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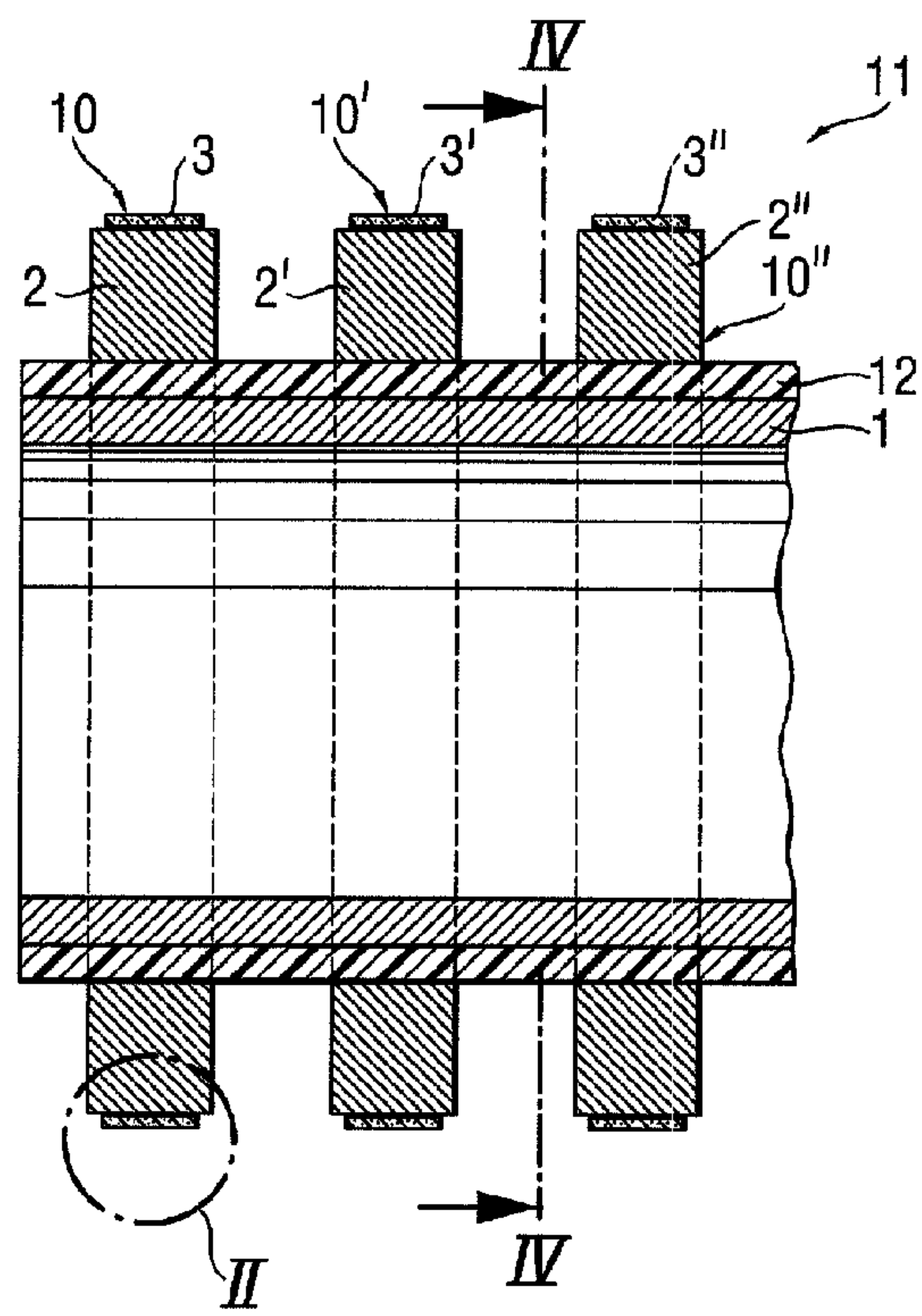
(71) Demandeurs/Applicants:
SIEMENS AG, DE;
SGL CARBON AG, DE

(72) Inventeurs/Inventors:
MEYER, ALOYSIUS, DE;
HAHN, INGOLF, DE;
STADIE, KLAUS, DE;
VESPER, WOLFGANG, DE

(74) Agent: FETHERSTONHAUGH & CO.

(54) Titre : MONTAGE DE BAGUES COLLECTRICES DANS LES MOTEURS ELECTRIQUES ET GENERATRICES
(54) Title: SLIP-RING ARRANGEMENT IN ELECTRIC MOTORS AND GENERATORS



(57) Abrégé/Abstract:
Slip-ring arrangement for electric motors and generators, in which brushes made of carbon materials and slip rings (10, 10', 10") of they slip-ring body (11) are electrically conductively connected to each other, the slip rings (10, 10', 10") comprising metallic slip rings (2, 2' and 2") of standard construction as the slip-ring base and an electrically conductive sliding layer (3, 3' and 3") made of a graphite material, the thickness of which amounts to a maximum of 11% of the radius of the slip ring (10, 10', I0") and which is electrically conductively fastened to the circumference of the metallic slip-ring base (2, 2' and 2") by gluing. Method for retooling slip-ring bodies having metallic slip rings by stripping the metallic slip rings and gluing on a sliding layer.

Abstract

Slip-ring arrangement in electric motors and generators

Slip-ring arrangement for electric motors and generators, in which brushes made of carbon materials and slip rings (10, 10', 10") of the slip-ring body (11) are electrically conductively connected to each other, the slip rings (10, 10', 10") comprising metallic slip rings (2, 2' and 2") of standard construction as the slip-ring base and an electrically conductive sliding layer (3, 3' and 3") made of a graphite material, the thickness of which amounts to a maximum of 11% of the radius of the slip ring (10, 10', 10") and which is electrically conductively fastened to the circumference of the metallic slip-ring base (2, 2' and 2") by gluing. Method for retooling slip-ring bodies having metallic slip rings by stripping the metallic slip rings and gluing on a sliding layer.

Figure 1

Rw 2000/102

Slip-ring arrangement in electric motors and generators

The invention relates to slip-ring arrangements for electrical machines having brushes made of carbon materials and slip-ring bodies, the brushes being electrically conductively connected to the slip rings of the slip-ring bodies.

Electric motors and generators with which electrical energy is converted into rotational energy or, conversely, rotational energy is converted into electrical energy, require a current supply to the rotatably arranged coil, which is connected in a force-locking or form-locking manner to the axis of rotation. This usually takes place by way of slip rings which are connected to the axis of rotation and concentric therewith and which are conductively connected to stationary brushes, or by way of the pairing of brushes with so-called commutators or collectors, which, in addition to producing the electrical connection between the stationary part and the rotating part of the electrical machine, also effect the commutation (in direct-current machines).

Usually, the slip rings and commutators consist of metals such as copper, copper alloys such as, for example, bronze, tin bronzes, nickel bronze, silver or steel. The slip rings are connected by insulating fastenings to the hub (axis of rotation) to form slip-ring bodies, being insulated with respect to the said hub and with respect to each other. Electrically conductive brushes are arranged stationarily along the circumference of the slip rings and are held in contact with the surface of the slip rings by spring force. For alternating-current motors and generators, slip rings are required individually or plurally for each phase.

