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TAPERED PULTRUDATE BELT AND METHOD FOR PREPARATION THEREOF

The invention relates to a rotor blade having a chord having a plurality of pultruded layers each having a length and width, a tip, and a rotor blade root. The invention also relates to a method for producing a rotor blade having a chord.

Rotor blades are, of course, well known in the prior art, particularly as components of wind turbines.

According to EP 2 778 393 A2, rotor blades usually consist of two half-shells that are glued together at their edges. Inside the rotor blade, two chords are arranged opposite to one another and connected to a main web. It is also conceivable that, in addition to the chord on the nose side and on the rotor blade trailing edge side, further belts with associated webs are arranged. Typically, the chords, in particular, consist of a plurality of pultruded layers laminated onto the inner side of the rotor blade shell. For cost reasons, the pultruded layers are substantially identical in construction. As the rotor blade tapers toward the tip, the pultrudates are sawn off in a tapering manner in the longitudinal direction. Chords produced in this manner are relatively costly in terms of material and are not optimally produced in terms of statics, as they contain too much material in their tip region.

WO 2010/034283 A2 describes a rotor blade with a chord whose width decreases in steps towards the tip and which is laminated onto the inner side of the rotor blade half shell in a protruding manner.

DE 10 2008 007 304 A1 describes a rotor blade for a wind turbine having a chord applied to the inner side of the rotor blade half shell, which protrudes into the interior of the rotor blade space on the inner side.

EP 2 341 239 A1 discloses a web for a wind turbine.

It is the object of the present invention to provide the aforementioned rotor blade having a chord which reduces the above disadvantages.

It is also the object of the invention to provide the aforementioned method, with which the rotor blade may be produced with a chord and which reduces the disadvantages mentioned above.

Surprisingly, the object may be solved by the aforementioned rotor blade having a tip and a rotor blade root, in which a chord is constructed from a plurality of pultruded layers and narrower pultruded layers extend closer to the tip in a longitudinal direction than wider pultruded layers.

Here, the narrower pultruded layer refers to a width of the pultruded layer that is narrower than the width of the wider pultruded layer. “Wider” and “narrower” refer to the widths of the pultruded layers in their relative proportions.

It has been shown that it is advantageous for the chords of a rotor blade if a width-to-thickness ratio of the chord is within predetermined limits, if possible even the same, over the entire longitudinal extent of the chord. The longitudinal direction corresponds to the longitudinal direction of the rotor blade and the longitudinal extension extends along the longitudinal direction. The width is perpendicular to the longitudinal direction.

The chord is particularly wide and thin at the rotor blade root, in an aerodynamic middle portion the belt is both wide and thick, and it tapers towards the tip and should also become thinner at the same time.

The rotor blade according to the invention solves this problem simply by providing a chord having a plurality of pultruded layers, and in the direction of the tip of the rotor blade, that is, in the tip region of the rotor blade, wider pultruded layers are formed shorter in a longitudinal direction than narrower pultruded layers. The invention uses the idea of arranging pultruded layers of different widths and lengths on top of one another, thus forming a taper and thinning in the direction of the tip.

In principle, pultrudate, due to it being only slightly flexible, is suitable for forming belts.

Preferably, wider pultruded layers extend more closely to the rotor blade root against the longitudinal direction than narrower pultruded layers.

In principle, the bending stiffness, which is increased by the chords, is high at the rotor blade root anyway, such that only thin cords are required in the region of the rotor blade root, while in the direction of the tip the taper is geometrically enforced.

Advantageously, each pultruded layer has a constant length and a constant width over its entire extent. A pultruded layer that is formed wider than another pultruded layer is preferably also formed shorter than the other pultruded layer.

Preferably, a maximum number of pultruded layers are first stacked on top of one another to form a chord, while the wider pultruded layers are preferably arranged on the rotor blade outer side and successively narrower pultruded layers or pultrudate layers of at most the same width are laid on the rotor blade inner side onto the pultruded layer on the rotor blade outer side. A step-pyramidal shape is created in preferably every cross-section. In the longitudinal direction to the tip, the pultruded layers are of different lengths. According to the invention, the wider pultruded layers are shorter than the narrower pultruded layers. As a result, the narrower pultruded layers extend closer to the tip in the longitudinal direction. Thus, it is possible to provide a chord that becomes narrower and thinner in the direction of the tip.

In the region of the rotor blade root, the inner and narrower pultruded layers are shorter than the outer and wider pultrudate layers.

Advantageously, in any cross-section of the rotor blade, the pultruded layers of the chord on the rotor blade outer side are wider than the pultruded layers of the chord on the rotor blade inner side. The statements on width always refer to a cross-section perpendicular to the longitudinal direction of the chord or rotor blade.

Advantageously, the arrangement of the pultruded layers is such that the narrower the pultruded layers are arranged in a cross-section, preferably in any cross-section, the narrower they become, or at most the same width they have, the more

they are arranged on the inside of the rotor blade, i.e., the narrower pultruded layers are arranged on the inside and the wider pultruded layers are arranged on the outside, such that a chord is produced which has a substantially staircase-pyramidal shape in a cross-section. This shape takes particular account of the loads on the chords, since the maximum loads on the chord occur on the rotor blade outer side, where the chord is also the widest, and the further one gets to the center chord of the rotor blade, the lower the loads acting on the chord. There the chord also becomes narrower.

Preferably, transverse edges of the pultruded layers are chamfered along their thickness. The length then changes along the thickness of the pultrudates. In this context, the term “transverse edge” is understood to mean the edge of the pultruded layer running perpendicularly or at an angle to the longitudinal direction, which terminates the pultruded layer towards the tip or the rotor blade root.

This allows the inner and longer pultruded layers to be laid continuously over the transverse edge. The inner pultruded layers are soft and guided with low curvature over the chamfered transverse edge.

Preferably, tip side transverse edges of the pultrudate are arranged perpendicular to the longitudinal direction. They can also be chamfered along the length. The length then changes along the width of the pultrudates. The distance to the tip is then determined by a closest or furthest point determined equally for all edges, or an average value of the edge.

Pultrudates of the same pultruded layer may reach the tip at different distances. Distances from the tip to the end of the pultrudate are then different. The pultrudates may form a longitudinal offset. Preferably, along the width of the pultruded layer, pultruded layers on the outer side are shorter than centrally arranged pultrudates of the pultruded layer. The pultrudates of a pultruded layer are particularly preferably of different lengths.

In this embodiment, pultruded webs on the rotor blade inner side are aligned with pultruded webs on the rotor blade outer side along their longitudinal edges on the

outside transverse to the longitudinal direction, at least in the portion of the longitudinal offset. The inside pultrudate webs should therefore not overhang laterally over the outside pultrudate web. The pultrudate web on the rotor blade inner side may also be narrower than the pultrudate web on the outside, which has already been narrowed by the longitudinal offset.

