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54 **Lightweight component**

The invention provides a lightweight component which, at least in part, has an essentially tubular body with a defined outer cross-sectional contour and a defined inner cross-sectional contour. The wall thickness of the component in the region of the tubular body is not constant along its cross section, and the inner cross-sectional contour and the outer cross-sectional contour of the component are designed in such a way that the change in the wall thickness along the cross section takes place essentially continually.

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Description

The present invention relates to a lightweight component having at least one essentially tubular region.

The term "lightweight components" used here is understood to mean components that have favorable strength properties and/or rigidity properties in relation to their weight.

Lightweight components of the type under discussion here are preferably used in sectors in which stringent requirements for strength and rigidity conflict with a low component weight. In general, this is more the case for objects capable of flight, for example hang gliders, lightweight aircraft, etc., and in sports, for example for the manufacture of ski poles, paddles for canoes or kayaks, golf clubs, tennis rackets, fishing rods, and the like.

One particularly important field of application of lightweight components is bicycle construction, and here in particular the construction of mountain bikes. The invention is therefore preferably described using the example of bicycle construction. However, it is pointed out that this is not to be construed as a limitation of the applicability of the invention in other areas in sports and in technology.

Bicycles, in particular bicycles that are used in sports, are allowed to have only a relatively low total weight, since a high weight adversely affects the riding characteristics. Apart from this, stringent requirements with regard to strength and rigidity are imposed on the components used in the bicycle sector, since on the one hand high rigidity is necessary in certain areas of the structure in the interest of rider safety, and on the other hand, in particular for bicycles that are used off-road, high impact loads may occur which result in stringent requirements for strength.

For this reason, so-called butted tubes have been used for quite some time as lightweight components for bicycle frames. For these tubes, which may be made of steel or also aluminum, the wall thickness in the tube center is smaller than at the tube ends. Typical butting for the top tube of a racing bike is, for example, a wall thickness of 0.9 mm in the end area and a wall thickness of 0.6 mm in the middle area. As a result of the increased wall thickness in the end areas of the tube, the stresses due to the clamping effect, which are particularly high in this area, are better tolerated by the welded or soldered connections, and in addition it is easier to establish a stable welded or soldered connection for tubes having a greater wall thickness.

However, it has been shown that even when butted tubes are used in lightweight bicycles, frame breakage may occur under high loads, so that a relatively high component weight is necessary in order to bear high loads.

Therefore, the object of the present invention is to provide a lightweight component which may be adapted in a particularly advantageous manner to the loads that occur during use, and which thus has a particularly favorable ratio of strength properties and rigidity properties with regard to the weight. A further aspect of the present invention is to provide a method for manufacturing such a lightweight component, and the preferred use of the lightweight component.

This object is achieved according to the invention by the

subject matter of Claim 1.

The method according to the invention is the subject matter of Claim 28.

Preferred refinements of the invention are the subject matter of the subclaims.

The lightweight component according to the invention offers significant advantages.

Conventional lightweight components, such as the butted tubes mentioned above, have a wall thickness that is unchangeable over the cross section. This does have the advantage that these parts may be assembled, for example welded to a bicycle frame, regardless of the angular orientation of the tubes, so that special monitoring of the orientation of the tubes is not necessary.

However, in contrast, the approach according to the invention has the significant advantage that the profile of the wall thickness over the cross section may be optimally adapted to the actual requirements with regard to strength and rigidity.

A consideration of the load on a bicycle frame, for example, shows that particularly high loads occur in the vertical plane of the frame, since the weight of the rider acts essentially in the vertical direction, and the impact loads acting on the front and rear wheel likewise essentially occur within a vertical plane. Loads situated outside this plane, in particular the torque generated about the bottom bracket bearing transverse axis during pedaling, the forces that occur when negotiating a curve, and the forces during pedaling while standing, when the bicycle is inclined during straight-ahead travel when pedaling, may likewise assume high values, but in their total scope and also frequency of occurrence they are lower than the forces occurring in the vertical direction.

The design according to the invention now allows the cross section of the tubular portion of the lightweight component to be designed in such a way that the force absorption capability of the components of a bicycle frame in the vertical frame direction is greater than in an arbitrary orientation perpendicular to this plane. As a result, for the same overall strength and rigidity, the weight may be reduced, or for the same weight, the strength and rigidity may be significantly increased in the load direction specified by the design.

In a bicycle, similar circumstances also occur with other components, for example the seat post. Depending on how far away the force transmission point, via which the weight of the rider acts on the seat, is situated from the connection point between the seat and the seat post, a torque results whose vector is perpendicular to the plane spanned by the frame, but whose acting force pair lies within this plane. In contrast, the load on the seat post in the lateral direction, i.e., with a torque vector in the plane of the frame, is significantly lower. Due to the approach according to the invention, the seat post may be reinforced in a targeted manner in the area in which the maximum load occurs.

The same also applies for other applications of lightweight components, for example for the design of golf clubs. In a golf club, the club head is accelerated by the hands of the player to a high speed (typical values are well above 100 km/h) within a fraction of a second (a typical

value is one-fourth second, for example). Due to the acceleration and the striking of the ball, the shaft of the golf club is significantly elastically deformed opposite the stroke direction, and then deforms in the opposite direction in the further course of the swing. The objective of golf club design is to configure the ratio of the weight of the club shaft to the weight of the club head in the most favorable way possible. Due to the lightweight component according to the invention, the golf club may be designed in such a way that the shaft has higher rigidity and strength values in the deformation direction than in a direction perpendicular to this typical deformation direction.

