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**Wilke et al.**

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(54) **COMPRESSION MOLDED HUB SHELL**

2310/204 (2013.01); B60B 2360/341  
(2013.01); B60B 2900/00 (2013.01)

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CPC ... B60B 27/023; B60B 5/02; B60B 2310/204;  
B60B 2360/341; B60B 2360/3412; B60B  
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See application file for complete search history.

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301/59

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*Primary Examiner* — Erez Gurari

**Related U.S. Application Data**

(60) Provisional application No. 61/769,806, filed on Feb.  
27, 2013.

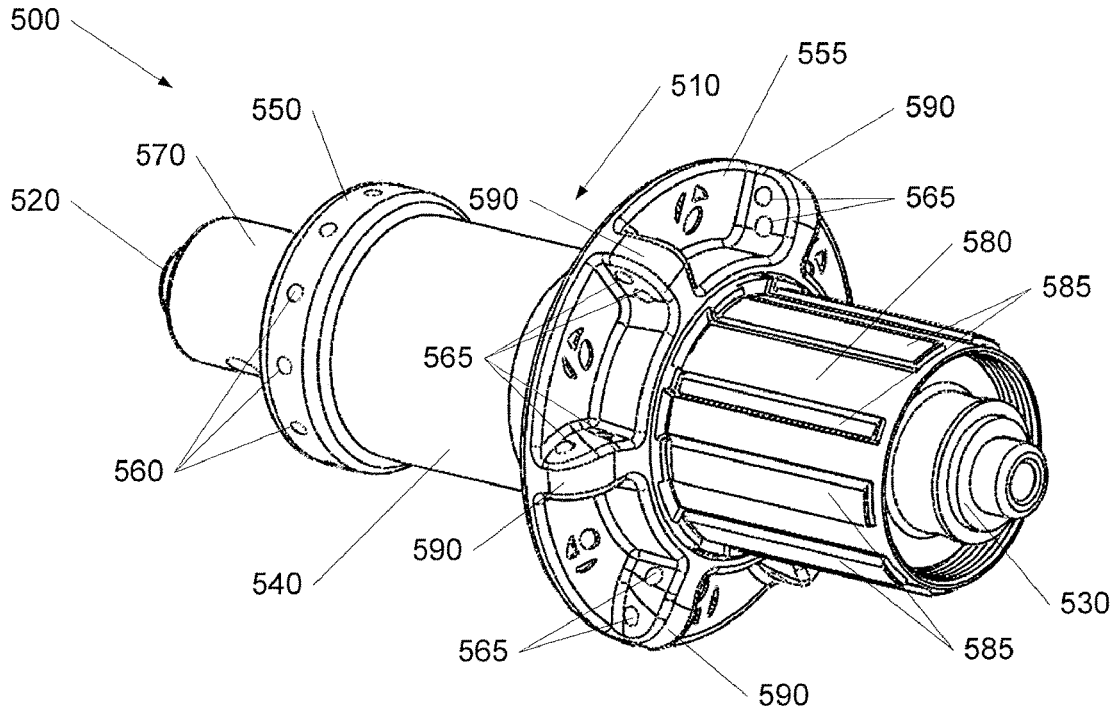
(57) **ABSTRACT**

An apparatus including a hub shell. The hub shell can  
include a hub body; a first spoke flange; and a second spoke  
flange. The first spoke flange and the second spoke flange  
can include a fiber reinforced plastic. The fiber reinforced  
plastic can include fibers having a range of lengths between  
0.2 and 3 inches.

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**B60B 27/02** (2006.01)  
**B60B 5/02** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B60B 27/023** (2013.01); **B60B 5/02**  
(2013.01); **B60B 27/04** (2013.01); **B60B**