Preferably, the number of pultruded layers in a cross-section decreases towards the tip side. As the pultruded layers decrease, the chord becomes thinner towards the tip region. This thinning is combined with a narrowing of the associated pultruded layers.

Usually, pultruded products are produced as semi-finished products with a rectangular cross-section, which are made available in rolls. In principle, they have an endless length. They have a much greater width than thickness, such that they have a web character. The pultrudate is cut to the required length. The cut is preferably perpendicular to the longitudinal direction. However, it can also be made at an angle, i.e., at an angle to the longitudinal direction.

Subsequent overlamination of the pultruded layers and manufacture of the chords in this manner results in no or only small cavities or air inclusions within the chords. For this purpose, the pultrudate is conveniently laminated together in a vacuum infusion process. The vacuum created in the vacuum infusion process causes the pultruded layer on the rotor blade inner side to be sucked onto the chamfered pultruded layer on the rotor blade outer side, such that it makes contact with the pultruded web on the rotor blade outer side over the entire chamfer and may be laminated to form a chord without air inclusions.

In this preferred embodiment of the invention, the pultrudates are not only stacked on top of one another, but also arranged adjacent to one another. Thus, each of the pultruded layers is formed by preferably at least two, three or any higher number of pultrudates arranged adjacent to one another. This embodiment of the chord has the advantage that pultrudates of the same width may be used to form a pultruded layer of greater width by laying them adjacent to one another, and

pultruded layers of different widths may be formed by laying a different number of pultruded layers adjacent to one another. The pultruded layers may thus be produced cost-effectively, since only one specific type of pultrudate having a specified width and thickness is ever used. There is no need to produce and use different pultrudates of different widths for the chord.

Particularly preferably, a pultruded layer rotor blade outer side has a first number of pultrudates arranged adjacent to one another and a middle pultruded layer has a second number of pultrudates arranged adjacent to one another, and a pultrudate layer on the rotor blade inner side has a third number of pultrudates arranged adjacent to one another in a cross-section along the width of the pultruded layer, the first number being greater than the second number and the second number being greater than the third number. Of course, two or four or more pultruded layers are also conceivable, to which the number of pultruded layers then refers accordingly.

It is also conceivable that cores of sandwich components, for example balsa or foam, may be arranged along the longitudinal direction of the pultruded layers, which are then overlaminated with the pultruded layers.

The cores may be applied internally to outer pultruded layers to align with inner pultruded layers and form a rectangular chord cross-section. The rectangular chord cross-section increases the buckling stiffness of the rotor blade after lamination.

The cores may also be located adjacent to the pultruded layers and be thicker than the chord, preferably the cores are as thick as the core of the sandwiched rotor blade shell. This creates a steady transition from the chord to the rotor blade shell surrounding it.

The object is solved in its second aspect by a method having the features of claim 11.

The method is suitable for the production of one of the above rotor blades. Conversely, any of the above rotor blades may be produced by any of the following methods.

According to the invention, a narrower pultruded layer on the rotor blade inner side is placed on a wider pultruded layer on the rotor blade outer side and the pultruded layer on the rotor blade inner side is extended in a longitudinal direction beyond the pultruded layer on the rotor blade outer side to the tip.

A pultruded layer on the rotor blade inner side is advantageously placed on the pultruded layer on the rotor blade outer side in the direction of the rotor blade root, which extends in the opposite longitudinal direction beyond the pultruded layer on the rotor blade inner side to the rotor blade root. The pultruded layer on the rotor blade inner side is therefore longer in the tip region than the pultruded layer on the rotor blade outer side and preferably narrower, and shorter and narrower in the rotor blade root region than the pultruded layer on the rotor blade outer side.

Finally, the pultruded layers are overlaid on the inside of the rotor blade by a scrim, a woven fabric, a nonwoven fabric or a combination of the aforementioned materials, and then infused with a resin and formed into a solid laminate.

The pultruded layers are preferably formed by a plurality of pultrudates arranged adjacent to one another, each extending in the longitudinal direction.

Preferably, a first number of pultrudates of equal width are arranged adjacent to one another to form pultruded layer on the rotor blade outer side in the portion on the rotor blade root side. The first number of equal-width pultrudates is also preferably of equal in length, and a third number of equal-width pultrudates is laid over the pultruded layer on the rotor blade outer side and is laid beyond the portion on the rotor blade root side into a portion on the tip side. Preferably, the pultruded layer on the rotor blade outer side does not extend beyond the portion on the rotor blade root side, but ends in the portion on the rotor blade root side, while the pultruded layer on the rotor blade inner side is laid further in the longitudinal direction into the portion on the tip side. Conveniently, the pultruded layer on the rotor blade outer side is wider but shorter than the pultruded layer on the rotor blade inner side, which is narrower but longer.

Preferably, not only two, but three, four or a higher number of pultruded layers are placed on top of one another, which successively run out to the tip one after the other. This results in a steadily tapering behavior of the chord.

The pultruded layers themselves may each be formed from one pultrudate or, more advantageously, from a different number of pultrudates, preferably of equal width. This is particularly cost-effective.

The longitudinal sides of the pultruded layers may be terminated by cores of sandwich components; this firstly gives the belts a rectangular cross-sectional shape and secondly adapts them to the thickness of the rotor blade shells in the sandwich area.

The invention is described with reference to examples of embodiments in ten figures. In the drawings:

Fig. 1 is a schematic view of a strand drawing machine for the production of pultrudates,

Fig. 2 is a schematic top view of a chord in a first embodiment,

Fig. 2a is a cross-sectional view along line 2a in Fig. 1,

Fig. 2b is a cross-sectional view along line 2b in Fig. 2,

Fig. 3 is a top view of a chord in a second embodiment,

Fig. 3a is a cross-sectional view along line IIIa-IIIa in Fig. 3,

Fig. 3b is a cross-sectional view along line IIIb-IIIb in Fig. 3,

Fig. 3c is a cross-sectional view along line IIIc-IIIc in Fig. 3,

Fig. 3d is a cross-sectional view along line IIId-IIId in Fig. 3,

Fig. 4 is a cross-sectional view along line IIIb-IIIb in a second embodiment with sandwich cores.

A strand drawing machine shown in Fig. 1 is used for strand drawing of a fiber-reinforced plastic profile, in which the plastic in the form of a resin is accumulated around fibers and or mats. Such plastic profiles are also called pultrudates 1. The individual fibers 2 are unwound as glass fibers, carbon fibers from preferably vertically mounted fiber spindles 3. The fibers 2, together with reinforcing materials and mats 4 or nonwovens arranged on corresponding, preferably horizontally mounted rolls 6, may be fed together as a bundle to a resin trough and preform station 7. It is preferably provided that the fibers 2 are arranged unidirectionally only. However, it may also be provided that only the fibers 2 or only the mats 4 or nonwovens are used as reinforcing material of the pultrudates 1.