According to the invention, the change in the contour of the outer and/or inner cross section takes place continually. Due to the continuous progression, a jump in rigidity and thus stress concentration are avoided. The strength properties are thus significantly improved, since the maximum occurring stresses are greatly reduced.

Besides the change in the wall thickness along the cross section, the lightweight component according to the invention may also have a change in the wall thickness along its length. This three-dimensional cross-sectional adaptation has the advantage that not only may the cross section be optimally designed with regard to the force absorption, but in addition the strength and rigidity properties may also be optimized in the longitudinal direction of the lightweight component. Thus, for example, for a bicycle frame the wall thickness in the area of welding points may be greater in order to absorb the increased stress that occurs due to the clamping effect.

The lightweight component according to the invention may be a tubular component which is then welded to other components, for example to form a bicycle frame. However, the bicycle component according to the invention may also be connected directly to a functional part, for example to a holding device for accommodating a bicycle seat. The functional device may be integrally formed directly on the tubular component, or may be connected to the lightweight component using a welding, soldering, or adhesive bonding process, or the like. However, instead of a joining process, other connection mechanisms, for example use of clamping devices and the like, are possible.

The invention may be implemented using different cross-sectional shapes of the outer cross section and of the inner cross section.

A circular ring-shaped outer cross-sectional contour is to be preferred for visual and possibly also technical reasons, resulting in a lightweight component in which the different wall thickness distribution is defined by the inner cross-sectional contour. Since for such a tube the distribution of the wall cross section is not visible from the outside, markings or the like are preferably applied here during manufacture to ensure the correct installation position of the tube.

However, the outer cross section of the tube may also be elliptical or slightly elliptical, in that case the wall thickness distribution preferably being symmetrical with respect to the longitudinal axis of the ellipse. In addition, an oval, i.e., egg-shaped, design is possible, which may be advantageous for many applications.

For an elliptical or oval outer contour, the inner contour may be cylindrical, so that optimal rigidity and strength conditions with regard to loads along the above-described plane of symmetry are achieved along the longitudinal axis of the ellipse.

The invention may also be implemented using a rectangular tube profile, in which case, however, it is then necessary to ensure that the outer and inner contours are suitably rounded in the transition from one rectangular side to the next rectangular side, in order for the transition as a whole to be continuous.

In addition to such a rectangular or also square outer cross-sectional contour and a correspondingly designed inner cross-sectional contour, other contours are also conceivable, for example triangular, pentagonal, hexagonal, octagonal, or some other type of polygonal contours for the outer and/or inner cross-sectional contour.

Preferred uses of the invention have been described above. Thus, the lightweight component for bicycles is suitable for practically all tubular components, i.e., top tube, down tube, seat tube, head tube, fork tubes, rear wheel stay, seat posts, handlebars, handlebar stem, and the like.

For manufacturing such a lightweight component, the invention proposes to subject a starting material or a blank to a shaping process that results in the desired cross-sectional contour, it being possible for this shaping process to be a non-cutting process, a cutting process, or a combination of a non-cutting and a cutting deformation process, or a casting or injection molding process.

The non-cutting deformation is particularly preferred, in which the tubular part is drawn over a mandrel having a suitable cross section. Another preferred method is the pushing or pressing of an initially cylindrical, tubular part into an elliptically symmetrical cross-sectional shape, the outer portion being subsequently brought to an essentially cylindrical outer contour by a cutting deformation process, preferably by turning.

In this type of manufacture, the tubular part may also be butted beforehand, so that the cross section is thicker in the end area of the tube than in the middle area.

In another preferred refinement of the manufacturing method according to the invention, the blank is a plate, which via a non-cutting or cutting deformation operation is given a surface contour that essentially corresponds to the desired wall thickness distribution for the finished component. The tubular component is then produced from this essentially flat blank, using a deformation process, the deformation process preferably taking place via a rolling operation. The abutting side edges of the blank are then welded.

If the tubular body is, for example, a tube with a cylindrical outer contour and a noncylindrical inner contour, the blank is a rectangle, having a flat bottom side and a correspondingly contoured top side, which via the rolling is then brought into a tube having a seam extending in the tube longitudinal direction.

Instead of the process that results in a longitudinal seam extending in the tube longitudinal direction, a process may also be selected in which the weld seam extends not in parallel to the tube longitudinal axis, but, rather, extends

helically around the tube.

The stated manufacturing methods are usable not only for cylindrical or elliptical tubes, but also for the other stated profile shapes.

The material of the tubular component is advantageously selected corresponding to the given requirements. It is particularly preferred to use an alloy that contains aluminum; in particular the elasticity behavior, i.e., the modulus of elasticity, should thus also be taken into account in selecting the alloy components.

In addition to or instead of aluminum as an alloy component, other materials having good lightweight component properties, in particular titanium and the like, may also be used.

It is also possible to manufacture the lightweight component according to the invention from plastic or a material containing plastic. If an essentially homogeneous plastic is used, the lightweight component may then also be manufactured using an injection molding process or the like. If an inhomogeneous material is used, for example an additional reinforcement with carbon fibers, glass fibers, or the like, the shaping methods that are customary in this field are used for the manufacture.