The sliding contacts (brushes) generally consist of carbon materials, possibly in combination with metals (for example metal graphite, for the production of which mixtures of metal powders, in particular copper, tin or lead, are pressed with graphite, in particular natural graphite, and subsequently hardened by calcining or sintering).

With all these material pairings, wear results from the reciprocal movement and also from the transmission of somewhat high currents, in which case dust can form from the abrasion, which can lead to shortening of the creepage path because of dirt accumulation and thus to arcing; on the other hand, an eroding of the contacting layers results. In this connection, because of the necessity of replacing the brushes and the subsequent treatment of the surface of the slip rings (stripping off of the defective spots such as grooves or suchlike), additional maintenance intervals result, which are shorter than the maintenance intervals of the (roller) bearings, something which causes substantially increased maintenance costs, above all as a result of additional down-times.

It is therefore desirable to keep the abrasion as low as possible and thus to lessen the frequency of the maintenance work caused as a result, or to make it at most the same as the frequency of the maintenance work for the bearings and/or other wearing parts.

From the patent specification DD 258 687 A1 and from VEM Journal 1975, pages 15 ff, it is known that in the case of a pairing of graphite brushes with slip rings made of graphite, the wear is very low. However, this system has the disadvantage that only small currents can be conducted through the graphite body of the slip rings because of its specific resistance, which is relatively high in comparison with metals. When high currents are conducted, the ohmic heat is unacceptably high. This can lead to damage to the system. In a slip ring, the introduction or removal of the current takes place by way of a metal conductor which extends parallel to the axis of rotation in a manner such that it is laterally offset with respect thereto and is electrically conductively connected to the body of the slip ring. Because the resistance inside a graphite slip ring is of a similar magnitude to the contact resistance between slip ring and brush, this leads, in the case of a constant induced current in the coil, to periodic voltage fluctuations in a generator, or, in a motor, to an uneven torque, depending on the length of path of the current and thus the active resistance in the slip ring.

Another construction is known from the patent specification DD 248 909. Here, a slip ring having a metallic slip-ring base and a carbon sliding ring soldered on to it is described, the slip-ring base having hollow spaces in order to be able to remove the waste heat by ventilation on all sides. The side of the carbon sliding ring that faces the metallic slip-ring base has to be metallized in order to ensure a low contact resistance and permit a soldered joint. As a result of the strong heating of the construction by the ohmic dissipated energy and also during soldering, thermal stresses occur. The outer portion of the metallic slip-ring base is therefore preferably provided with recesses for compensation of thermal stresses.

The object is therefore to find a construction for slip rings which leads to as little wear as possible and, on the other hand, allows a sufficiently high current load, in order that systems of this kind can also be used in the high-current range without the strong temperature rises known from the prior art occurring. A further object is to be able to retrofit existing machines having metallic slip rings, in such a way that the wear becomes less, with as few parts as possible needing to be replaced.

This object is achieved by a slip-ring construction which comprises a metallic slip ring of standard construction as a slip-ring base and a sliding layer glued on to this slip-ring base, which sliding layer preferably consists of a carbon material. If a carbon material is used, it is advantageous to use a graphite material, particularly preferably an isostatically pressed graphite material. Furthermore, the ~~bending~~ flexural strength of the graphite material should preferably amount to at least 30 MPa (= 30 N/mm^2) in order that the layer thickness of the carbon material can be kept sufficiently small. The result of this construction is, on the one hand, that the contact-surface pairing has minimal wear, because the material of the friction partner of the brushes can be chosen in such a way that the abrasion between these materials which are moved against each other is considerably lower than that between a pairing of metals or a pairing with metal and carbon material for the brushes. On the other hand, as a result of this construction, the contact resistance between the metallic base of the slip ring and the sliding layer is centrosymmetrical.

The invention therefore relates to a slip-ring arrangement for electric motors and generators in which brushes made of carbon materials and the slip rings of the slip-ring bodies are electrically conductively connected to each other, characterised in that the slip rings comprise metallic slip rings of standard construction (slip-ring base) and an electrically conductive sliding layer made of a graphite material, the thickness of which amounts to a maximum of 11% of the outer radius of the slip ring and which is electrically conductively fastened to the circumference of the metallic slip-ring base by gluing. It is also possible that not all of the slip rings of the slip-ring body are provided with the sliding layer.

As is conventional to the skilled person, the arrangement consisting of the hub, the insulator (preferably the insulating covering in the form of a lateral cylinder surface) and the slip rings, which in the case of the invention are made up of the metallic slip-ring base and the sliding layer, is called the slip-ring body herein.

The thickness of the sliding layer is upwardly limited by its conductivity (the thicker the sliding layer, which is poorly conductive in comparison with metals, the higher the resistance between the terminal lead, which is conductively connected to the metallic slip-ring base, and the connecting lead at the brushes). It has proven advantageous to make the thickness of the sliding layer not greater than 11% of the radius of the outer lateral surface of the sliding layer.

The metallic slip-ring base is usually a squat cylindrical supporting ring which can be constructed such that it is solid, with (mainly circular) recesses, or as a spoked wheel. It is also possible, and preferred, for the width of the slip-ring base in the vicinity of the outer lateral surface to be greater in this region than in the rest of the ring. The slip-ring base is thus given the appearance of a flat ring (which can also have recesses), on the circumference of which, in a preferred manner, is formed a wide (in the direction parallel to the axis) lateral cylinder surface like a collar. A sliding layer with constant thickness is electrically conductively fastened on the (outer) lateral surface of this slip-ring base. This fastening is preferably produced by conductive gluing. The advantage of gluing is that the electrical connection has a contact area that is as large as possible, this lowers the contact resistance and divides the force between both materials on to an area which is as large as possible. With gluing, the heating to temperatures at which solder melts that is otherwise required in the case of the production of a soldered joint is dispensed with. When soldering, particular safety measures, such as dismantling or putting on a thermal shield, are namely required in order to avoid damage to the slip-ring base.

The sliding layer consists of an electrically conductive graphite material. Preferably, a graphite material having a flexural ~~bending~~ strength of at least 30 MPa is used as the material for the sliding layer. Furthermore, isostatically pressed graphite material is preferably used. The thickness of the sliding layer should be kept as low as possible because of the specific resistance which is higher in comparison with the metallic slip-ring base. In this connection, however, it is to be taken into account that, on the one hand, the mechanical stability of the sliding layer decreases with smaller thickness, and, on the other hand, the abrasion in connection with the brushes (usually and preferably consisting of carbon materials) is to be determined by the suitable selection of the material and its thickness in such a way that the maintenance intervals, which become necessary because of the renewing of the sliding layer, are equal to or greater than the average rolling-bearing lifetime. The thickness of the sliding layer should not, therefore, amount to more than 11% of the outer radius of the slip ring (i.e. of the outer radius of the sliding layer);

preferably, the thickness of the sliding layer is 10% or less of this radius, in particular 8% or less, with proportions of 6% and below or 4% and below being particularly preferred.