In the strand drawing machine shown in Fig. 1 for the production of pultrudates 1, both fibers 2 and mats 4 are used to reinforce pultrudates 1. The mats 4 and fibers 2 are first pulled through the resin trough and preform station 7. In the process, liquid resin accumulates around the fibers 2. The resin deposited around the fibers 2 is drawn into a curing tool 8 together with the fibers 2 and the mats 4. A forming die is provided in the curing tool 8, which preferably gives the pultrudates 1 the desired cross-sectional shape in terms of width and thickness. The cross-section of the pultrudates 1 is constant over the entire longitudinal extension corresponding to the drawing direction. The cross-section of the pultrudates 1 is rectangular. However, the pultrudates 1 may also assume a plate-like or strip-like shape.

In the curing tool 8, the resin material is cured by applying heat to the resin, which may be a two-component system. The drawing speed and the heat are coordinated in such a manner that the pultrudate has reached its final strength and is cured after leaving the curing tool 8, and no further crosslinking of the resin occurs even by subsequent heating.

In principle, the pultrudate is an endless strand drawn part which is continuously pulled out of the curing tool 8 by means of a drawing tool 11 and may then be cut to a desired length in a sawing machine 12. However, it is also conceivable that the pultrudate 1 is wound onto a roll in one piece and supplied for further use. Particularly when provided in rolls, the pultrudates 1 usually have widths of up to

one meter and thicknesses of one millimeter to five millimeters. The pultrudates 1 are used to form chords in rotor blades according to the invention. Of course, other uses of pultrudates 1 are also possible.

For example, the rotor blade has two chords 20 that face one another in an interior of the rotor blade and that are laminated onto the inner sides of rotor blade half shells facing one another. A main web runs between the two chords 20. The further structure of the rotor blade will not be described in detail herein, since the invention refers to conventional rotor blades with regard to the structure of the rotor blade. The chords 20 extend from a rotor blade root 31 into a tip region of the rotor blade.

Expediently, the thickness to width ratio of the chord 20 is approximately constant along a longitudinal direction L of the rotor blade corresponding to the longitudinal direction L of the chord. It advantageously moves at least within predetermined barriers.

In the tip region, however, the rotor blade becomes increasingly narrower, such that conventionally the wide pultrudates are chamfered towards the tip region, and such that the width of the pultrudates towards the tip region becomes increasingly narrower. For this purpose, pultrudates are conventionally sawn off at an angle.

According to the invention, the chord 20 tapering in width towards the tip region is provided by arranging the pultrudates 1 either in different widths B and lengths L one above the other, or by arranging the pultrudates 1 of the same width B or different widths B and different lengths L adjacent to one another and one above the other, such that the chord 20 formed out of them tapers towards the tip region.

Figs. 2, 2a and 2b show a first embodiment of the chord 20 according to the invention. The chord 20 comprises three pultruded layers 21, 22, 23.

The chord 20 shown in a top view in Fig. 2 has a rotor blade root side portion 25, a middle portion 26, and a tip side portion 27. The chord 20 becomes progressively narrower from a rotor blade root to a tip. Here, the width B of the chords 20

decreases in two steps. In other embodiments, higher numbers of steps are of course also possible.

Fig. 2a shows a cross-section of the chord 20 in the rotor blade root side portion 25. In the cross-section, the chord 20 has a wide pultruded layer 21 on the rotor blade outer side consisting of four individual pultrudates 211, 212, 213, 214, each of which may be produced by way of example in a strand drawing machine as shown in Fig. 1. A narrower, middle pultruded layer 22, consisting of three individual pultrudates 221,222, 223, and an even narrower pultruded layer 23 on the rotor blade inner side, consisting of two pultrudates 231, 232, form together with the pultruded layer 21 on the rotor blade outer side the chord 20. The pultrudates 211, 212, 213, 214, 221, 222, 223, 231, 232 of the pultruded layers 21, 22, 23 are formed with an identical width B within the pultruded layers 21, 22, 23, but also between the pultruded layers 21, 22, 23.

The pultrudates 211, 212, 213, 214, 221, 222, 223, 231, 232 may therefore advantageously be produced by a single strand drawing machine as shown in Fig. 1 and need only be cut to length L as shown in Fig. 2 to form chord 20.

A review of Fig. 2 shows that the pultruded layer 21 on the rotor blade outer side has a first width B_1 and a first length L_1. The middle pultruded layer 22 has a second width B_2 and a second length L_2, while the pultruded layer 2 on the rotor blade inner side has a third width B_3 and a third length L_3. Here, the first width B_1 is greater than the second width B_2 and the latter is greater than the third width B_3, while the third length L_3 is greater than the second length L_2 and the latter is greater than the first length L_1. The wide pultruded layers are shorter than the narrow pultruded layers.

Fig. 2b shows a section in the middle portion 26 of the belt 20. The pultruded layer 21 on the rotor blade outer side has already run out in the middle portion 26, i.e., is no longer present. In the middle portion 26, only the middle pultruded layer 22 as well as the pultruded layer 23 on the rotor blade inner side having three pultrudates 221, 222, 223 and respectively two individual pultrudates 231, 232 are

still present. In the middle portion 26, however, the middle pultruded layer 22 is arranged, on the rotor blade outer side, directly on the rotor blade shell.

A section in the tip side portion, which is not shown, would still consist only of the pultruded layer 23 on the rotor blade inner side having the two pultrudates 231, 232.

By arranging pultrudates 211, 212, 213, 214, 221, 222, 223, 231, 232 of the same width next to one another and arranging pultrudates 211, 212, 213, 214, 221, 222, 223, 231, 232 of different lengths L one above the other, it is possible to produce a chord 20 which has a width B tapering towards a tip 30 and at the same time a thickness D decreasing towards the tip 30, such that the aforementioned ratio of width B to thickness D does not remain constant, but is nevertheless within predetermined limit values.

In the embodiment according to Fig. 2, the pultruded layer 23 on the rotor blade inner side is not located centrally above the pultruded layer 23 on the rotor blade outer side and the middle pultruded layer 22 along the width B, but is offset towards one longitudinal side. The displacement d between the middle lines of the pultruded layer 21 on the rotor blade outer side and the middle pultruded layer 22 toward the pultruded layer 23 on the rotor blade inner side is shown by the deviation of the dashed central line from the solid middle line.

It is also conceivable that the middle pultruded layer 22 is arranged offset from and on top of the pultruded layer 21 on the rotor blade outer side in order to curve the chord 20 in the depth direction.