Further advantages, features, and application options of the present invention result from the following description of the figures in conjunction with the drawing. In the figures:

Fig. 1a through **1h** show various cross-sectional shapes of the lightweight component according to the invention;

Fig. 1l shows a longitudinal view of the exemplary embodiment according to **Fig. 1a**;

Fig. 2a shows a schematic side view of a bicycle frame of the diamond type;

Figs. 2b, 2c show cross sections of the down tube of the bicycle frame according to **Fig. 2a** at various section planes;

Fig. 3a shows a schematic, sectional partial view of a seat post and its arrangement in the bicycle frame;

Figs. 3b through **3c** show partial sectional partial views of the seat post according to **Fig. 3a**;

Fig. 4 shows a partial sectional cross-sectional view for illustrating one exemplary embodiment of the manufacturing method according to the invention;

Fig. 5a shows a top view and

Figs. 5b through **5e** show partial sectional illustrations of a lightweight component for explaining a further exemplary embodiment of the manufacturing method according to the invention; and

Figs. 6a, 6b show partial sections of a tool or a lightweight component for explaining a further exemplary embodiment of the manufacturing method according to the invention.

A plurality of various cross-sectional shapes for the lightweight component according to the invention are now described, with reference to **Figs. 1a** through **1k**.

The lightweight component according to **Fig. 1a**, as illustrated in a side view in **Fig. 1l**, is an elongated tube 1 which (in the exemplary embodiments shown in **Figs. 1a** through **1h**) extends symmetrically with respect to a straight center line 2.

The illustrations according to **Figs. 1a** through **1h** show cross-sectional illustrations of the tube along a section line

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The exemplary embodiment according to **Fig. 1a** shows a cross section 2 of a tube having a circular outer cross-sectional contour 3 and an elliptical inner cross-sectional contour 4 that is arranged symmetrically with respect to a center line or center plane 5.

In this exemplary embodiment, the highest strength and rigidity values occur in a plane that is directed perpendicularly with respect to a line 6 and that perpendicularly intersects the plane of symmetry 5. In other words, the optimal rigidity vector is perpendicular to the plane of symmetry 5.

In the exemplary embodiment according to **Fig. 1b**, both the outer cross-sectional contour 10 and the inner cross-sectional contour 11 have a circular design that is symmetrical with respect to a plane of symmetry 15.

The cross-sectional distribution apparent in **Fig. 1b** results from the fact that the midpoint 12 of the outer cross-sectional circle is shifted relative to the midpoint 13 on the line of symmetry 15.

This cross-sectional design results in a component whose highest bearable tensile stresses are in the lower area 16 of the line of symmetry. This component may then be used in a particularly advantageous manner, for example, when the component is subjected to bending loads that act in the direction of the arrow 17.

In the exemplary embodiment according to **Fig. 1c**, the outer cross-sectional contour 20 is elliptical and the inner cross-sectional contour 21 is circular. The contours are symmetrical with respect to the plane of symmetry 25.

In this design, optimal strength and rigidity values occur in the plane of symmetry 25.

This design may be used in a particularly advantageous manner when the forces act in a plane that coincides with the plane of symmetry 25 or that is slightly shifted parallel to same.

In the exemplary embodiment according to **Fig. 1d**, the outer cross-sectional contour 30 has an oval design, while the inner cross-sectional contour 31 is circular. In this exemplary embodiment as well, the cross section as a whole is symmetrical with respect to a plane of symmetry 35.

This design is particularly advantageous for lightweight components that are subjected to bending stress by forces that act in the direction of the arrow 37.

In the exemplary embodiment according to **Fig. 1e**, the outer cross-sectional contour 40 is circular, while the inner cross-sectional contour 41 is oval. Overall, this profile is likewise symmetrical with respect to the plane of symmetry 27. Optimal load values result here as well for a bending load along the arrow 47.

In the exemplary embodiment according to **Fig. 1f**, the outer cross-sectional contour 50 is essentially rectangular, i.e., is even square in the exemplary embodiment shown. However, the rectangular profile is provided with considerable rounding in the transition region 51 from a first side face 52 to a second side face 53, so that the cross-sectional change is continual overall. The inner cross-sectional contour of the tube 54 is elliptical. The tube as a whole is situated symmetrically with respect to a plane of symmetry 55.

For this tube as well, an optimal load-bearing capacity results for forces that act in the area of the plane of symmetry 55.

The exemplary embodiment according to **Fig. 1g** shows a lightweight tube for which the outer contour 60 has a hexagonal design.

Here as well, the design is such that the transition region is provided with rounding 64 in the transition from a first side face 61 to a second side face 62 in order to avoid rigidity jumps.

The inner cross-sectional contour 66 has an elliptical design. The profile as a whole is symmetrical with respect to a first plane of symmetry 65 and to a second plane of symmetry 67.

The profile has the highest strength and rigidity values for forces that lie in the plane 67. **Fig. 1h** shows a further exemplary embodiment for the cross-sectional design of the lightweight tube according to the invention.

In this exemplary embodiment, the outer cross-sectional contour 70 and the inner cross-sectional contour 71 each have a circular design. The outer cross-sectional contour has the midpoint 72, and the inner cross-sectional contour is symmetrical with respect to its midpoint 73.

As is apparent in the figure, the midpoint 73 is shifted above the midpoint 72, and in particular (in the illustration according to **Fig. 1h**) is shifted to the right by the magnitude x_1 , and at a right angle thereto is shifted upwardly by the magnitude y_1 .

This design results in a distribution of the flexural rigidity and the strength, which has a particularly favorable effect for bending stresses that act along the arrow 76.

Such a design may be used, for example, for lightweight tubes in which in addition to a force that acts essentially in the vertical direction, a force component occurs perpendicularly or obliquely with respect to the vertical direction, for example for the rear wheel chain stay of a bicycle.

In the exemplary embodiments discussed above, the term "elliptical" has been frequently used for indicating the cross-sectional contour. It is pointed out that this term "elliptical" is not to be understood in the strictly geometric sense. In all cases, deviations from a strictly elliptical contour are also possible; however, for the cross-sectional contours shown there it is important to achieve a contour in which a larger longitudinal axis and a smaller transverse axis, with a curvature extending in between, essentially symmetrically with respect to the transverse axis and the longitudinal axis, is provided, it being possible to describe this curvature not only by a second-order geometric function, but also by a higher-order curve with the appropriate selection of coefficients.

