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(54) Title: FRICTION ROLLER HAVING ONE OR MORE FABRIC-REINFORCED MATERIAL LAYER AND METHODS

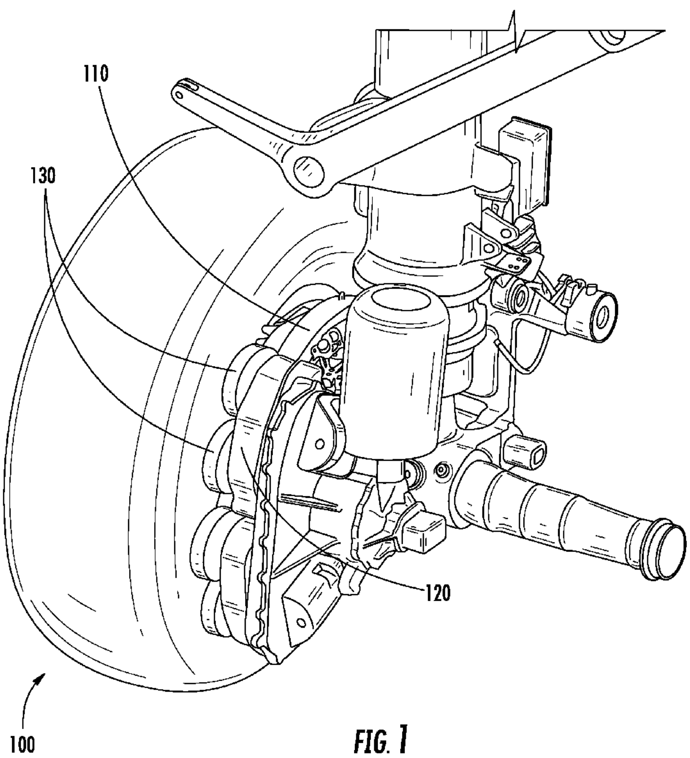

FIG. 1

(57) Abstract: A friction roller having one or more fabric-reinforced material layer and methods are disclosed. In some aspects, a drive roller includes a coupling element configured to be driven by a rotary force input, a body portion surrounding the coupling element, and an outer contact portion surrounding the body portion and configured for transferring torque from the rotary force input to a driven element. In particular, in some aspects, the body portion includes one or more layers of elastomer-reinforced fabric including at least one fabric layer arranged between at least two of a plurality of elastomeric layers, the at least one fabric layer and the elastomeric layers being bonded together to form the body portion.

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FRICTION ROLLER HAVING ONE OR MORE FABRIC-REINFORCED MATERIAL LAYER AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application relates to and claims priority to U.S. Provisional Patent Application Serial No. 62/172,482, filed on June 8, 2015, and U.S. Provisional Patent Application Serial No. 62/222,895, filed on September 24, 2015, the disclosures of which are incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] The subject matter herein generally relates to the design and construction of rollers and wheels for friction drive systems and methods. The subject matter herein more particularly relates to the construction of a body and/or outer contact portion of a friction roller.

BACKGROUND

[0003] In conventional configurations for aircraft landing gear systems, the main landing gear wheels are driven by elastomeric rollers that apply torque by friction on a crown track attached to the wheels. Because of this arrangement, it is desirable to have a flexible (i.e., soft) contact between the rollers and the crown track in order to accommodate the relative displacements of the wheel with the landing gear structure (e.g., about 5 degrees of freedom).

[0004] Because of the high forces on the wheel, however, the elastomer needs to be relatively stiff, but a stiff elastomer at the surface lowers the coefficient of friction and results in a high heat build-up in the body of the roller. Furthermore, low hysteresis compounds tend to be poor in abrasion resistance.

[0005] As a result, it would be desirable for a friction roller to be able to carry the high loads but to give low heat build-up. In addition, it would be further desirable for at least an outer portion of such a roller to provide both high abrasion resistance for wear and a high coefficient of friction.

SUMMARY

[0006] In accordance with this disclosure, improvements in the design and construction of rollers and wheels for friction drive systems and methods are provided. In one aspect, a drive roller is provided in which a coupling element is configured to be driven by a rotary force input, a body portion surrounds the coupling element, and an outer contact portion surrounds the body portion and is configured for transferring torque from the rotary force input to a driven element. In some embodiments, the body portion comprises one or more layers of elastomer-reinforced fabric including at least one fabric layer arranged between at least two of a plurality of elastomeric layers, the at least one fabric layer and the elastomeric layers being bonded together to form the body portion.

[0007] In another aspect, roller drive system is provided. A crown track is configured to be rotationally coupled to a driven element, a coupling element is configured to be driven by a rotary force input, a body portion surrounds the coupling element, and an outer contact portion surrounding the body portion is configured for engaging the crown track for transferring torque from the rotary force input to the driven element. In some embodiments, the body portion comprises one or more layers of elastomer-reinforced fabric including at least one fabric layer arranged between at least two of a plurality of elastomeric layers, the at least one fabric layer and the elastomeric layers being bonded together to form the body portion.

[0008] In yet another aspect, a method for making a drive roller is provided. The method includes positioning one or more layers of elastomer-reinforced fabric about a coupling element that is configured to be driven by a rotary force input, the one or more layers of elastomer-reinforced fabric comprising at least one fabric layer positioned between at least two of a plurality of elastomeric layers. The method further includes bonding the at least one fabric layer and the elastomeric layers together to form a body portion and positioning an outer contact portion about the body portion.

[0009] Although some of the aspects of the subject matter disclosed herein have been stated hereinabove, and which are achieved in whole or in part by the presently disclosed subject matter, other aspects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a perspective side view of an aircraft landing gear assembly including a friction drive roller assembly.

[0011] Figure 2 is a side view of elements of a friction drive roller assembly associated with a crown track of an aircraft landing gear assembly.

[0012] Figure 3 is a perspective side view of a friction drive roller.

[0013] Figures 4-5 are side sectional views illustrating friction drive rollers.

[0014] Figure 6 is a side view illustrating a body portion of a friction drive roller including a fiber-reinforced laminated material.

[0015] Figure 7 is a perspective side view of a method of forming a fiber-reinforced laminated material for use as a body portion of a friction drive roller.

[0016] Figure 8 is a side view of a method of forming a fiber-reinforced laminated material for use as a body portion of a friction drive roller.

[0017] Figures 9A-9C are side views of various embodiments of a fiber-reinforced laminated material for use as a body portion of a friction drive roller .

[0018] Figure 10 is a side sectional view illustrating a lobed drive roller of an alternate embodiment of the invention.

[0019] Figure 11 is a side view of a lobed drive roller engaged with a contoured crown track of an alternate embodiment of the invention.

[0020] Figure 12 is a detail view of the lobed drive roller engaged with a contoured crown track according to the embodiment illustrated in Figure 11.

DETAILED DESCRIPTION

[0021] Figures. (also "FIGS.") 1-12 illustrate various aspects, views, and/or features associated with improvements in the design and construction of rollers and wheels for friction drive systems and methods. In one aspect, the present subject matter comprises a friction drive system for use in the main landing gears of aircraft. Referring to the embodiment illustrated in FIGS. 1-2, a landing gear system comprises a landing gear wheel **100** that is connected to a crown track **110** for rotation together. To drive the motion of landing gear wheel **100**, one or more rotary force inputs **120** are configured to drive the rotation of a corresponding one or more friction drive rollers **130**, which are sized and positioned to frictionally engage crown track **110**. In some embodiments, friction drive rollers **130** are movable into and out of contact with crown track **110** (See, e.g., arrows in FIG. 2) to selectively engage or disengage rotary force input **120** from driving the motion of landing gear wheel **100**.

[0022] In contrast to conventional configurations in which stiff elastomer rollers (e.g., rubber) are used to couple rotary force input **120** to crown track **110**, at least a portion of the body of friction drive rollers **130** disclosed herein comprise a fabric-reinforced elastomer. Fabric reinforcement of the elastomer adds stiffness to the elastomeric material in addition to conferring durability and/or fatigue resistance. In particular, in some embodiments, the use of woven fabric serves to increase both stiffness and mechanical properties to a level not attainable through filler addition alone.

[0023] In the non-limiting example illustrated in FIGS. 3-5, friction drive roller **130** includes a coupling element **131** at is core configured to be driven by rotary force input **120**. Coupling element **131** in the illustrated examples is a substantially ring-shaped hub having an internal gear configuration in which teeth are cut into the inside diameter of the ring for engagement with a complementary gear element on rotary force input **120**. Those having ordinary skill in the art will recognize that any of a variety of other known mechanisms for connecting rotary force input **120** and coupling element **131** for rotation together (e.g., a keyed joint, adhesive bonding) are also contemplated for use with the present subject matter.

