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Habermacher

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(54) **BICYCLE WHEEL**

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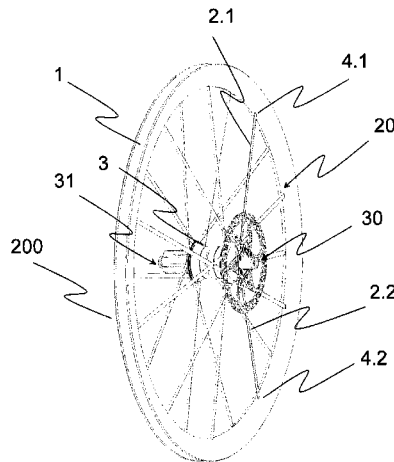
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(57) **ABSTRACT**

A method is provided for producing a bicycle wheel made of a fiber composite material, including laminating, in one piece and in one step, a rim, a plurality of spokes each including a first spoke section and a second spoke section, and a center having a first center disc and a second center disc, wherein all fibers for the rim, the spokes, and the center are laid in mold parts in the one step; curing the laminated rim, spokes, and center to form the bicycle wheel; and removing the formed bicycle wheel in said one piece from the mold, wherein the spokes are laminated and cured such that the first spoke section and the second spoke section have a substantially straight shape.

3 Claims, 13 Drawing Sheets



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B29L 31/30 (2006.01)
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(2013.01)

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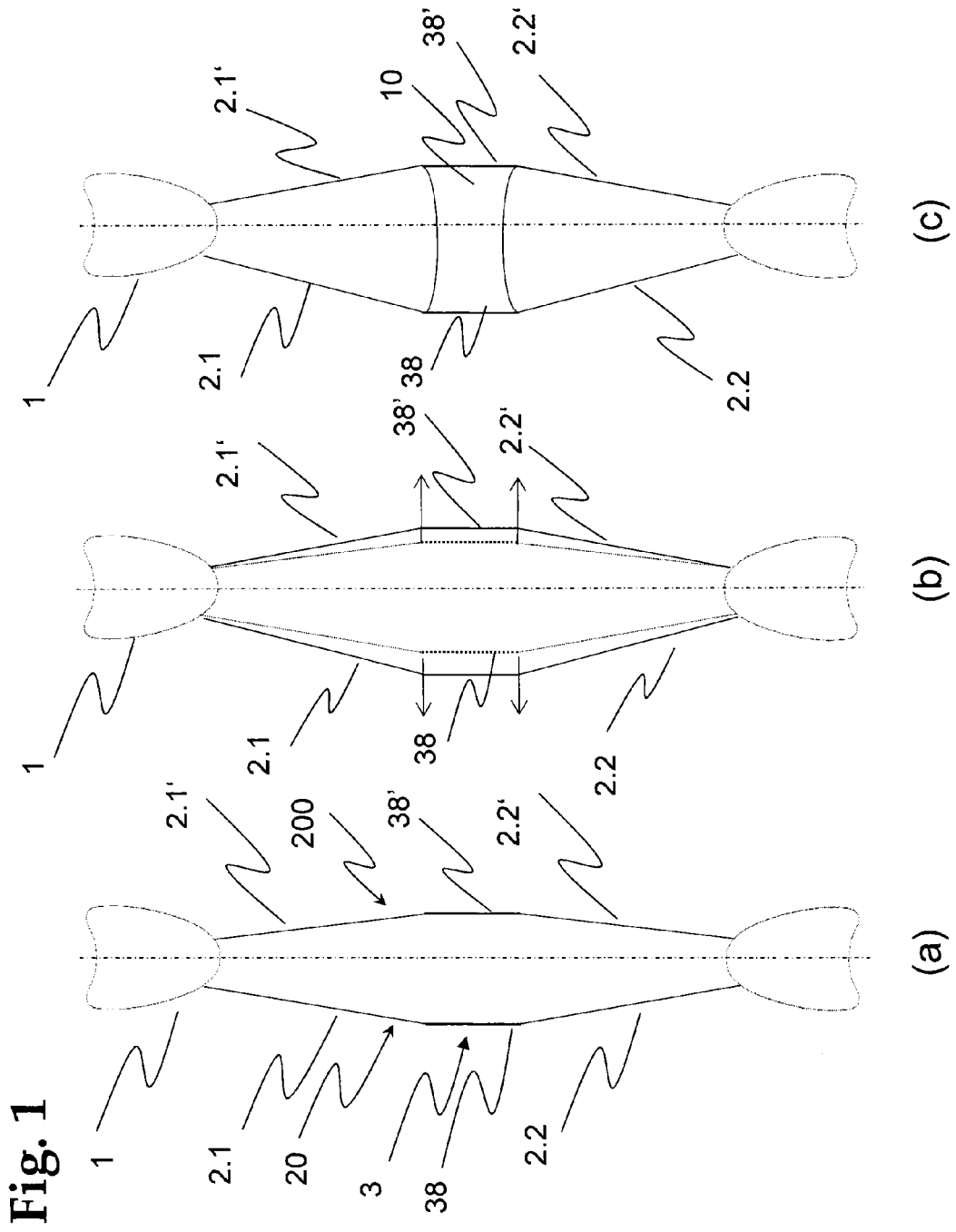
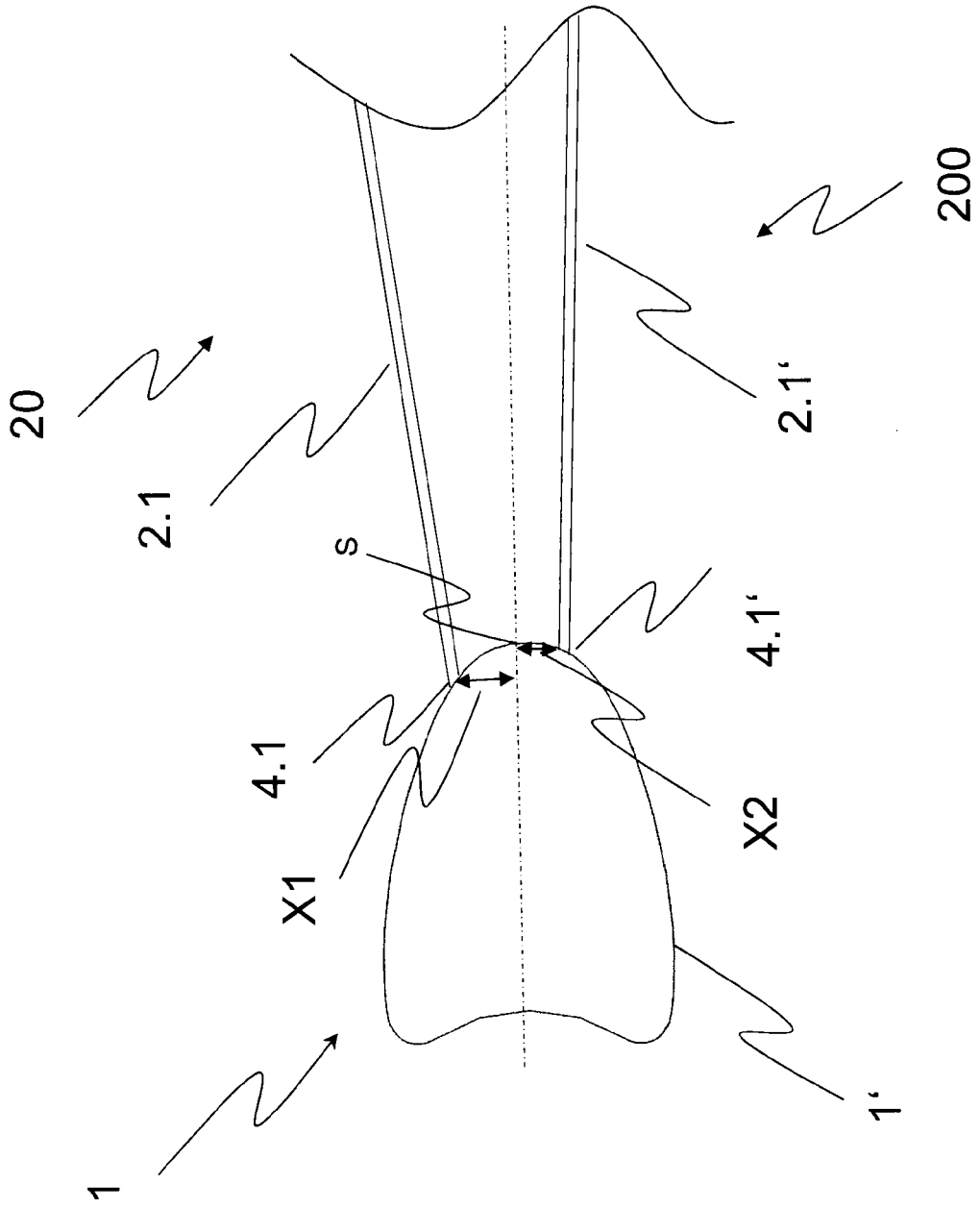