However, for the exemplary embodiments shown, a curve pattern in which the curvature follows a second-order function is generally to be preferred.

In the exemplary embodiments discussed in the present patent application, a symmetrical design of the lightweight component is frequently described. It is pointed out that in the exemplary embodiments shown, a symmetry in the strictly geometric sense is not necessary in order to achieve the desired effect in each case. Rather, the profiles may also

have a more or less asymmetrical design.

In the exemplary embodiments shown in **Figs. 1a** through **1h**, the adjacent cross sections of the tubular body are identical; i.e., each cross section perpendicular to the line 2 has the same cross section.

However, within the scope of the invention it is also possible for adjacent cross sections to have a different design. Here as well, according to the invention an approach is used in which the change in the cross sections in the longitudinal direction takes place continually.

Thus, for example, for the frame tube of a bicycle, the end areas of the tube may be designed with larger cross-sectional wall thicknesses than the middle tubes.

Within the scope of the invention, it is likewise possible to change the cross-sectional shape along the tube length. For example, the cross-sectional shape in one region of the tube may correspond to the cross-sectional shape according to **Fig. 1a**, and in one region may correspond to the cross-sectional shape according to **Fig. 1b**.

In addition, in particular for the exemplary embodiments according to **Fig. 1a** it is possible for the elliptical inner cross-sectional contour to continually transition into a circular inner cross-sectional contour in a certain area of the tube, for example in a middle area or in an end area.

Corresponding transitions are also possible for the other exemplary embodiments shown.

Fig. 2 shows a further exemplary embodiment and application example of the lightweight component according to the invention.

Fig. 2a shows the illustration of a typical bicycle frame of the diamond type, including a top tube 100, a down tube 101, a seat tube 102, and a head tube 103.

Situated at the connection point between the down tube 101 and the seat tube 102 is a bottom bracket bearing 104, which has a cylindrical tube piece extending perpendicularly with respect to the plane of the drawing in **Fig. 2a**.

All tube parts are manufactured from a light alloy. The outer cross-sectional contour of all tubes is cylindrical.

As shown in **Fig. 2c**, the down tube is designed in such a way that the wall thickness at the lower side facing the front wheel is much greater than at the side facing the top tube.

In addition, as shown in **Fig. 2b**, which illustrates the cross section along the line IIa-IIa, additional reinforcement is provided in the region of the head tube 103. This takes into account the fact that significantly higher loads occur in this region than, for example, in the region of the cross section IIIa-IIIa shown in **Fig. 2c**. The greater wall thickness in the region of the down tube pointing toward the front wheel results in higher strength in this region. Frame breakage in the area of the down tube may thus be prevented, despite a lightweight design.

Fig. 3a shows a further exemplary embodiment of the lightweight component according to the invention, in particular the design of a seat post for a bicycle.

Fig. 3a illustrates the seat tube 120, having a cylindrical design in the illustration, of a bicycle frame of the diamond type, which is welded to a top tube 121 in a known manner. The seat post 125 according to the invention is inserted into the seat tube 120. As is apparent from the illustration

according to **Fig. 3a**, the wall thickness of the tubular region tapers toward the ends of the seat post, and reaches its maximum in the middle area.

Since the highest bending load occurs in the region of the clamping site 124, as a result of this cross-sectional profile greatly increased strength, with lower weight, is achieved compared to a cylindrical design.

The cross-sectional configuration is indicated in **Figs. 3c** and **3d**.

Fig. 3c shows the cross section along the line IV-IV, and shows a circular outer cross-sectional contour 130 and an elliptical inner cross-sectional contour 131. The contour is symmetrical with respect to a plane of symmetry 132 in which the longitudinal axis of the elliptical cross-sectional contour is also situated, and with respect to the plane of symmetry 134 in which the short axis of the elliptical inner cross-sectional contour is situated.

Along the cross section V-V, which is farther from the frame clamping site 124, which follows, than the cross section IV-IV, the outer cross-sectional contour 140 still has a circular cylindrical design, and also has the same diameter as the outer cross-sectional contour 130, whereas, although the inner cross-sectional contour 141 is elliptical, the wall thicknesses are much smaller than for the cross section in the region IV-IV. The cross sections are symmetrical with respect to a longitudinal axis 142 in which the longitudinal axis of the elliptical cross-sectional contour is also situated, and with respect to a plane of symmetry 144 in which the transverse axis of the elliptical cross-sectional contour is situated. This profile as well has its greatest rigidity and strength along the plane 144, the same as the profile explained with reference to **Fig. 3c**. Therefore, the seat post will be situated in such a way that the planes 134 or 144 coincide with the plane spanned by the frame. Since no rigidity jumps occur, a strength and rigidity profile that is optimally adapted to the stress profile is achieved, so that the seat post has optimal strength and rigidity properties with the lowest weight.

A first method for manufacturing the lightweight component according to the invention is now described with reference to **Figs. 4a** through **4c**.

The starting point of this method is a tube piece 150 that is cylindrical overall, and that has a circular outer cross-sectional contour 151 and a circular inner cross-sectional contour 152.

In a first method step, the tube is deformed by forces that are directed through the center line, along a plane 155 that intersects the midpoint of the outer and the inner cross-sectional circle. For example, a customary pressing device that is provided with appropriately designed pressing jaws is used to apply the forces.