To produce the chord 20 according to Fig. 2, only one type of pultrudate is required.

Fig. 3 shows a second embodiment of the chord 20 according to the invention, which also has a width B decreasing towards the tip side end and also a thickness D decreasing towards the tip side end. Thickness D in this context means, in cross-section, a maximum thickness of chord 20 along a middle line in the longitudinal direction.

As in the first embodiment, the chord 20 comprises the rotor blade root side portion 25, the middle portion 26, and the tip side portion 27. In the rotor blade root side portion 26, four pultruded layers 21, 21a, 22, 23 are now stacked on top of one another, as shown by the cross-section along line IIIa-IIIa in Fig. 3.

Two pultruded layers 21, 21a on the rotor blade outer side each comprise a single pultrudate 211, 211a of the first width B_1 as well as a single middle pultrudate 221 of the second width B_2 arranged on the rotor blade inner side on the two pultruded layers 21, 21a on the rotor blade outer side, and the pultruded layer 23 on the rotor blade inner side also comprises a single pultrudate 231 of the third width B_3 arranged on the middle pultruded layer 23 on the rotor blade inner side. Here, the first width B_1 is greater than the second width B_2 and the second width B_2 is greater than the third width B_3.

Fig. 3 shows that each of the four pultruded layers 21, 21a, 22, 23 is formed by a single continuous pultrudate 211, 211a, 221, 231. The two pultrudates 211, 211a on the rotor blade outer side have the same first width B_1, and the pultrudate 211 on the rotor blade outer side has a length L'_1, and the pultrudate 211a on the rotor blade outer side has a first length L_1. The middle pultrudate 221 has a second width B_2 and a second length L_2, and pultrudate 231 on the rotor blade inner side has a third width B_3 and a third length L_3. The first width B_1 is larger than the second width B_2. The second width B_2 is larger than the third width B_3. The same applies to the lengths, with length L'_1 being shorter than the first length L_1.

In a tip side portion 25a of the rotor blade root side portion 25, the chord 20 still has the first width B_1, but the thickness D of the chord 20 is reduced in that the chord 20 there now has only three of the pultruded layers 21a, 22, 23, with the pultruded layer 21a on the rotor blade outer side having the first width B_1, the middle pultruded layer 22 having the second width B_2, and the pultruded layer 23 on the rotor blade inner side having the third width B_3. In a section along line IIIc-IIIc, the width of the chord 20 is reduced to the second width B2 by the fact that the pultruded layer 21a on the rotor blade outer side has run out, and the thickness D is reduced because the chord 20 there consists of only two pultruded

layers 22, 23, namely the middle pultrudate 221 and the pultrudate 231 on the rotor blade inner side. Towards the tip 30, the middle pultruded layer 22 also extends at the end of the central portion 26, and the tip side portion 27 of the chord 20 is formed only by the pultruded layer 23 on the rotor blade inner side. The four pultruded layers 21, 21a, 22, 23 are formed by three pultrudates of different widths 211, 211a, 221, 231, three different strand drawing methods are therefore required to produce the chord 20 in accordance with the second embodiment.

Fig. 3d shows a cross-section along line IIId-IIId in the longitudinal direction L of chord 20. In particular, it can be seen that the tip side ends of the two pultrudates 211, 211a on the rotor blade outer side are chamfered very shallowly. Here, the chamfer corresponds to a ratio of 100:1, i.e., a height of one millimeter is chamfered over 100 mm. This allows the other pultrudate 211a on the rotor blade outer side extending on the pultrudate 211 on the rotor blade outer side along a chamfer 32 to follow the chamfer 32. Although pultrudates 1 are cured components, they are quite flexible and may therefore follow the flat chamfer 32 in particular, as well as another flat chamfer 33.

In Fig. 4, it is shown that the chord 20 according to the invention has the shape of a step pyramid in cross-section. Cores 36 of sandwich components in the form of balsa wood or foam may be arranged laterally on longitudinal sides of the pultrudates 211a, 221, 231 over their entire longitudinal extent. The width of the cores 26 corresponds to the projection of the pultrudate 211a on the rotor blade outer side or the middle pultrudate 221 relative to the middle pultrudate 221 lying on it or respectively the inner pultrudate 231 on the rotor blade inner side. A thickness D of the cores 26 may be such that it does not exceed the thickness D of the chord 20 as shown on the right side in Fig. 4.

However, other thicknesses D of the cores 26 are also conceivable, which are shown on the left side in Fig. 4. There, the thickness of the core 36 is selected such that it continuously brings the thickness of the chord to a thickness of the sandwich core of the rotor blade shell surrounding the chord. The left core 36 has

a height equal to the height of the sandwich core of the rotor blade shell, and the chamfered core 36 continuously transfers a thickness of the chord to the thickness of the rotor blade shell.

Constructions of pultruded layers in the first and second embodiments have in common that the pultrudates 211, 211a, 212, 213, 214, 221, 222, 223, 231, 232 of the chords 20 are overlaid with a fiber, fabric and/or scrim layer after being applied to the rotor blade shell. For this purpose, they are preferably placed on a fiber, fabric and/or scrim layer lying on the rotor blade inner shell. The chord 20 is thus arranged simultaneously between two fabric layers. Those may be infused with a resin system in a vacuum infusion method such that the pultrudates 211, 211a, 212, 213, 214, 221, 222, 223, 231, 232 are, on the one hand, bonded to one another and, on the other hand, bonded in particular onto the inner side of the rotor blade half shell. These are conventional infusion methods that will not be described further herein.

List of Reference Signs

1	pultrudate
2	fibers
3	fiber spindles
4	mats
6	rolls
7	preform station
8	curing tool
11	drawing tool
12	sawing machine
20	chord
21	pultruded layer
21a	pultruded layer
22	pultruded layer
23	pultruded layer
25	rotor blade root side portion

25a	tip side portion of the portion on the rotor blade root side
26	middle portion
27	tip side portion
30	tip
31	rotor blade root
32	chamfer
33	chamfer
36	cores
211	pultrudate
211a	pultrudate
212	pultrudate
213	pultrudate
214	pultrudate
221	pultrudate
222	pultrudate
223	pultrudate
231	pultrudate
232	pultrudate
d	displacement
B	width
B_1	first width
B_2	second width
B_3	third width
D	thickness
L	length/longitudinal direction
L_1	first length
L'1	length
L_2	second length
L_3	third length

PATENTKRAV

1. Rotorblad med en flange (20) med en flerhed af pultrusionsprofillag (21, 21a, 22, 23) hver især med en længde (L) og en bredde (B), en spids (30) og en rotorbladrod (31),

kendetegnet ved, at smallere pultrusionsprofillag (22, 23) i en længderetning (L) når længere hen mod spidsen (30) end bredere pultrusionsprofillag (21, 21a), og at der på indvendige flader på rotorbladets inderside af pultrusionsprofiler (211a, 221) er påført kerner (36) af sandwichkomponenter, og at kernerne har en tykkelse (D), der medfører, at en tykkelse af flangen (20) hele tiden svarer til en tykkelse af sandwichkernen, der omgiver flangen (20), på en rotorbladskal.