[0024] Surrounding this coupling element **131**, a body portion **133** comprises one or more layers of elastomer-reinforced fabric. In some embodiments, the body portion **133** includes at least one fabric layer **134** and a plurality of elastomeric layers **135**, where each fabric layer **134** is arranged between two elastomeric layers **135**. The fabric layers **134** and the elastomeric layers **135** are bonded together to form body portion **133**. In some embodiments, fiber materials that are known for use in composite structures are also appropriate for use in the construction of at least one fabric layer **134**. In some representative examples the at least one fabric layer **134** is composed include a woven or non-woven fabric made from carbon fibers, carbon nanofibers, cellulose, graphite, glass, aramid, nylon, rayon, polyester, and/or combinations thereof. In some particular embodiments, the at least one fabric layer **134** are comprised of an epoxy-carbon or epoxy-graphite prepreg. Further, where each fabric layer **134** comprises single-direction fibers, it is advantageous to use at least two layers together, with the fiber directions being aligned in different directions (e.g., the fiber direction of one layer being oriented 90° from that of another layer). Regardless of the particular composition or form, at least one fabric layer **134** is arranged between at least two of elastomeric layers **135** as indicated above. In some embodiments, elastomeric layers **135** are comprised of rubber stock that is calendered to be as thin as possible, but on the order of five (5) to ten (10) times the thickness of the fabric layer **134**.

[0025] Regardless of the particular compositions of fabric layer **134** and elastomeric layers **135**, in some embodiments, fabric layer **134** and elastomeric layers **135** are separate elements that are layered together to form the desired shape of body portion **133**, and the layers are subsequently bonded together. (See, e.g., FIG. 4) Alternatively, in other embodiments, one or more of fabric layer **134** and one or more elastomeric layers **135** are integrated together into a corresponding one or more composite fabric-elastomer layers **136** that are employed as discrete "sheets" of substantially two-dimensional, elastomer-coated fabric. (See, e.g., FIG. 5) In some embodiments, for example, composite fabric-elastomer layers **136** comprise elastomeric material that is reinforced with up to 10 parts per hundred rubber (phr) fiber selected from the group consisting of carbon fibers, carbon nanofibers, cellulose, graphite, glass, aramid, nylon, rayon, polyester, and combinations thereof. Specifically, for example, in some embodiments, each fabric layer **134** is bonded to elastomeric layers **135** using commercially available resorcinol formaldehyde latex (RFL) treatments, adhesives such as CHEMLOK®, and/or combinations thereof to form composite fabric-elastomer layers **136**. Alternatively or in addition, in some embodiments, each fabric layer **134** is calendered (e.g., by frictioning and/or skimming) or otherwise sandwiched within elastomeric layers **135** prior to assembling the layers for bonding. In yet further alternative embodiments, each fabric layer **134** is coated with the elastomer (e.g., by frictioning and/or skimming via calendering) on only one side of each fabric layer **134** prior to assembling the layers for bonding.

[0026] In any form, composite fabric-elastomer layers **136** are arranged in radial layers (e.g., around coupling element **131**) to form body portion **133**. In some embodiments, a further bonding process is performed to bond successive strata of composite fabric-elastomer layers **136** together. Furthermore, one or more process steps in this formation of body portion **133** results in each fabric layer **134** being substantially encapsulated by one or more surrounding elastomeric layers **135**. In such embodiments, elastomeric layers **135** are configured to substantially fill the interstices of fabric layer **134** such that the individual layers of elastomer and fabric are virtually indiscernible.

[0027] Regardless of the form of fabric layer **134** and elastomeric layers **135**, one method of achieving a radial configuration of these elements is shown in FIG. 6, wherein fabric layer **134** and elastomeric layers **135** are arranged in a radial array in which multiple discrete sheets of fabric layer **134** and elastomeric layers **135** are arranged in substantially concentric annular shells around coupling element **131**. In this configuration, successive layers of fabric layer **134** and elastomeric layers **135** are laid up and molded about coupling element **131**.

[0028] In other embodiments, fabric layer **134** and elastomeric layers **135** are spirally rolled around a central core (i.e., around coupling element **131**) to define alternating layers of material as illustrated in FIGS. 7-8. Additionally, fabric layer **134** and elastomeric layers **135** are each single sheets of material that are wound in a substantially continuous spiral configuration, such as is illustrated in FIG. 8. In alternative embodiments, multiple composite fabric-elastomer layers **136** are wound in a discontinuous spiral about the center as shown in FIGS. 9A-9C. In these alternate embodiments, composite fabric-elastomer layers **136** comprise a plurality of panels (e.g., a first composite fabric-elastomer panel **136a**, a second composite fabric-elastomer panel **136b**, a third composite fabric-elastomer panel **136c**) that are wound sequentially in a substantially end-to-end arrangement around coupling element **131** to together form body portion **133**.

[0029] Referring to FIGS. 9A-9C, the sequential panels of composite fabric-elastomer layers **136** are sized such that they wrap distances around coupling element **131** that are designed such that seams **139** between the individual panels of composite fabric-elastomer layers **136** (e.g., between a first panel **136a** and a second panel **136b**) are not radially aligned. The lengths of composite fabric-elastomer layers **136** are selected such that they wrap distances that do not divide evenly into the circumference of body portion **133** at that layer. Since seams **139** are essentially discontinuities in the fabric reinforcement, alignment of these discontinuities between adjacent panels of composite fabric-elastomer layers **136** result in weak spots forming in body portion **133**. By designing the location of seams **139** to not align with one another in any particular region or regions of body portion **133**, the ability of body portion **133** to effectively transfer forces (e.g., from rotary force input **120** to crown track **110**) is improved. In the embodiments illustrated in FIGS. 9A-9C, the panels can be sized to wrap an arc of about 375° (See, e.g., FIG. 9A), about 190° (See, e.g., FIG. 9B), or about 40° (See, e.g., FIG. 9A) around coupling element **131**. Those having ordinary skill in the art will recognize that these embodiments are only provided as representative examples, and other configurations and panel sizes can be used to achieve a desired form for body portion **133**.

[0030] In any configuration, the design of at least a portion of body portion **133** of friction drive roller **130** focuses on carrying the high loads without causing undesirable heat build-up.

Where body portion **133** is formed by a spiral roll of elastomer-reinforced fabric, shear forces that develop as a result of the torques applied to friction drive roller **130** are taken up in tension within the layers of the elastomer-reinforced fabric of body portion **133**. As a result, this configuration of body portion **133** of friction drive roller **130** is configured to provide better resistance to the high shear forces and heat build-up over conventional rollers. In addition, the specific composition and/or construction of body portion **133** is selected to produce a desired stiffness.

[0031] In some embodiments, friction drive roller **130** is provided with an outer roller surface. Referring to the embodiments illustrated in FIGS. 3-5, friction drive roller **133** comprises an outer contact portion **140** that surrounds body portion **133** and is configured for transferring torque from rotary force input **120** to a driven element (e.g., crown track **110** associated with landing gear wheel **100**). Outer contact portion **140** comprises a plurality of outer material layers **141** (e.g., further elastomeric material layers having the same or different composition from elastomeric layers **135**) arranged about body portion **133**. For example illustrated in FIG. 4, outer material layers **141** are arranged in a spiral winding. In some alternative embodiments, outer material layers **141** are arranged in concentric radial shells similar to the construction of body portion **133** discussed above with respect to the embodiment of FIG. 8. In other embodiments, outer contact portion **140** is composed of a single, comparatively thicker layer of substantially solid rubber material as shown in FIG. 5. In any form, the material of outer contact portion **140** is selected to have a high coefficient of friction to more efficiently transfer the torque from rotary force input **120** to the driven element. In this case, the term high coefficient of friction means equal to or greater than 1.0. In typical operating conditions for existing rollers, the range of the coefficient of friction is between 0.5 and 1.0 for dry conditions. Also, wet, fouled or extremely cold conditions lower the coefficient of friction is lower. Furthermore, a high abrasion resistance extends the life of the material of outer contact portion **140**.

[0032] Those skilled in the art understand that the coefficient of friction drops with increasing pressure and velocity. For tire grip, with increasing pressure and velocity the coefficient of friction initially increases until the material fills the nooks and crannies of the mating surface when the coefficient of friction remains constant. Then the coefficient of friction begins to decrease with increased pressure and velocity as more pressure does not cause an increase in the fill.

[0033] In some embodiments, body portion **133** and outer contact portion **140** are co-formed and in some cases co-cured in the desired shape. Furthermore, this assembly of body portion **133** and outer contact portion **140** can be post-vulcanization bonded to coupling element **131**, one or more mechanical fasteners can be used (not shown), or a combination of bonding mechanisms can be used to couple all of the elements of friction drive roller **130** together. Referring to FIG. 4, the illustrative embodiment shows that body portion **133** is constructed to have an innermost elastomeric layer **135a** bonded to an outer surface of coupling element **131**, either over the entire outer surface of coupling element **131** or at one or more discrete joints. In some embodiments, innermost elastomeric layer **135a** is simply the first of one or more elastomeric layers **135** that are integrated with the at least one fabric layer **134**. Alternatively, in other embodiments, innermost elastomeric layer **135a** is a separate layer that is not associated with a fabric layer **134**.