**11 Claims, 6 Drawing Sheets**



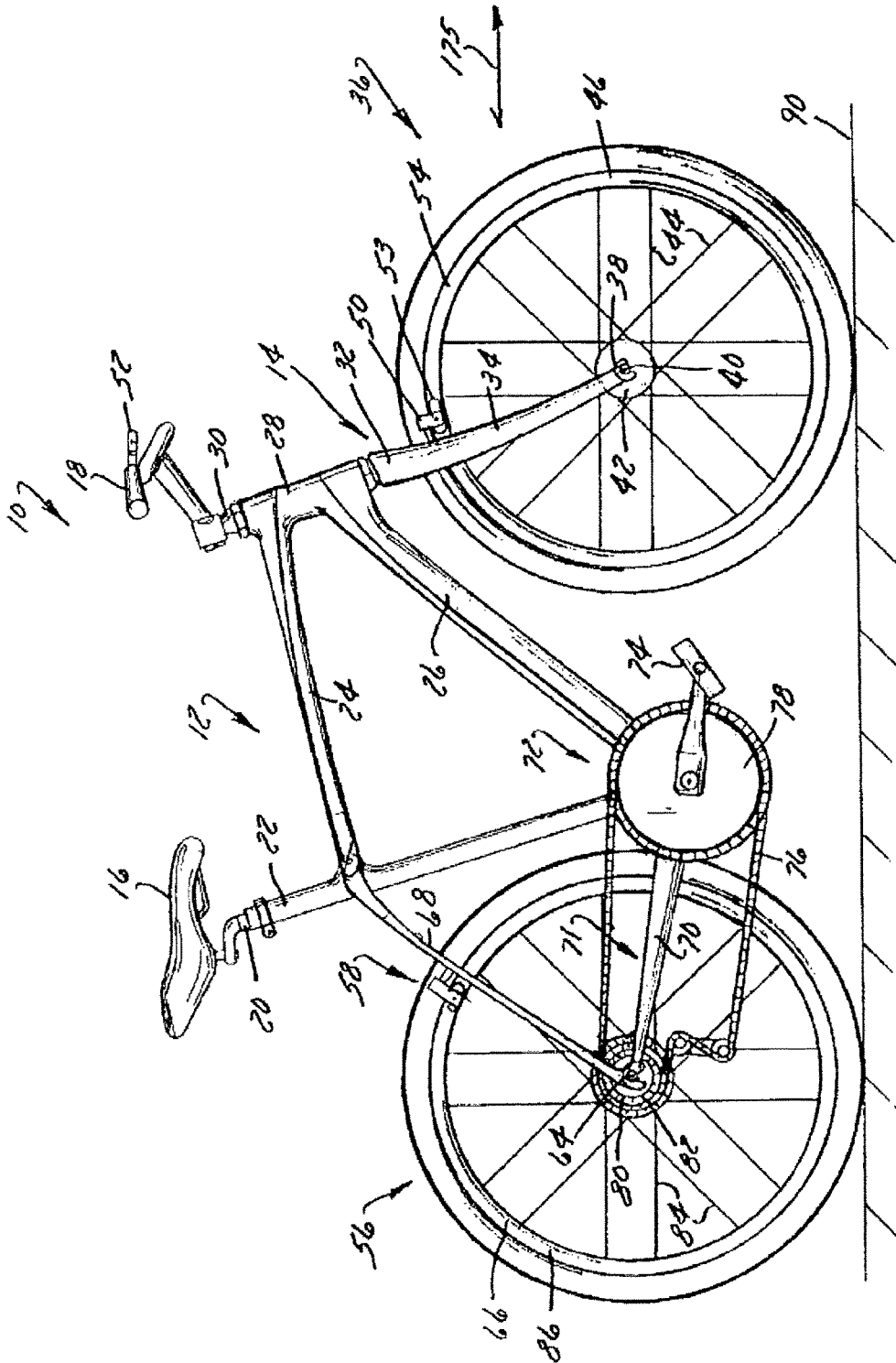


FIG. 1

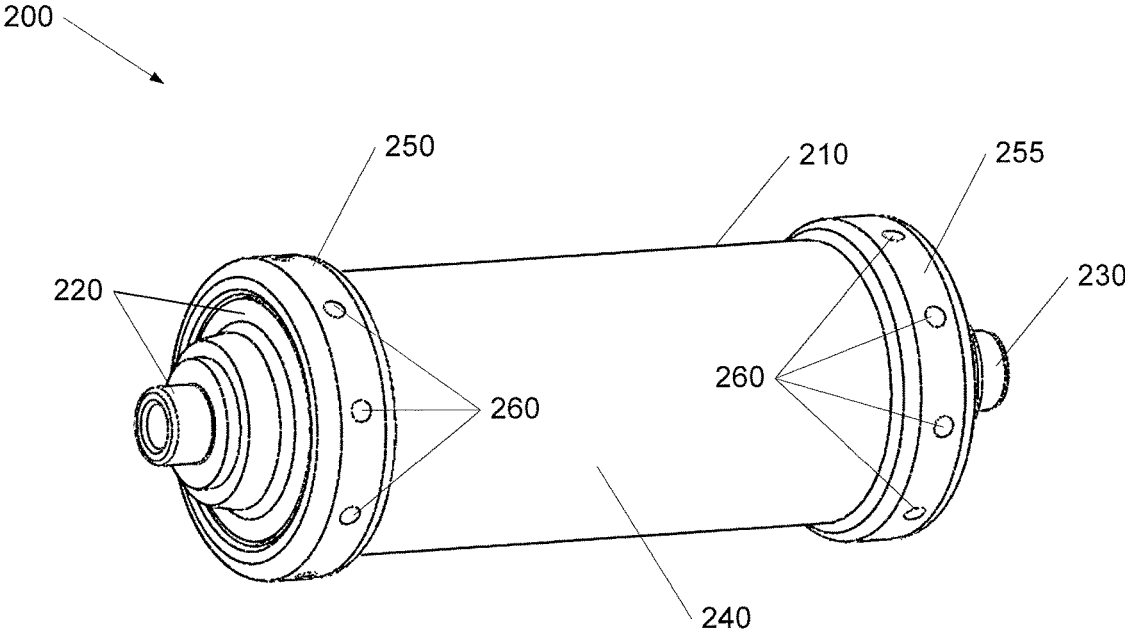


FIG. 2

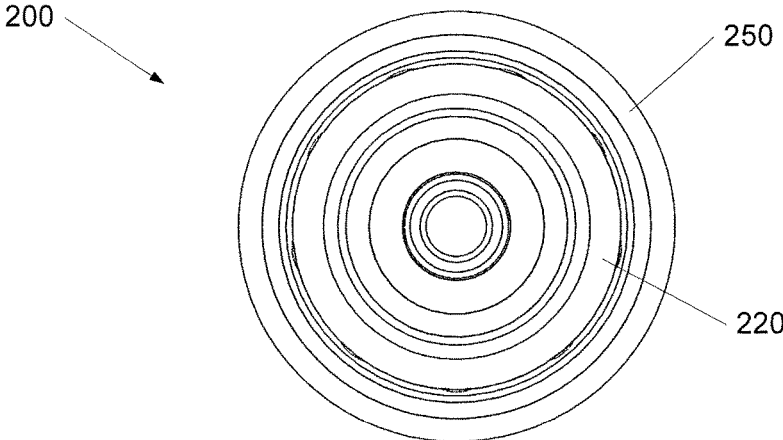
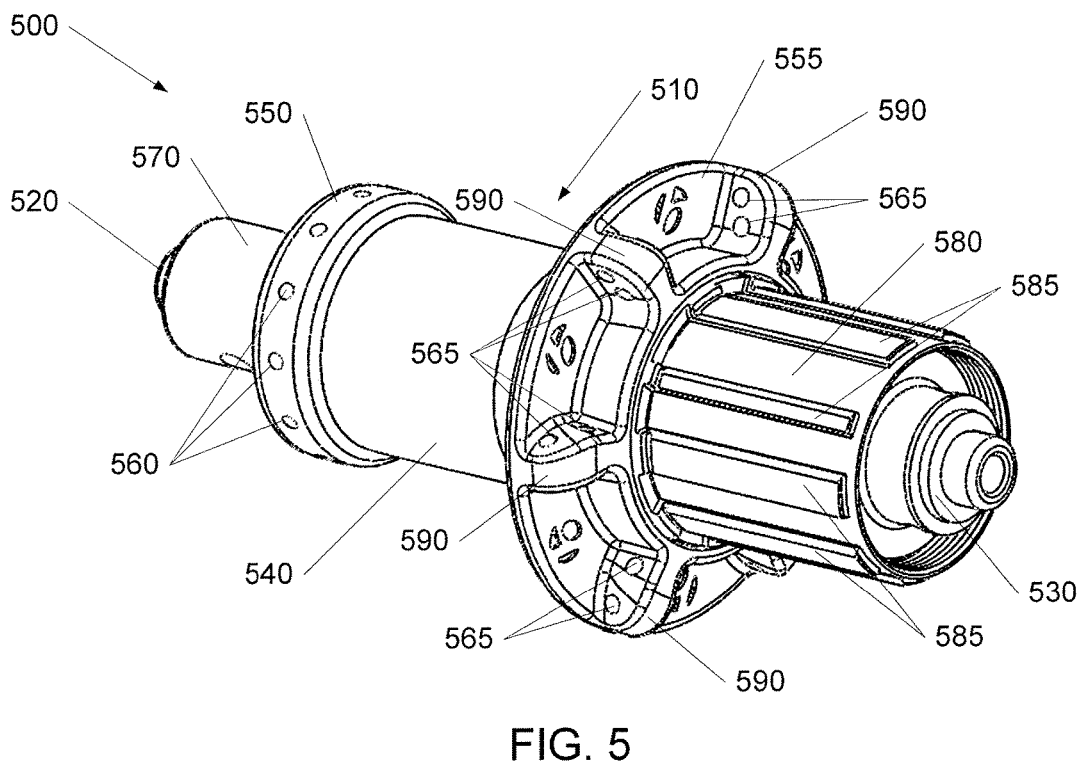
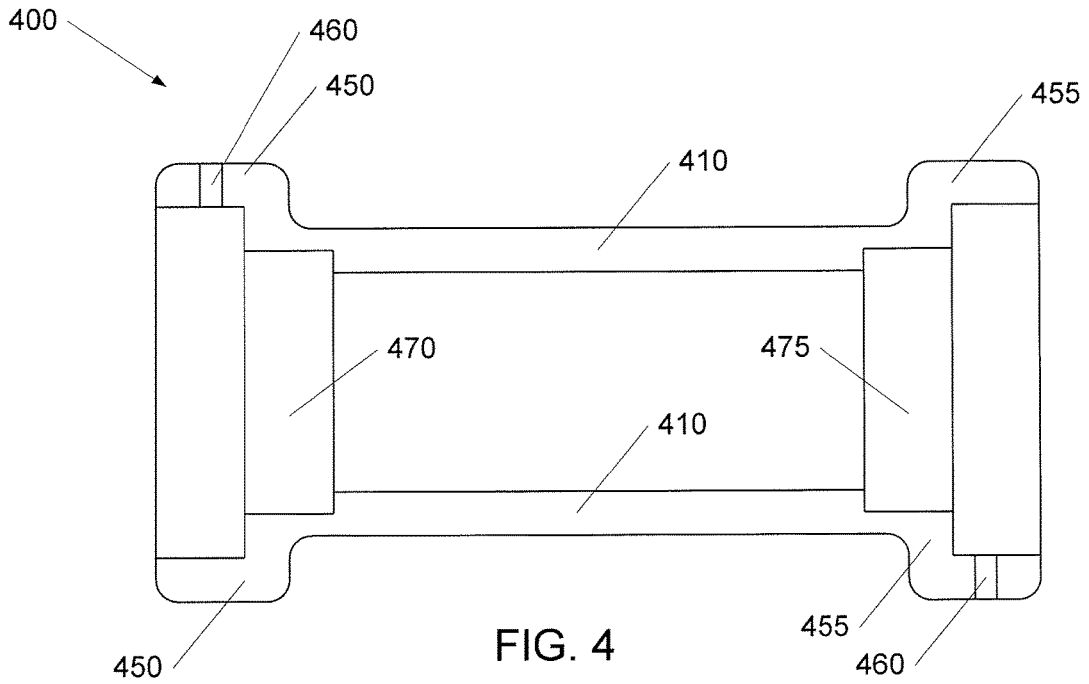