Conductive adhesives are used in order to glue together the sliding layer and metallic slip-ring base. These adhesives are preferably to be chosen in such a way that their temperature stability is so great that a firm gluing of the sliding layer on to the metallic slip-ring base is also ensured at the temperatures at the slip ring that occur during the operation of the slip-ring arrangement. Preferably, however, adhesives which do not have a suitable inherent conductivity but to which, however, a metal powder, preferably copper powder, is added, are also used. Particularly preferably, after the depositing of the adhesive layer, the metal powder is scattered over the coated surfaces in order to obtain an electrically conductive adhesive connection. The metal powders used preferably have a granulation of 0.01 mm to 0.2 mm. In particular, epoxy-resin adhesives, phenolic-resin adhesives, cyanate-ester-resin adhesives as well as adhesives based on polyurethane resins, polyester resins and amine resins are counted among the adhesives used. Particularly preferably, phenolic-resin adhesive is used for the slip rings in accordance with the invention. The layer thickness of the adhesive on the metal surface of the slip-ring base or on the inside surface of the sliding layer preferably amounts to between 0.02 mm and 0.2 mm, particularly preferably between 0.05 mm and 0.1 mm. In the gluing process, the sliding-layer segments are placed precisely on to the supporting slip-ring base and pressed on with even pressure. In this connection, the gap width between the individual segments of the sliding layer is to be kept as small as possible.

Graphite brushes are preferably used as the sliding partner for the sliding layer of the slip rings, i.e. brushes made of carbon materials with a graphitic character. Among these materials are counted in particular electrographite and burnt carbon materials which contain natural graphite.

The fact that the sliding layer, which preferably consists of the above-mentioned rigid ~~bending-resistant~~ carbon material, can be renewed without problem when necessary is to be mentioned as a further advantage of this construction; in order to do this, it is necessary only to strip off the remaining sliding layer and the adhesive layer down to the metal, whereupon a new sliding layer can then be put on. Changes in the brush position during this overhaul are not required in this case. In the case of a pure metal embodiment, the slip ring has to be reworked when worn, without going below a minimum diameter, or the entire slip ring has to be exchanged, in which case the brushes also have to be renewed.

The partial or complete retrofitting of existing machines having purely metallic slip rings is to be carried out without problem in such a way that the metallic contact layer on the outer lateral surface of the existing slip rings in the slip-ring body is prepared, preferably worn down, particularly preferably by stripping off, in such a way that the sliding layer can be put on in the required thickness and connected to the remaining metallic slip-ring base by gluing. The sliding layer can then be reworked if necessary in order to remove surface irregularities, for example by stripping off or grinding. The advantage of the embodiment in accordance with the invention emerges in particular in the case of this retrofitting, because the thickness (in the radial direction) of the gliding layer of metallic slip rings is usually great enough to be stripped off to the required diameter without loss of stability. This applies in particular to metallic slip rings which have two layers in the radial direction, a metallic supporting layer and a separate outer gliding layer.

It is of particular advantage to prepare the metallic slip rings of an existing machine (for example by grinding, turning or milling) in such a way that at at least one of the edges of the outer lateral surface of the remaining metallic slip-ring base, there remains in each case a projection (in the direction of the increasing radius) which is preferably 0.5 mm to 5 mm wide, in particular 1 mm to 3 mm wide, and 0.5 mm to 3 mm high, preferably 1 to 2 mm high. The sliding layer is glued into the cylindrical groove which comes about in this way, in such a way that the sliding layer ends at the projections or preferably projects above them by up to 5 mm, in particular up to 3 mm.

The word "tangent" is defined and will be used as follows:

"A tangent is that straight line which borders on the outer lateral surface of the slip-ring and passes perpendicular to the rotational axis of the electrical machine."

In the arrangement in accordance with the invention, the entire slip-ring body can be clamped for overhaul or renewal of the sliding layer, the slip rings are stripped off down to the metallic base, and the sliding layer can be replaced (simultaneously with one or more slip rings).

The sliding ring can comprise a closed ring; it is, however, preferred for the sliding layer to be made up of a plurality of segments, which are cut from one or more graphite rings, in which case they are put on to the carrier in at least two segments, particularly preferably in at least three segments. In this connection, it is favourable for the joint between two adjoining sliding-layer segments not to be made parallel to the axis of rotation (i.e. at right angles to the tangent), but instead at an angle to the tangent of a maximum of 75°, preferably a maximum of 60°, and particularly preferably up to 45°. It has therefore proven advantageous, if the sliding layer is put on in one piece in the form of a ring, to slit the latter circumferentially at an angle β with respect to the tangent, which angle is preferably to be sized in such a way that the slit extends at least once around the entire circumference of the sliding layer. If the sliding layer is put on in more than one segment, it is advantageous for these segments not to be sized with the same (arc) length; instead the (arc) length of the longest segment should be at least 110% of the length of the other (or second-longest) segment. The thickness of the sliding layer amounts to up to 11% of the outer radius of the slip ring, preferably a maximum of 5mm, in particular 4 mm and less.

Figure 1 shows a diagrammatic longitudinal section through a slip-ring body;
Figure 2 shows a detail enlargement in accordance with section II in Figure 1;
Figure 3 shows a detail enlargement in accordance with the section of Figure 2 of an alternative embodiment to Figure 1;
Figure 4 shows a cross-section in accordance with line IV-IV in Figure 1;
Figure 5 shows a lateral plan view of a slip-ring body in accordance with Figure 4; and
Figure 6 shows a plan view of a slip-ring body in accordance with an alternative embodiment to Figure 4.

A slip-ring body 11 according to the invention having a total of three slip rings 10, 10', 10" is shown in Figure 1, which is a section through the slip-ring body 11 in a plane parallel to the axis of rotation. Fastened to an insulating layer 12, which is mounted on a hub 1, are metallic rings 2, 2', 2" as a slip-ring base. A respective sliding layer 3, 3', 3" in the form of a cylindrical ring is glued on to the lateral surface of each of these metallic rings 2, 2', 2" with the aid of an electrically conductive adhesive. This construction can be seen from Figure 2, which is an enlargement of a section of Figure 1. Here, a metallic portion of the slip-ring base 2 is shown, on which the annular sliding layer 3 is secured by the electrically conductive adhesive 6.

The above-mentioned preferred embodiment, in which the slip-ring base 2 is constructed in such a way that there remains at the edges of its outer lateral surface a respective projection 4, 4', is to be seen in Figure 3. This is a modified embodiment of the embodiment shown in Figure 2 and Figure 1. In contrast to the construction shown in Figure 1, a respective projection 4 and 4' has here been left at both edges of the outer lateral surface of the slip-ring base 2, as a result of which there is formed, in the centre of the outer limiting surface of the slip-ring base 2, a groove 5 into which the sliding layer can be inserted in a manner such that it is flush. The electrically conductive adhesive 6 is brushed on to the base of the groove 5, the sliding layer 3 is put on and glued to the slip-ring base 2.