[0034] In any of the above-described arrangements, outer contact portion **140** of friction drive roller **130** provides a high coefficient of friction (e.g., a coefficient of friction that equal to or greater than 1.0) for engaging a driven element. Additionally, outer contact portion **140** of friction drive roller **130** provides a high abrasion resistance for wear. Referring to FIGS. 1 and 2, outer contact portion **140** is configured to transfer torque to a driven element, such as crown track **110** in the case of a frictional drive system for landing gear wheel **100**. In common configurations in which crown track **110** is a substantially smooth, circular element, the ability of friction drive roller **130** to transfer torque from rotary force input **120** to crown track **110**, and thus to landing gear wheel **100**, depends primarily on the frictional engagement of outer contact portion **140** with crown track **110**. Accordingly, the material composition of outer contact portion **140** discussed above directly impacts the ability of friction drive roller **130** to provide an efficient transfer of torque.

[0035] Alternatively, the crown track and friction roller of such a system is configured to exhibit improved coupling that does not rely on frictional engagement alone. The crown track and friction roller allows the lobed drive roller **150** to maintain or increase the coefficient of friction with increasing pressure by working around the limitation of a decreasing coefficient of friction. In the embodiment illustrated in FIGS. 1 and 2, the pressures are greater than 1,000 pounds per square inch (6,895 kilopascals) and approaching 2,000 pounds per square inch (13,790 kilopascals). As illustrated in FIGS. 10-12, a lobed drive roller **150** is configured for use with a contoured crown track **115**. Similar to the construction of friction drive roller **130** discussed above, in these embodiments, lobed drive roller **150** comprises a coupling element **151** at its core that is configured to be driven by rotary force input **120**. Although not shown in FIGS. 10-12, those having ordinary skill in the art will recognize that coupling element **151** can have some form of engagement element (e.g., an internal gear configuration as discussed above with respect to coupling element **131**) configured for engagement with rotary force input **120**. In addition, lobed drive roller **150** also comprises a body portion **153** surrounding coupling element **151** and an outer contact portion **160** configured for transferring torque to an associated driven element (e.g., provided either as an outermost region of body portion **153** as shown in FIGS. 11-12 or as a separate element that surrounds body portion **153**). In some embodiments, body portion **153** again comprises one or more layers of elastomer-reinforced fabric. In this regard, body portion **153** can be constructed in any of a variety of configurations substantially similar to those discussed above with respect to the construction of body portion **133** of friction drive roller **130**. Alternatively, body portion **153** need not be composed of a fabric-reinforced elastomer material. In some particular embodiments, for example, body portion **153** is composed of a stiff elastomer material substantially similar to conventional rollers.

[0036] In any configuration, in contrast to the construction of friction drive roller **130**, lobed drive roller **150** comprises one or more lobes **162** that extend outwardly from outer contact portion **160**. Any of a variety of methods can be used to form lobes **162**. In the embodiment shown in FIG. 10, coupling element **151** has a contoured, sprocket-like outer surface having one or more protrusions **152** that correspond to the one or more lobes **162** to be formed. With this structure, as body portion **153** is formed about, adhered to, or otherwise positioned about coupling element **151**, the shape of body portion **153** substantially mimics the contour of the outer surface of coupling element **151** (e.g., as defined by the one or more protrusions **152**) to correspondingly define lobes **162** at outer contact portion **160**.

[0037] In the embodiment illustrated in FIG. 10, body portion **153** is formed from a layup **157** of elastomer-reinforced fabric (e.g., a plurality of spiral windings of fabric and elastomer layers), which is positioned about coupling element **151** and bonded thereto. In some embodiments, one or more mold elements are sized and/or configured to apply substantially uniform pressure to the outer surface of layup **157** to bend or otherwise form it into a shape that conforms to the contour of coupling element **151**. In this way, lobes **162** are formed as the elastomer-reinforced fabric is layered over protrusions **152** of coupling element **151**.

Accordingly, the particular shape and configuration of lobes **162** is influenced by a combination of the shape and/or configuration of coupling element **151** (e.g., the size, shape, and positions of protrusions **152**) and the way in which body portion **153** is formed, coupled, and/or molded onto coupling element **151**. Alternatively, element **151** and body portion **153** are shaped and configured to be substantially ring-shaped (i.e., similar to coupling element **131** and body portion **133** discussed above), and lobes **162** are build-up independently during the formation of outer contact portion **160**.

[0038] However lobes **162** are formed, improved coupling with the associated driven element is achieved where lobes **162** of lobed drive roller **150** are configured to positively engage with one or more surface features on a complementary driven element. FIGS. 11-12 illustrate engagement of lobed drive roller **150** with a contoured crown track **115**. In such a configuration, contoured crown track **115** comprises one or more protuberances **116** that are configured to engage with lobes **162** of lobed drive roller **150**. In some embodiments, the shape and arrangement of protuberances **116** on contoured crown track **115** are designed such that a substantially sinusoidal surface contour is defined. Lobes **162** extending from lobed drive roller **150** are correspondingly shaped and arranged to be substantially enmeshed between adjacent ones of protuberances **116**.

[0039] In this arrangement, in addition to lobed drive roller **150** being able to transfer torque to contoured crown track **115** by pure frictional contact, this coupling is enhanced by the positive engagement of lobes **162** with protuberances **116**. Referring to FIG. 12, with lobes **162** being enmeshed between adjacent protuberances **116**, rotation of lobed drive roller **150** causes a given one of lobes **162** to impose a force having a compressive component on an associated “upstream“ protuberance **116a** of contoured crown track **115**. Thus, lobed drive roller **150** and contoured crown track **115** are operable in a manner substantially similar to a geared connection for the transmission of torque. As a result, whereas the coupling of friction drive roller **130** with crown track **110** can slip in situations where the experienced load exceeds the frictional coupling, greater loads can be transferred by lobed drive roller **150**. In some embodiments, this increased load transfer capacity compared to the substantially purely frictional load transfer of friction drive roller **130** is achieved even where the design of outer contact portion **160** defines a pressure angle having a value that is greater than standard values used in the design of gears (e.g., pressure angle shown in FIG. 12 is about 42° compared to standard values associated with gears being about 14.5°, 20°, or 25°).

[0040] Furthermore, the design of lobed drive roller **150** helps to minimize wear of outer contact portion **160** compared to conventional friction drive rollers. In some embodiments where the engagement of lobed drive roller **150** and contoured crown track **115** is designed such that each of lobes **162** is configured to be at least partially nested between "upstream" protuberance **116a** and a "downstream" protuberance **116b**, the increased stiffness of body portion **153** (e.g., compared to conventional friction drive rollers) helps to minimize the "upstream" and "downstream" bulge slip wear. In addition, "downstream" protuberance **116b** is functional to prevent substantial deformation of the enmeshed one of lobes **162** as a result of its interaction with "upstream" protuberance **116a**. (See, e.g., FIG. 12)

[0041] In any configuration, the friction drive rollers discussed herein are adapted to be used in place of conventional designs as part of a frictional drive system for use in aircraft landing gear systems such as those shown in FIGS. 1-2. In addition to these exemplary implementations of fabric-reinforced friction drive roller described herein, those having skill in the art should recognize that fabric-reinforced friction drive roller can be implemented in any of a variety of other applications in which it is desired for such an element to be able to carry high loads, provide high abrasion resistance, and a high coefficient of friction but to give low heat build-up.

[0042] Other embodiments of the current invention will be apparent to those skilled in the art from a consideration of this specification or practice of the invention disclosed herein. Thus, the foregoing specification is considered merely exemplary of the current invention with the true scope thereof being defined by the following claims.

CLAIMS

What is claimed is:

1. A drive roller comprising:

a coupling element configured to be driven by a rotary force input;

a body portion comprising one or more layers of elastomer-reinforced fabric surrounding the coupling element, the one or more layers of elastomer-reinforced fabric comprising at least one fabric layer arranged between at least two of a plurality of elastomeric layers, the at least one fabric layer and the elastomeric layers being bonded together to form the body portion; and

an outer contact portion surrounding the body portion and configured for transferring torque from the rotary force input to a driven element.

2. The drive roller of claim 1, wherein the coupling element comprises a substantially ring-shaped hub having an internal gear configuration in which teeth are cut into the inside diameter of the hub for engagement with a complementary gear element of the rotary force input.

3. The drive roller of claim 1, wherein the one or more fabric layers comprise fiber materials selected from the group consisting of carbon fibers, carbon nanofibers, cellulose, graphite, glass, aramid, nylon, rayon, polyester, and combinations thereof.

4. The drive roller of claim 1, wherein the elastomer-reinforced fabric is spirally-wound about the coupling element.

5. The drive roller of claim 1, wherein the one or more layers of elastomer-reinforced fabric comprises the at least one fabric layer being encapsulated within the elastomeric layers.

6. The drive roller of claim 1, wherein the outer contact portion comprises a solid rubber material selected to have a coefficient of friction equal to or greater than 1.0.

7. The drive roller of claim 1, wherein the elastomer is reinforced with up to 10 parts per hundred rubber (phr) fiber selected from the group consisting carbon fibers, carbon nanofibers, cellulose, graphite, glass, aramid, nylon, rayon, polyester, and combinations thereof.

8. The drive roller of claim 1, wherein the outer contact portion comprises one or more lobes extending outwardly therefrom;

wherein the driven element comprises one or more protuberances extending outwardly therefrom; and

wherein the one or more lobes are configured for engaging the one or more protuberances for transferring torque from the rotary force input to the driven element.