2. Rotorblad ifølge krav 1,

kendetegnet ved, at bredere pultrusionsprofillag (21, 21a) når længere hen til rotorbladroden (31) end smallere pultrusionsprofillag (22, 23).

3. Rotorblad ifølge krav 1 eller 2,

kendetegnet ved, at pultrusionsprofillag (21, 21a) på rotorbladets yderside er udformet bredere end pultrusionsprofillag (23) på rotorbladets inderside.

4. Rotorblad ifølge krav 2,

kendetegnet ved, at pultrusionsprofillagene (21, 21a), der i ethvert tværsnit i længderetningen L af rotorbladet befinder sig på rotorbladets yderside, på flangen (20) er udformet bredere end pultrusionsprofillagene (23) på rotorbladets inderside.

5. Rotorblad ifølge et af kravene 1 til 4,

kendetegnet ved, at pultrusionsprofillagene (21a, 21, 22, 23) i et tværsnit bliver desto smallere eller højst har den samme bredde (B), jo mere de er placeret på rotorbladets inderside.

6. Rotorblad ifølge et af kravene 1 til 5,

kendetegnet ved, at pultrusionsprofillagene (21, 22, 23) langs et tværsnit er dannet af mindst to ved siden af hinanden liggende pultrusionsprofiler (211, 212, 213, 214, 221, 222, 223, 231, 232).

7. Rotorblad ifølge et af de foregående krav,

kendetegnet ved, at et antal pultrusionsprofillag (21, 21a, 22, 23) i et tværsnit i længderetningen (L) aftager hen mod enden ved spidsen og/eller hen mod enden ved rotorbladroden.

8. Rotorblad ifølge et af de foregående krav,

kendetegnet ved, at tværgående kanter på pultrusionsprofillagene (21, 21a, 22, 23) er udformet således, at de ved en ende ved spidsen og/eller roden skråner hen mod rotorbladets yderside.

9. Rotorblad ifølge et af de foregående krav,

kendetegnet ved, at forskellige pultrusionsprofiler (211, 212, 213, 214, 221, 222, 223, 231, 232) i samme pultrusionsprofillag (21, 22, 23) nærmer sig spidsen (30) i forskellige afstande.

10. Rotorblad ifølge et af de foregående krav,

kendetegnet ved, at et pultrusionsprofillag (21) på rotorbladets yderside indeholder et første antal af pultrusionsprofiler (211, 212, 213, 214), der er placeret ved siden af hinanden, og et midterste pultrusionsprofillag (22) indeholder et andet antal af pultrusionsprofiler (221, 222, 223), og et pultrusionsprofillag (23) på rotorbladets inderside indeholder et tredje antal af pultrusionsprofiler (231, 232) i et tværsnit, og at det første antal er større end det andet antal, og det andet antal er større end det tredje antal.

11. Fremgangsmåde til fremstilling af et rotorblad med en flange, hvor

et smallere pultrusionsprofillag (23) på rotorbladets inderside lægges på et bredere pultrusionsprofillag (21) på rotorbladets yderside, og det smallere

pultrusionsprofillag (23) på rotorbladets inderside i en længderetning (L) strækker sig forbi pultrusionsprofillaget (21) på rotorbladets yderside og hen til spidsen (30), og der ved længdekanter på pultrusionsprofillag (21, 21a, 22, 23) placeres kerner (36) af sandwichkomponenter, og kernerne (36) udformes med en tykkelse (D), der medfører, at en tykkelse af flangen (20) kommer til at svare til en tykkelse af sandwichkernen, der omgiver flangen (20), i en rotorbladskal.

12. Fremgangsmåde ifølge krav 11,

kendetegnet ved, at tværgående kanter på pultrusionsprofillag affases ved enden ved spidsen og/eller ved enden ved rotorroden.

13. Fremgangsmåde ifølge krav 11 eller 12,

kendetegnet ved, at det smallere pultrusionsprofillag (23) på rotorbladets inderside lægges på det bredere pultrusionsprofillag (21) på rotorbladets yderside, og det bredere pultrusionsprofillag (21) på rotorbladets yderside strækker sig modsat længderetningen (L) forbi pultrusionsprofillaget (23) på rotorbladets inderside og hen til rotorbladroden (31).