FIG. 3



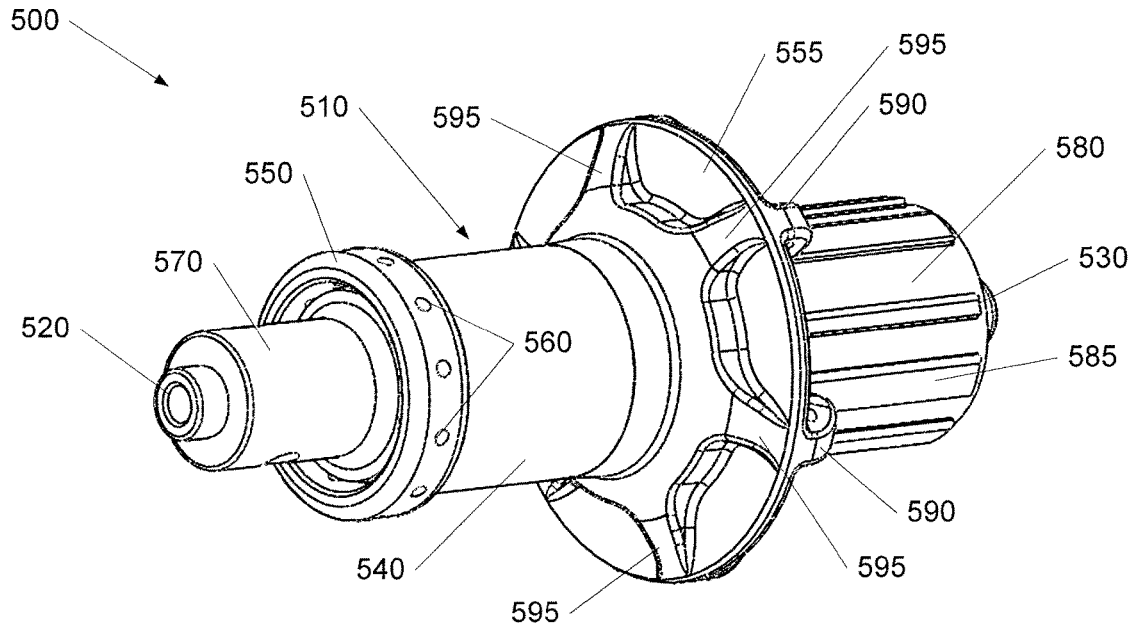


FIG. 6

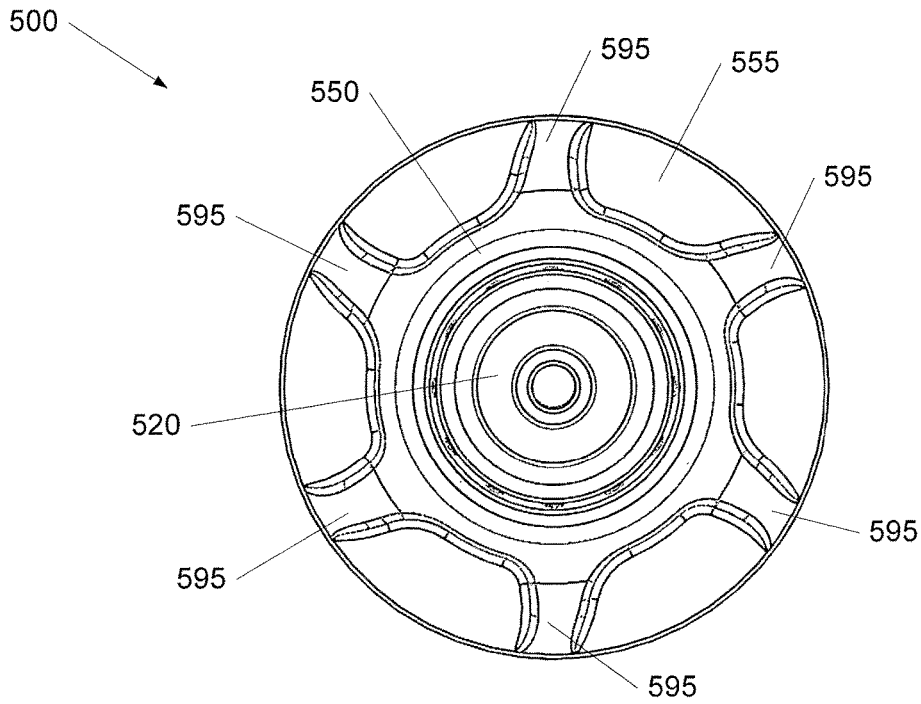


FIG. 7

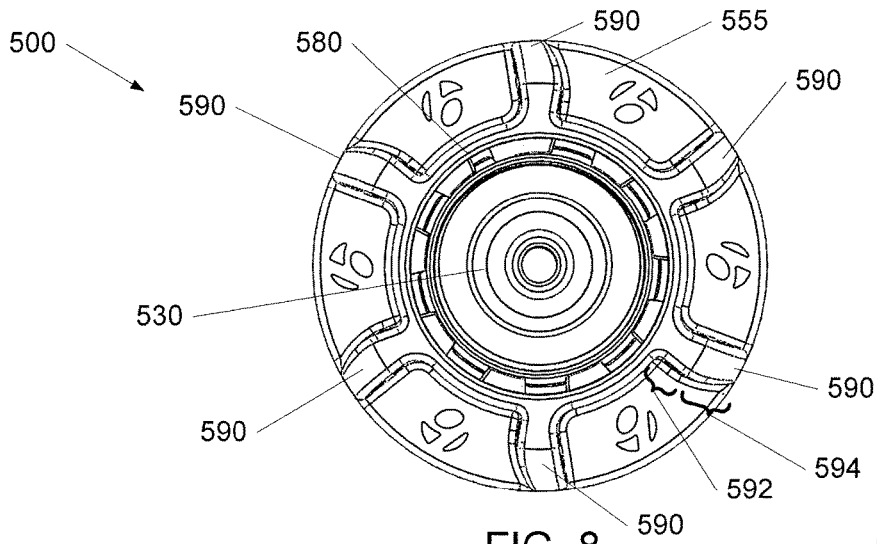


FIG. 8

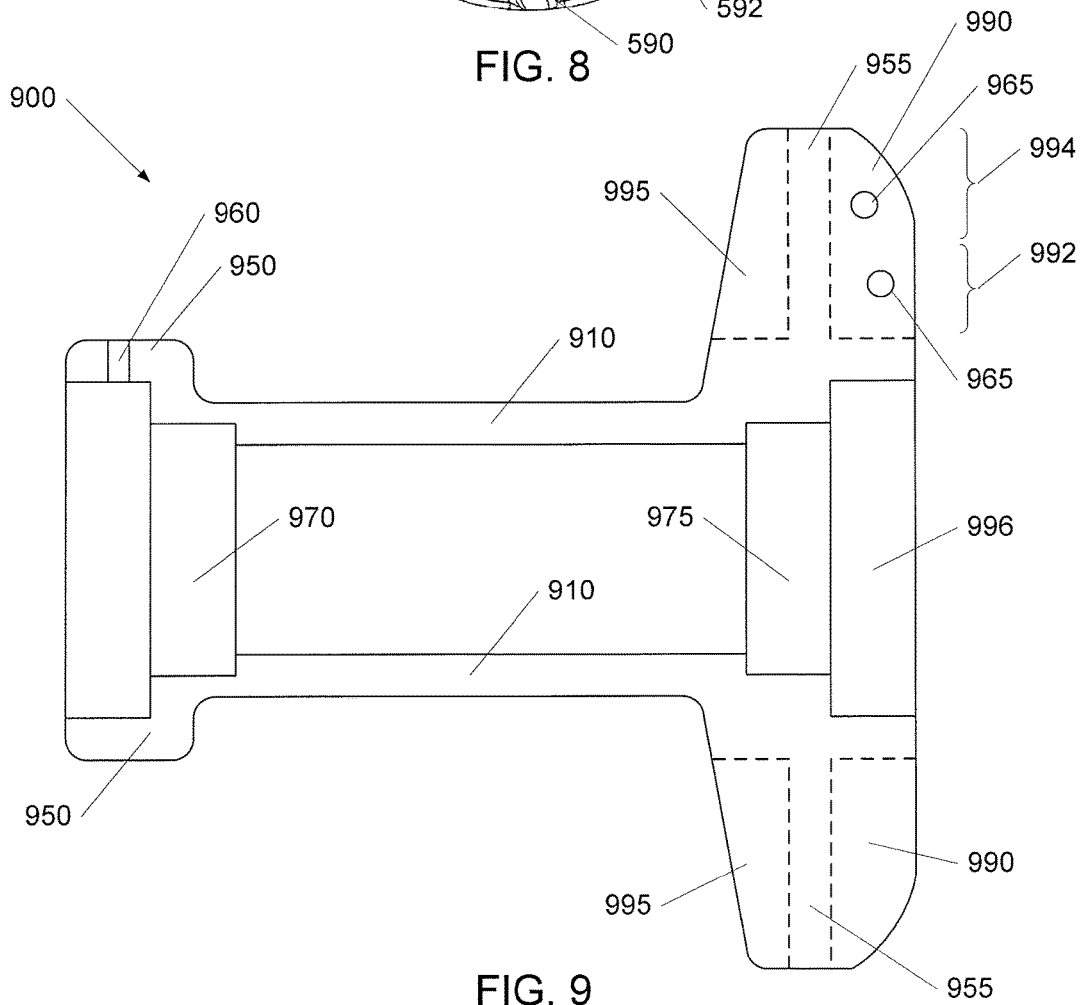
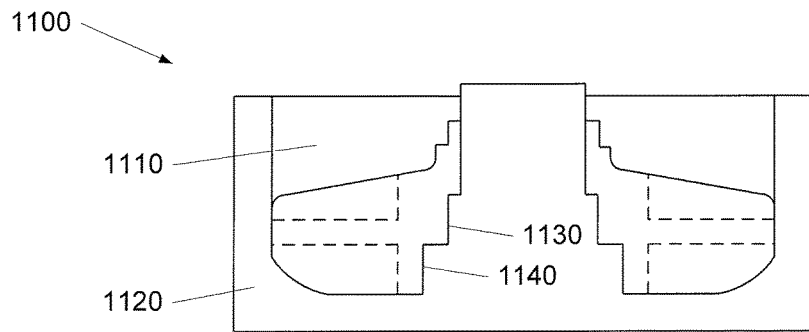
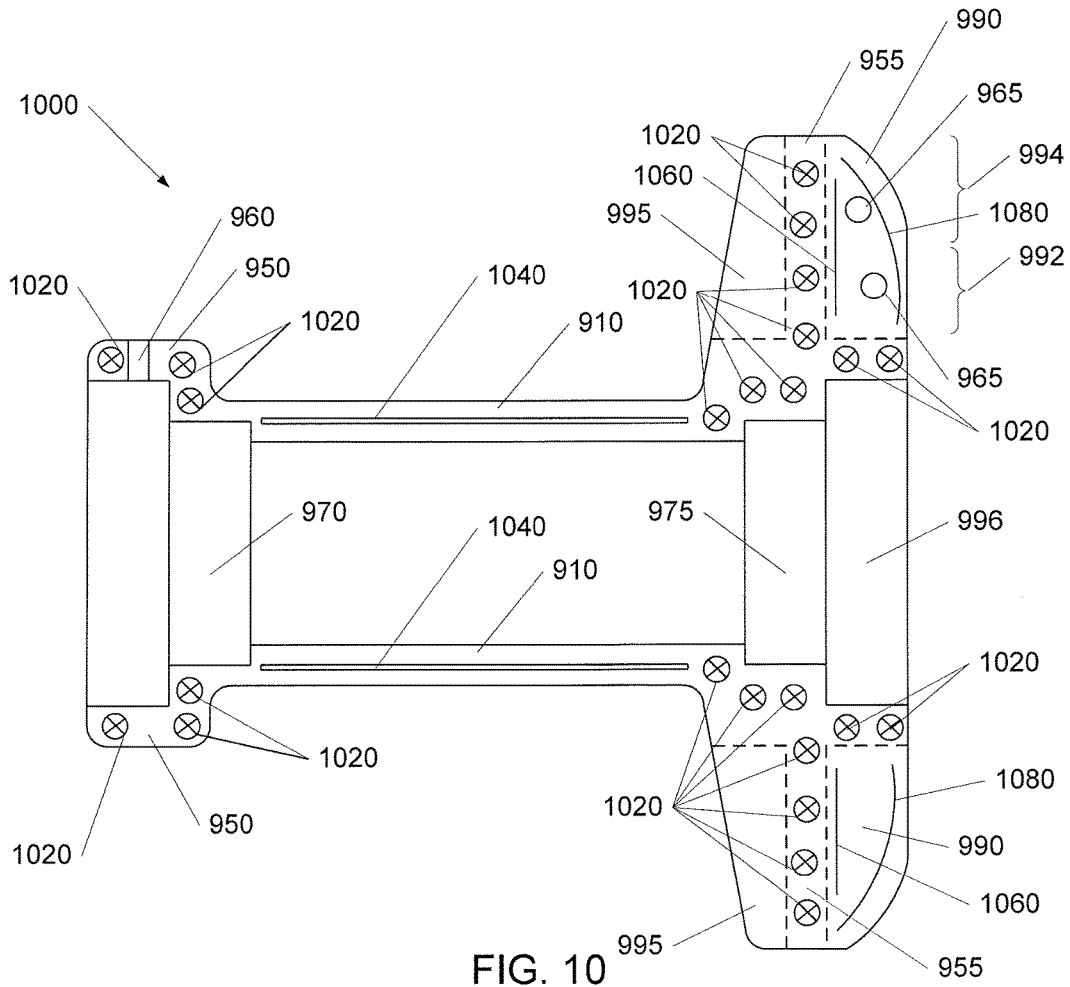


FIG. 9



**COMPRESSION MOLDED HUB SHELL****CROSS-REFERENCE TO RELATED PATENT APPLICATIONS**

This application claims the benefit of U.S. Provisional Application No. 61/769,806, filed Feb. 27, 2013, titled "COMPRESSION MOLDED HUB SHELL," which is incorporated herein by reference in its entirety.

**BACKGROUND**

The present invention relates generally to the field of bicycle hubs and more particularly to the field of hub shells.

**SUMMARY**

One illustrative embodiment is related to an apparatus including a hub shell. The hub shell can include a hub body; a first spoke flange; and a second spoke flange. The first spoke flange and the second spoke flange can include a fiber reinforced plastic. The fiber reinforced plastic can include fibers having a range of lengths between 0.2 and 3 inches.

Another illustrative embodiment is related to a method. The method can include providing a high precision mold for at least a portion of a hub shell. Fiber reinforced plastic can be placed in the mold. The fibers of the fiber reinforced plastic can have a range of lengths between 0.2 and 3 inches. The high precision mold can be heated and compressed.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings.

FIG. 1 is a side view of a bicycle in accordance with an illustrative embodiment.

FIG. 2 is a perspective view of a front hub assembly in accordance with an illustrative embodiment.

FIG. 3 is a side view of the front hub assembly of FIG. 2 in accordance with an illustrative embodiment.

FIG. 4 is a section view of a hub shell in accordance with an illustrative embodiment.

FIG. 5 is a perspective view of a drive side of a rear hub assembly in accordance with an illustrative embodiment.

FIG. 6 is a perspective view of a non-drive side of the rear hub assembly of FIG. 5 in accordance with an illustrative embodiment.

FIG. 7 is a side view of the non-drive side of the rear hub assembly of FIG. 5 in accordance with an illustrative embodiment.

FIG. 8 is a side view of the drive side of the rear hub assembly of FIG. 5 in accordance with an illustrative embodiment.

FIG. 9 is a section view of a hub shell in accordance with an illustrative embodiment.