Fig. 2



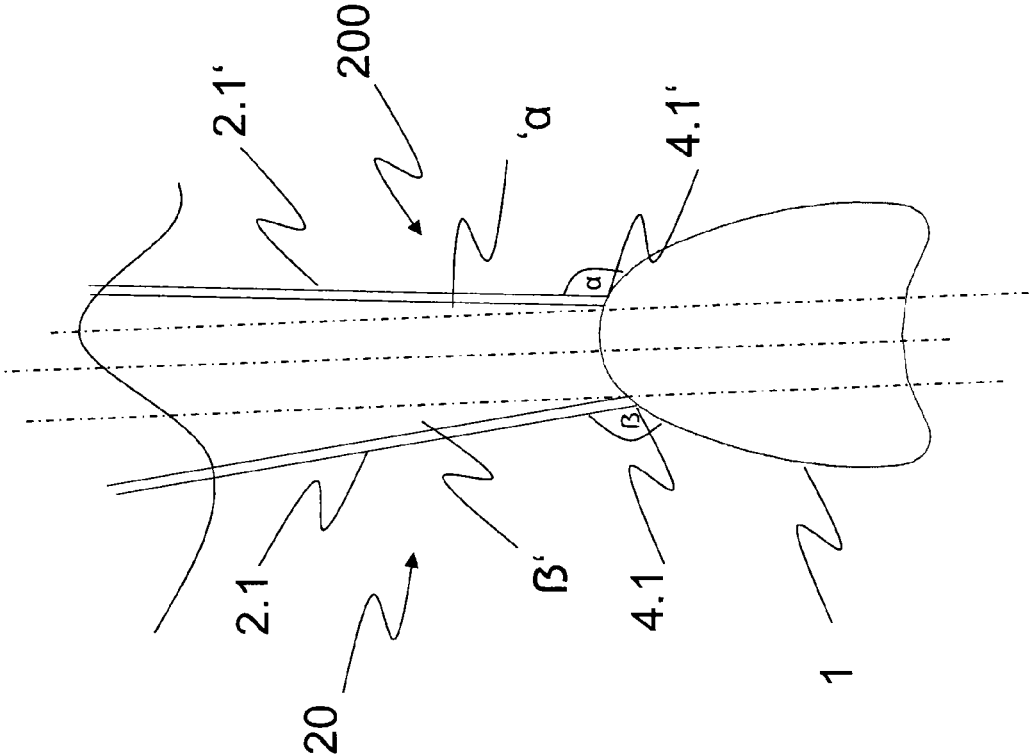


Fig. 3

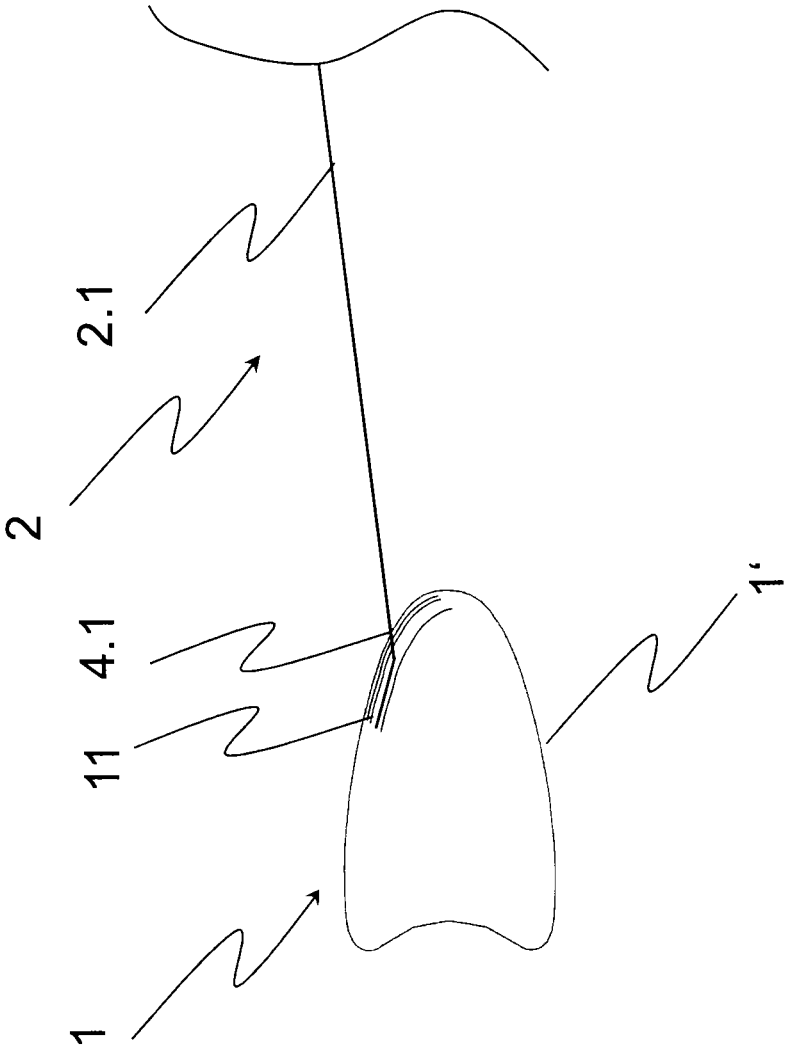


Fig. 4

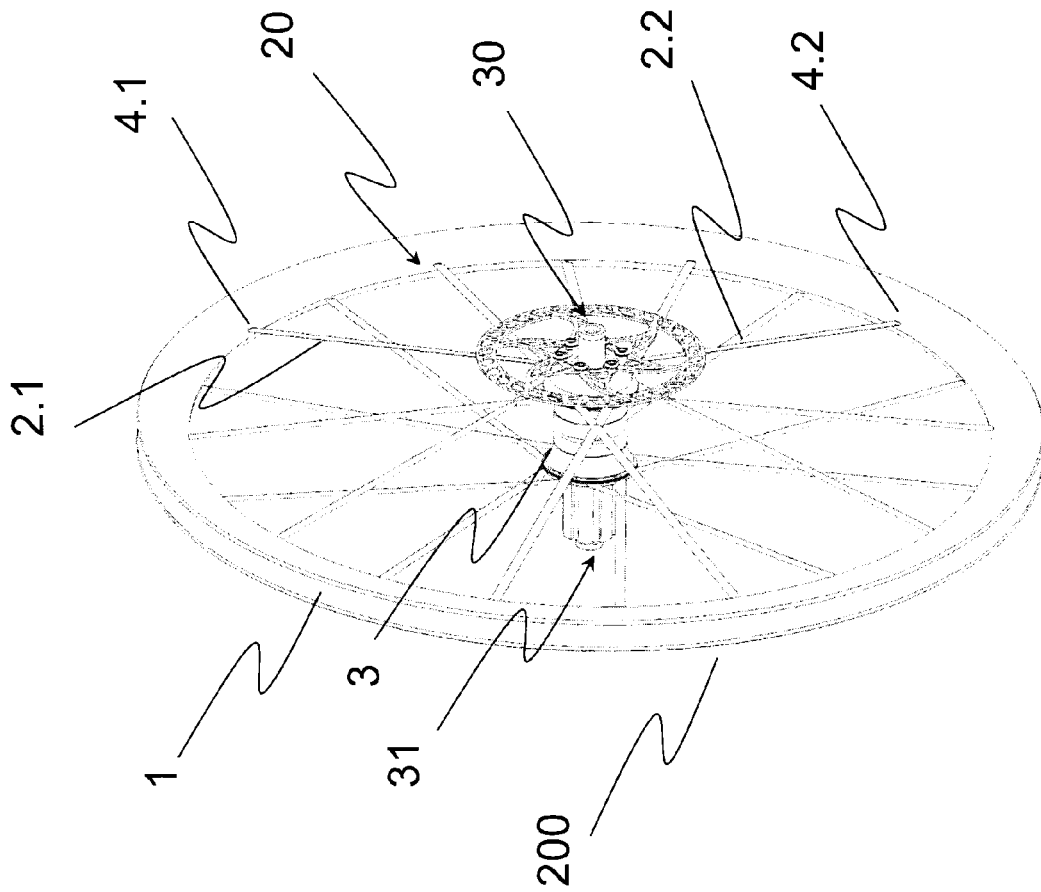


Fig. 6

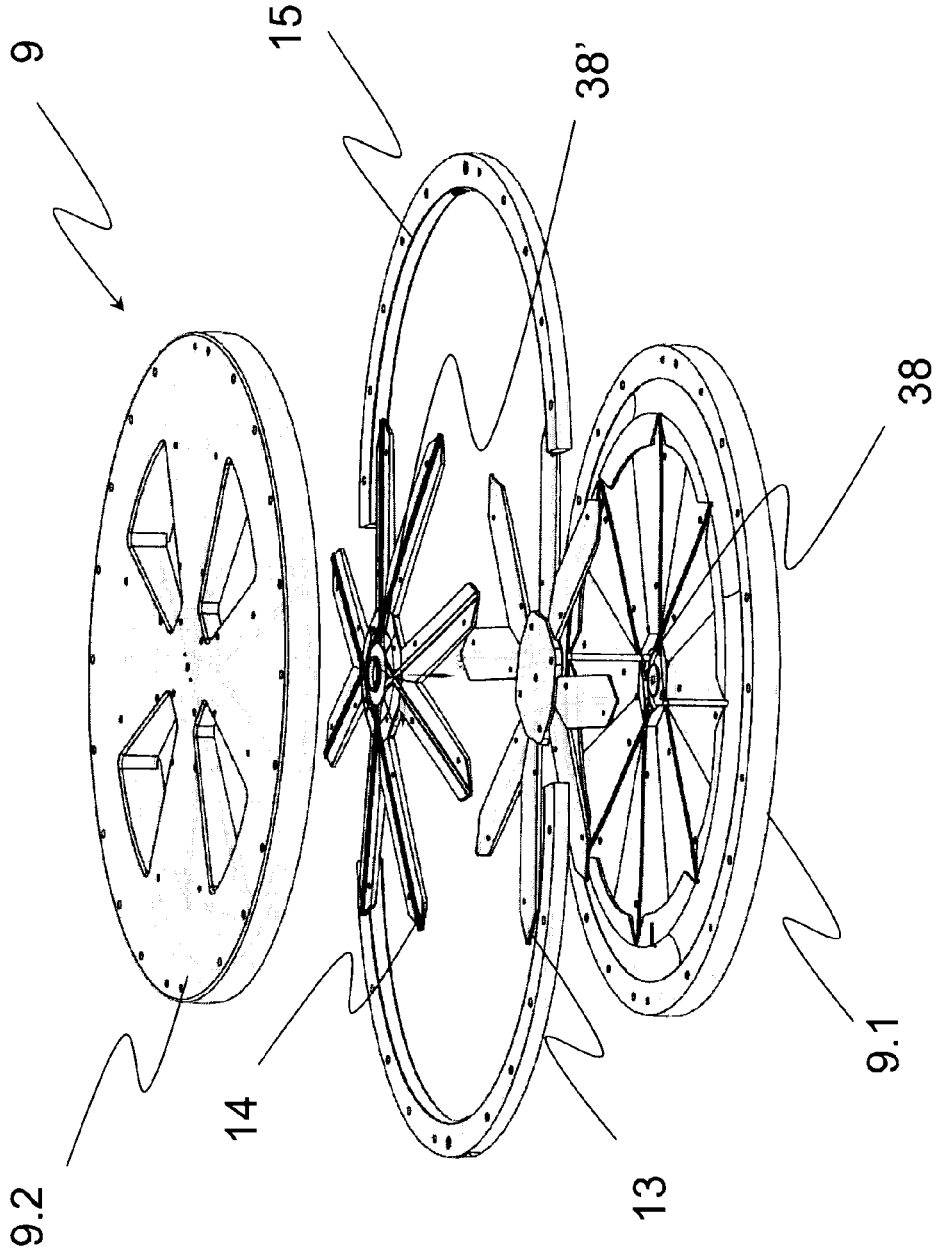