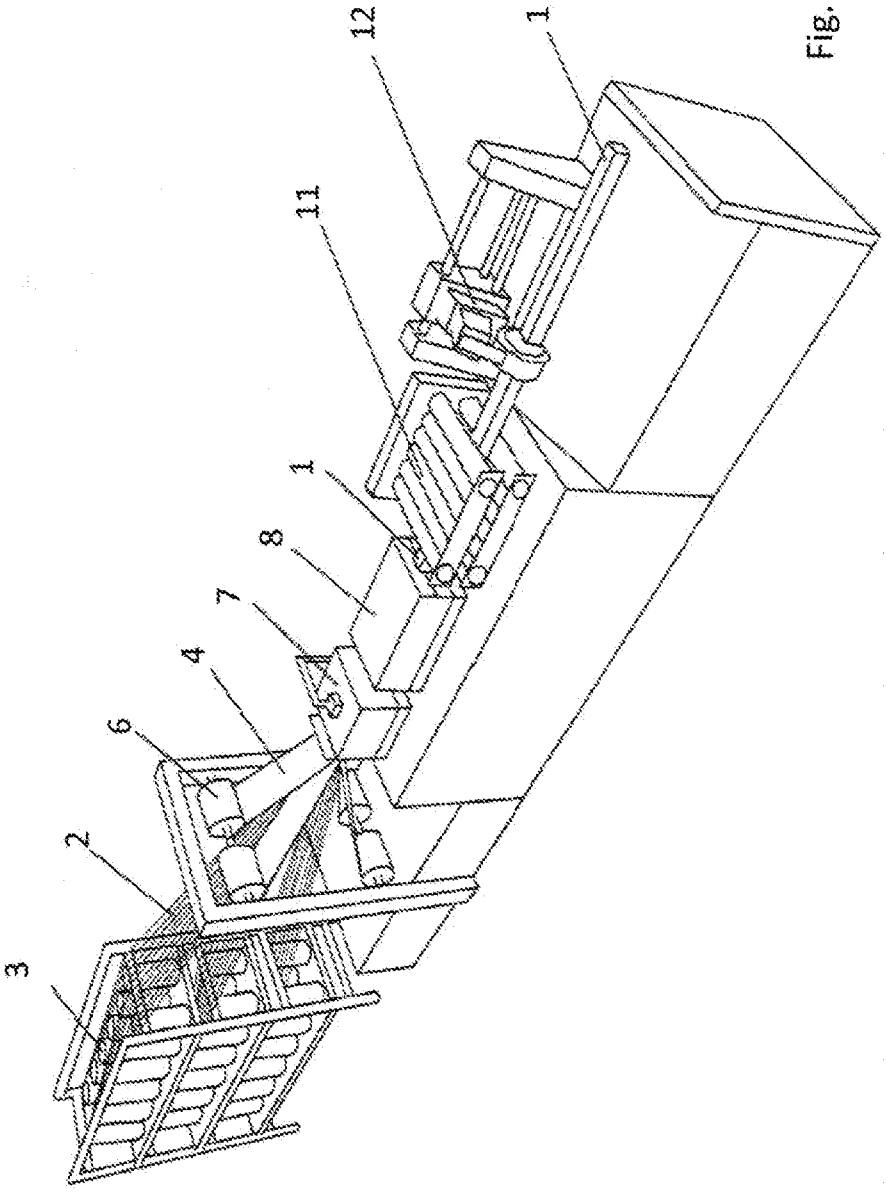

Fig. 1

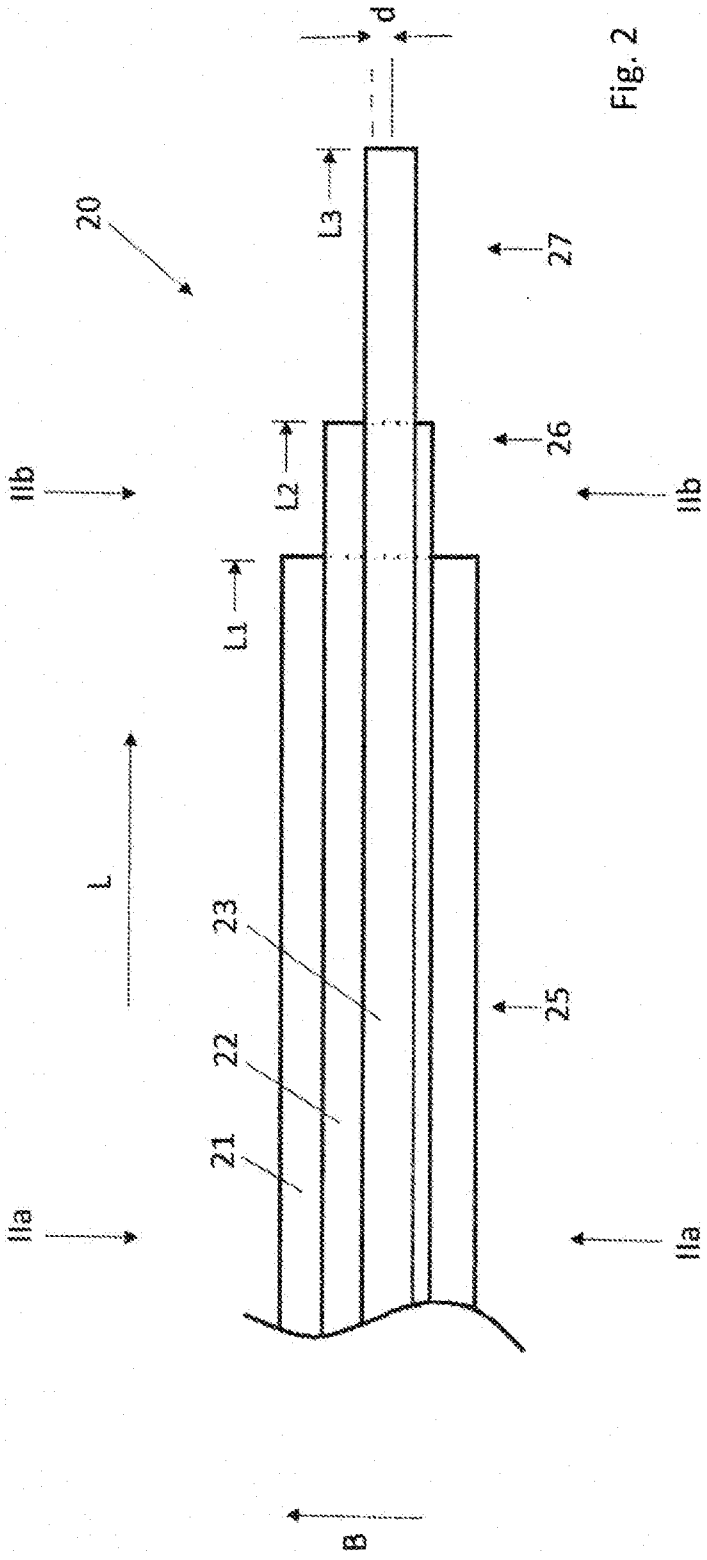

Fig. 2

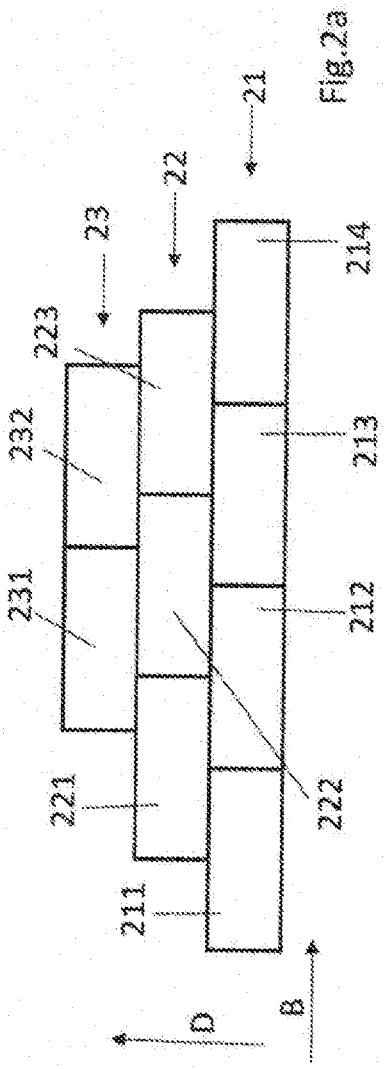
21
22
23
214
213
212
211
223
232
231
221
222
D
B