FIG. 10 is a section view of a reinforced hub shell in accordance with an illustrative embodiment.

FIG. 11 is a section view of a hub shell mold in accordance with an illustrative embodiment.

**DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS**

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the figures, can be arranged, substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and make part of this disclosure.

The present disclosure is directed to an enhanced bicycle braking surface and method of enhancing a bicycle braking surface. Referring to FIG. 1, a side view of a bicycle 10 in accordance with an illustrative embodiment is shown. The bicycle 10 can have a frame assembly 12. The bicycle 10 can include a seat 16 and handlebars 18 that are attached to frame assembly 12. A seat post 20 can be connected to seat 16 and can slidably engage a seat tube 22 of the frame assembly 12. A top tube 24 and a down tube 26 can extend forwardly from the seat tube 22 to a head tube 28 of the frame 12. Handlebars 18 can be connected to a stem or steer tube 30 that can pass through the head tube 28 and can be connected or integrally formed with a fork crown 32. The handlebar 18 can include a stem that is constructed to slidably engage an interior cavity of the steer tube 30. One or more of the structures of bicycle 10 and frame assembly 12 can be constructed from similar materials, a variety of different materials, and various combinations thereof. The frame assembly 12 and seat tube 22 can be formed of metal-type materials, such as steel, aluminum-type materials, fiber reinforced plastic, carbon fiber materials, and/or materials that are sufficiently formable and robust enough to support a rider of bicycle 10.

A fork assembly 14 can include a pair of fork blades or fork legs 34 that can extend from generally opposite ends of a fork crown 32 and can be constructed to support a front wheel assembly 36 at an end thereof or a dropout 38. The dropouts 38 can engage generally opposite sides of an axle 40 constructed to engage a hub 42 of the front wheel assembly 36. The hub 42 can be, for example, a freehub or a freewheel hub. A number of spokes 44 can extend from hub 42 to a rim 46 of the front wheel assembly 36. A tire 48 can be engaged with rim 46 such that rotation of the hub 42 and the rim 46, relative to the fork legs 34, rotates the tire 48. The rim 46 can be covered with a brake material, in part or in its entirety, to enhance braking characteristics.

The bicycle 10 can include a front brake assembly 50 having an actuator 52 attached to handlebars 18 and a pair of brake pads 53 positioned on generally opposite sides of front wheel assembly 36. The brake pads 53 can be constructed to engage a brake wall 54 of the rim 46 thereby providing a stopping or slowing force to front wheel assembly 36. A rear wheel assembly 56 can include a brake assembly 58 similar to the front wheel brake assembly 50. Brake assemblies 50, 58 can be any brake configuration such as, but not limited to, a rim brake or disk brake assembly wherein a rotor and a caliper are positioned proximate one or more of front wheel axle 40 or a rear axle 64, respectively. The rotor can be covered with a brake material, in part or in



its entirety, to enhance braking characteristics. A rear wheel **66** can be positioned generally concentrically about rear axle **64**.

A pair of seat stays **68** (FIG. 2) and a pair of chain stays **70**, **71** can extend rearward relative to the seat tube **22** and the offset rear axle **64** from a crankset **72**. The crank set **72** can include a set of pedals **74** that can be operationally connected to a flexible drive member such as a chain **76** via one or more variable diameter chain gears or a chain ring or sprocket **78**. Rotation of chain **76** can communicate a drive force to a gear cluster **80** positioned proximate rear axle **64**. The gear cluster **80** can be generally concentrically orientated with respect to the rear axle **64** and can include a number of variable diameter gears.

The gear cluster **80** can be operationally connected to a hub **82** of the rear wheel **66**. The hub **82** can be, for example, a freehub or a freewheel hub. A number of spokes **84** can extend radially between the hub **82** and a rim **86** of rear wheel **66** of rear wheel assembly **56**. The rim **86** can be covered with a brake material. Rider operation of the pedals **74** can drive the chain **76** thereby driving the rear wheel **66** which in turn propels the bicycle **10**. The fork assembly **14** can be constructed to support a forward end **88** of the bicycle **10** above a ground surface **90**. The handlebar **18** can be connected to the frame **12** and the fork assembly **14** such that operator manipulation of the handlebar **18** can be communicated to the fork assembly **14** to facilitate rotation of the front wheel assembly **36** relative to the frame assembly **12** along a longitudinal axis, indicated by arrow **175**, of the bicycle **10**. Manipulation of the handlebar **18** can steer the bicycle **10** during riding.

The construction of bicycle **10** depicted in FIG. 1 is merely exemplary of a number of bicycle configurations. Whereas bicycle **10** is shown as what is commonly understood as a street or road bike, the present disclosure is applicable to a number of bicycle configurations including those bicycles with more aggressive suspension systems commonly found in off-road or mountain bike frame configurations, and/or hybrids, cross-over or multi-purpose bicycle frame configurations.

Referring to FIG. 2, a perspective view of a front hub assembly **200** in accordance with an illustrative embodiment is shown. Referring to FIG. 3, a side view of the front hub assembly **200** of FIG. 2 in accordance with an illustrative embodiment is shown. The front hub assembly **200** can include a hub shell **210**, a first end cap **220**, and a second end cap **230**. The first end cap **220** and the second end cap **230** can thread onto an axle (not shown). The first end cap **220** and the second end cap **230** can cover a first bearing (not shown) and a second bearing (not shown). The first bearing and the second bearing can sit between the axle and hub shell **210**. Hence, hub shell **210** can be free to rotate around the axle.

The hub shell **210** can include a hub shell body **240**, a first spoke flange **250** and a second spoke flange **255**. The hub shell body **240**, can be a cylindrical shape, however, any shape can be used. The first spoke flange **250** and the second spoke flange **255** can be located at the ends of the hub shell body **240**. The first spoke flange **250** and the second spoke flange **255** can include spoke holes **260**. Spokes (not shown) can be inserted through the spoke holes **260** and connected to a rim (not shown). The spoke holes **260** can include countersinking to bury the ends of the spokes. The first spoke flange **250** and the second spoke flange **255** can reinforce the ends of the hub shell **210**. For example, the first spoke flange **250** and the second spoke flange **255** can be thicker than the hub shell body **240**. The first spoke flange

**250** and the second spoke flange **255** can include ribs to further reinforce the ends of the hub shell **210**. The hub shell body **240** can be about 3 inches long with an average diameter of about 1.25 inches; however, any dimensions can be used.

In one illustrative embodiment, the hub shell **210** can be molded as one piece. Features such as the spoke holes **260** can be drilled after molding. Alternatively, the first spoke flange **250** and the second spoke flange **255** can be separately molded and bonded to the hub shell body **240**, which can be a tube made of, for example, fiber reinforced or metal. The hub shell **210** can be made of fiber reinforced plastic. The fiber can be a carbon fiber. In other embodiments, fibers such as aramid (e.g., Kevlar™), fiberglass, boron fibers, ceramic fibers, nylon, or any other fiber can be used. The fiber can be a combination of fibers. A resin system of the fiber reinforced plastic can be, for example, an epoxy. The resin can be fortified with particulate, nanotubes, fibers, and nanostructures. In one embodiment, the fiber reinforced plastic can be a thermoset. In another embodiment, the fiber reinforced plastic can be a thermoplastic. The hub shell **210** can include bismaleimide, polyphenylene sulfide, polyetherimide, polyamide, polyetheretherketone, polystyrene, nylon, polypropylene, polyethylene, vinyls, acrylics, and/or polycarbonates. In one embodiment, the resin can be chosen to have mechanical properties similar to aluminum.

The glass transition temperature (T<sub>g</sub>) of the plastic/resin can be any temperature. In one embodiment, the resin can have a glass transition temperature (T<sub>g</sub>) greater than 265 degrees Fahrenheit. In another embodiment, the T<sub>g</sub> of the resin can be greater than 310 or 340 degrees Fahrenheit. In another embodiment, the T<sub>g</sub> of the resin can be in a range of about 300 degrees Fahrenheit to about 420 degrees Fahrenheit. Plastic/resin with a glass transition temperature (T<sub>g</sub>) greater than 310 degrees Fahrenheit can improve heat dissipation and thermal stability.