Figure 4 shows a section along the line IV-IV of Figure 1. Fastened to the insulating layer 12 over the hub 1 is the annular slip-ring base 2", on to which the sliding layer 3" is glued. The multi-part construction of the sliding layer 3" can be seen in this Figure 4, a three-part embodiment being shown here, with the sliding-layer segments $3''_1$, $3''_2$, $3''_3$ and the joint locations 7, 7' and 7".

Figure 5 shows a plan view of a slip ring of this type, the direction of viewing being at right angles to the axis and at right angles to the diameter of the slip ring. The sliding layer 3 is glued on to the slip-ring base 2 in a plurality of segments, a joint 8 between two segments of the sliding layer being visible here.

The angle α of the joint 8 with respect to the tangent is 60°.

Finally, Figure 6 shows in a plan view, like Figure 5, a further preferred embodiment, in which the ring 3 forming the sliding layer is slit. The angle β of the slit 9 with respect to the tangent is preferably chosen in such a way that the slit extends along a spiral line on the lateral surface of the cylindrical sliding layer and the length of the slit is greater than the circumference of the lateral surface. The advantage of this embodiment is that the ring can be expanded in order to be put on to the slip-ring base 2 which is fastened to the hub 1, in which case it can be inserted into the groove 5 even, if applicable, over a raised projection 4 or 4' of the slip-ring base (present in accordance with the representation in Figure 3) without danger of breaking. The slit sliding layer 3 is subsequently glued to the slip-ring base 2 so that it is flush and the width of the slit 9 is as small as possible. The acute angle β (small angle) of the slit 9 with respect to the tangent further minimises possible irregularities or joints and thus reduces the abrasion.

The invention is explained by the following examples:

Comparative example

In a standard 6 kV-electric motor (type "1LS1 456-4HA60-Z" from Siemens AG, No. 904 068) having slip rings in accordance with the prior art made of steel X10Cr13 and associated optimised brushes, namely metal graphite brushes "RC53" from the company SGL CARBON GmbH, during operation with rated load, the temperature of the supply air, at the winding, in the slip ring space, at the brushes and at the slip rings was determined. The abrasion at the brushes and slip rings was determined.

Example

The slip-ring body from the comparative example (with a diameter of 280 mm) was clamped centrally on to a turning lathe and the slip rings made of steel were stripped off to an outer diameter of 270 mm. Three ring segments consisting of an isostatically pressed graphite of the type 300 from the company SGL CARBON GmbH having the dimensions: inside diameter 270 mm, outside diameter 282 mm, width 30 mm, were glued on to the smooth surface which resulted from the stripping off, with the aid of a phenolic resin as adhesive that was filled with copper powder of the type FFL from the company Norddeutsche Affinerie (composition: 50% by weight resin, 50% by weight copper powder). The joint locations between the segments were made with an inclination of 60°. The slip-ring body was once again clamped centrally and stripped off to 280 mm outer diameter. The slip-ring body was reinstalled in the motor. Apart from this, the brushes were exchanged for graphite brushes of the type RE65 from the company SGL CARBON GmbH. The same measurements as in the comparative example were made. The results are summarised in the table.

	Comparison	Example
Brush	RC53	RE65
Sliding layer	steel X10Cr13	isographite 300
Brush wear	0.3 mm/100 h	<0.05 mm/100 h
Ring wear	not measurable	not measurable

Extensive comparisons between the two configurations with different operating times and different load produced the result that the temperature of the brushes in the embodiment in accordance with the invention was on average 13 to 23°C lower than that of the comparison, and the temperature of the slip rings was on average 12 to 18°C lower than in the comparison. Because of the lower temperature load in the slip-ring arrangement in accordance with the invention, the lifetime of the components of the electrical machines, such as the bearings, for example, can be increased.

In the case of a comparatively high running time (a few hundred hours), in comparison, a clear eroding of the brushes of the conventional arrangement (comparison) was established, while the arrangement in accordance with the invention did not show any measurable brush wear of the brushes used. The wear at the slip rings was not measurable in the case of this short running time.

Furthermore, tests with the comparative slip-ring arrangement and the slip-ring arrangement in accordance with the example were carried out on testing stands in order to test the systems under extreme loads. In this connection, the slip-ring arrangements were mounted on a 710 KW motor and turn-on tests in the form of run-ups with different rotor currents were carried out, i.e. a very high performance was demanded of them for a short time. In the case of the comparative slip-ring arrangement in accordance with the background prior art, these tests were able to be carried out up to a 3.2-fold loading of the rated current, something which corresponds to a current density per brush of approximately 32 A/cm^2. In this connection, in the standard embodiment, however, both the slip rings and the brush gliding surfaces showed heavy damage as a result of melting (sparking of the brushes was observed). The slip-ring arrangement in accordance with the invention in accordance with the Example was able to be carried out up to an approximately 3.5-fold loading of the rated current, something which corresponds to a current density over the slip-ring arrangement in accordance with the invention of 40 A/cm^2. Even at this still higher loading, no damage to the slip rings and brushes (sparking of the brushes) of the arrangement in accordance with the invention could be observed.

A fundamental advantage of the slip-ring arrangement in accordance with the invention consists in that the slip rings can be used almost without exchange. Only the sliding layer can be renewed if necessary, without, however, significantly affecting the metallic slip-ring base. On the other hand, the metallic slip rings used hitherto had to be renewed over time, because in the case of each due maintenance of the electrical machines for exchanging the bearings, they had to be stripped off in order to even out the formation of grooves on the slip ring surface.

List of reference symbols

1	hub
2, 2', 2"	metallic slip-ring base (ring shape)
3, 3', 3" $3''_1$, $3''_2$, $3''_3$	sliding layer
4, 4'	projection
5	groove
6	adhesive
7, 7', 7"	joint location
8	joint
9	slit
10	slip ring
11	slip-ring body
12	hub insulation
α	angle of 8
β	angle of 9

Claims

1. Slip-ring arrangement for electric motors and generators in which brushes made of carbon materials and slip rings (10, 10', 10") of the slip-ring body (11) are electrically conductively connected to each other, characterised in that the slip rings (10, 10', 10") comprise metallic slip rings (2, 2' and 2") of standard construction as the slip-ring base and an electrically conductive sliding layer (3, 3' and 3") made of a graphite material, the thickness of which amounts to a maximum of 11% of the radius of the slip ring (10, 10', 10") and which is electrically conductively fastened to the circumference of the metallic slip-ring base (2, 2' and 2") by gluing.

2. Slip-ring arrangement according to claim 1, characterised in that the material of the sliding layer (3, 3' and 3") has a flexural strength of at least 30 MPa.

3. Slip-ring arrangement according to one of claims 1 or 2, characterised in that the sliding layer (3, 3' and 3") consists of an isostatically pressed graphite material.