The pressing operation is controlled in such a way that an elliptical outer cross-sectional contour 156 and an elliptical inner cross-sectional contour 157 are formed, as is apparent in the illustration according to **Fig. 4b**.

As shown in **Fig. 4c**, the outer cross section 156 is subsequently shaped into a circular outer cross-sectional contour 158, using a machining process. The elliptical inner cross-sectional contour 157 is thereby retained.

As a result, the area 159 illustrated in crosshatch in **Fig.**

4c is absent, resulting in a circular tube with an elliptical inner cross section.

A turning process is preferably used as the cutting method, a precision turning process preferably being used to achieve a slight notching effect. For increased surface requirements, the tube may also be subjected to a grinding process after the turning process.

A further manufacturing method is explained with reference to **Figs. 5a** through **5e**.

Fig. 5a shows the top view of a rectangular blank 170 having a rectangular shape with fairly long side edges 171a and 171b and short side edges 172a and 172b. As illustrated by the section along the line VI-VI, illustrated in **Fig. 5b**, the profile has a cross-sectional design such that the profile height in the region of the short edge 172a is much greater than in the region of the short edge 172b. A minimum of the profile height is reached approximately at the middle of the profile.

Fig. 5c shows a cross section of the blank along the line VII-VII. As is apparent here, in the middle, i.e., in the region of the line VI-VI, the profile has a maximum, which correspondingly also occurs at the two outer edges, i.e., in the region of the side edges 171a and 171b.

This blank is now deformed via a tube-shaping rolling process, using a device (not illustrated), in such a way that a lightweight component results, as shown in cross section in **Fig. 5d** and in the longitudinal direction in **Fig. 5e**. The side edges 171a and 171b abut one another, and are welded together at the joint. Instead of two parts that are welded together, it is also possible to weld three or more parts together in the longitudinal direction.

As the result of this design it is possible to achieve any desired cross-sectional shape. This means that a genuine three-dimensional cross-sectional adaptation to the load conditions that actually prevail is possible.

The profile of the blank may be easily produced by pressing. For this purpose, via electrical discharge machining or the like, for example, a tool may be created whose contour is adapted to the desired contour of the blank. The three-dimensional design may be implemented in a very cost-effective manner via the pressing operation and the subsequent rolling and welding.

In the exemplary embodiment shown, the weld seam is straight, i.e., symmetrical with respect to the longitudinal plane of symmetry of the lightweight component. Within the scope of the invention, it is also possible to achieve differing seam shapes. Any desired implementations of the tubular cross section are thus ultimately possible, for example implementations in which the weld seam extends helically or in some other way around the tube after the rolling operation is finished and the manufacture of the tube is thus complete. This may prevent the situation that the weld seam is situated at a high-load location on the lightweight component, which could possibly reduce the strength.

A further exemplary embodiment of the manufacturing method according to the invention is now explained with reference to **Fig. 6**. **Fig. 6a** shows in a highly schematic manner the lower portion 190 of a pressing tool, which cooperates with an upper portion 191. Provided between the

lower portion 190 and the upper portion 191 is a cavity that corresponds to one-half the cross-sectional shape of the lightweight component to be manufactured. Even though it is not immediately apparent from the cross-sectional illustration according to **Fig. 6a**, it should be emphasized that here as well, the adaptation of the wall thickness may be not only two-dimensional, i.e., an adaptation of the wall thickness over the cross section, but also three-dimensional, i.e., an adaptation of the wall thickness with regard to the cross section and the longitudinal section.

A blank of the lightweight component 193 to be manufactured is placed in the mold and subjected to load with a predefined pressing force until the desired blank shape illustrated in **Fig. 6a** results.

As illustrated in **Fig. 6b**, two lightweight halves 193 formed in this way are placed on top of one another and welded, soldered, or adhesively bonded to one another at the contact point 194.

This method is also very well suited for cost-effectively producing three-dimensional designs of lightweight components.

Claims

1. A lightweight component which, at least in part, has an essentially tubular body with a defined outer cross-sectional contour and a defined inner cross-sectional contour,

characterized in that

the wall thickness of the component in the region of the tubular body is not constant along its cross section, and the inner cross-sectional contour and the outer cross-sectional contour are designed in such a way that the change in the wall thickness along the cross section takes place essentially continually.

2. The lightweight component according to Claim 1, characterized in that the wall thickness of the component in the region of the tubular body is not constant along its longitudinal extension, and the adjacent inner cross sections and outer cross sections are designed in such a way that the change in the wall thickness along the longitudinal direction of the tubular body takes place essentially continually.

3. The lightweight component according to Claim 1 or 2, characterized in that the essentially tubular body runs linearly, at least in part.

4. The lightweight component according to Claim 1, characterized in that the essentially tubular body runs in a curve, at least in part.

5. The lightweight component according to at least one of Claims 1 through 4, characterized in that the inner cross-sectional contour and the outer cross-sectional contour in the region of the essentially tubular body are designed in such a way that the cross-sectional configuration is symmetrical with respect to a section plane extending in the tube longitudinal direction.

6. The lightweight component according to at least one of the preceding claims, characterized in that the outer cross-sectional contour in the region of the essentially tubular body is essentially circular.

7. The lightweight component according to at least one of Claims 1 through 5, characterized in that the inner cross-

sectional contour in the region of this essentially tubular body is essentially elliptical.

8. The lightweight component according to at least one of Claims 1 through 5, characterized in that the inner cross-sectional contour in the region of this essentially tubular body is essentially oval.

9. The lightweight component according to Claim 6, characterized in that the inner cross-sectional contour in the region of this essentially tubular body is circular, the outer circle that defines the outer cross-sectional contour and the inner circle that defines the inner cross-sectional contour being situated concentrically with respect to one another.