The chop of the fiber can be from a range from about 0.01 inches to about 3 inches. The chop of the fiber can be defined as the average length of a fiber. In another embodiment, chop of the fiber can be from a range from about 1 inch to about 2 inches. In another embodiment, chop of the fiber can be 1 inch. In another embodiment, chop of the fiber can be 2 inches. In another embodiment, the chop of the fiber can include a plurality of different lengths. For example, half of the fiber can have a 1 inch chop and half of the fiber can have a 2 inch chop. In another embodiment, the fiber can be inserted into a mold so that fibers of a predetermined chop are positioned to flow into particular areas of the mold. For example, smaller fibers can be positioned to flow into detailed features. In one embodiment, the fiber can be a prepreg, i.e., already covered with the resin.

The hub shell **210** can include a first bearing seat (not shown) and a second bearing seat (not shown). A bearing can include, for example, an outer race, an inner race, and bearing rollers located between the outer race and inner race. When the hub shell **210** and/or the ends of the hub shell are molded, the first bearing seat and second bearing seat mold features can be molded with a high precision mold configured according to a bearing manufacturer's recommended bearing seat tolerances. In one example, a high precision mold can be a mold that results in a molding that has critical features, such as the bearing seat areas, that are within 0.5 mm. In another example, a high precision mold can be a mold that results in a molding that has critical features, such as the bearing seat areas, that are within 0.2 mm. In another example, a high precision mold can be a mold that results in a molding that is substantially ready for finishing, such as

paint. When the resin and fiber chop are molded, the resin and fiber chop can flow into the precise features of the high precision mold. Thus, when the hub shell **210** is unmolded, the bearing seat will be ready to accept a bearing with no further machining required. In contrast, a molded long-strand carbon fiber is unable to conform to a small, high precision mold within the required tolerances to properly accept a bearing without further machining.

In one embodiment, the fiber and resin can be placed in a heated compression mold. Referring to FIG. **11**, a section view of a hub shell mold **1100** in accordance with an illustrative embodiment is shown. The hub shell mold **1100** can include a first portion **1110** and a second portion **1120**; however, any number or configuration of portions can be used. The fiber and resin can be placed in hub shell mold **1100** between the first portion **1110** and the second portion **1120** and compressed.

The hub shell mold **1100** can be a high precision mold. The hub shell mold **1100** can include a bearing seat area **1130** and a drive ring seat area **1140**. The bearing seat area **1130** and the drive ring seat area **1140** can be configured so that the tolerances of the corresponding areas of a molding are within 0.5 mm, 0.2 mm or less. The bearing seat area **1130** and the drive ring seat area **1140** can be packed with a chop of fiber, as described above, to result in the 0.5 mm, 0.2 mm or less tolerances. Similarly, aesthetic areas of the mold can be packed with a chop of fiber, as described above, to result in a molding that does not require substantial finishing. As the compression mold is heated the resin can begin to soften or melt. As pressure is applied to the compression mold, the resin and fibers can flow into the details of the mold.

In another embodiment, the fiber and resin can be weighed. The weight of the fiber and resin can be matched to the mold volume. The weighed fiber and resin can be placed in a compression mold and molded as above.

In another embodiment, the hub shell **210** can include a flange for attaching a disk brake rotor or a drum brake drum. Alternatively, mounting tabs can be integrated into the first spoke flange **250** and/or the second spoke flange **255**.

Advantageously, the hub shell **210** can be as strong as an aluminum piece but 40% lighter. Advantageously, the hub shell **210** does not require additional machining to accept the first and second bearings thereby reducing manufacturing costs.

Referring to FIG. **4**, a section view of a hub shell **400** in accordance with an illustrative embodiment is shown. The hub shell **410** can include a hub shell body **440**, a first spoke flange **450**, a second spoke flange **255**, and spoke holes **460**, as described above.

The hub shell **400** can include a first bearing seat **470** and a second bearing seat **475**. A bearing can include, for example, an outer race, an inner race, and bearings located between the outer race and inner race. In one example, the outer race of a first bearing can mate with or form an interference fit with the first bearing seat **470**; and the outer race of a second bearing can mate with or form an interference fit with the second bearing seat **475**. Alternatively, the hub shell **400** can be configured to using a single bearing or multiple bearings. In other embodiments, the bearing can be a taper bearing, a thrust bearing, or any other kind of bearing.

When the hub shell **410** and/or the ends of the hub shell are molded, the first bearing seat **470** and the second bearing seat **475** mold features can be molded with a high precision mold configured according to a bearing manufacturer's recommended bearing seat tolerances. When the resin and fiber

chop are molded, the resin and fiber chop can flow into the precise features of the high precision mold. Thus, when the hub shell **410** is unmolded, the first bearing seat **470** and the second bearing seat **475** will be ready to accept a bearing with no further machining required. In contrast, a molded long-strand carbon fiber is unable to conform to a small, high precision mold within the required tolerances to properly accept a bearing without further machining.

Advantageously, the hub shell **410** can be as strong as an aluminum hub shell but 40% lighter. Alternatively, the weight of the hub shell **410** can remain the same as an aluminum hub shell, yet be stronger. Advantageously, the hub shell **410** does not require additional machining to accept the bearings thereby reducing manufacturing costs.

Referring to FIG. **5**, a perspective view of a drive side of a rear hub assembly **500** in accordance with an illustrative embodiment is shown. Referring to FIG. **6**, a perspective view of a non-drive side of the rear hub assembly **500** of FIG. **5** in accordance with an illustrative embodiment is shown. Referring to FIG. **7**, a side view of the non-drive side of the rear hub assembly **500** of FIG. **5** in accordance with an illustrative embodiment is shown. Referring to FIG. **8**, a side view of the drive side of the rear hub assembly **500** of FIG. **5** in accordance with an illustrative embodiment is shown. The rear hub assembly **500** can include a hub shell **510**, a first end cap **520**, a second end cap **530**, an axle **570**, and a cassette body **580**. The cassette body **580** can include splines **585**. The first end cap **520** and the second end cap **530** can thread onto the axle **570**. The first end cap **520** and the second end cap **530** can cover a first bearing (not shown) and a fourth bearing (not shown). The first bearing and a second bearing (not shown) can sit between the axle **570** and hub shell **510**. Hence, hub shell **510** can be free to rotate around the axle **570**. A third bearing (not shown) and the fourth bearing can sit between the axle **570** and the cassette body **580**. Hence, cassette body **580** can be free to rotate around the axle. The cassette body **580** can include pawls (not shown) configured to engage a drive ring (not shown) of the hub shell **510**. The pawls and the drive ring can operate so that in one direction, the cassette body **580** and the hub shell **510** are engaged; in the other direction, the cassette body **580** and the hub shell **510** are disengaged.

The hub shell **510** can include a hub shell body **540**, a first spoke flange **550** and a second spoke flange **555**. The hub shell body **540**, can be a cylindrical shape, however, any shape can be used. The first spoke flange **550** and the second spoke flange **555** can be located at the ends of the hub shell body **540**. The first spoke flange **550** can include spoke holes **560**. The second spoke flange **555** can include spoke holes **565**. Spokes (not shown) can be inserted through the spoke holes **560**, **565** and connected to a rim (not shown). The spoke holes **560**, **565** can include countersinking to bury the ends of the spokes. The first spoke flange **550** and the second spoke flange **555** can reinforce the ends of the hub shell **510**. For example, the first spoke flange **550** and the second spoke flange **555** can be thicker than the hub shell body **540**. The first spoke flange **550** and the second spoke flange **555** can include ribs to further reinforce the ends of the hub shell **510**. The hub shell body **540** can be about 3 inches long with an average diameter of about 1.25 inches; however, any dimensions can be used.

The first spoke flange **550** can be located on the non-drive side and the second spoke flange **555** can be located on the drive side. The drive side can mean the side on which the cassette body **580** is located. The cassette body **580** can be configured to hold a cassette which can be driven by a chain.