4. Slip-ring arrangement according to one of claims 1 to 3, characterised in that the sliding layer (3, 3' and 3") consists of annular segments.

5. Slip-ring arrangement according to claim 4, characterised in that joint locations (7, 7' and 7")

between the segments of the sliding layer have an angle α of a maximum of 75° with respect to the tangent.

6. Slip-ring arrangement according to one or more of claims 4 to 5, characterised in that the segments have different arc lengths, the length of the longest segment amounting to at least 110% of the length of the second-longest segment.

7. Slip-ring arrangement according to one or more of claims 1 to 6, characterised in that the slip-ring base (2, 2', 2") is constructed in such a way that at at least one of the edges of its outer lateral surface it has a projection (4, 4').

8. Slip-ring arrangement according to claim 7, characterised in that the at least one projection (4, 4') has a width of between 0.5 mm and 5 mm and a height of between 0.5 mm and 3 mm.

9. Slip-ring arrangement according to one or more of claims 1 to 3, characterised in that the sliding layer comprises a ring which is slit circumferentially at an angle β with respect to the tangent.

10. Slip-ring arrangement according to claim 9, characterised in that the angle β is sized in such a way that the slit extends at least once around the entire circumference of the sliding layer.

11. Slip-ring arrangement according to one or more of claims 1 to 10, characterised in that the gluing of the

sliding layer (3, 3' and 3") and metallic slip-ring base (2, 2' and 2") takes place with a temperature-stable adhesive, which renders possible a permanent connection of the sliding layer (3, 3' and 3") to the slip-ring base (2, 2' and 2") even in operation of the slip-ring arrangement.

12. Slip-ring arrangement according to one or more of claims 1 to 11, characterised in that the gluing of the sliding layer (3, 3' and 3") and metallic slip-ring base (2, 2' and 2") takes place with an adhesive to which a metal powder is added.

13. Slip-ring arrangement according to one or more of claims 1 to 12, characterised in that graphite brushes are used as the brushes.

14. Slip-ring arrangement according to one or more of claims 1 to 13, characterised in that not all of the slip rings (10, 10', 10") of the slip-ring body (11) have a sliding layer made of a graphite material.

15. Slip-ring body (11) in accordance with the slip-ring arrangement of claims 1 to 14.

16. Method for retooling slip-ring bodies in electrical machines having metallic slip rings, characterised in that the metallic contact layer on the outer lateral surface of at least one of the existing metallic slip rings is stripped in accordance with the thickness of the sliding layer to be put on, and in that a sliding layer (3, 3', 3") in accordance with one

or more of claims 1 to 12 is then put on.

17. Method for retooling slip-ring bodies in electrical machines having metallic slip rings in accordance with claim 16, characterised in that the stripping of the metallic contact layer in at least one of the metallic slip rings takes place in such a way that at at least one edge of the outer lateral surface of the remaining metallic slip-ring base (2, 2' and 2"), a projection (4, 4'), preferably in accordance with claim 8, is retained, and in that a sliding layer (3, 3', 3") in accordance with one or more of claims 1 to 12 is put on.

