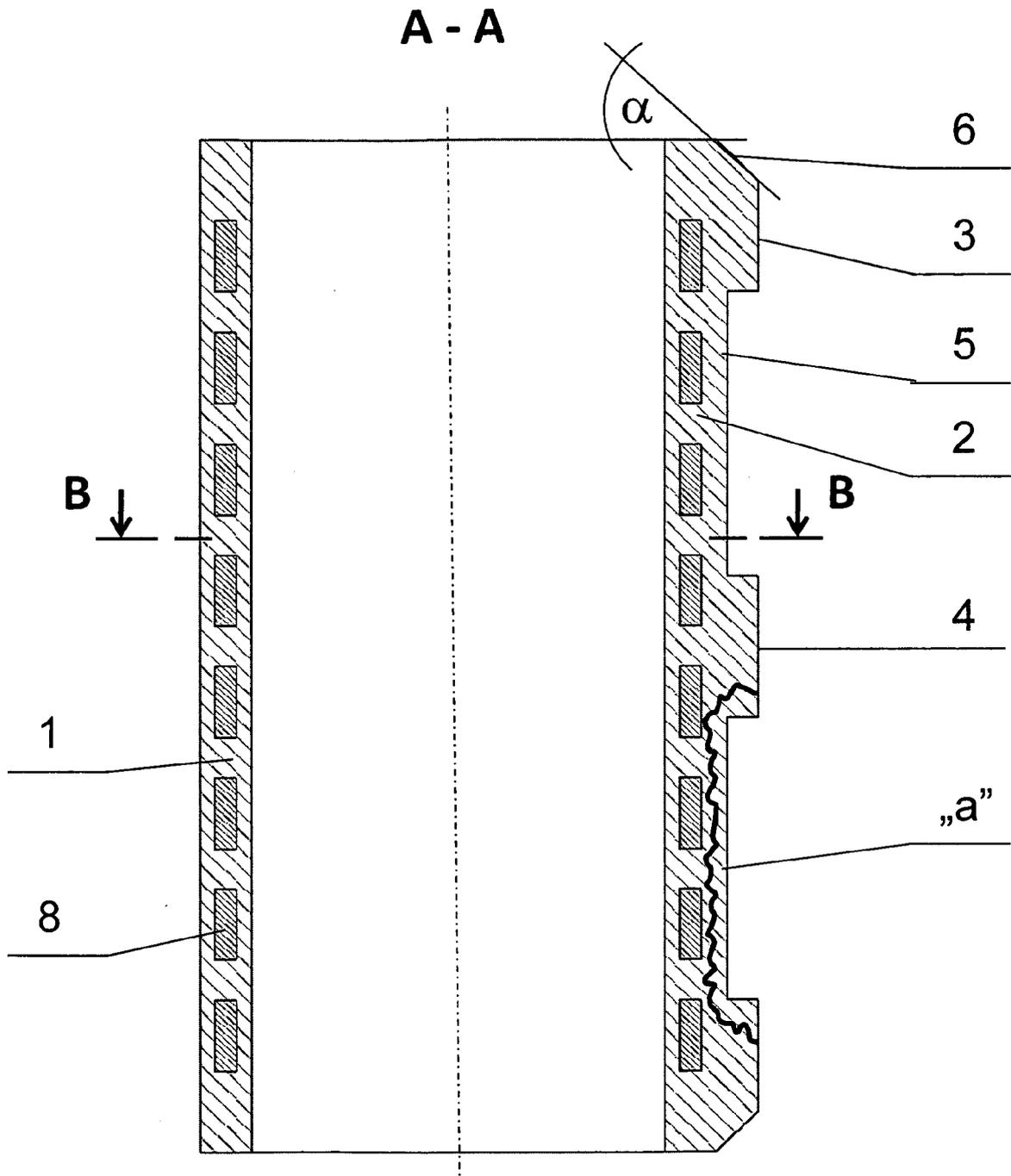


Fig. 2

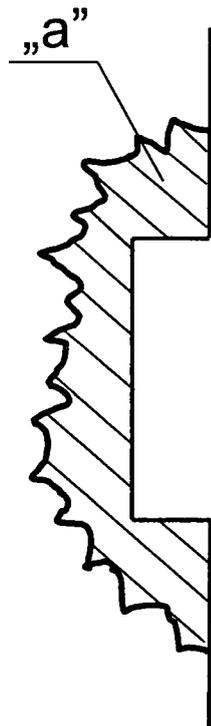


Fig. 3

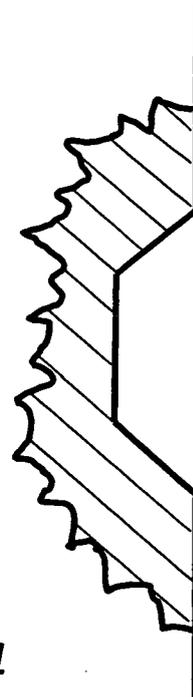


Fig. 4

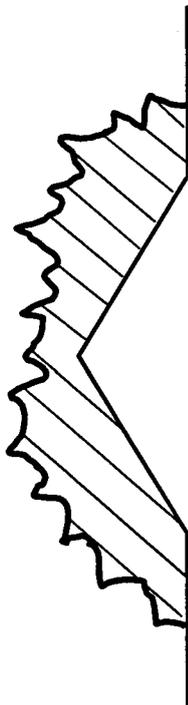


Fig. 5

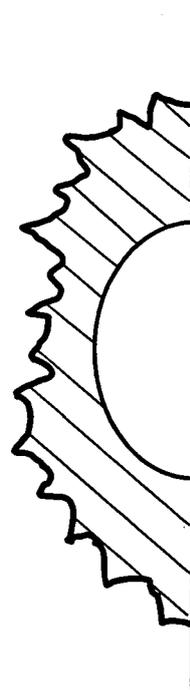


Fig. 6

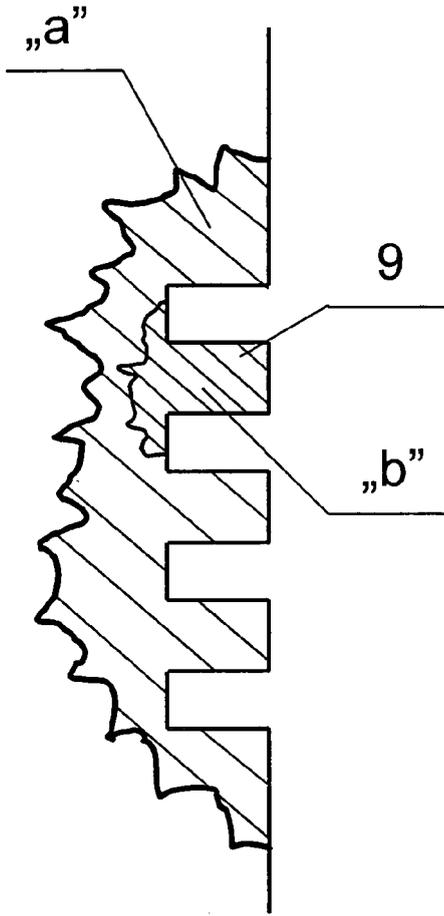


Fig. 7

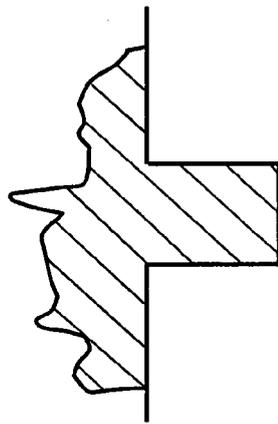


Fig. 8

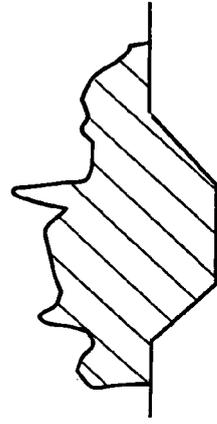


Fig. 9

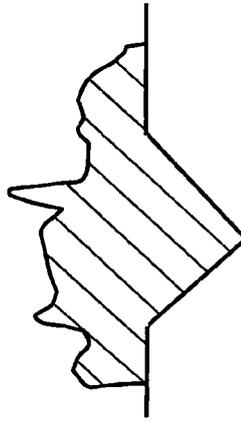


Fig. 10