9. A roller drive system comprising:

a coupling element configured to be driven by a rotary force input;

a body portion comprising one or more layers of elastomer-reinforced fabric surrounding the coupling element, the one or more layers of elastomer-reinforced fabric comprising at least one fabric layer arranged between at least two of a plurality of elastomeric layers, the at least one fabric layer and the elastomeric layers being bonded together to form the body portion;

an outer contact portion surrounding the body portion; and

a crown track configured to be rotationally coupled to a driven element;

wherein the outer contact portion is configured for engaging the crown track for transferring torque from the rotary force input to the driven element.

10. The roller drive system of claim 9, wherein the outer contact portion comprises one or more lobes extending outwardly therefrom;

wherein the crown track comprises one or more protuberances extending outwardly therefrom; and

wherein the one or more lobes are configured for engaging the one or more protuberances for transferring torque from the rotary force input to the driven element.

11. A method for making a drive roller, the method comprising:

positioning at least one fabric layer between at least two of a plurality of elastomeric layers to form one or more layers of elastomer-reinforced fabric;

positioning the one or more layers of elastomer-reinforced fabric about a coupling element that is configured to be driven by a rotary force input;

bonding the at least one fabric layer and the elastomeric layers together to form a body portion; and

positioning an outer contact portion about the body portion.

12. The method of claim 11, wherein positioning the one or more layers of elastomer-reinforced fabric about the coupling element comprises spirally winding the one or more layers of elastomer-reinforced fabric about the coupling element.

13. The method of claim 12, wherein positioning at least one fabric layer between at least two of a plurality of elastomeric layers includes coating the at least one fabric layer with elastomeric materials prior to spirally winding the one or more layers of elastomer-reinforced fabric about the coupling element.

14. The method of claim 11, wherein positioning the outer contact portion about the body portion comprises encapsulating the elastomeric layers and the at least one fabric layer with a surface coating of elastomeric material.

15. The method of claim 14, wherein encapsulating the elastomeric layers and the at least one fabric layer with a surface coating of elastomeric material comprises encapsulating the elastomeric layers and the at least one fabric layer with a solid rubber material selected to have a coefficient of friction equal to or greater than 1.0.

16. The method of claim 11, wherein bonding the at least one fabric layer and the elastomeric layers together further comprises:

applying one or more of resorcinol formaldehyde latex (RFL) treatments, adhesives, or combinations thereof to the at least one fabric layer; and

adhering the at least one fabric layer to the elastomeric layers.

17. The method of claim 11, wherein bonding the at least one fabric layer and the elastomeric layers together further comprises frictioning or skimming via calendering the at least one fabric layer within the elastomeric layers prior to positioning the one or more layers of elastomer-reinforced fabric about the coupling element.

18. The method of claim 11, wherein bonding the at least one fabric layer and the elastomeric layers together further comprises encapsulating the at least one fabric layer within the elastomer sections.

19. The method of claim 11, wherein positioning the one or more layers of elastomer-reinforced fabric about the coupling element, bonding the at least one fabric layer and the

elastomeric layers together, and positioning an outer contact portion about the body portion comprises co-forming and co-curing the body portion and the outer contact portion.

20. The method of claim 11, wherein positioning an outer contact portion about the body portion comprises forming one or more lobes extending outwardly from the outer contact portion.