Fetherstonhaugh & Co.
Ottawa, Canada
Patent Agents

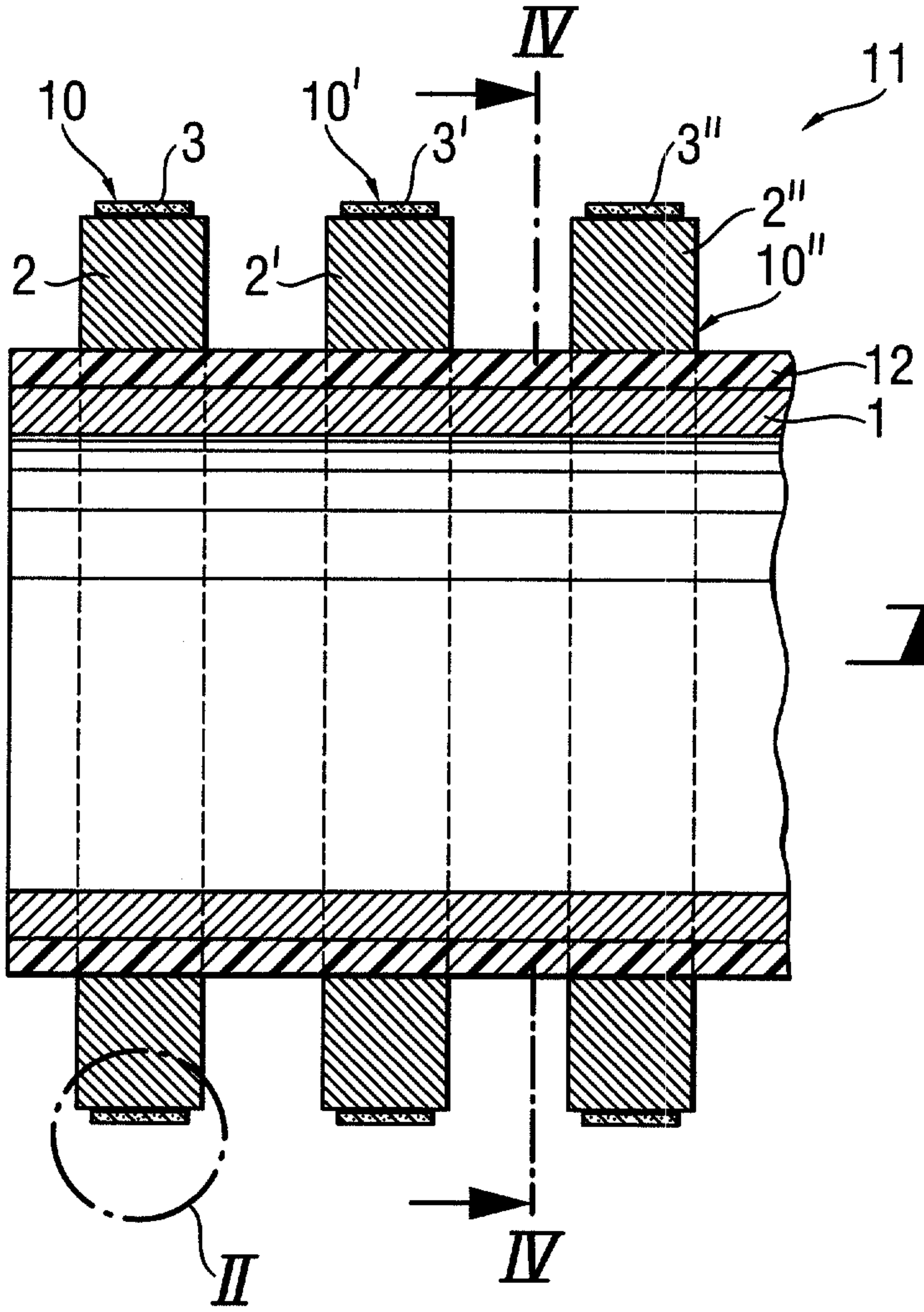


Fig. 1

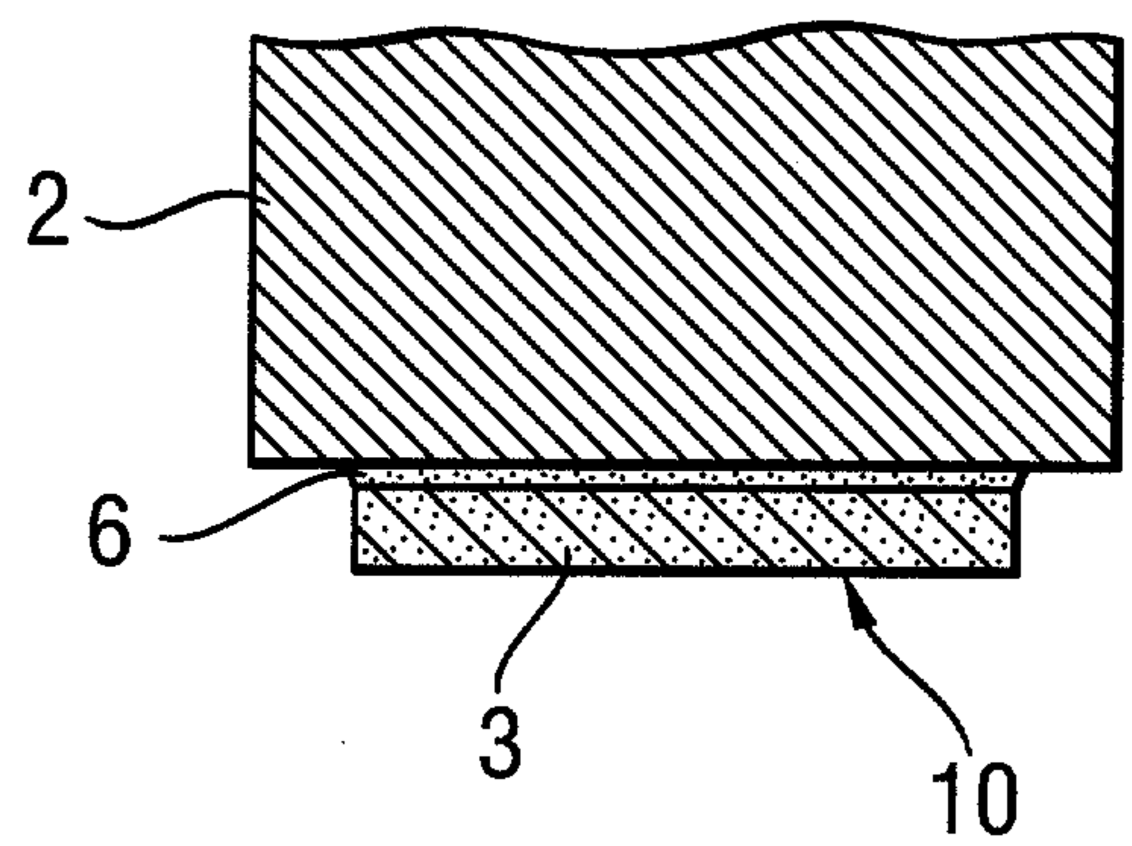