Fig.2a

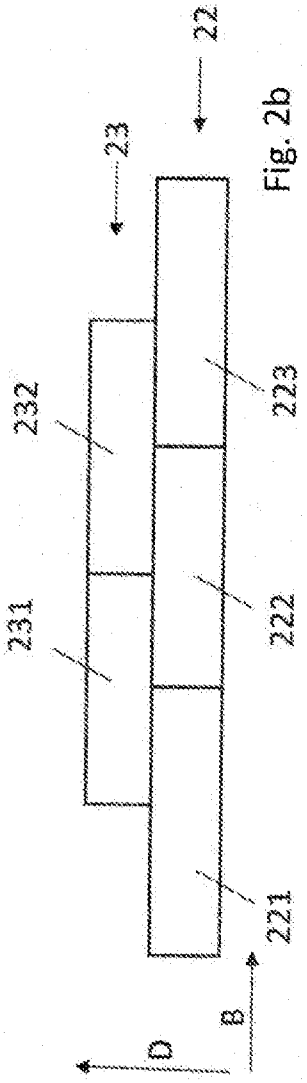
22
23
223
232
231
222
221
D
B

Fig. 2b

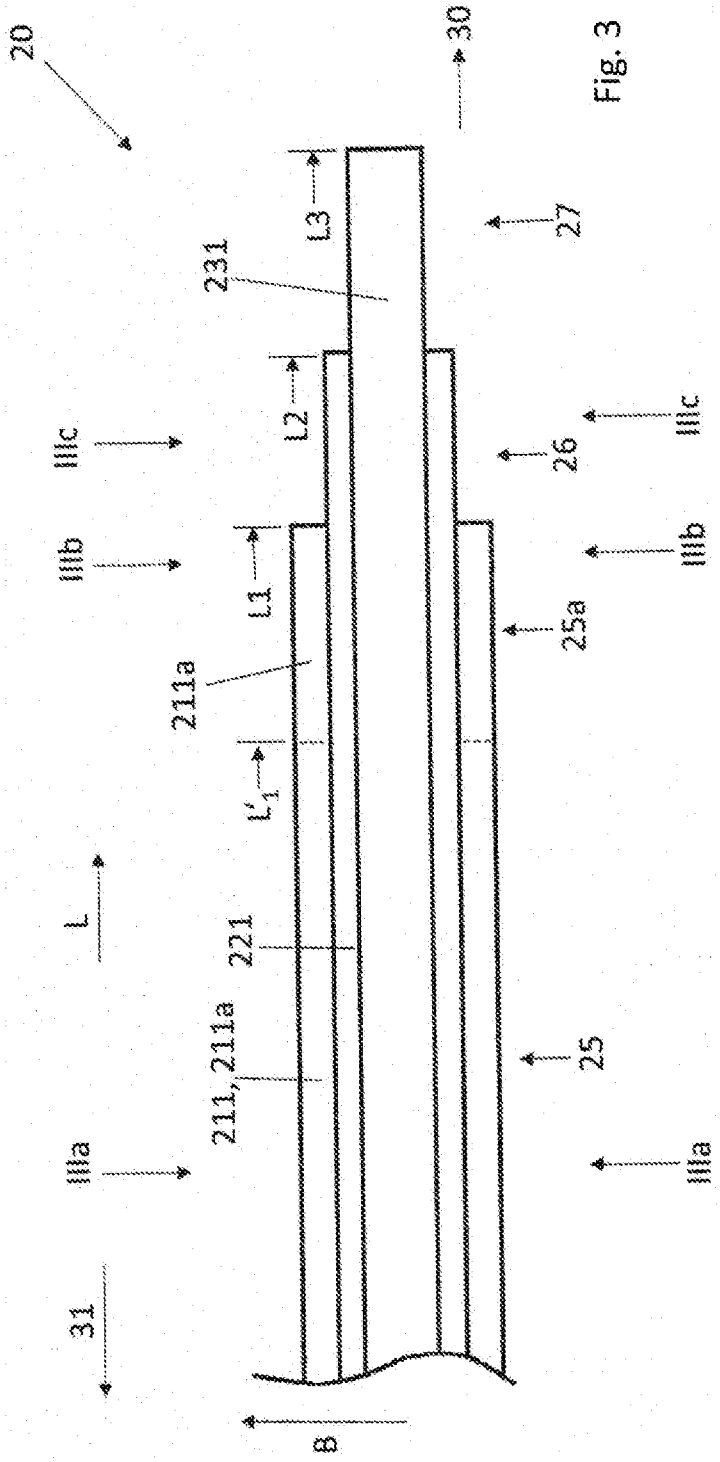
20
30
27
231
L3
L2
IIIc
IIIb
L1
211a
L'1
L
221
211, 211a
IIIa
31
B
26
25a
25