10. The lightweight component according to at least one of the preceding claims, characterized in that the distribution of the flexural rigidity is not rotationally symmetrical with respect to a center axis of this tubular body.

11. The lightweight component according to Claim 1 or one of Claims 3 through 10, characterized in that the torsional rigidity of adjacent cross sections is constant in the longitudinal direction of this essentially tubular body.

12. The lightweight component according to at least one of Claims 2 through 10, characterized in that the torsional rigidity of adjacent cross sections is not constant in the longitudinal direction of this essentially tubular body.

13. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component additionally has a functional part that is provided for connection to a bicycle seat.

14. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as a top tube of a diamond bicycle frame.

15. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as a down tube of a bicycle frame.

16. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as a seat tube of a bicycle frame.

17. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as a head tube of a bicycle frame.

18. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as part of a bicycle fork.

19. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as part of a handlebar stem.

20. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as part of bicycle handlebars.

21. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component includes only this tubular region.

22. The lightweight component according to at least one of

the preceding claims, characterized in that the component is made of an essentially homogeneous material.

23. The lightweight component according to Claim 22, characterized in that the lightweight component is made essentially of metal.

24. The lightweight component according to Claim 23, characterized in that this lightweight component is made of an alloy that contains aluminum.

25. The lightweight component according to Claim 23 or 24, characterized in that the component is at least partially made of a metal alloy that contains titanium.

26. The lightweight component according to at least one of Claims 1 through 22, characterized in that the lightweight component is at least partially made of plastic.

27. The lightweight component according to at least one of Claims 1 through 21, characterized in that the component is at least partially made of a plastic that is reinforced with a fiber core, this fiber core preferably being made of glass fibers or carbon fibers.

28. A method for manufacturing a lightweight component having, at least in part, an essentially tubular body with a defined outer cross-sectional contour and a defined inner cross-sectional contour, characterized in that as the result of a change in shape of a starting material, the wall thickness of the component in the region of the tubular body is designed in such a way that the wall thickness is not constant along the cross section, and the change in the wall thickness over the cross section takes place essentially continually.

29. The method for manufacturing a lightweight component according to at least one of Claims 1 through 25, characterized in that at least this tubular part is manufactured by being seamlessly drawn.

30. The method for manufacturing a lightweight component according to at least one of Claims 1 through 25, characterized in that initially a cylindrical part having an essentially constant wall thickness is seamlessly shaped via a drawing operation, this tubular part is then deformed into an essentially elliptical shape by applying a pressing force that acts essentially in the longitudinal direction of the tube, and the outer diameter of the tube is then machined in such a way that an essentially cylindrical outer diameter of the tubular region results.

31. The method according to Claim 30, characterized in that this change in shape of the outer diameter takes place via a machining operation.

32. The method according to Claim 31, characterized in that the outer diameter of the tubular part is subjected to turning to provide the desired diameter.

33. The method according to Claim 28, characterized in that this tubular region is produced by drawing over a mandrel, the outer cross-sectional contour of this mandrel essentially corresponding to the inner cross-sectional contour of this tubular part.

34. The method according to Claim 28, characterized in that this tubular region is produced by deforming an essentially flat starting material into the desired cross-sectional dimensions, and then deforming it to form a tubular region.

35. The method according to Claim 34, characterized in that this starting material has an essentially flat design, and the

side edges of this rectangle extending in the longitudinal direction are joined together after the deformation.

36. The method according to Claim 35, characterized in that the joining takes place using a process that is selected from a group of processes that includes a joining process, a soldering process, a brazing process, a welding process, and an adhesive bonding process.

37. The method according to Claim 34, characterized in that the shaping of this rectangular, essentially flat starting material takes place via a rolling operation.

38. The lightweight component according to at least one of Claims 1 through 12, characterized in that the lightweight component is designed in such a way that it is formed as part of a motorcycle fork.