Fig. 7

Fig. 8

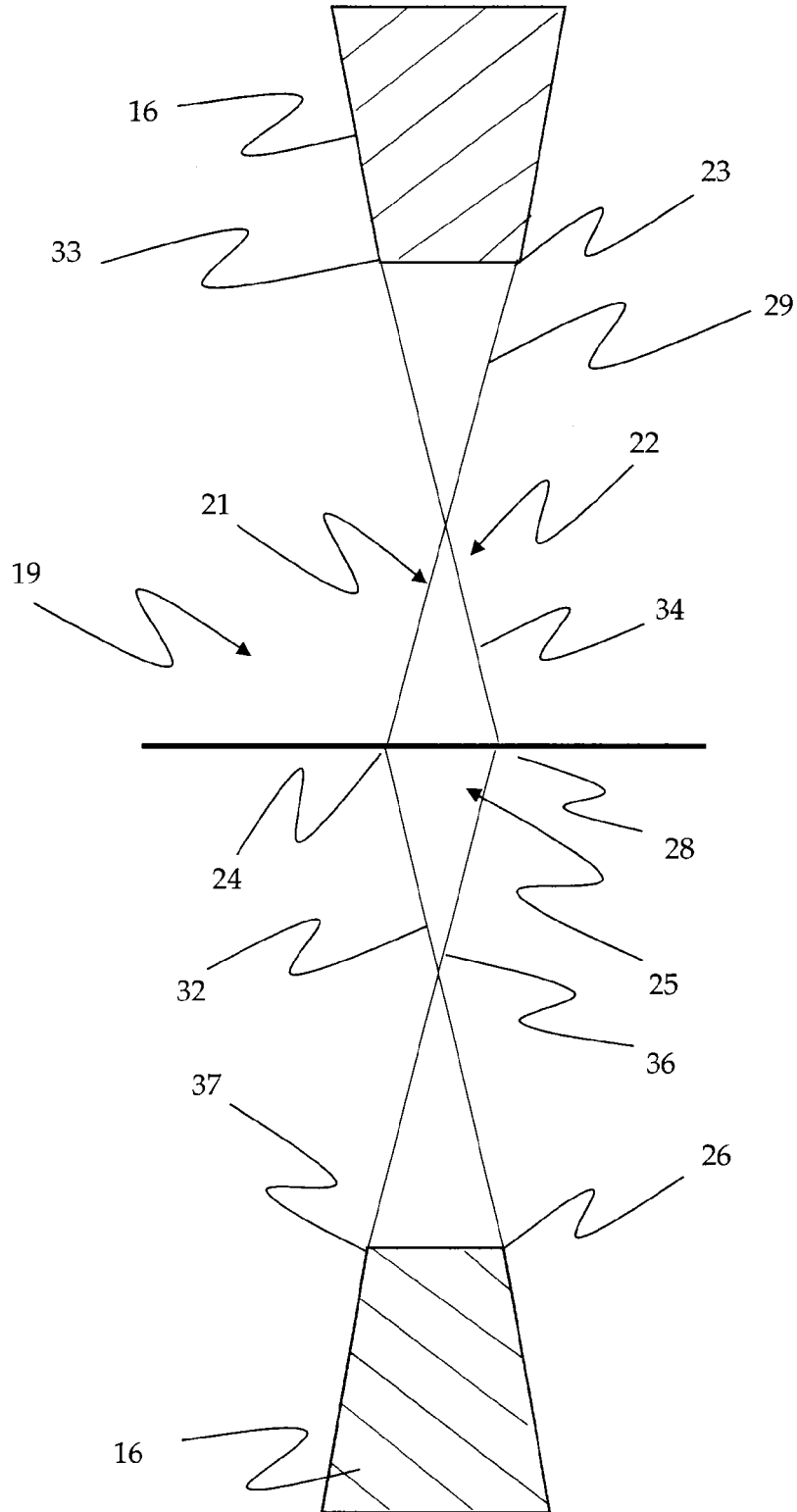


Fig. 9(a)

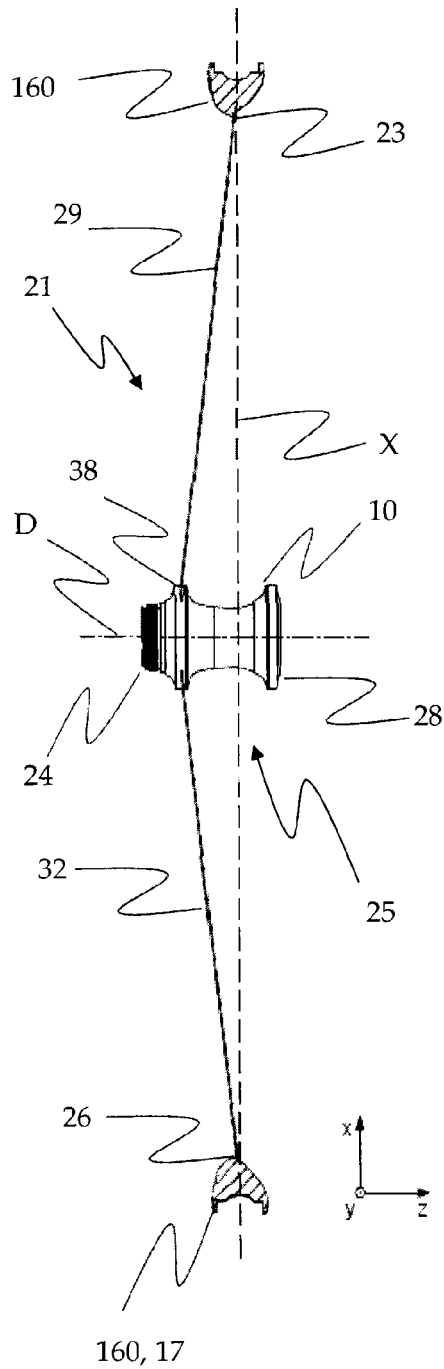


Fig. 9(b)

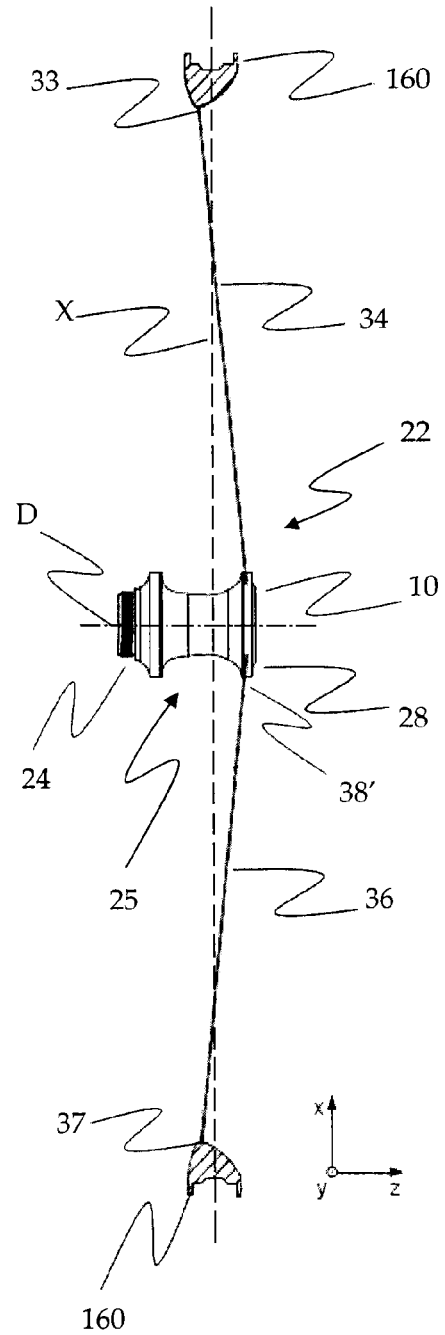


Fig. 10(a)