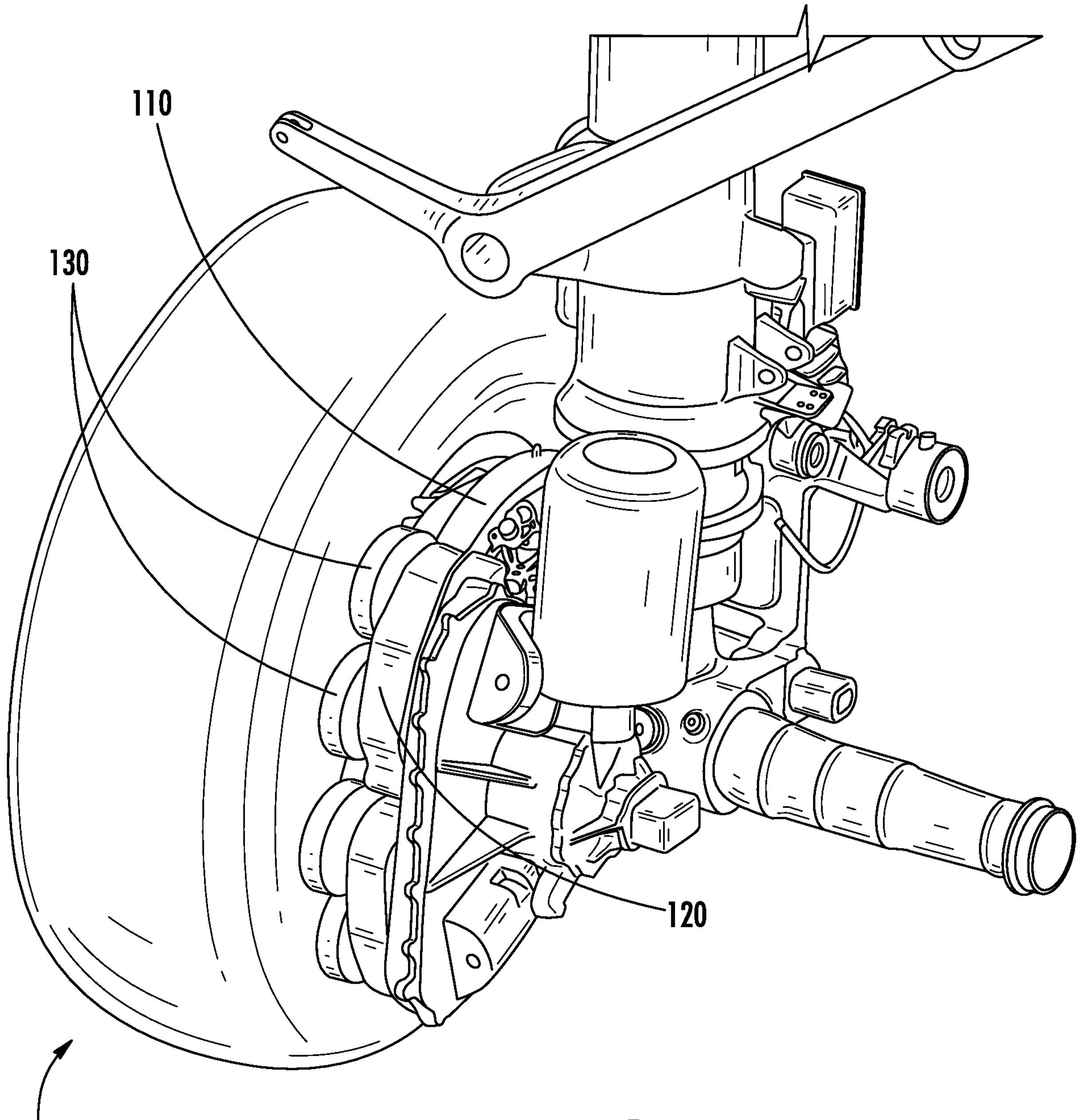


FIG. 1

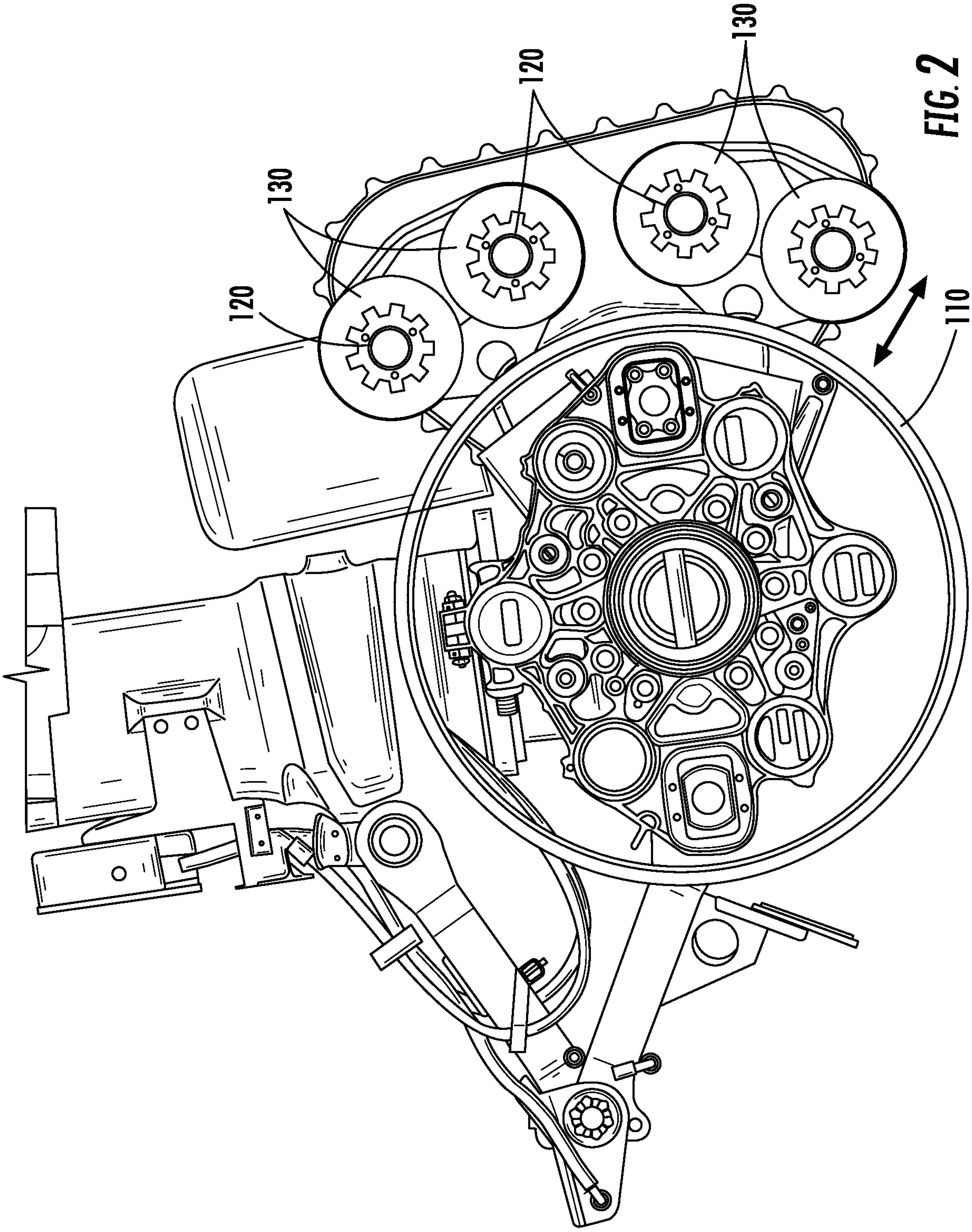


FIG. 2

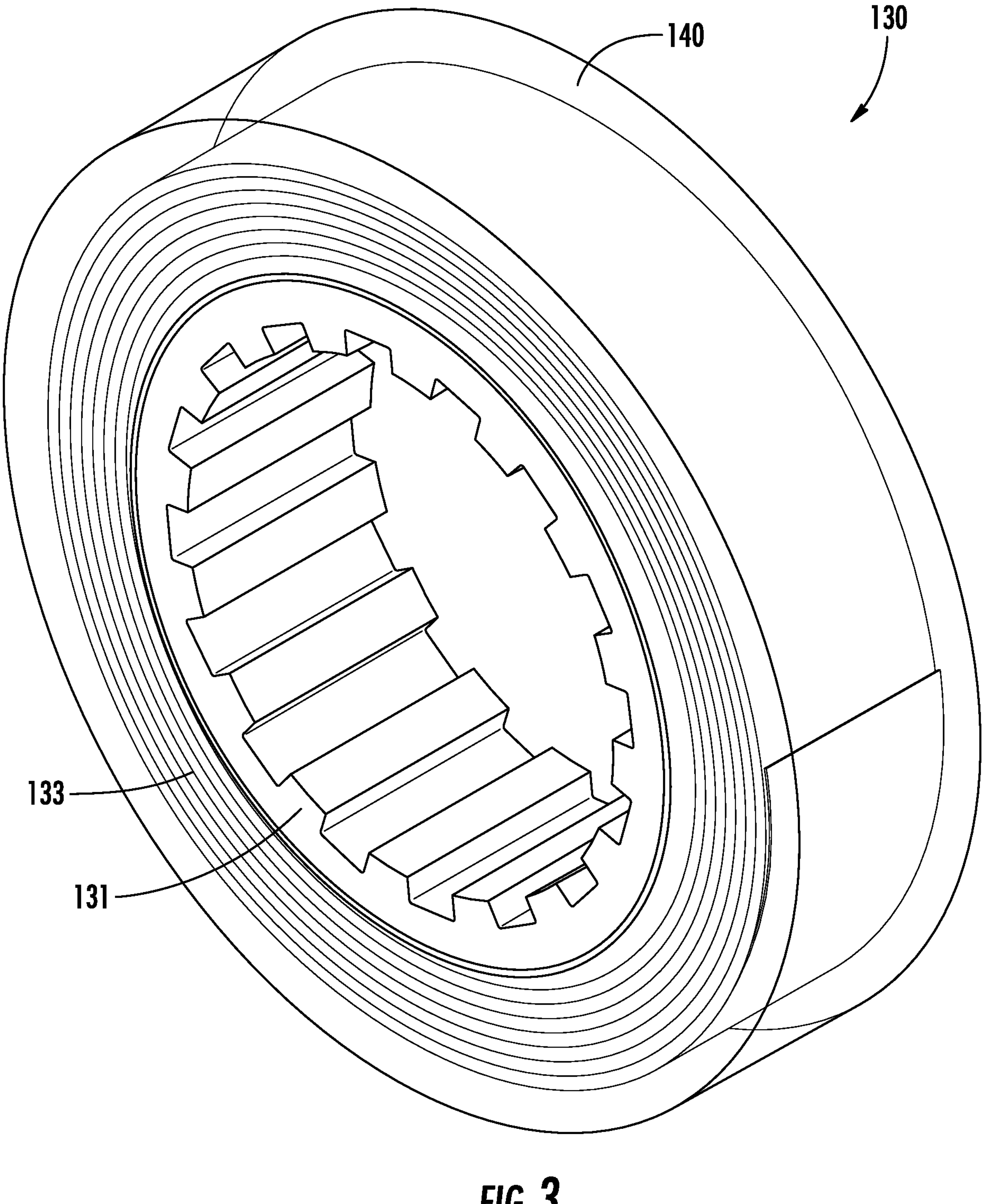
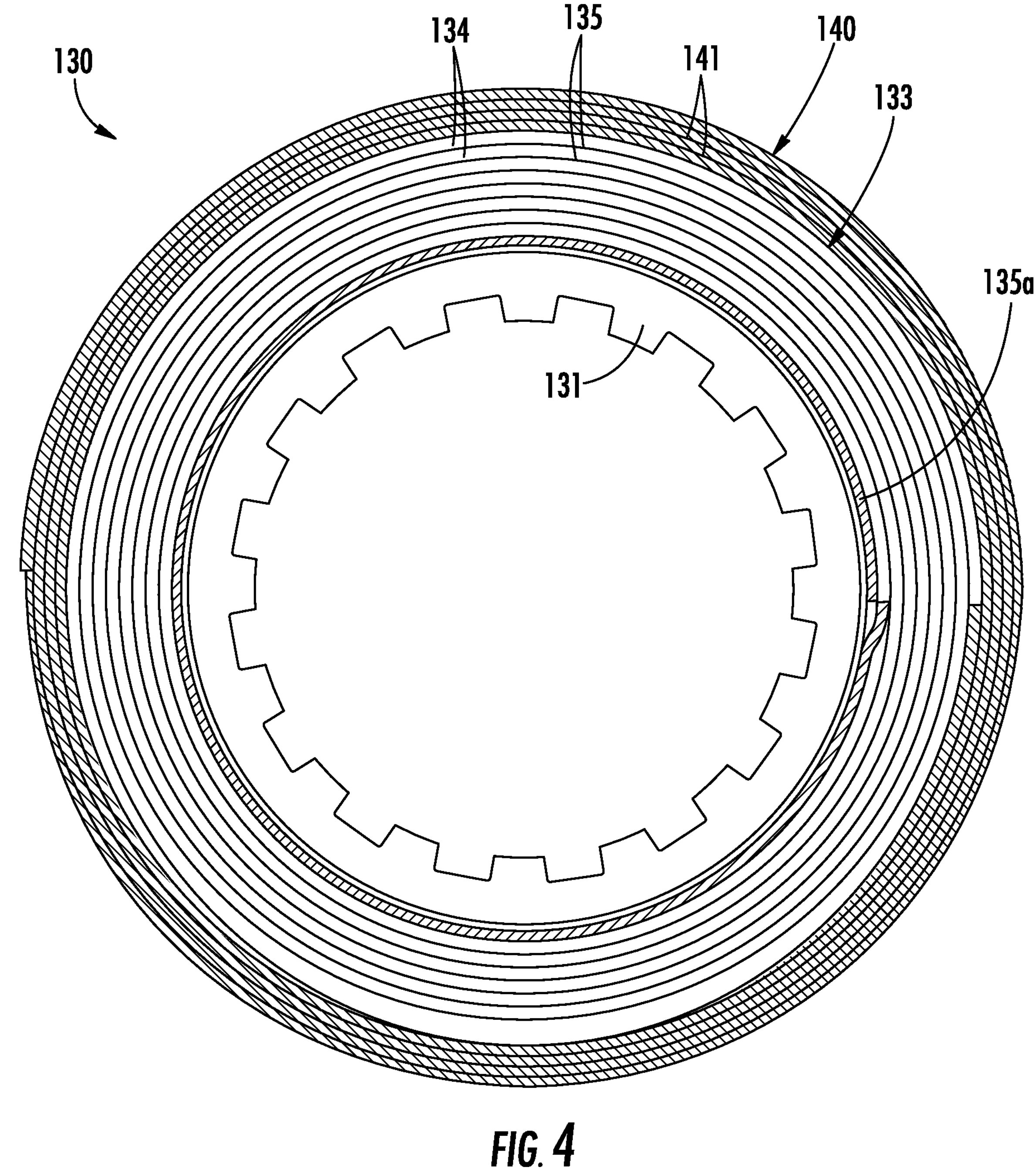