Fig. 2

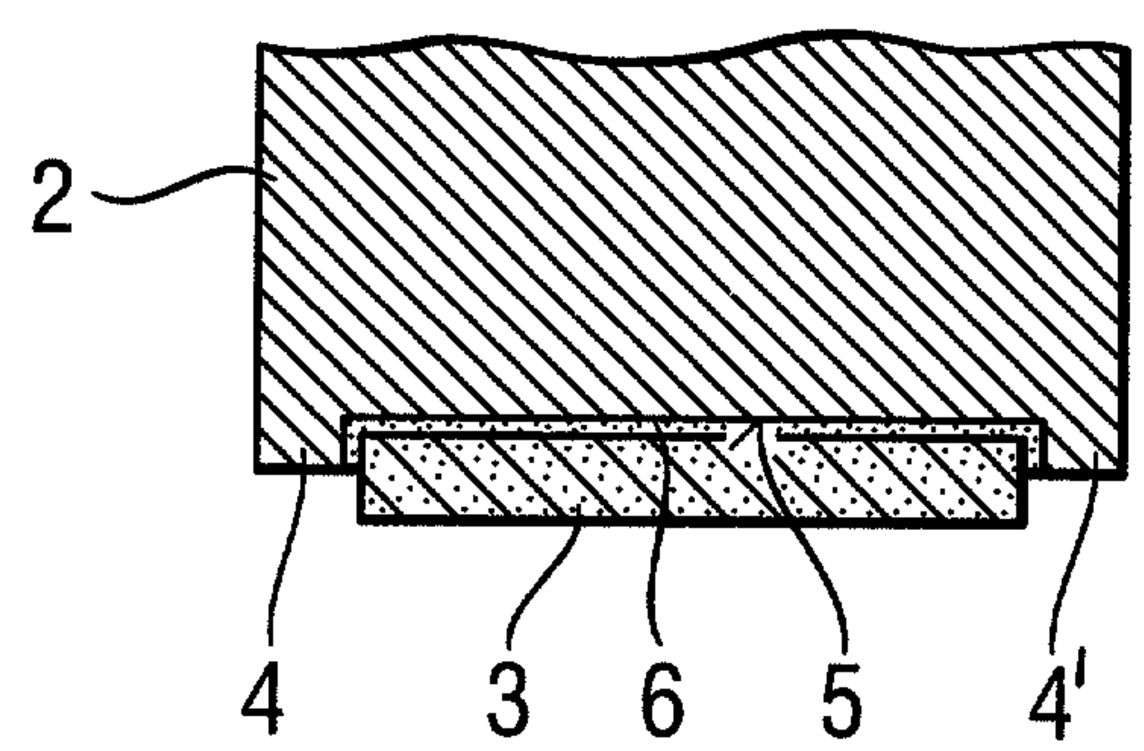


Fig. 3

Fig. 4

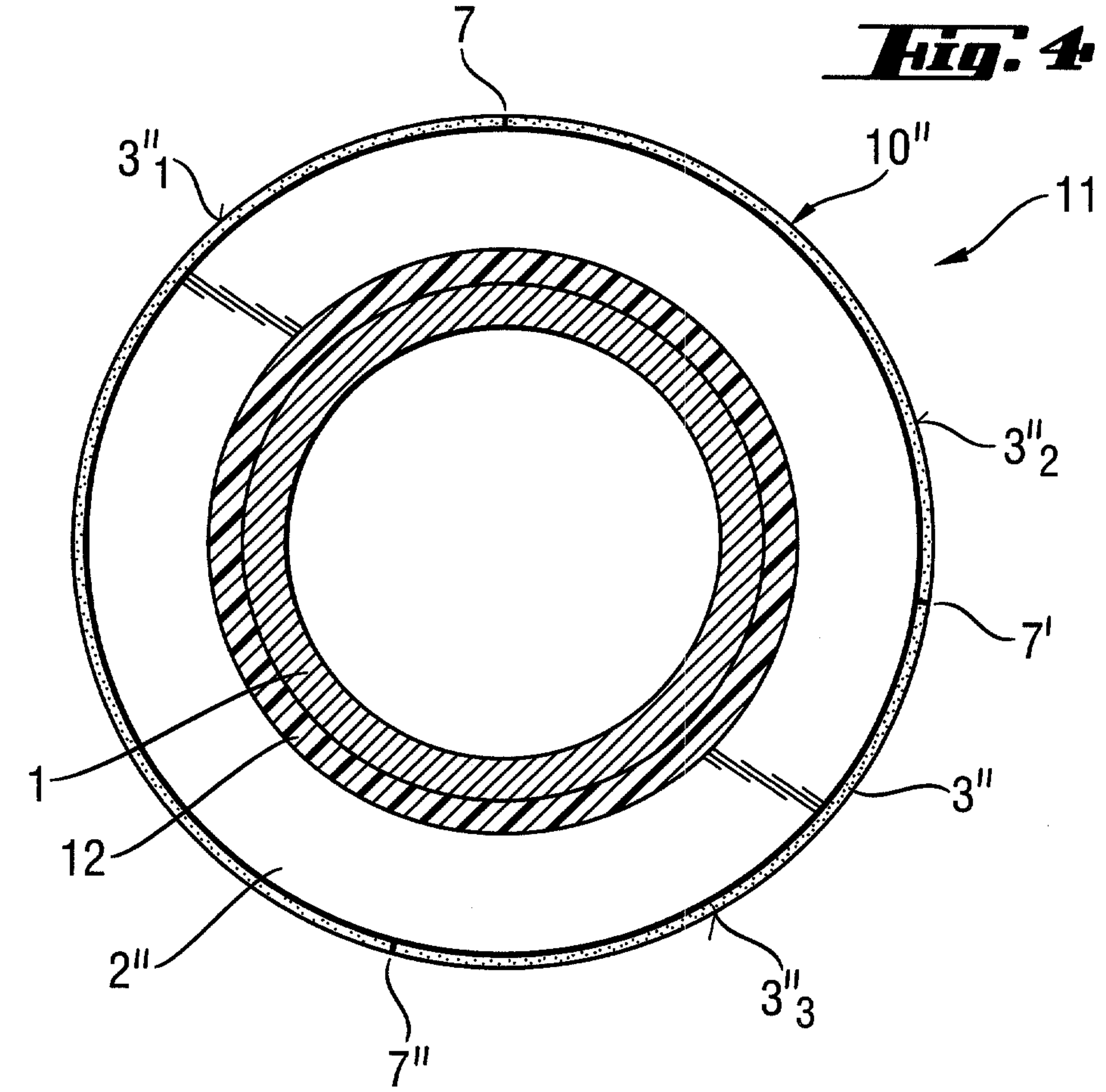


Fig. 5

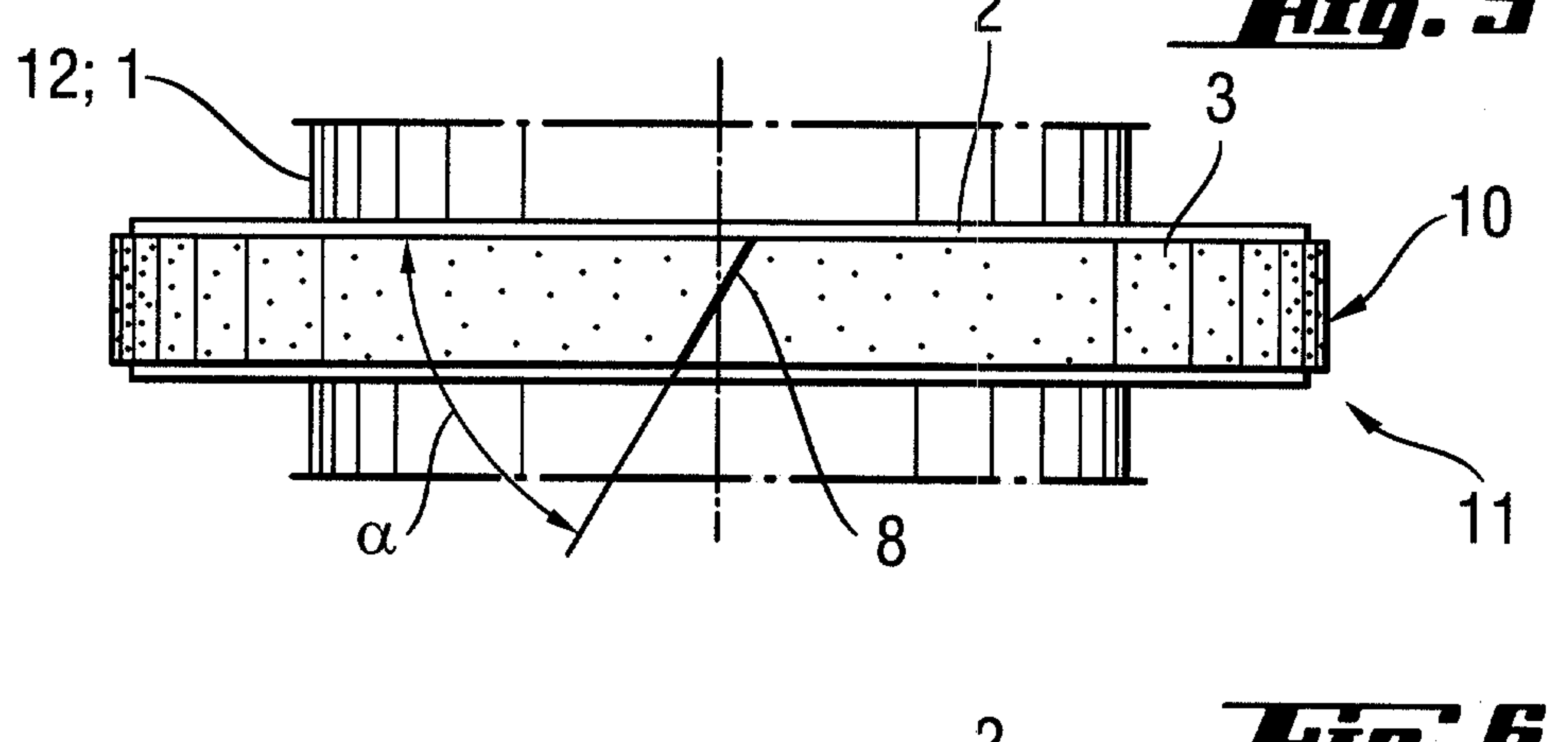