Fig. 10(b)

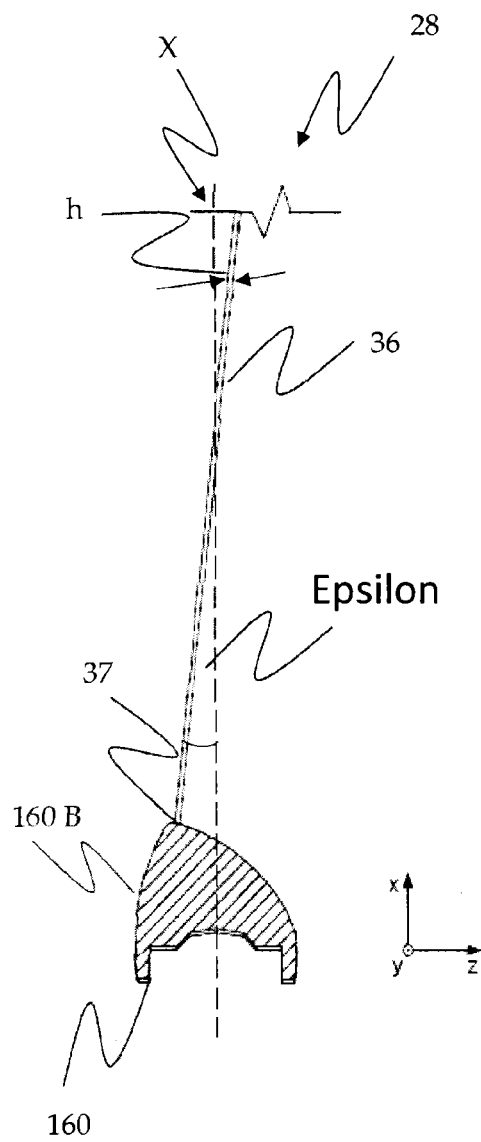
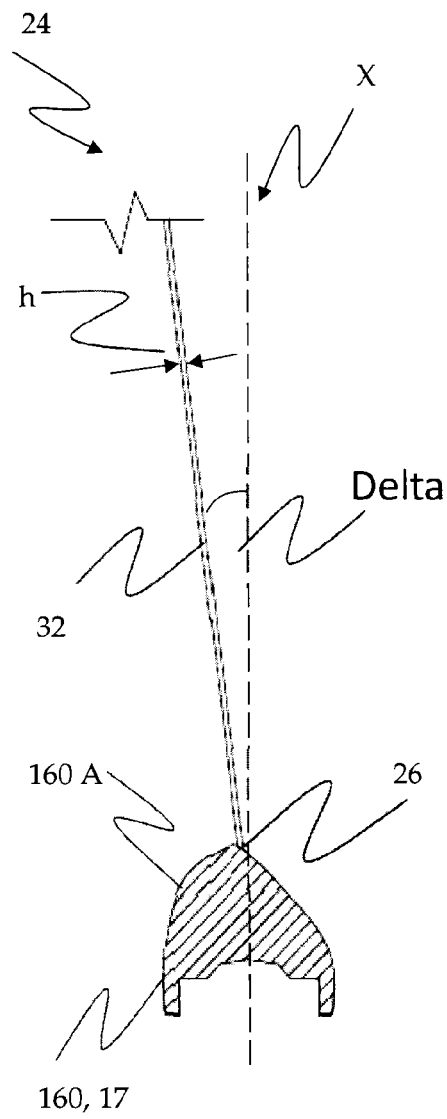


Fig. 11(a)

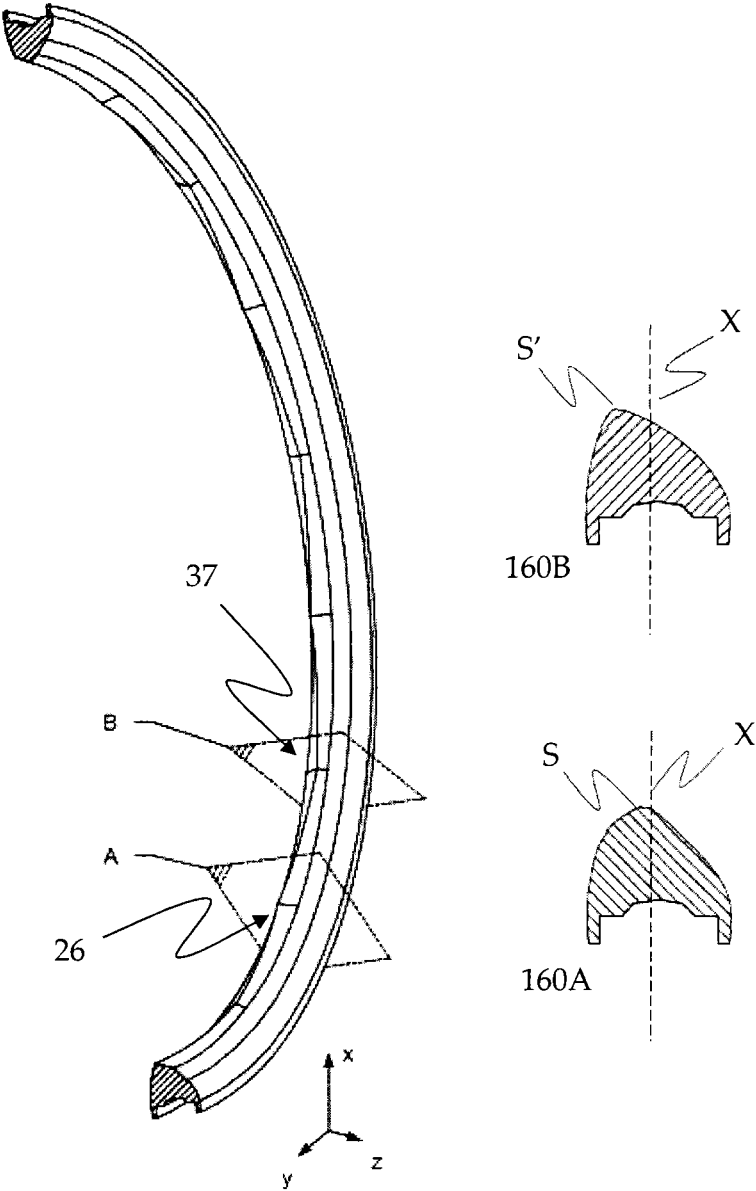


Fig. 11(b)

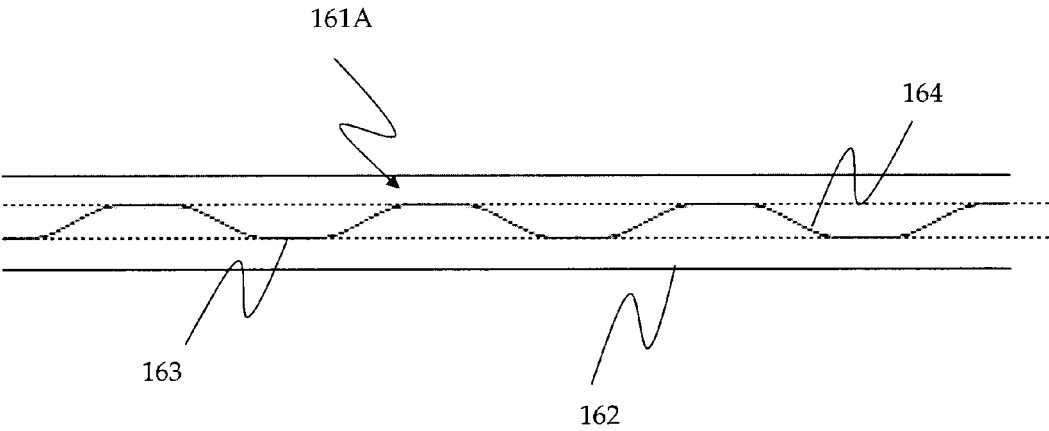


Fig. 11(c)

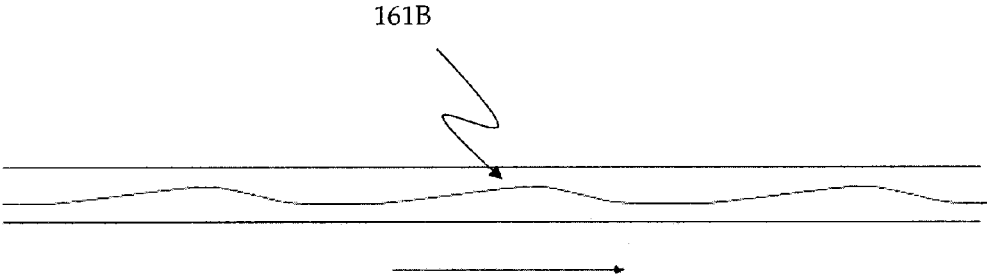
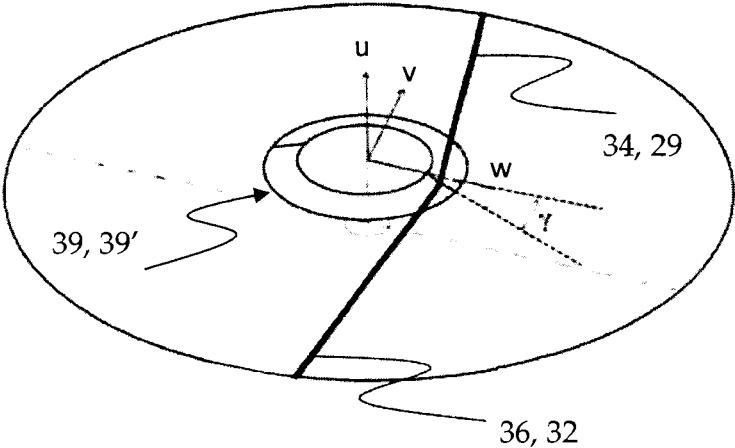


Fig. 12



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BICYCLE WHEEL

TECHNICAL FIELD

The present invention relates to a method for producing a bicycle wheel. Furthermore, the present invention relates to a bicycle wheel.