FIG. 3



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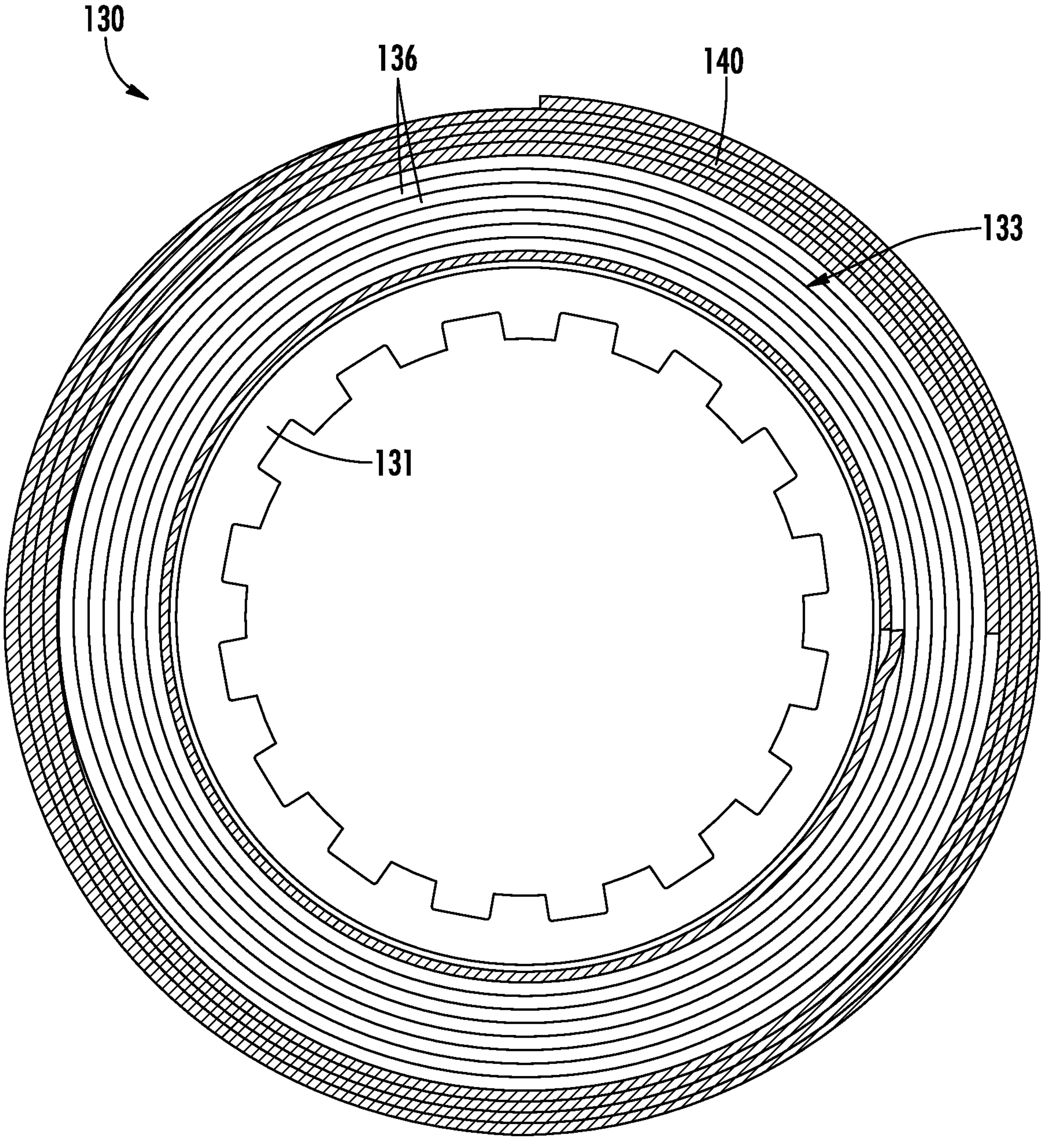