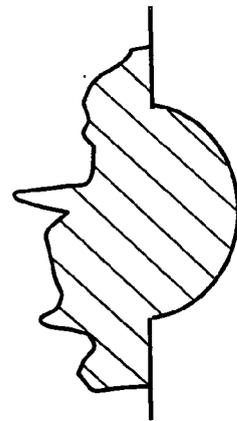


Fig. 11

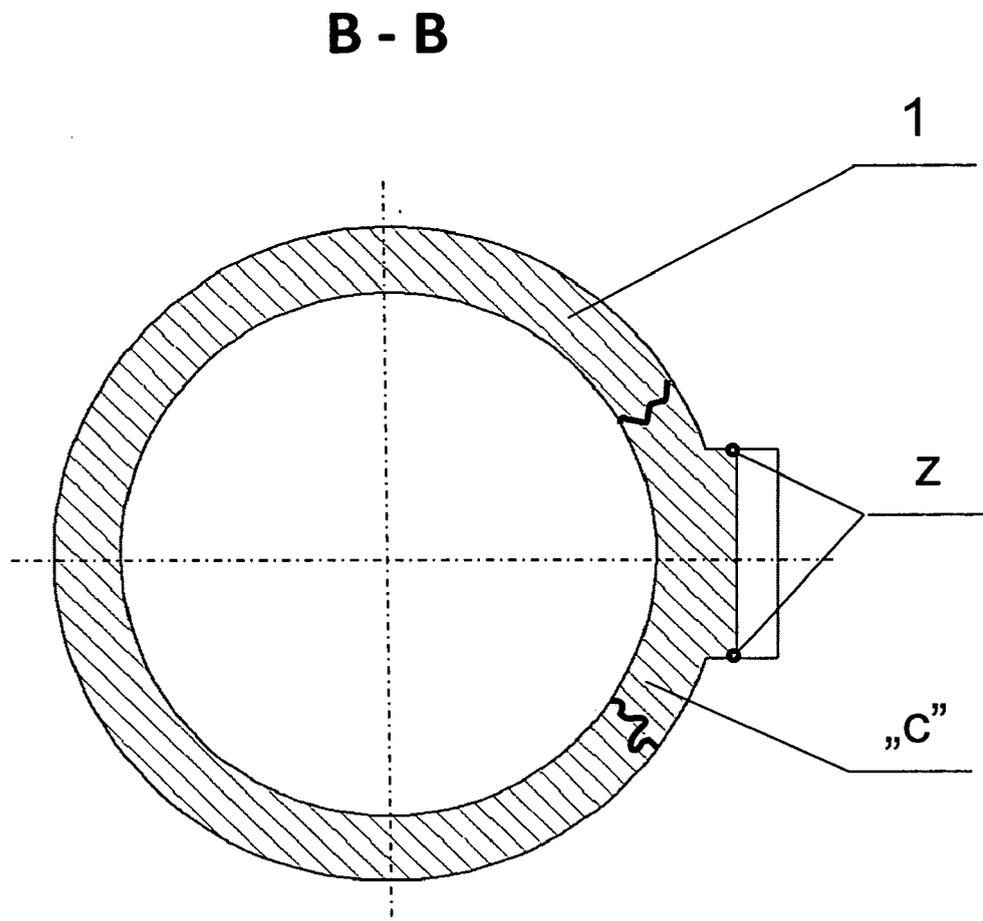


Fig. 12

Fig. 13

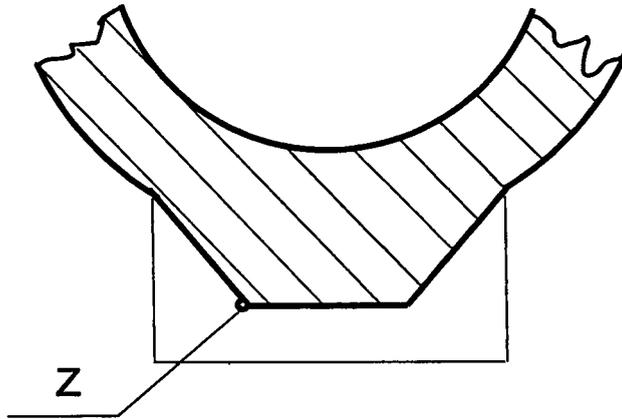


Fig. 14

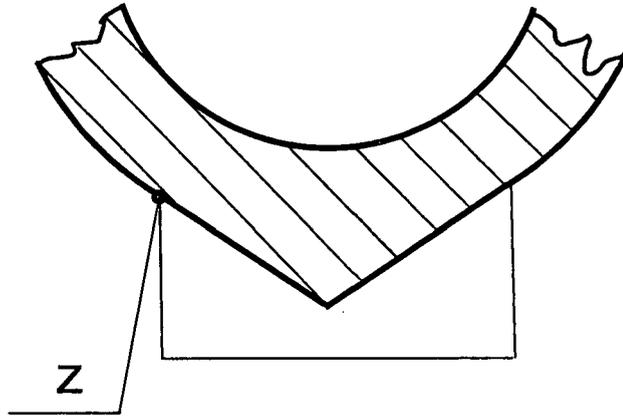
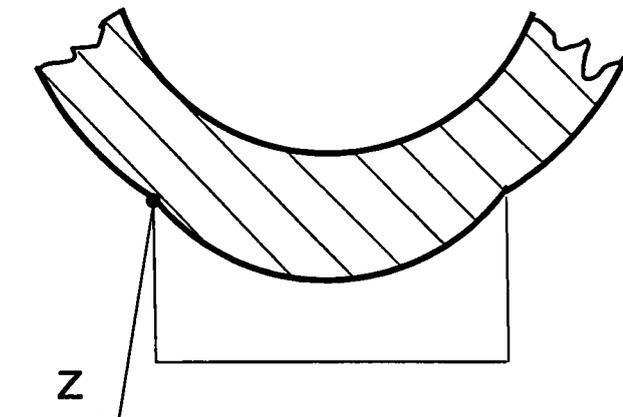


Fig. 15



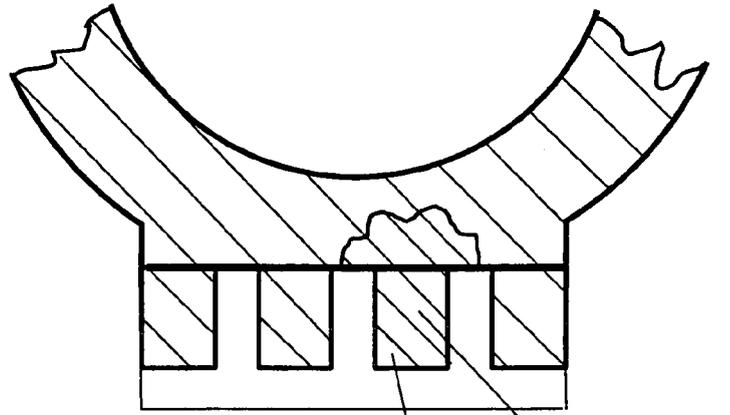


Fig. 16

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„d”

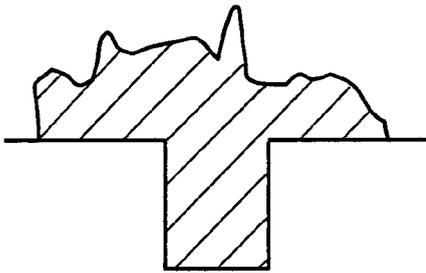


Fig. 17

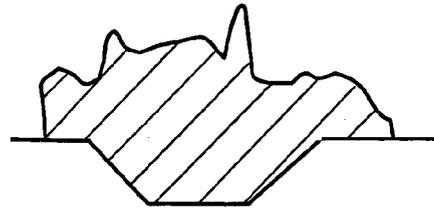