STATE OF THE ART

Numerous developments have been made in recent years in the field of bicycle wheels, in particular for the sport of cycling. In this area of sports, weight, rigidity of material and aerodynamics, which is mainly attributed to rim geometry, play an essential role. In its basic elements, a wheel consists of a hub, spokes and rim. This also applies to wheels made of fiber composite materials, in particular carbon. In the field of bicycle wheels which are made from fiber composite materials, a basic distinction is made between disc wheels, wheels with solid spokes, compression spokes and wheels with pre-tensioned spokes. According to the present invention, wheels are considered wherein both the spokes and the rim are made from a fiber composite material, preferably carbon.

EP 2030765 A2 describes a method for producing a wheel for bicycles, wherein the rim and spokes are made of a cured fiber composite material, for example carbon, and the wheel has pre-tensioned spokes. As can be taken from EP 2030765 A2, the production of the rim and the subsequent attachment of the spokes take place in two separate procedures. A plurality of working steps is necessary for the production of the rim alone, beginning with the production of the outer rim profile, followed by preparing a molded plastic element which is connected to the outer rim profile and covered with a covering layer. The individual spokes which, just as the rim, consist of a fiber composite, are mounted on the already prefabricated rim only in a second process independent of the first procedure. The entire wheel is hardened again at the end to ensure a strong bond between the rim and the spokes.

In this manufacturing method, as in conventional processes for the processing of fiber composite materials, lamination is used. Curing also falls under the process step of lamination. Examples of conventional laminating methods are published in DUBBEL, Handbook of Mechanical Engineering, 22nd edition, F25.

The process previously described in the prior art has the disadvantage that essentially two separate processes are required, one for the production of the rim, spokes and hub, and another for the fixing of the individual spokes to the rim and to the central holder, i.e. to the hub.

As already mentioned, aerodynamics play an increasing role in cycling. In general, the aerodynamic resistance of the wheel as well as the robustness in crosswinds is to be optimized. In this context, many companies thus attempt the development of special wheel geometries. Many of the rim cross-sections developed in recent years have a V-shape, however "bellied" cross-sections have also increased in importance, in order to better control the release behavior in crosswinds. The release behavior of the flow at the rim profile has a great influence on the riding comfort and line guidance in crosswinds.

For years, the Zipp company has marketed so-called aero wheels, in which the rim has a kind of golf ball surface.

US 2014/0292061 from the firm Reynolds Cycling LLC is noted at this point as an example of a current development in the field of rim geometries for carbon wheels. This document discloses an asymmetric geometry of a rim made

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from carbon fiber with pre-tensioned steel spokes. Also described is the production of the asymmetric rim geometry, in particular the arrangement of the carbon fiber layers in a negative mold. Mentioned also are the fixing and pre-tensioning of spokes. This document, however, does not indicate how the individual spokes are to be reliably fixed to the asymmetric rim and how the pre-tensioning process for the individual spokes is carried out.

In EP 1985465 A1, a spoke, a wheel and a method for manufacturing a spoke from a fiber composite material are described. In the manufacture of the wheel, the production of the spokes first takes place in a separate process step in the sense of a prefabrication. These spokes are then joined in a further process step with the likewise prefabricated rim. A disadvantage of this method is the connection of the rim and the spokes in two steps. In order to ensure the greatest possible hold of the spokes in the rim, it is necessary to specially fan out the spokes at their ends, so that a reliable connection of the spokes with the rim can be made at all possible.

Other examples of bicycle wheels made of composite materials in which pre-tensioned spokes are used can be found in EP 1795370 A1 and DE 9201179. In both documents, the spokes are inserted into a recess, which is seated on the rim, and fixed and tensioned, for example by means of a screw connection, in a separate process step.

SUMMARY OF THE INVENTION

It is the object of the invention to provide a method for producing a bicycle wheel made of a fiber composite material and a bicycle wheel, wherein the disadvantages of known solutions are, at least in certain areas, avoided. Furthermore, the riding comfort of the bicycle wheel is to be optimized and the production method is to be improved. The production method is characterized in particular by the small number of process steps, whereby the risk of potential production losses is minimized and production times can be reduced accordingly.

The object is achieved by characteristics of the claims.

When hereinafter a bicycle wheel is mentioned, this term covers both the rear wheel and front wheel.

When hereinafter a laminated state of the first and second spoke sections is mentioned, this is defined as the initial state of the spokes. For bicycle wheels with pre-tensioned spokes, in this initial state the first and second spoke sections are not tensioned and are not yet applied with spoke pre-tensioning force.

When hereinafter for bicycle wheels with pre-tensioned spokes a pre-tensioned state of the first and second spoke sections is mentioned, this is defined as a final state of the spokes, in which the spokes are applied with a spoke pre-tensioning force, i.e. pre-tensioned. The subsequently used hub holds the spokes in the pre-tensioned state and therefore in the final state.

When hereinafter compression spokes are mentioned, these are defined as spokes which, in contrast to pre-tensioned spokes, are substantially not preloaded in the production of the bicycle wheel. For this type of spoke, the loading only occurs in the use of the bicycle wheel on the road.

These spokes are also held in a final state by the inserted hub, but not in a pre-tensioned state.

According to the inventive method for producing a bicycle wheel made of a fiber composite material, the lamination of a rim, of spokes, each having a first and a second spoke section, and a center, having a first and a

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second center disc, takes place in one piece in a single step, in that all fibers for the rim, spokes and center are laid in one process step into mold parts provided for this purpose and curing is subsequently carried out. After curing, the bicycle wheel comprising the rim, spokes and center is removed from the mold parts. The spokes are laminated and cured such that the first and second spoke sections have a substantially straight shape.

Lamination in one step means that the molds comprising the shape of the rim, spokes and center are applied with fibers in one step, before curing takes place. The fibers of the spokes, preferably unidirectional fibers, are laid completely from a first base point to an opposite base point.

In the method according to the invention, after the completion of laminating and curing, a bicycle wheel is obtained which comprises the rim, the center with first and second center discs and the still un-pre-tensioned spokes connected in one piece to the rim and the center discs.

In a second step, the pre-tensioning of the spokes and the insertion of the hub may occur. The pre-tensioning of the spokes preferably takes place in which the center or the two center discs are pulled apart in the horizontal direction approximately to the size of the subsequently used hub, before the hub is inserted.

In a further embodiment of the inventive method, the hub is placed between the two center discs, without a prior pre-tensioning of the spokes. In this embodiment, a bicycle wheel with so-called compression spokes, the spokes are substantially not preloaded during production of the bicycle wheel.

By manufacturing in one piece, time-consuming additional process steps, such as a connecting of prefabricated spokes to the rim, are avoided. Further, by manufacturing in one piece, additional adhesion points are circumvented, which have proven disadvantageous in particular in those areas of the bicycle wheel affected by braking forces, for example in the area which receives the brake disc, where the braking forces are transferred via the spokes to the rim. In addition, weight is saved by avoiding additional adhesion points. Through one-piece production, in particular the base points, the points where the spokes join the rim, can be advantageously formed. The spokes are preferably laminated continuously such that the fiber course of the first and second spoke sections extends continuously between the base points arranged on the rim.

Further advantages which result in particular from the inventive production are a highly precise concentricity, quiet operation even at high speeds, and a much improved rotational inertia.

In the inventive method, the curing may preferably occur in an autoclave. After the rim, spokes and center have been laminated in the two mold parts, a freely formable filler, for example a vacuum hose or a foam material, is introduced between the mold parts. When a negative pressure is applied, in that air is sucked out of the mold, the volume of the freely formable filler increases correspondingly and presses the laminated rim into a desired position.

The transfer molding method is available as an alternative curing method. In the use of the transfer molding process, dry fibers are used, i.e. fibers which upon application have not yet been impregnated with resin, in comparison to the prepreg fibers. In the transfer molding process, the mold parts are pressed together and brought into their desired shape through the introduction of compressed air into a freely formable filler. During molding, the introduction of resin and the process of curing occurs in one step.

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In a preferred embodiment of the invention, the formation of the spokes takes place in that a punch form is applied to the laminated spokes in the mold parts. This punch has projections which substantially form-fittingly interact with the mold parts and serve to bring the spokes into a desired form, for example to mold an elliptical cross-section. Through this additional form, it is possible to produce spokes of high quality. Furthermore, the spokes may be laminated from unidirectional scrim without an additional cover layer.

Further examples for fibers are aramid, glass fiber, and boron fiber, or a combination of said fibers.

In a preferred embodiment of the invention of the inventive bicycle wheel, the spokes form a first and a second spoke group. The spokes of the first spoke group extend between the first base points arranged on the rim, a disc brake side of the center, wherein the center is preferably formed by two opposing center discs, and the second base points, which are substantially opposite the first base points, and are likewise arranged on the rim. The spokes of the second spoke group extend between further first base points arranged on the rim, a non-disc brake side of the center, wherein the center is preferably formed as further center discs, and further second base points, which lie substantially opposite the first base points, and are likewise arranged on the rim. The spokes comprising the first and second spoke sections extend in their fiber orientation continuously between the two base points.