FIG. 5

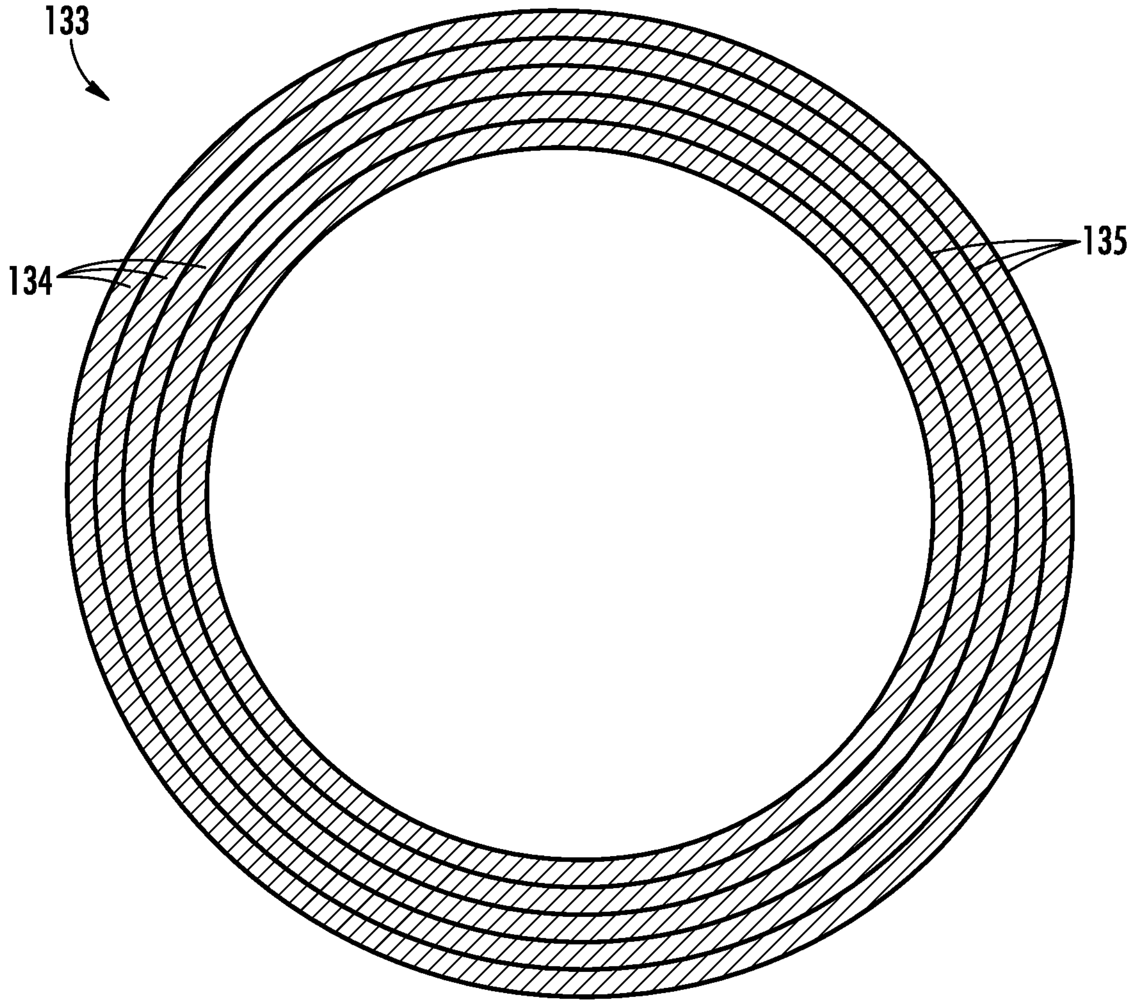

FIG. 6

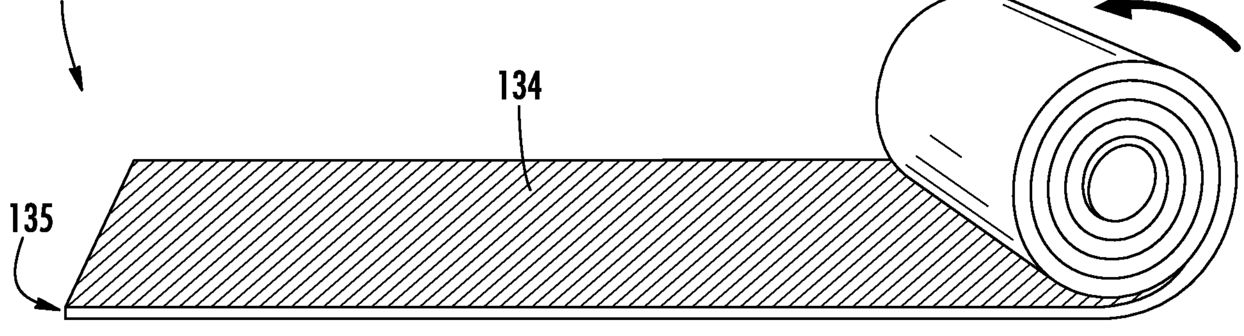

FIG. 7

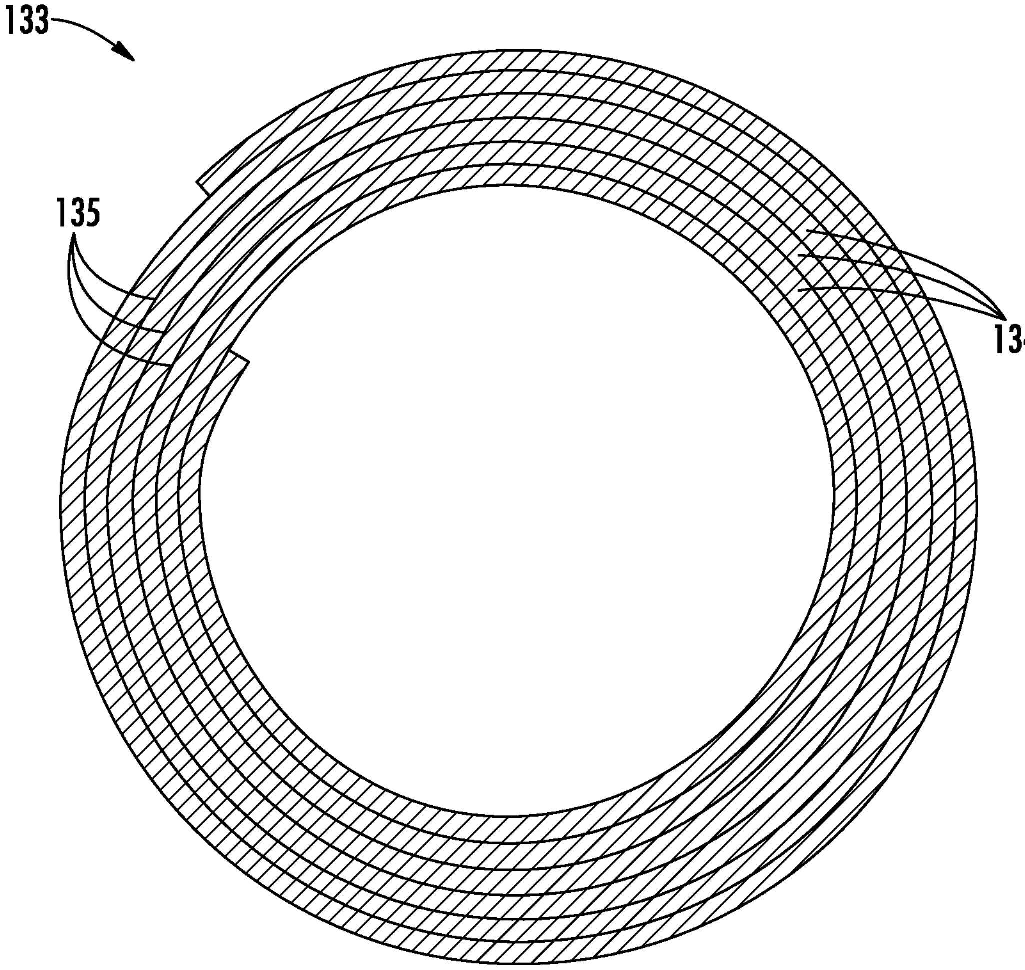

FIG. 8

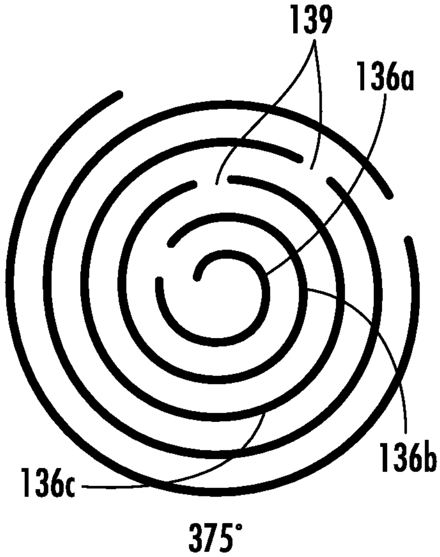

FIG. 9A

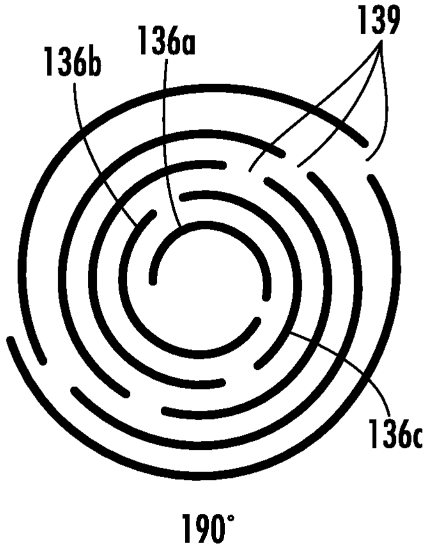

FIG. 9B

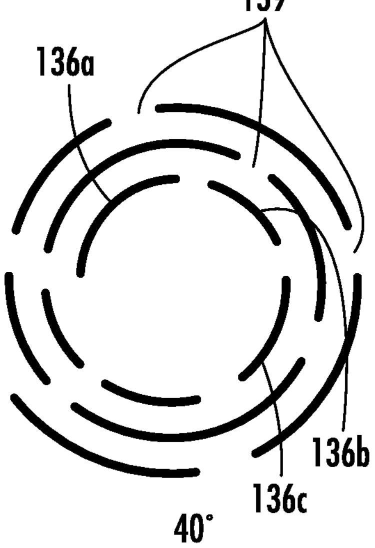

FIG. 9C

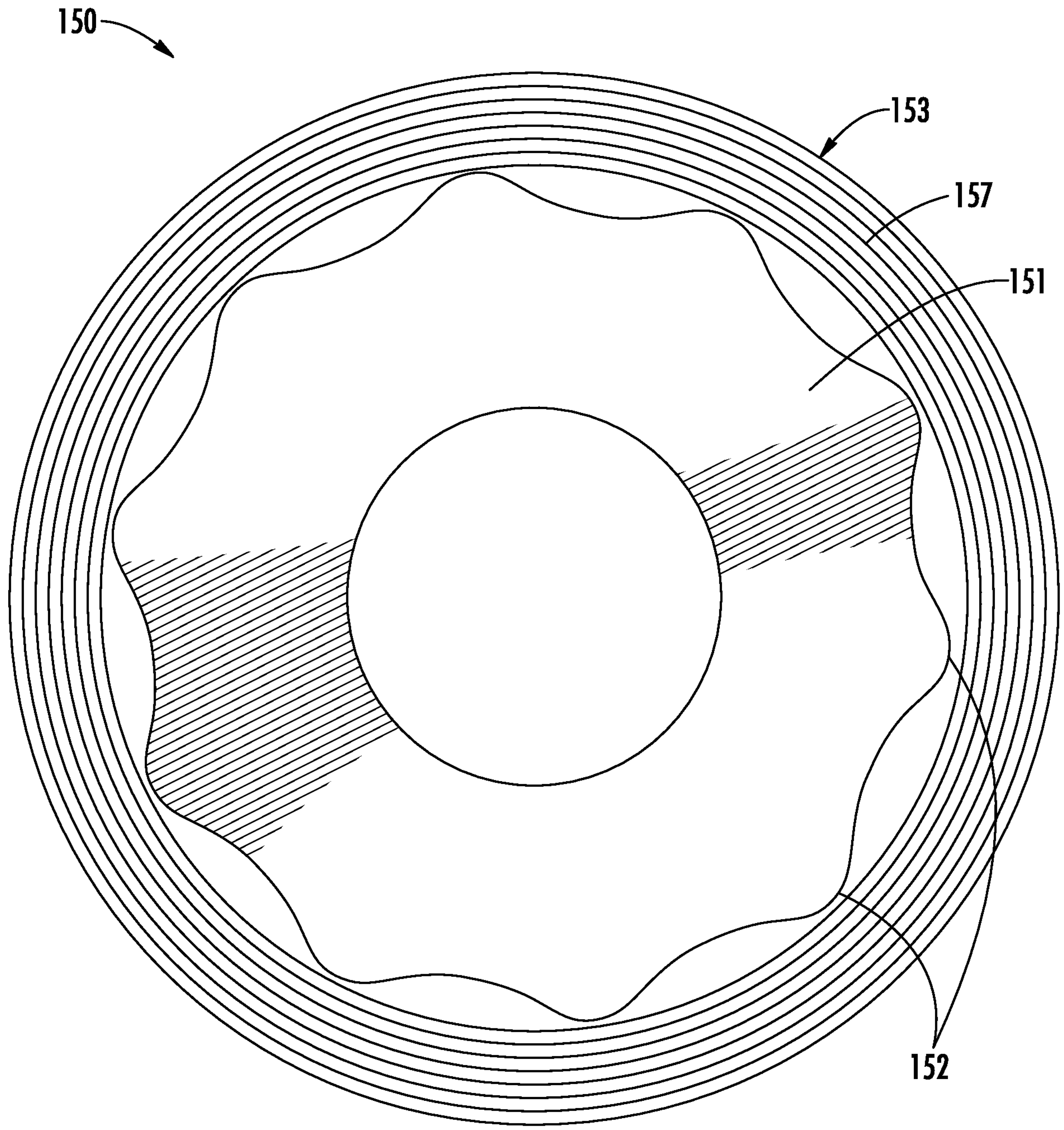

FIG. 10

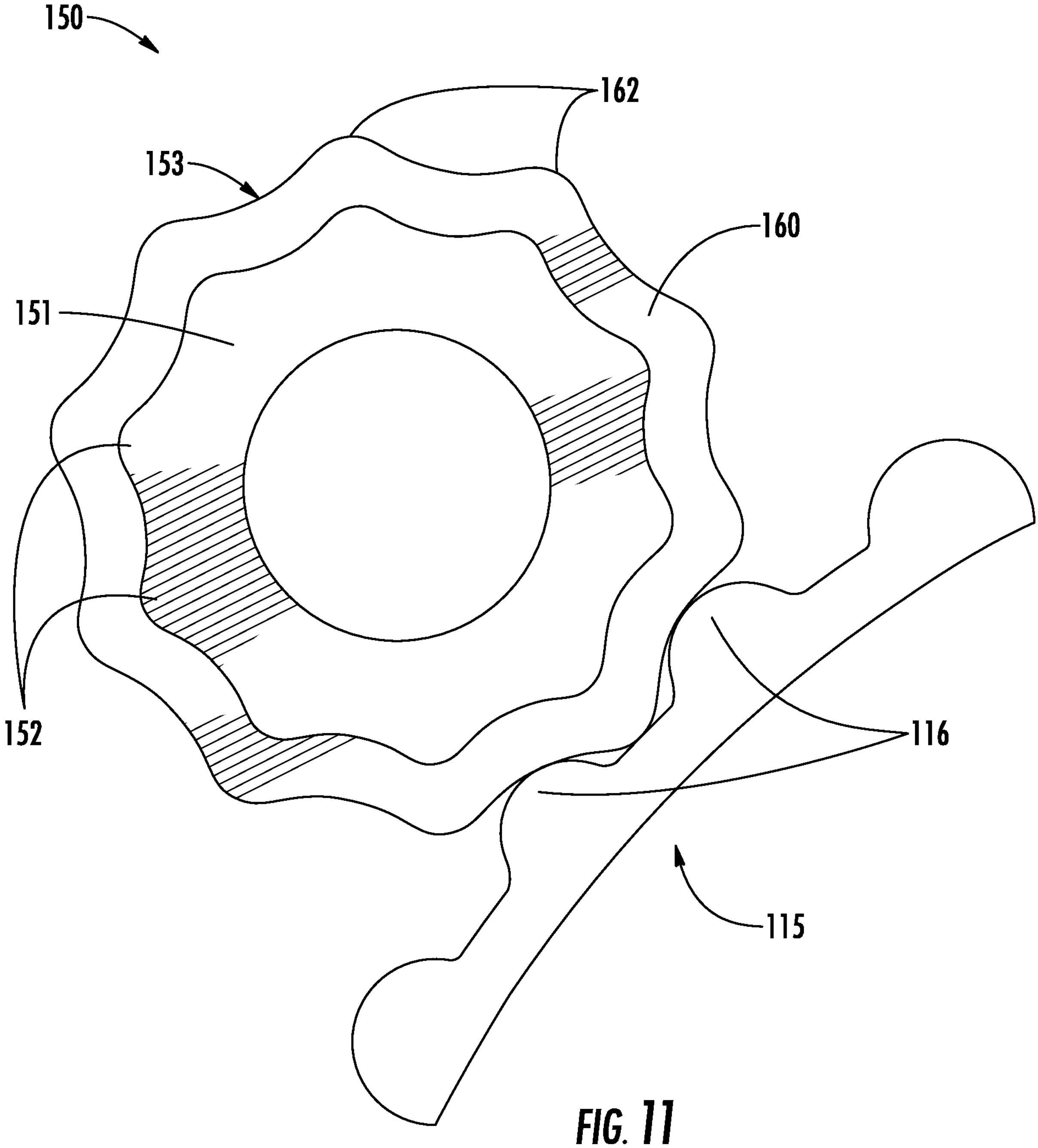

FIG. 11

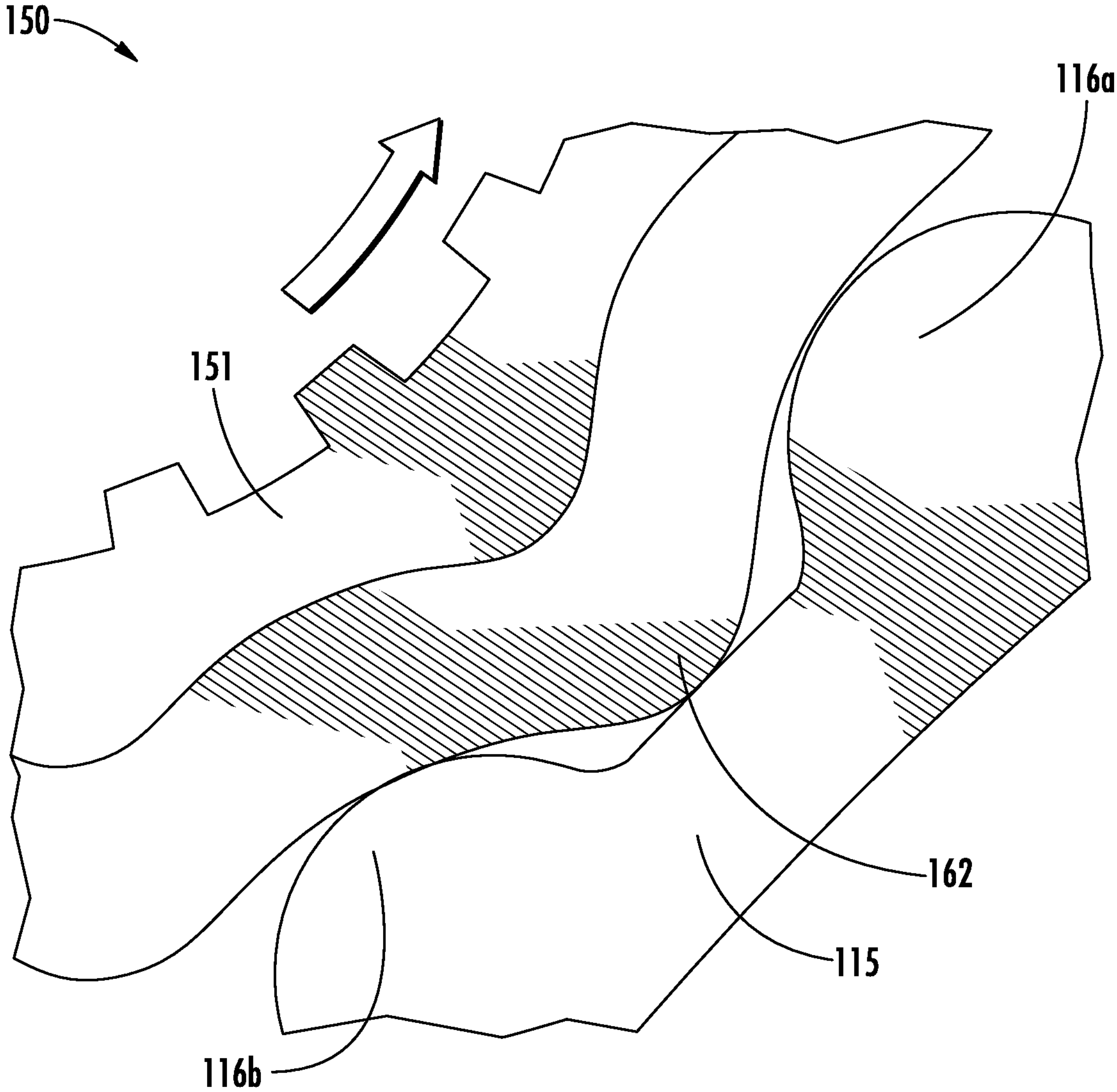

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/036423

A. CLASSIFICATION OF SUBJECT MATTER

INV. B32B5/02 B32B7/12 B32B25/04 B32B25/10 B32B27/12
B32B1/00 B64C25/40 F16H13/00 F16H55/34 F16H55/48

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B65C F16H B64C B64D B62D B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2014/160242 A1 (LORD CORP [US]; HALLADAY JAMES R [US]; KRAKOWSKI FRANK J [US]; HALILOV) 2 October 2014 (2014-10-02) paragraphs [0034], [0030], [0041]; claims; figures -----	1-20
A	WO 2011/062639 A2 (LORD CORP [US]; HALLADAY JAMES R [US]; SHERIDAN PATRICK M [US]; DOWNIN) 26 May 2011 (2011-05-26) abstract claims; figures 1,2 -----	1-20
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 September 2016	30/09/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Mazet, Jean-François

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 2 527 249 A1 (AIRBUS OPERATIONS SAS [FR]) 28 November 2012 (2012-11-28) claims; figures	9,10
A	WO 2014/023941 A1 (AIRBUS OPERATIONS LTD [GB]) 13 February 2014 (2014-02-13) abstract claims; figure 1	9,10
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Information on patent family members

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