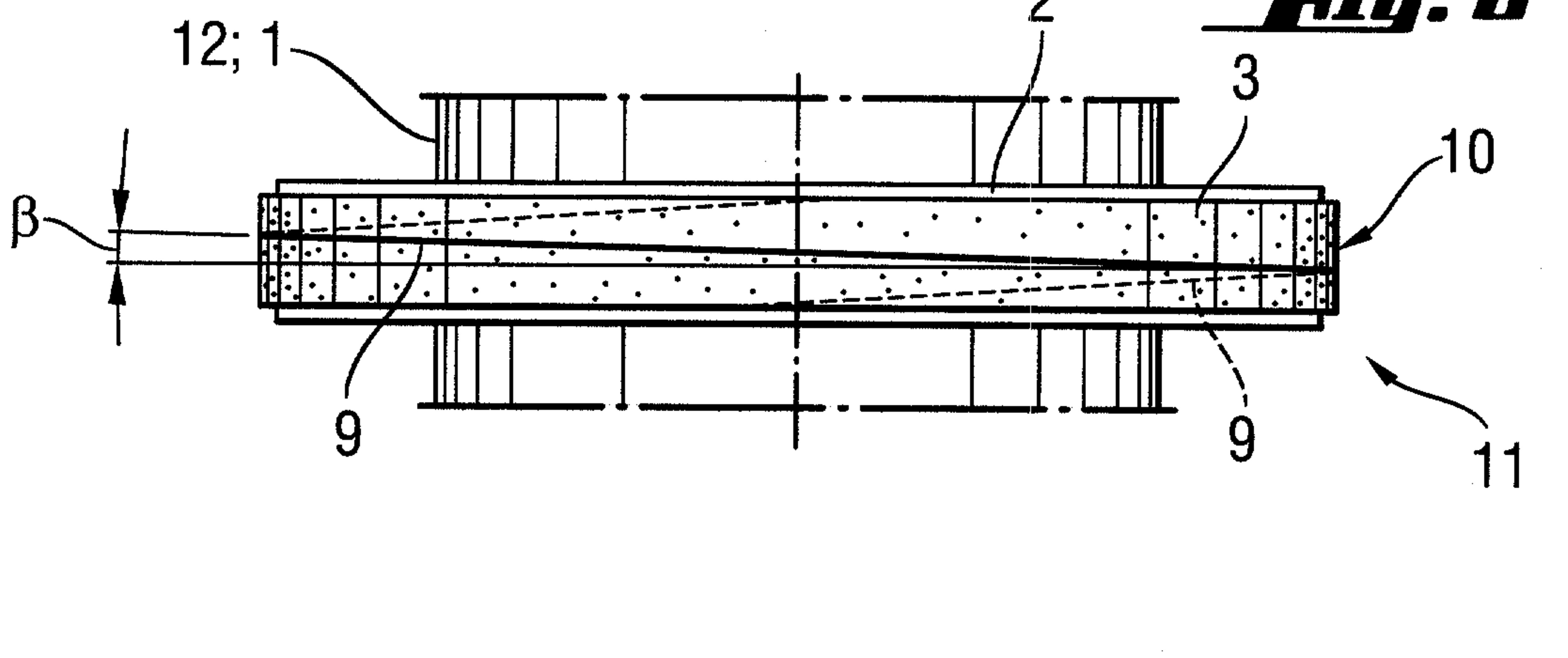
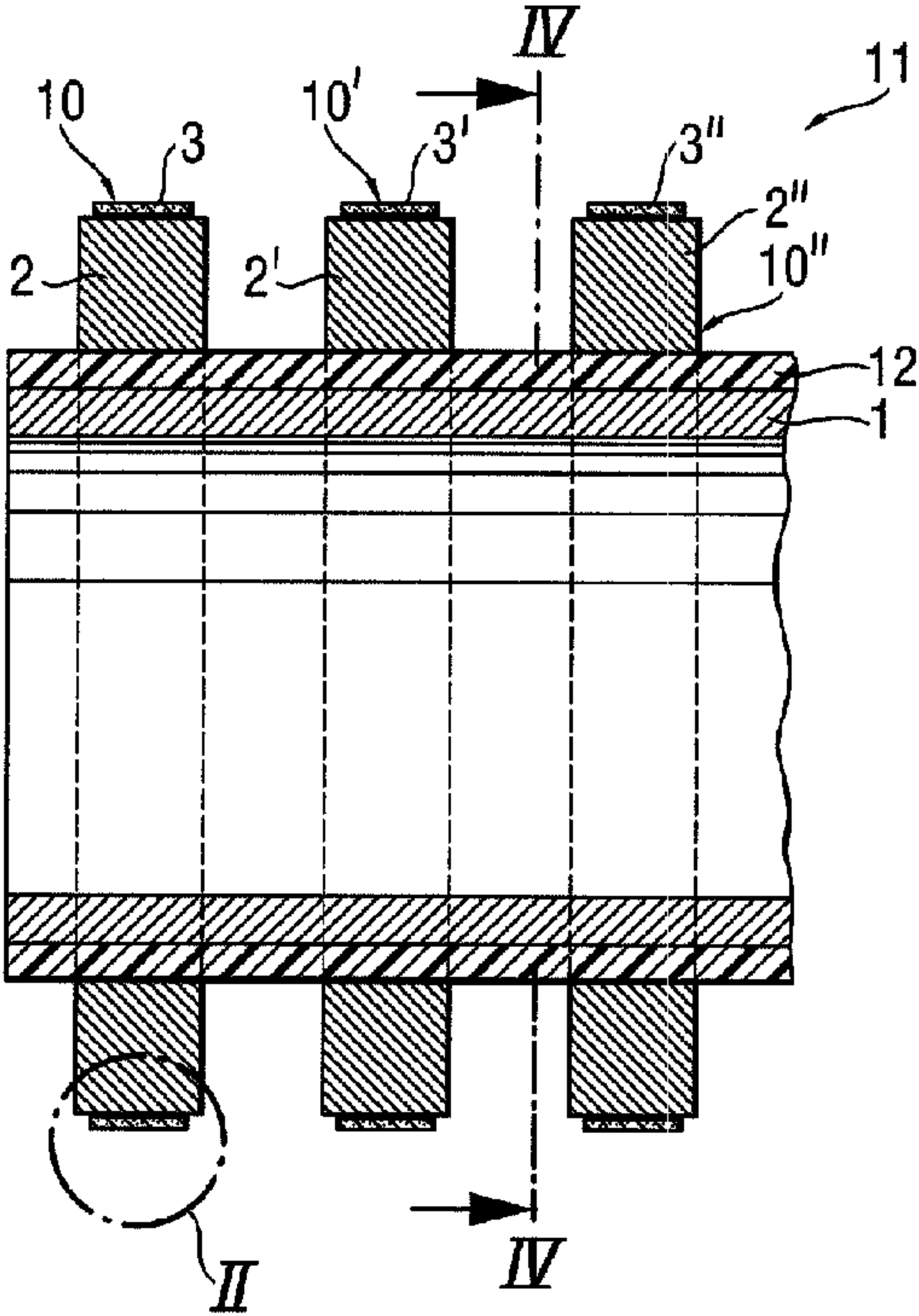


Fig. 6




IV
11
10
3
10'
3'
3''
2''
2
2'
10''
12
1
II
IV