In a further preferred embodiment of the invention, the spokes form a first and a second spoke group. The first spoke sections of the spokes of the first spoke group extend here between the first base points arranged on the rim on a brake disc side and the brake disc side of the center. The second spoke sections of the spokes of the first spoke sections extend between the brake disc side of the center and second base points arranged on the rim on the brake disc side. The first spoke sections of the spokes of the second spoke group extend between first base points arranged on the rim on a non-brake disc side and the non-brake disc side of the center. The second spoke sections of the spokes of the second spoke group extend between the non-brake disc side of the center and second base points arranged on the rim on the non-brake disc side.

In a further embodiment, the first spoke sections of the spokes of the first spoke group extend between first base points arranged on the rim on a non-brake disc side and the brake disc side of the center. The second spoke sections of the spokes of the first spoke group extend between the brake disc side of the center and second base points arranged on the rim on the non-brake disc side. The first spoke sections of the spokes of the second spoke group extend between first base points arranged on the rim on a non-brake disc side and the brake disc side of the center. The second spoke sections of the spokes of the second spoke group extend between the non-brake disc side of the center and second base points arranged on the rim on the brake disc side. Through this inventive arrangement of the spokes, a better force introduction from the spokes into the wheel occurs. Furthermore, this leads to an improvement of the fiber orientation, so that the stability of the spokes in the base points is increased. The risk that the spokes could tear out of the base points is minimized.

In a further preferred embodiment, the first and second base points of the first spoke group and/or the first and second base points of the second spoke group are spaced apart from an apex S of the rim. The distance from the first and second base points of the first spoke group to the apex

S of the rim is greater than the distance between the first and second base points of the second spoke group. The apex S of the rim is the region of the rim body which is opposite to the rim well. In the pre-tensioning of the spokes, the rim well is positioned centrally. According to the invention, the rim is preferably formed as a symmetrical body, particularly preferably as a symmetrical hollow body. Assuming a symmetrical rim geometry, the lowest point of the rim well and the apex S lie in one plane, the plane of symmetry of the rim, which forms at the same time a vertical plane of symmetry of the bicycle wheel.

The apex S runs in the sectional plane of symmetry of the bicycle wheel with the rim body and faces the center of the bicycle wheel. To improve the driving experience, it is advantageous if the spoke tension in the pre-tensioned state is approximately equal in both the spokes of the first spoke group on the brake disc side as well as in the spokes of the second spoke group on the non-brake disc side. This is achieved inter alia through the inventive arrangement of the base points. A symmetrical shape of the rim also improves the aerodynamics of the bicycle wheel per se.

In a preferred embodiment variant, the center has two opposed center discs, one on the brake disc side and one on the non-brake disc side, wherein the center discs are inclined by an angle γ to an axis w, wherein the angle γ has a value between 6° and 8° . An advantage which results from the inclination of the center discs is the minimizing of radial interlaminar forces which can arise, for example, during pre-tensioning of the spokes.

In a further preferred embodiment variant, the first and second spoke sections of the spokes form individual crossing points, wherein the crossing points are formed through individual unidirectional fiber layers of the spoke sections. Through the arrangement in a plurality of layers, the cross-section is thickened at the crossing point. The crossing point of the spoke sections is formed according to the invention in that the layers of the first spoke section are alternately laminated with the layers of the further first spoke section, so that an interweaving is formed at the crossing point. Through this interweaving results a solid spoke crossing, wherein this spoke crossing increases the system rigidity. For example, a first layer of the first spoke section is overlaid by a first layer of a further first spoke section, wherein this first layer is then overlaid by a second layer of the first spoke section, followed by a second layer of the second spoke section. In a preferred embodiment, the crossing point is formed by at least four layers. An interweaving occurs through the inventive construction of the crossing point, so that additional material-fitting connections of the individual spoke portions can be avoided.

In a further preferred embodiment, the first and second spoke sections of the first spoke sections enclose an introduction angle β (beta) in the pre-tensioned state with the outer geometry of the rim, in particular the rim body, which introduction angle is preferably between 120° and 180° and the first and second spoke sections of the second spoke group enclose an introduction angle α (alpha), which is greater than 90° .

In a further preferred embodiment of the invention, the rim does not have a symmetrical but rather an asymmetrical rim body. Here, the asymmetrical rim body has a cross-sectional area or a cross-section which is asymmetric with respect to the plane of symmetry of the bicycle wheel.

In one embodiment of the bicycle wheel with an asymmetrical rim body, the asymmetrical rim body has a different rim cross-section in the region of the first and second base points of the spokes of the first spoke group than in the

region of the first and second base points of the spokes of the second spoke group. Due to the variation of the cross-section, the rim is not rotationally symmetrical, i.e. designed to be rotationally asymmetrical with respect to the rotational axis of the bicycle wheel.

In a further embodiment of the bicycle wheel with asymmetrical rim body, the asymmetrical rim body has the same rim cross-section in the region of the first and second base points of the spokes of the first spoke group as in the region of the first and second base points of the spokes of the second spoke group. Unlike the previously illustrated embodiment, the cross-section does not vary and the rim is rotationally symmetrical with respect to the axis of rotation of the bicycle wheel.

In a further embodiment of the bicycle wheel with symmetrical rim body, the symmetrical rim body has the same rim cross-section in the region of the first and second base points of the spokes of the first spoke group as in the region of the first and second base points of the spokes of the second spoke group. The rim is therefore rotationally symmetrical with respect to the axis of rotation of the bicycle wheel.

In a further embodiment of the bicycle wheel with a symmetrical rim body, the rim is not rotationally symmetrical, i.e. designed to be rotationally asymmetrical with respect to the axis of rotation of the bicycle wheel.

In a further preferred embodiment the angles "delta" and "epsilon" of the spokes in relation to the symmetry plain of the bicycle wheel are, on the brake disc side as well as on the non-brake disc side, substantially equal. This results in an approximately equal pre-tensioning force of the pre-tensioned spokes. Furthermore, the brake force application is optimized.

In a preferred embodiment, the dimensions of the spoke height h are smaller than those of the spoke width b. Thus, the spoke has a rather flat geometry. Preferably, the ratio of spoke height to spoke width is smaller than 0.5. This has generally proved advantageous in pre-tensioning straight laminated, cured spokes. Stress peaks resulting from a bending of the spokes, which may arise during pre-tensioning, can thus be kept to a minimum.

In a further embodiment of the inventive bicycle wheel, the spokes are designed as compression spokes.

In order to achieve the advantageous force application in the transition from the spokes to the rims, in particular in the rim apex region, the geometry or the peripheral course of the rim apex region respectively varies, i.e. the rim apex line along the inner periphery of the rim varies between waved and flat apex regions. The two rim baselines for their part, as in conventional rims, run in circular manner (along the outer periphery of the rim). The rim apex region and the rim baselines are spatially connected via constantly running spatial areas. In preferred embodiments usually at least a G1 consistency is provided for the outer surfaces of the rims. In further preferred embodiments maximally a G2 consistency is provided for the outer surfaces of the rims.

In an alternative embodiment the flat (running in parallel to the rim baselines) apex regions may run obliquely in relation to the rim baselines in the direction of movement of the wheel in order to reduce air drag. In one embodiment these are implemented at an acute angle in the direction of movement of the wheel, wherein the declining flank of the apex purposely declines in a more acute manner.

In an alternative embodiment instead of flat (running in parallel to the rim baselines) apex regions may run obliquely in relation to the rim baselines against the direction of movement of the wheel in order to reduce air drag. In one

embodiment these are implemented at an acute angle in the direction of movement of the wheel, wherein the declining flank of the apex purposely declines in a more acute manner.

BRIEF DESCRIPTION OF THE FIGURES

The invention will be described hereinafter in greater detail in conjunction with drawings by means of exemplary embodiments.

FIG. 1 shows a schematic view of the cross-section through a bicycle wheel in a laminated state (a), a state during pre-tensioning (b), and a pre-tensioned state (c),

FIG. 2 shows a partially schematic sectional view of one half of the rim cross-section, a first and second spoke section, and the first and second spoke group in a pre-tensioned state,

FIG. 3 shows the view of FIG. 2 with the insertion angles α (alpha) and β (beta) of the first spoke sections of the first and second spoke group, in the pre-tensioned state, in a partially schematic sectional view,

FIG. 4 shows a schematic partial sectional view through the rim, wherein the integration of the spokes in the rim is shown,

FIG. 5 shows a sectional view through a crossing point of spoke sections,

FIG. 6 shows a perspective view of the inventive bicycle wheel,

FIG. 7 shows an exploded view of a tool for the production of the inventive wheel

FIG. 8 shows a schematic vertical sectional view of a further embodiment of the bicycle wheel according to the invention, in particular the guiding of the first and second spoke sections,

FIG. 9(a) shows the embodiment of FIG. 8 in a detailed view with asymmetrical rim and spoke course on the brake disc side of the bicycle wheel,

FIG. 9(b) shows the embodiment of FIG. 8 in a detailed view with asymmetrical rim and spoke course on the non-brake disc side of the bicycle wheel,

FIG. 10(a) shows a partial detail of FIG. 9(a) comprising a cross-section through the rim and a spoke section in the pre-tensioned state on the brake disc side,

FIG. 10(b) shows a partial detail of FIG. 9(b) comprising a cross-section through the rim and a spoke section in the pre-tensioned state on the non-brake disc side,

FIG. 11(a) shows the rims of FIG. 10(a) and FIG. 10(b) in a perspective view without spokes,

FIG. 11(b) shows a first embodiment of a rim apex region,

FIG. 11(c) shows a second embodiment of a rim apex region,

FIG. 12 shows a schematic representation of the bicycle wheel in a view from above with a possible embodiment of the center discs, as they can be found on the brake disc side as well as the non-brake disc side of the bicycle wheel.