The second spoke flange **555** can have a radius of about twice the radius of the hub shell body **540**; however, the second spoke flange **555** can have any radius. In one embodiment, the second spoke flange **555** can have a radius of about 1.25 inches (i.e., a diameter of about 2.5 inches). In one embodiment, the second spoke flange **555** can be about 0.2 inches thick; however, the second spoke flange **555** can have any thickness.

The second spoke flange **555** can be designed to handle more stress than the first spoke flange **550**. In many applications, the spokes associated with the second spoke flange **555** need to be under greater tension than the first spoke flange **550** so that the rear wheel will remain true under power. The second spoke flange **555** can be positioned farther inward than the first spoke flange **550**.

The second spoke flange **555** can include first ribs **590** and second ribs **595**. In one embodiment, the first ribs **590** and second ribs **595** can be aligned. In one embodiment, the spoke holes **565** can be located in the first ribs **590**. The first ribs **590** can be curved like the blades of an impeller. In a first portion **592** of one of the first ribs **590**, a first spoke can be attached at a first angle relative to the second spoke flange **555**. In a second portion **594** of one of the first ribs **590**, a second spoke can be attached at a second angle relative to the second spoke flange **555**. Alternatively, the first ribs **590** and second ribs **595** can be misaligned. In one embodiment, the spoke holes **565** can be located in the second ribs **595**.

In one illustrative embodiment, the hub shell **510** can be molded as one piece. Alternatively, the first spoke flange **550** and the second spoke flange **555** can be separately molded and bonded to the hub shell body **540**, which can be a tube made of, for example, fiber reinforced or metal. The hub shell **510** can be made of fiber reinforced plastic. The fiber can be a carbon fiber. In other embodiments, fibers such as aramid (e.g., Kevlar™), fiberglass, boron fibers, ceramic fibers, nylon, or any other fiber can be used. The fiber can be a combination of fibers. A resin system of the fiber reinforced plastic can be, for example, an epoxy. The resin can be fortified with particulate, nanotubes, fibers, and nanostructures. In one embodiment, the fiber reinforced plastic can be a thermoset. In another embodiment, the fiber reinforced plastic can be a thermoplastic. The hub shell **510** can include bismaleimide, polyphenylene sulfide, polyetherimide, polyamide, polyetheretherketone, polystyrene, nylon, polypropylene, polyethylene, vinyls, acrylics, and/or polycarbonates. In one embodiment, the resin can be chosen to have mechanical properties similar to aluminum.

The glass transition temperature ( $T_g$ ) of the plastic/resin can be any temperature. In one embodiment, the resin can have a glass transition temperature ( $T_g$ ) greater than 265 degrees Fahrenheit. In another embodiment, the  $T_g$  of the resin can be greater than 310 or 340 degrees Fahrenheit. In another embodiment, the  $T_g$  of the resin can be in a range of about 300 degrees Fahrenheit to about 420 degrees Fahrenheit. Plastic/resin with a glass transition temperature ( $T_g$ ) greater than 310 degrees Fahrenheit can improve heat dissipation and thermal stability.

The chop of the fiber can be from a range from about 0.01 inches to about 3 inches. The chop of the fiber can be defined as the average length of a fiber. In another embodiment, chop of the fiber can be from a range from about 1 inch to about 2 inches. In another embodiment, chop of the fiber can be 1 inch. In another embodiment, chop of the fiber can be 2 inches. In another embodiment, the chop of the fiber can include a plurality of different lengths. For example, half of the fiber can have a 1 inch chop and half of the fiber can have a 2 inch chop. In another embodiment, the fiber can be

inserted into a mold so that fibers of a predetermined chop are positioned to flow into particular areas of the mold. For example, smaller fibers can be positioned to flow into detailed features. In one embodiment, the fiber can be a prepreg, i.e., already covered with the resin.

The hub shell **510** can include a first bearing seat (not shown) and a second bearing seat (not shown). A bearing can include, for example, an outer race, an inner race, and bearings located between the outer race and inner race. When the hub shell **510** and/or the ends of the hub shell are molded, the first bearing seat and second bearing seat mold features can be molded with a high precision mold configured according to a bearing manufacturer's recommended bearing seat tolerances. When the resin and fiber chop are molded, the resin and fiber chop can flow into the precise features of the high precision mold. Thus, when the hub shell **510** is unmolded, the bearing seat will be ready to accept a bearing with no further machining required. In contrast, a molded long-strand carbon fiber is unable to conform to a small, high precision mold within the required tolerances to properly accept a bearing without further machining.

In one embodiment, the fiber and resin can be placed in a heated compression mold. As the compression mold is heated the resin can begin to soften or melt. As pressure is applied to the compression mold, the resin and fibers can flow into the details of the mold.

In another embodiment, the fiber and resin can be weighed. The weight of the fiber and resin can be matched to the mold volume. The weighed fiber and resin can be placed in a compression mold and molded as above.

In another embodiment, the hub shell **910** can include a flange or flanges for attaching a disk brake rotor or a drum brake drum. Alternatively, mounting tabs for a disk or drum can be integrated into the first spoke flange **950** and/or the second spoke flange **955**.

Advantageously, the hub shell **510** can be as strong as an aluminum piece but 40% lighter. Advantageously, the hub shell **510** does not require additional machining to accept the first and second bearings thereby reducing manufacturing costs.

Referring to FIG. 9, a section view of a hub shell **900** in accordance with an illustrative embodiment is shown. The hub shell **900** can include a hub shell body **910**, a first spoke flange **950**, and a second spoke flange **955**, as described above. The first spoke flange **950** and the second spoke flange **955** can be located at the ends of the hub shell body **910**. The first spoke flange **950** can include spoke holes **960**. The second spoke flange **955** can include spoke holes **965**.

The second spoke flange **955** can include first ribs **990** and second ribs **995**. In one embodiment, the first ribs **990** and second ribs **995** can be aligned. In one embodiment, the spoke holes **965** can be located in the first ribs **990**. The first ribs **990** can be curved like the blades of an impeller. In a first portion **992** of one of the first ribs **990**, a first spoke can be attached at a first angle relative to the second spoke flange **955**. In a second portion **994** of one of the first ribs **990**, a second spoke can be attached at a second angle relative to the second spoke flange **955**. Alternatively, the first ribs **990** and second ribs **995** can be misaligned. In one embodiment, the spoke holes **965** can be located in the second ribs **995**.

The hub shell **900** can include a first bearing seat **970** and a second bearing seat **975**. In one example, the outer race of a first bearing can mate with or form an interference fit with the first bearing seat **970**; and the outer race of a second bearing can mate with or form an interference fit with the second bearing seat **975**. Alternatively, the hub shell **900** can be configured to using a single bearing or multiple bearings.

In other embodiments, the bearing can be a taper bearing, a thrust bearing, or any other kind of bearing.

The hub shell **900** can include a drive ring seat **996**. A drive ring can be defined as a ring with teeth facing inwards and configure to interact with the pawls of a cassette body. The drive ring can be made of aluminum, steel, titanium, any other metal, or an alloy thereof. Alternatively, the drive ring can be a composite or ceramic. In one example, a drive ring can mate with, key into, or form an interference fit with the drive ring seat **996**. Alternatively, the drive ring can be bonded into the drive ring seat **996**. Alternatively, the drive ring can be co-molded with the hub shell **900**. Alternatively, the drive ring can be molded as part of the hub shell **900**; reinforcing materials and fillers can be placed in the drive ring section of the mold before compression molding to toughen the drive ring pawl contact surface and strengthen the area. In another embodiment, a molded drive ring (part of the hub shell **900**) can be plated to toughen the pawl contact surface.

When the hub shell **910** and/or the ends of the hub shell are molded, the first bearing seat **970**, the second bearing seat **975**, and drive ring seat **996** mold features can be molded with a high precision mold configured according to a bearing manufacture's recommended bearing seat tolerances. When the resin and fiber chop are molded, the resin and fiber chop can flow into the precise features of the high precision mold. Thus, when the hub shell **910** is unmolded, the first bearing seat **970** and the second bearing seat **975** will be ready to accept a bearing with no further machining required. In contrast, a molded long-strand carbon fiber is unable to conform to a small, high precision mold within the required tolerances to properly accept a bearing without further machining.