Fig. 18

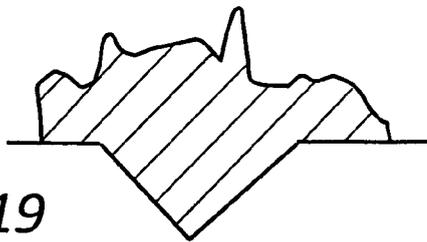


Fig. 19

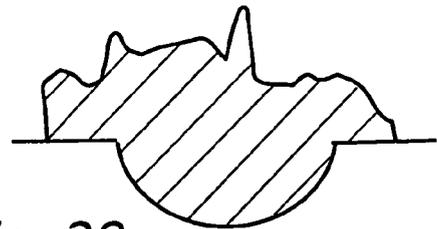


Fig. 20



EUROPEAN SEARCH REPORT

Application Number
EP 11 46 0020

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 6 445 269 B1 (LAUREOTE SYLVAIN [FR] ET AL) 3 September 2002 (2002-09-03) * the whole document *	1-8	INV. H01F27/32
A	----- GB 2 220 945 A (HITACHI LTD [JP]) 24 January 1990 (1990-01-24) * page 1, paragraph 1 * * page 34, line 1 - page 35, line 10; figures 34 - 38 *	1-8	
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			H01F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 October 2011	Examiner Van den Berg, G
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EPC FORM 1503 03.82 (P04C01)

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

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25-10-2011

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