MODES OF IMPLEMENTING THE INVENTION

When hereinafter a laminated state of the first and second spoke sections is mentioned, this is defined as the initial state of the spokes. For bicycle wheels with pre-tensioned spokes, in this initial state the first and second spoke sections are not tensioned and are not yet applied with spoke pre-tensioning force.

When hereinafter for bicycle wheels with pre-tensioned spokes a pre-tensioned state of the first and second spoke sections is mentioned, this is defined as a final state of the spokes, in which the spokes are applied with a spoke

pre-tensioning force, i.e. pre-tensioned. The subsequently used hub holds the spokes in the pre-tensioned state and therefore in the final state.

In an exemplary embodiment, the spoke pre-tensioning force, which is applied during pre-tensioning to the first and second spoke sections, is approximately as large on the non-brake disc side as on the brake disc side of the bicycle wheel, preferably the difference between the two pre-tensioning forces is less than 200 N.

FIG. 1 shows an example of the three steps (a) to (c) of the process of pre-tensioning a bicycle wheel with pre-tensioned spokes. In a preferred embodiment, the spokes are made from a UD (unidirectional) scrim of carbon fiber with a tension E-module of 130 GPa to 215 GPa. The image 1(a) shows a cross-section through the bicycle wheel in the laminated state. Here, the rim 1, the spokes 2 of the first and second spoke group 20, 200 comprising the first and second spoke sections 2.1, 2.2; 2.1', 2.2' and the center 3, having a first and second center disc 38, 38', are laminated in one step, wherein the first and the second spoke sections 2.1, 2.2, 2.1' and 2.2' have a substantially straight shape. FIG. 1(b) shows the process of pre-tensioning, the center 3, preferably consisting of two center discs 38, 38', is pulled in the horizontal direction, to approximately the size of the hub, wherein the spoke sections 2.1, 2.2, 2.1' and 2.2' are transferred from the laminated state into a pre-tensioned state. In the last step, as shown in FIG. 1(c), the hub 10 is inserted, which holds the spokes in the pre-tensioned state. In order to keep stress peaks, which can occur during pre-tensioning from the bending of the spokes, as low as possible, the spokes have a flat geometry. The ratio of spoke height to spoke width is small, preferably less than 0.5.

In a preferred embodiment, the dimensions of the spoke height h are smaller than those of the spoke width b . Thus, the spoke has a rather flat geometry. Preferably, the ratio of spoke height to spoke width is smaller than 0.5. This has generally proved advantageous in pre-tensioning straight laminated, cured spokes. Stress peaks resulting from a bending of the spokes, which may arise during pre-tensioning, can thus be kept to a minimum.

FIG. 2 shows a cross-section through the rim 1, and a partial view of a first spoke section 2.1 of the first spoke group 20 and the first spoke section 2.1' of the second spoke group 200. The spokes 2 of the first spoke group 20 extend between the first base points 4.1 of a brake disc side of the center 3 and a second base point 4.2 (not shown in FIG. 2). The spokes of the second spoke group 200 extend between a first base point 4.1' of a non-brake disc side of the center 3 and a second base point 4.2' (not shown in FIG. 2). The base points are arranged on the rim body 1' of the rim 1. In this embodiment, the rim 1, in particular the rim body 1', is designed as a symmetrical body. In the embodiment according to FIG. 2, the distance X1 which the base point 4.1 takes from the plane of symmetry of the rim 1 is greater than the distance X2 which the base point 4.1' likewise takes from the plane of symmetry. In a preferred embodiment, the distance X2 is approximately half the distance X1 relative to the rim geometry shown.

FIG. 3 shows the arrangement of FIG. 2, supplemented by the insertion angle β (beta), which encompasses the first and second spoke section 2.1, 2.2 of the first spoke group 20, in the pre-tensioned state to the outer geometry of the rim 1, measured from base point 4.1 and 4.2 (not shown). Furthermore, the insertion angle α (alpha) is shown, which encompasses the first and second spoke section 2.1', 2.2' of the second spoke group 200 in the pre-tensioned state, to the outer geometry of the rim 1, measured from first and second

base points 4.1', 4.2'. In the preferred embodiment shown in FIG. 3, the insertion angle β (beta) is between 120° and 180° with respect to the rim geometry shown. The insertion angle α (alpha) has a value of greater than 90° .

Further represented in FIG. 3 is an angle β' (beta-prime) and an angle α' (alpha-prime). The angle α' (alpha-prime) is measured between a plane parallel to the plane of symmetry of the rim 1, which extends through the base point 4.1' and the first spoke section 2.1', in the pre-tensioned state on the non-brake disc side 31. The angle β' (beta-prime) is measured between a plane parallel to the plane of symmetry of the rim 1, which extends through the base point 4.1 and the first spoke section 2.1, in the pre-tensioned state on the brake disc side. The angles α' (alpha-prime) and β' (beta-prime) differ by a value less than or equal to 2° , wherein α' (alpha-prime) is preferably greater than β' (beta-prime). This relationship between α' (alpha-prime) and β' (beta-prime) is independent of the chosen geometry of the rim 1.

FIG. 4 shows a partial view of a cross-section through the rim 1, in the region in which the spokes 2 or the spoke section 2.1 is integrated. In the production of the bicycle wheel, the rim 1, the spokes 2 and the center 3 are laid in one step into an aluminum mold or steel mold. In a preferred embodiment, the spoke 2 is made of a unidirectional scrim of carbon fiber and the rim 1 is made from a fabric, preferably also of carbon fiber.

In a further preferred embodiment, the spokes 2 and the rim 1 are made from a scrim, the spokes from a unidirectional scrim and the rim from a multidirectional scrim.

The spoke 2 is constructed in multiple layers from the unidirectional scrim. Here, its fibers run continuously from a first base point over the center 3 of the bicycle wheel to a second base point 2 arranged on the rim body (not shown in FIG. 4). In the integration of the rim 2 in the rim body 1', the unidirectional scrim of the spoke 2 is attached on the inside of the rim body 1' by at least one, preferably a plurality, of layers of the fabric 11, from which the rim 1 is made. The number of layers 11 and their orientation may vary. An additional bonding of the spoke 2, for example at the base point 4.1, is not required.

FIG. 5 shows a section through the crossing point 8, which extends for example through two first spoke sections 2.1, 2.3. Since the first spoke sections are symmetrical to the second spoke sections and form a spoke 2, the second spoke sections also have crossing points 8 (not shown in FIG. 5). As exemplified in FIG. 5, the first spoke section 2.1 and the further first spoke section 2.3 are constructed of a plurality of layers of a unidirectional scrim. The crossing point preferably comprises four layers 2.3.1, 2.3.2, 2.1.1, 2.1.2. In the preferred embodiment according to FIG. 5, the layers 2.1.1 and 2.1.2 of the first spoke portion 2.1 are alternately laminated with the layers 2.3.1 and 2.3.2 of the further first spoke section 2.3, so that an interweaving results at the crossing point 8. In FIG. 5, it is not immediately apparent that a thickening of the spoke cross-section results from the at least four layers.

FIG. 6 shows a perspective view of the inventive bicycle wheel. Shown are the spokes of the first 20, the second spoke group 200 and the non-brake disc side 31 and the brake disc side 30 of the inventive bicycle wheel and the rim 1. A spoke is shown by way of example with reference characters, comprising a first and a second spoke section 2.1, 2.2, wherein this spoke extends continuously between the base points 4.1 and 4.2, which are arranged on the rim 1, and forms a spoke of the first spoke group 20.

FIG. 7 shows a preferred embodiment of the inventive negative mold 9. The negative mold 9 comprises a first part

9.1 and a second part 9.2. In these two parts, the fibers for the rim body, the spokes, the center having a first and second center disc 38, 38' are laid into the corresponding recesses in one step. A further mold 15 forms the geometry of the rim well. In addition, two punch forms 14 and 13 are shown. In the assembled state, the negative mold 9 act in a form-fitting manner with the punch forms 13 and 14 with recesses for the spokes. In this way, a desired spoke cross-section is formed.

FIG. 8 schematically shows a further embodiment of the inventive bicycle wheel in a vertical sectional view. The strongly simplified illustration of the rim 16 may have a symmetrical or asymmetrical rim body. In the preferred embodiment shown in FIG. 8, the spokes form a first and a second spoke group 21, 22. The spokes 19 of the first and second spoke group 21, 22 have first and second spoke sections 29, 32, 34, 36. As shown in FIG. 8, the first spoke section 29 of the first spoke group 21 extends between the first base point 23 arranged on the rim 16 on a non-brake disc side 28 as well as a brake disc side 24 of the center 25 and the second spoke section 32 extends between the brake disc side 24 of the center 25 and second base points 26 arranged on the rim 16 on the non-brake disc side. The first spoke sections 34 of the spokes 19 of the second spoke group 22 extend between first base points 33 arranged on the rim 16 on the brake disc side and the non-brake disc side 28 of the center 25. The second spoke sections 36 extend between the non-brake disc side 28 of the center and second base points 37 arranged on the rim on the brake disc side. In the embodiment shown in FIG. 8, the spoke sections are straight. The spokes are pre-tensioned. The center 25 has two opposing center discs, one on the brake disc side 24 and one on the non-brake disc side 28 (not shown in FIG. 8).