Fig. 3

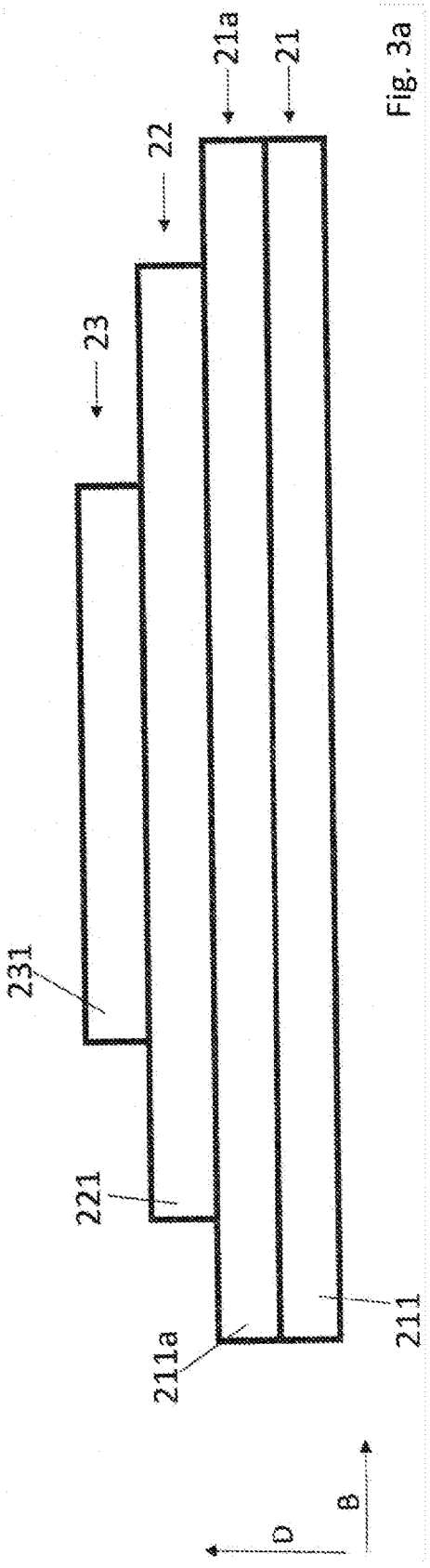

Fig. 3a

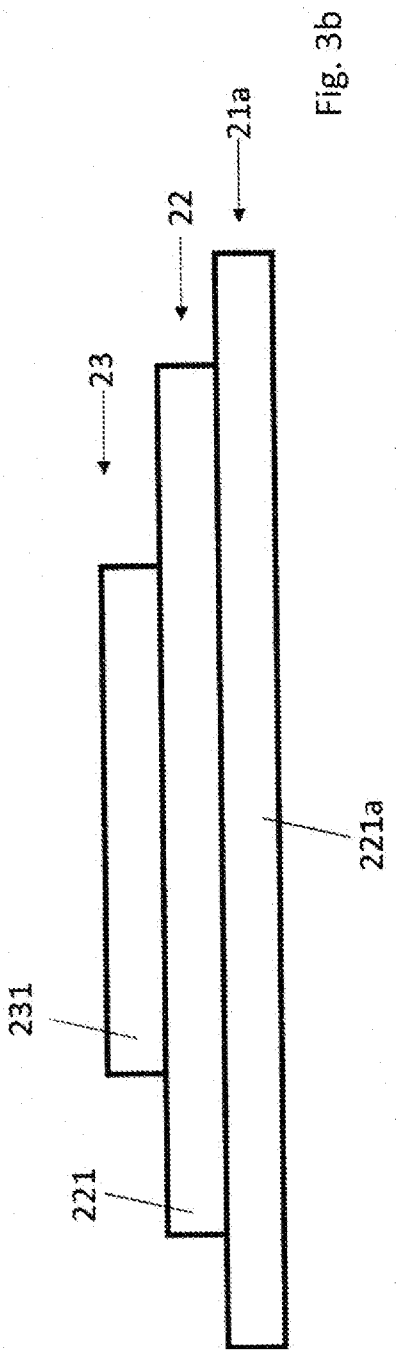

Fig. 3b

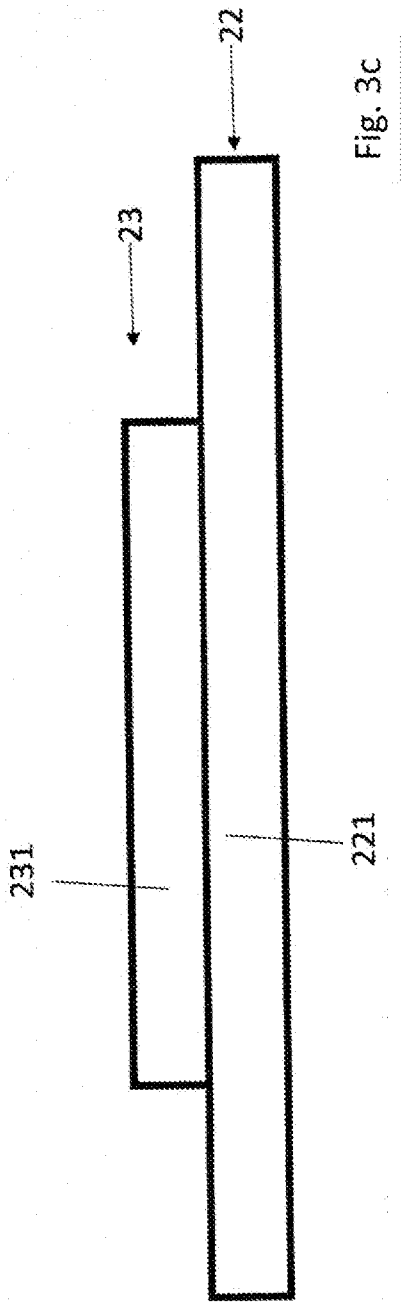

Fig. 3c

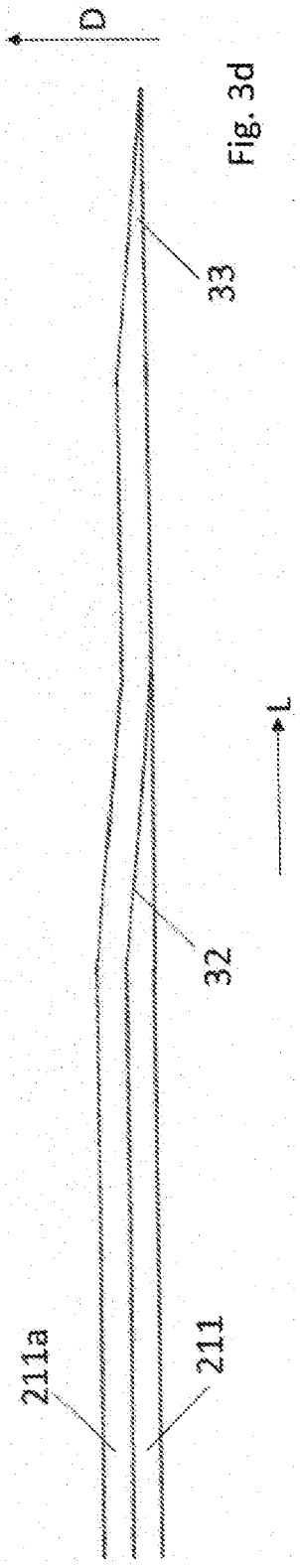

Fig. 3d

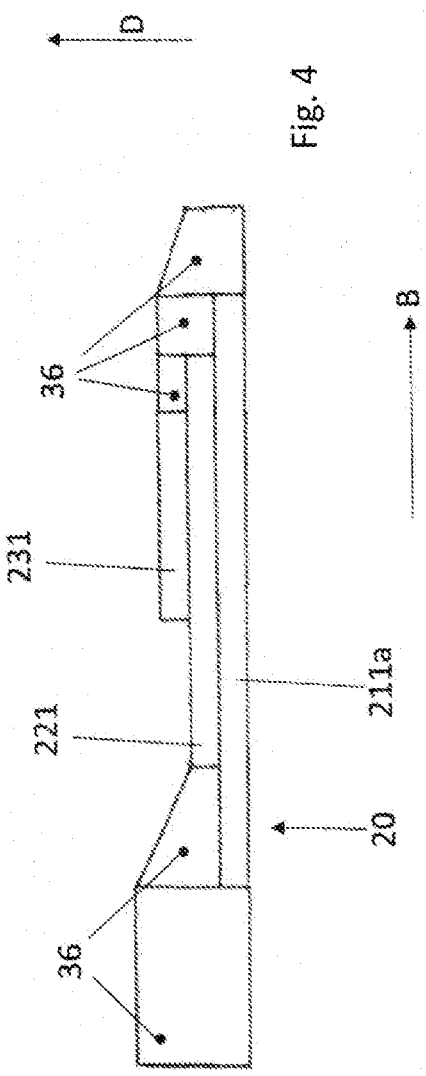

Fig. 4