39. Use of a lightweight component according to at least one of Claims 1 through 12 for constructing a bicycle.

4 page(s) of drawings are appended

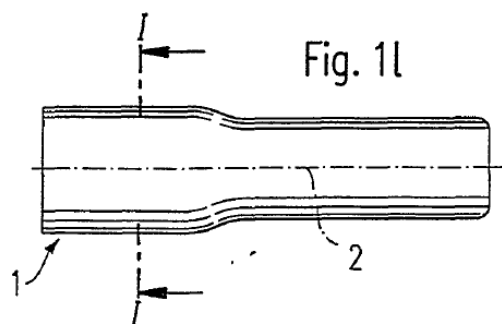
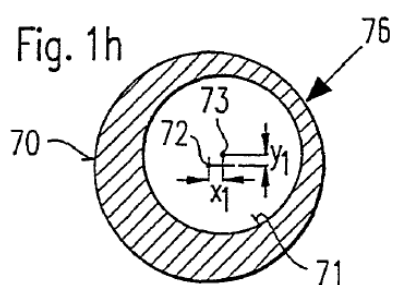
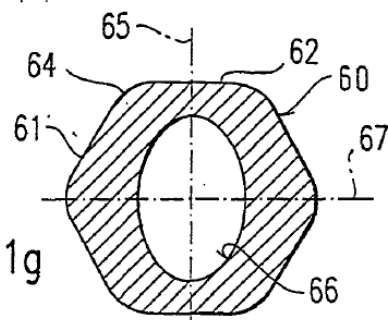
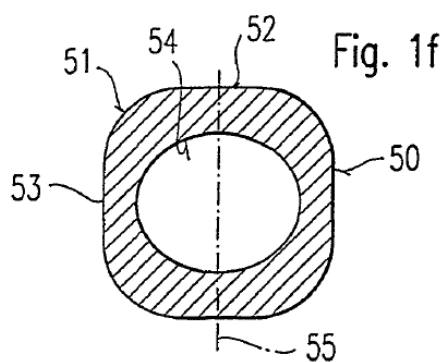
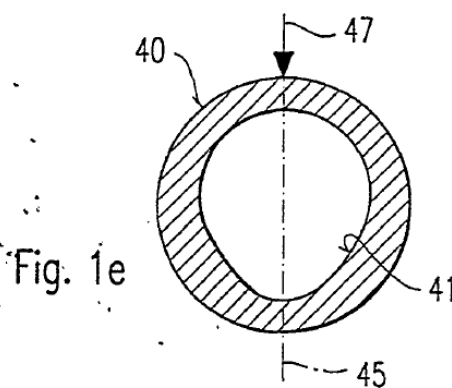
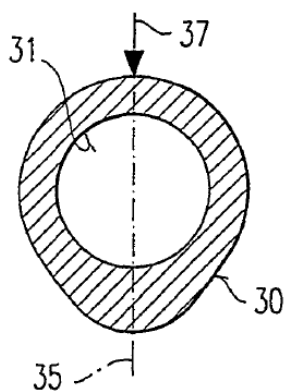
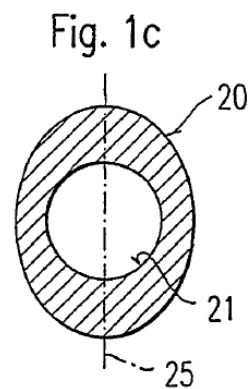
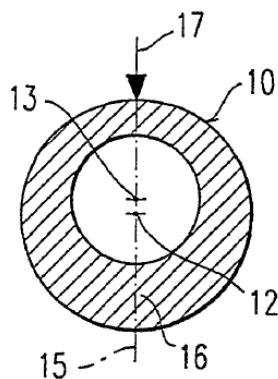
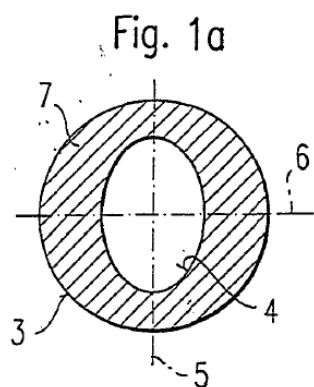


Fig. 2a

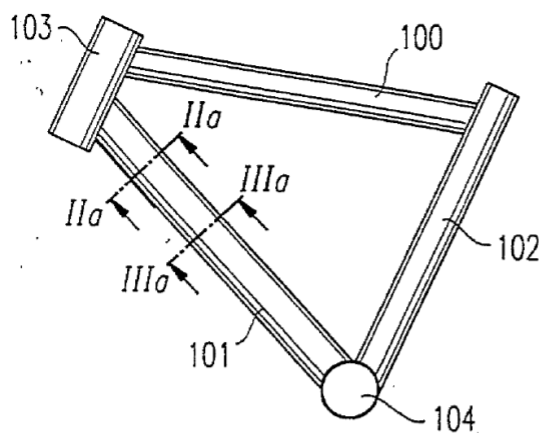


Fig. 2b

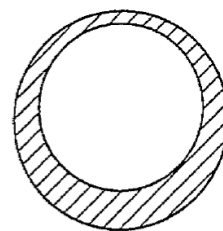


Fig. 2c

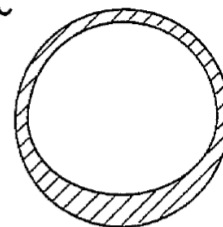


Fig. 3a

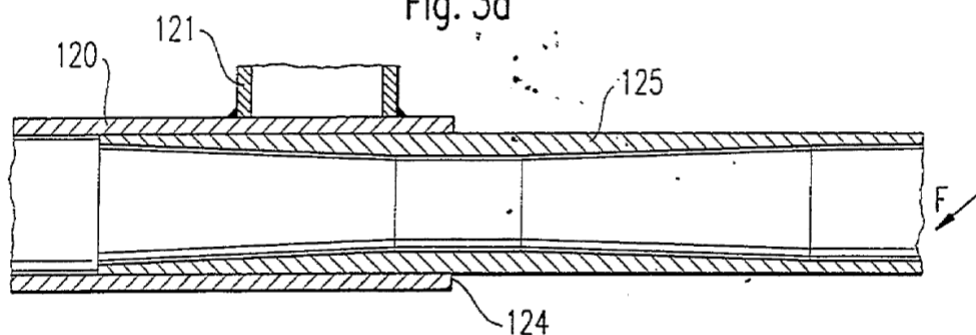


Fig. 3b

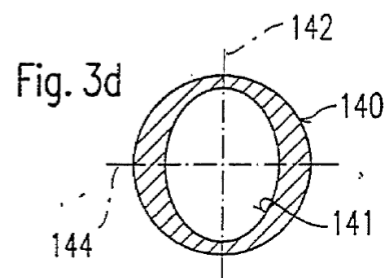
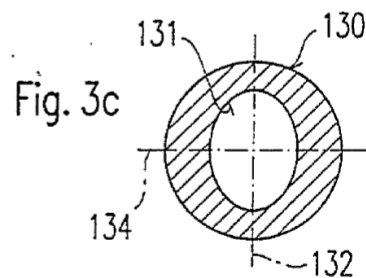
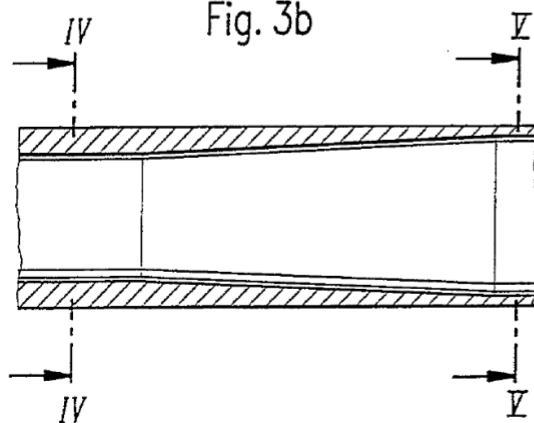