In FIG. 9(a), the schematic representation of FIG. 8 is shown in more detail using the example of a rim 160 having an asymmetrical rim body, which is not symmetrical with respect to a vertical plane of symmetry X. A cross-section is shown. Using the example of a spoke comprising a first and a second spoke section 29, 32, the course of the spoke of the first spoke group 21 is shown. The plane X represents the vertical plane of symmetry and the horizontal axis D is the rotational axis of the bicycle wheel. In the embodiment shown, the first and second spoke sections 29, 32 are shown in the pre-tensioned state. The hub 10 is inserted in the center 25. The center 25 is formed by two opposing center discs 38, 38'. The hub 10 is used to keep the spokes in the pre-tensioned, final state. The bicycle wheel has a brake side disc side 24 and a non-brake side disc 28. The first spoke section 29 extends between the first base point 23, the point at which the spoke section 29 is embedded in the rim 160 and the center disc 38 on the brake disc side 24. The base point 23 is oriented toward the non-brake disc side 28. The second spoke section 32 extends between the center disc 38 on the brake disc side 24 and the second base point 26, which is oriented toward the non-brake disc side 28. The second spoke section is embedded in the rim 160 at this base point 26.

In FIG. 9(b), the schematic representation of FIG. 8 is shown in more detail using the example of a rim 160 having an asymmetrical rim body, which is not symmetrical with respect to a vertical plane of symmetry X. Using the example of a spoke comprising a first and a second spoke section 34, 36, the course of the spoke of the second spoke group 22 is shown. The plane X represents the vertical plane of symmetry and the horizontal axis D is the rotational axis of the bicycle wheel. In the embodiment shown, the first and second spoke sections 34, 36 are shown in the pre-tensioned state. The hub 10 is inserted in the center 25. The center 25

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is formed by two opposing center discs **38, 38'**. The hub **10** is used to keep the spokes in the pre-tensioned, final state. The bicycle wheel has a brake side disc side **24** and a non-brake side disc **28**. The first spoke section **34** extends between the first base point **33**, the point at which the spoke section **34** is embedded in the rim **160** and the center **25** formed as a center disc **38'** on the non-brake disc side **28**. The base point **33** is oriented toward the brake disc side **24**. The second spoke section **36** extends between the center disc **38'** on the non-brake disc side **28** and the second base point **37**, which is oriented toward the brake disc side **24**. The second spoke section **36** is embedded in the rim **160** at this base point **37**.

FIG. **10(a)** shows a cross-sectional view of a detail of FIG. **9(a)** with the rim **160** having an asymmetrical rim body. **X** is the plane of symmetry of the bicycle wheel. Shown is a portion of the second spoke section **32**, which extends on the brake disc side **24** and is connected at the second base point **26** with the rim **160**. Also shown in FIG. **10(a)** is a spoke angle delta, which encloses the spokes of the first spoke group to the plane of symmetry of the bicycle wheel, in the pre-tensioned state. The second spoke section **32** in the pre-tensioned state is shown to represent the spokes of the first spoke group.

FIG. **10(b)** shows a cross-sectional view of a detail of FIG. **9(b)** with the rim **160** having an asymmetrical rim body. **X** is the plane of symmetry of the bicycle wheel. Shown is a portion of the second spoke section **36**, which extends on the non-brake disc side **28** and is connected at the second base point **37** with the rim **160**. Also shown in FIG. **10(b)** is a spoke angle epsilon, which encloses the spokes of the second spoke group to the plane of symmetry of the bicycle wheel, in the pre-tensioned state. The second spoke section **36** in the pre-tensioned state is shown to represent the spokes of the first spoke group.

The spoke height **h** is shown exemplarily in the embodiment according to FIG. **10(a)** and FIG. **10(b)**. A spoke width **b** cannot be seen in the view of FIG. **10(a)**, **10(b)**. In a preferred embodiment, the dimensions of the spoke height **h** are smaller than those of the spoke width **b**. Thus, the spoke has a rather flat geometry. Preferably, the ratio of spoke height to spoke width is smaller than 0.5. This spoke geometry is not limited to the shown embodiment of the bicycle wheel. It has generally proved advantageous in pre-tensioning straight laminated, cured spokes. Stress peaks resulting from a bending of the spokes, which may arise during pre-tensioning, can be kept to a minimum.

The base points **26** and **27** are formed in a rounded manner, in particular in the transition of the spokes to the rim.

From the comparison of the two rim cross-sections **160A** and **160B**, it can be seen that the rim cross-section has a different cross section in the region of the base point **26** from which the first spoke sections **32** of the first spoke group **21** emerge than the rim cross-section in the region of the base point **37** from which the first spoke sections **32** of the second spoke group **22** emerge.

The spoke angles delta and epsilon are approximately the same size, so that an approximately equal pre-tensioning force is present on the brake disc side and the non-brake disc side.

FIG. **11(a)** shows a partial representation of the rim **160** of FIG. **10(a)**, FIG. **10(b)** in a perspective view.

Furthermore, it is at least partially apparent from FIG. **11(a)** that rim **160** is not rotationally symmetrical, i.e. designed to be rotationally asymmetrical in relation to rotation axis **D**. The asymmetry is achieved by means of a

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variation of the rim cross-section. For a better visualization, two intersections **A** and **B** are shown in the regions of base points **26** and base points **37**, in order to visualize the differing cross-sections **160A** and **160B**. Both cross-sections represent an asymmetrical rim body, i.e. both rim bodies are asymmetrical in relation to symmetry plain **X** of the bicycle wheel. The rotation asymmetry of the rim in relation to rotation axis **D** is achieved by means of a displacement of apex **5** towards apex **5'** in the direction of the **Z**-axis. As particularly apparent from the embodiment according to FIG. **11(a)** rim apex region **161** does not run in circular manner but in waved manner with apexes running in flat or oblique manner.

FIG. **11(b)** shows a possible course of a rim apex region **161A** comprising apexes **163, 164** running in flat or oblique manner in relation to the two rim baselines **162**, which run in circular manner in conventional rims (along the outer periphery of the rim).

The apexes **163** with flat courses run in parallel manner to rim baselines **162**. The apexes **164** are, viewed in the direction of movement of the bicycle wheel, at defined angles, in relation to rim baselines **162**, i.e. they run in oblique manner in relation to these.

FIG. **11(c)** shows an alternative embodiment of a course of a rim apex region **161B**. The shown arrow indicates the direction of movement of the bicycle wheel. According to this embodiment the apex region may, instead of being flat (running in parallel to the rim baselines), run obliquely in relation to the rim baselines in the direction of movement of the wheel, e.g. at an acute angle in the direction of movement of the wheel, wherein the declining flank of the apex purposely declines in a more acute manner.

FIG. **12** shows a schematic representation of the bicycle wheel in a view from above, wherein with reference to this illustration, a possible embodiment of the center disc **39, 39'** is explained. As shown schematically, the spoke sections **34, 36, 29, 32** are connected with the center disc **39, 39'**, wherein the center disc is inclined at an angle gamma (γ) to an axis **w**. This inclination angle is preferably between 6 and 8°. The center disc and the rim do not lie in the same plane.

LIST OF REFERENCE CHARACTERS

- 1 rim
- 1' symmetrical rim body
- 1" a rim well
- 2 spoke(s)
- 2' spoke(s) (comparative spoke according to the prior art)
- 2" spoke course in the pre-tensioned state
- 30 brake disc side
- 20 first spoke group (brake disc side)
- 2.1, 2.3 first spoke section (brake disc side)
- 2.2 second spoke section (brake disc side)
- 4.1 first base point(s) (brake disc side)
- 4.2 second base point(s) (brake disc side)
- insertion angle (brake disc side)
- ' angle (brake disc side)
- 31 non-brake disc side
- 200 second spoke group (non-brake disc side)
- 2.1' first spoke section (non-brake disc side)
- 2.2' second spoke section (non-brake disc side)
- 4.1' base point(s) (non-brake disc side)
- 4.2' base point(s) (non-brake disc side)
- α insertion angle (non-brake disc side)
- α' angle (non-brake disc side)
- 10 hub
- 3 one center

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8 crossing point
2.3.1, 2.3.2, 2.1.1, 2.1.2 fabric layers
9 negative mold
9.1 first part negative mold
9.2 second part negative mold
15 mold
13, 14 punch form
16, 160 rim
17, 170 rim body
18 rim well
21 first spoke group
19 spokes
22 second spoke group
29 first spoke sections (first spoke group)
32 second spoke sections **32** (first spoke group)
23 first base points (first spoke group)
26 second base points (second spoke group)
28 non-brake disc side
24 brake disc side
25 center
34 first spoke sections (second spoke group)
36 second spoke sections (second spoke group)
33 first base points (second spoke group)
37 second base points (second spoke group)
X vertical plane of symmetry of the bicycle wheel
D axis of rotation
38, 38' center discs
39, 39' spoke surface of extent

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160 A, 160 B rim cross-section
h spoke height
 The invention claimed is:
1. A method for producing a bicycle wheel made from a
 5 fiber composite material, comprising:
 laminating, in one piece and in one step, a rim, a plurality
 of spokes each comprising a first spoke section and a
 second spoke section, and a center having a first center
 disc and a second center disc, wherein all fibers for the
 10 rim, the spokes, and the center are laid in mold parts in
 the one step;
 curing the laminated rim, spokes, and center to form the
 bicycle wheel;
 removing the formed bicycle wheel in said one piece from
 15 the mold; and
 inserting a hub, in a second step, without pre-tensioning
 the spokes,
 wherein the spokes are laminated and cured such that the
 first spoke section and the second spoke section have a
 20 substantially straight shape.
2. The method according to claim **1**, wherein the lami-
 nation is performed such that fibers of the first spoke section
 and the second spoke section extend continuously between
 base points arranged on the rim.
 25 **3.** The method according to claim **1**, wherein the spokes
 are laminated, without a cover layer, from a unidirectional
 scrim.

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