Advantageously, the hub shell **910** can be as strong as an aluminum hub shell but 40% lighter. Alternatively, the weight of the hub shell **910** can remain the same as an aluminum hub shell, yet be stronger. Advantageously, the hub shell **910** does not require additional machining to accept the bearings thereby reducing manufacturing costs.

Referring to FIG. **10**, a section view of a reinforced hub shell **1000** in accordance with an illustrative embodiment is shown. The hub shell **1000** can include a hub shell body **910**, a first spoke flange **950**, and a second spoke flange **955**, as described above. The first spoke flange **950** and the second spoke flange **955** can be located at the ends of the hub shell body **910**. The first spoke flange **950** can include spoke holes **960**. The second spoke flange **955** can include spoke holes **965**.

The second spoke flange **955** can include first ribs **990** and second ribs **995**. In one embodiment, the first ribs **990** and second ribs **995** can be aligned. In one embodiment, the spoke holes **965** can be located in the first ribs **990**. The first ribs **990** can be curved like the blades of an impeller. In a first portion **992** of one of the first ribs **990**, a first spoke can be attached at a first angle relative to the second spoke flange **955**. In a second portion **994** of one of the first ribs **990**, a second spoke can be attached at a second angle relative to the second spoke flange **955**. Alternatively, the first ribs **990** and second ribs **995** can be misaligned. In one embodiment, the spoke holes **965** can be located in the second ribs **995**.

The hub shell **1000** can include a first bearing seat **970** and a second bearing seat **975**. In one example, the outer race of a first bearing can mate with or form an interference fit with the first bearing seat **970**; and the outer race of a second bearing can mate with or form an interference fit with the second bearing seat **975**. Alternatively, the hub shell **900** can be configured to using a single bearing or multiple bearings.

In other embodiments, the bearing can be a taper bearing, a thrust bearing, or any other kind of bearing.

The hub shell **1000** can include a drive ring seat **996**. A drive ring can be defined as a ring with teeth facing inwards and configure to interact with the pawls of a cassette body. The drive ring can be made of aluminum, steel, titanium, any other metal, or an alloy thereof. Alternatively, the drive ring can be a composite or ceramic. In one example, a drive ring can mate with, key into, or form an interference fit with the drive ring seat **996**. Alternatively, the drive ring can be bonded into the drive ring seat **996**. Alternatively, the drive ring can be co-molded with the hub shell **900**. Alternatively, the drive ring can be molded as part of the hub shell **900**; reinforcing materials and fillers can be placed in the drive ring section of the mold before compression molding to toughen the drive ring pawl contact surface and strengthen the area. In another embodiment, a molded drive ring (part of the hub shell **900**) can be plated to toughen the pawl contact surface.

The hub shell **1000** can include fiber reinforcements. The hub shell **1000** can include annular reinforcements **1020**, axial reinforcements **1040**, radial reinforcements **1060**, and/or curved radial reinforcements **1080**. Each of the annular reinforcements **1020**, axial reinforcements **1040**, radial reinforcements **1060**, and curved radial reinforcements **1080** can include unidirectional fibers. The annular reinforcements **1020**, axial reinforcements **1040**, radial reinforcements **1060**, and curved radial reinforcements **1080** can be a bundle of unidirectional fibers, a sheet of unidirectional fibers, or combinations thereof. The annular reinforcements **1020** can be located, for example, in the first spoke flange **950** and the second spoke flange **955**. The axial reinforcements **1040** can be, for example, located between and aligned between the first spoke flange **950** and the second spoke flange **955**. The radial reinforcements **1060** can, for example, radiate from the axis of the hub shell **1000** and be located in first ribs **990**. The curved radial reinforcements **1080** can, for example, radiate from the axis of the hub shell **1000**, be located in first ribs **990**, and curve around spoke holes **965**. The annular reinforcements **1020**, axial reinforcements **1040**, radial reinforcements **1060**, and curved radial reinforcements **1080** can be used in any part of the hub shell **1000** to provide structural reinforcement.

When the hub shell **910** and/or the ends of the hub shell are molded, the first bearing seat **970**, the second bearing seat **975**, and drive ring seat **996** mold features can be molded with a high precision mold configured according to a bearing manufacture's recommended bearing seat tolerances. When the resin and fiber chop are molded, the resin and fiber chop can flow into the precise features of the high precision mold. Thus, when the hub shell **910** is unmolded, the first bearing seat **970** and the second bearing seat **975** will be ready to accept a bearing with no further machining required. In contrast, a molded long-strand carbon fiber is unable to conform to a small, high precision mold within the required tolerances to properly accept a bearing without further machining.

Advantageously, the hub shell **1000** can be as strong as an aluminum hub shell but 40% lighter. Alternatively, the weight of the hub shell **1000** can remain the same as an aluminum hub shell, yet be stronger. Advantageously, the hub shell **1000** does not require additional machining to accept the bearings thereby reducing manufacturing costs.

One or more flow diagrams may have been used herein. The use of flow diagrams is not meant to be limiting with respect to the order of operations performed. The herein described subject matter sometimes illustrates different

components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely exemplary, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively “associated” such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as “associated with” each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being “operably connected”, or “operably coupled”, to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being “operably couplable”, to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as “open” terms (e.g., the term “including” should be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases “at least one” and “one or more” to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles “a” or “an” limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases “one or more” or “at least one” and indefinite articles such as “a” or “an” (e.g., “a” and/or “an” should typically be interpreted to mean “at least one” or “one or more”); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of “two recitations,” without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to “at least one of A, B, and C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., “a system having at least one of A, B, and C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention

analogous to “at least one of A, B, or C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., “a system having at least one of A, B, or C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase “A or B” will be understood to include the possibilities of “A” or “B” or “A and B.”

The foregoing description of illustrative embodiments has been presented for purposes of illustration and of description. It is not intended to be exhaustive or limiting with respect to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the disclosed embodiments. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents.

What is claimed is:

1. An apparatus, comprising:

a hub shell comprising:

a hub body;  
a first spoke flange; and  
a second spoke flange;

wherein:

at least the first spoke flange and the second spoke flange comprise a fiber reinforced plastic; and  
the fiber reinforced plastic include fibers having a range of lengths between 0.2 and 3 inches;

wherein:

the second spoke flange comprise spoke holes;  
a bundle of continuous unidirectional fibers surround each of the spoke holes;  
the bundles of continuous unidirectional fibers are embedded in the fiber reinforced plastic including the fibers having the range of lengths between 0.2 and 3 inches;  
the second spoke flange comprises a first set of ribs on a drive side of the second spoke flange; and  
each rib of the first set of ribs is curved and comprises a first inner portion and a second outer portion such that a first spoke hole of the spoke holes located in the first inner portion is at a first angle and a second spoke hole of the spoke holes located in the second outer portion is at a second angle.

2. The apparatus of claim 1, wherein the fibers have an average length of about 2 inches.

3. The apparatus of claim 1, wherein a radius of the second spoke flange is about twice a radius of the hub body.

4. The apparatus of claim 1, wherein the first spoke flange comprises spoke holes.

5. The apparatus of claim 1, wherein the second spoke flange comprises a second set of ribs on a non-drive side of the second spoke flange.

6. The apparatus of claim 1, wherein the first set of ribs comprise spoke holes, and the spoke holes are perpendicular to an axis of the hub shell.

7. The apparatus of claim 1, wherein the second spoke flange is formed by compression molding.

8. The apparatus of claim 1, wherein the hub body comprises fiber reinforced plastic include fibers having a range of lengths between 0.2 and 3 inches.

9. The apparatus of claim 1, further comprising a bearing seat formed to accept a bearing without further machining, where the bearing seat has a tolerance of 0.5 mm or less.

10. The apparatus of claim 1, further comprising at least one of annular, axial, and radial fiber reinforcements. 5

11. The apparatus of claim 10, wherein the fiber reinforcements comprise unidirectional fiber.

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