Fig. 4a

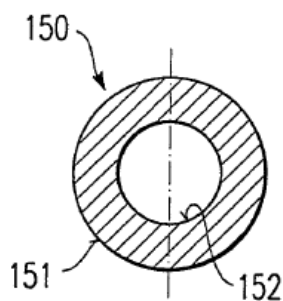


Fig. 4b

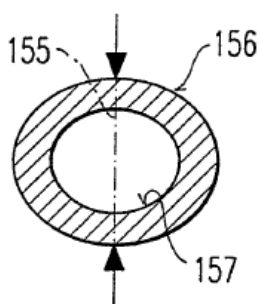


Fig. 4c

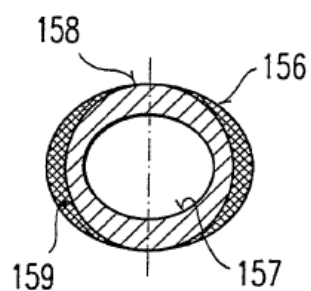


Fig. 5a

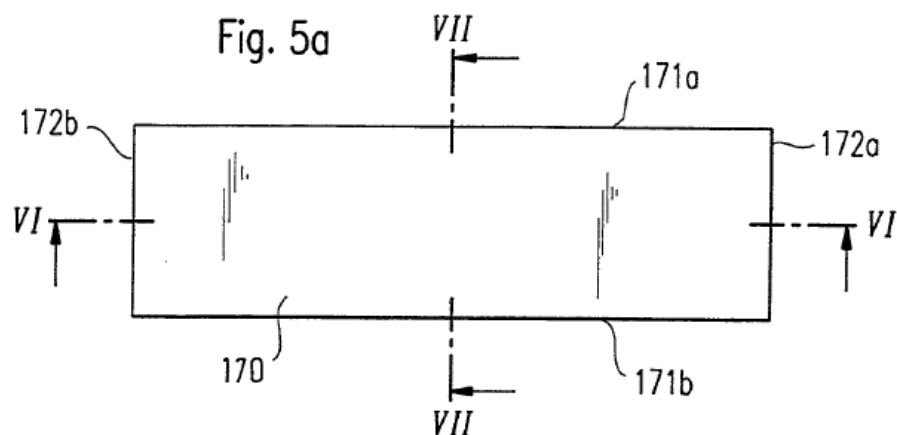


Fig. 5b



Fig. 5c

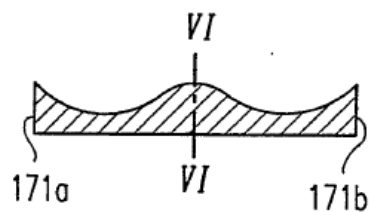


Fig. 5d

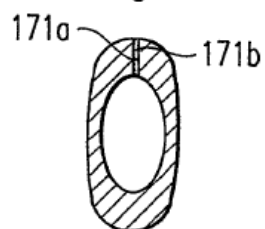


Fig. 5e

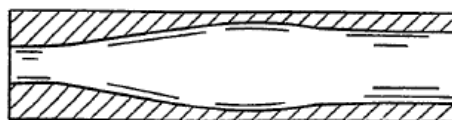


Fig. 6a

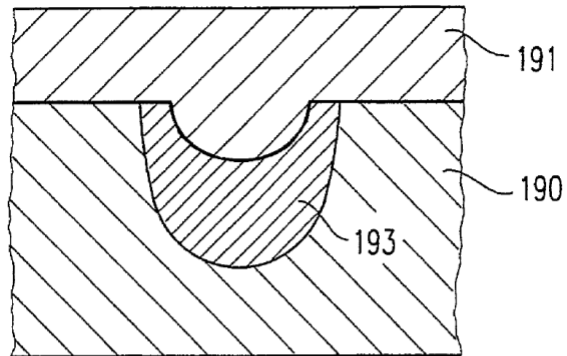
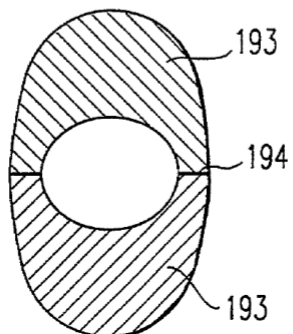


Fig. 6b



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ATA-Certified Translator (#62196) & Interpreter, English <> German

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CERTIFICATION

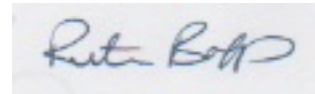
I hereby certify that

- (1) I am a German into English and English into German translator, certified by the American Translators Association;
- (2) I have translated and/or reviewed the translation of the following document from German into English:

German Unexamined Patent Application DE 196 29 740 A1

“Lightweight Component”

- (3) The attached English translation is a true and correct translation of the German language source document to the best of my knowledge and belief.
- (4) I declare that all statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. I understand that willful false statements and the like are punishable by fine or imprisonment, or both.



Date: March 22, 2023

Ruth Boggs, MA, CT



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