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Kikuchi et al.

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(54) **BAT SYSTEM WITH PERFORMANCE LIMITING STRUCTURE AND METHODS OF MAKING SAME**

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Related U.S. Application Data

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(60) Provisional application No. 62/749,759, filed on Oct. 24, 2018.

(51) **Int. Cl.**

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A63B 59/50	(2015.01)
A63B 102/18	(2015.01)

(52) **U.S. Cl.**
CPC ***A63B 59/50*** (2015.10); *A63B 2102/18* (2015.10); *A63B 2102/182* (2015.10); *A63B 2209/00* (2013.01)

(58) **Field of Classification Search**
CPC A63B 59/50
USPC 473/564
See application file for complete search history.

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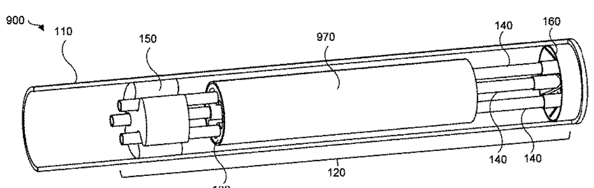
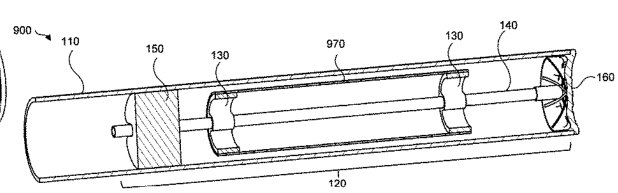
(57) **ABSTRACT**

A bat, which has a hollow barrel and an internal assembly configured to resist deformation of the hollow barrel, is disclosed. The internal assembly includes a rod disposed longitudinally in the hollow barrel, a ring attached to the rod, a deformable sleeve disposed around the ring and extending longitudinally in the hollow barrel. The sleeve can include an outer diameter smaller than an inner diameter of the hollow barrel. The bat can include an end cap attached to an end of the hollow barrel and having a recess configured to receive an end of the rod. The rod can be configured to maintain the deformable sleeve in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, the sleeve is disposed a predetermined gap distance from an inner surface of the hollow barrel.

20 Claims, 14 Drawing Sheets





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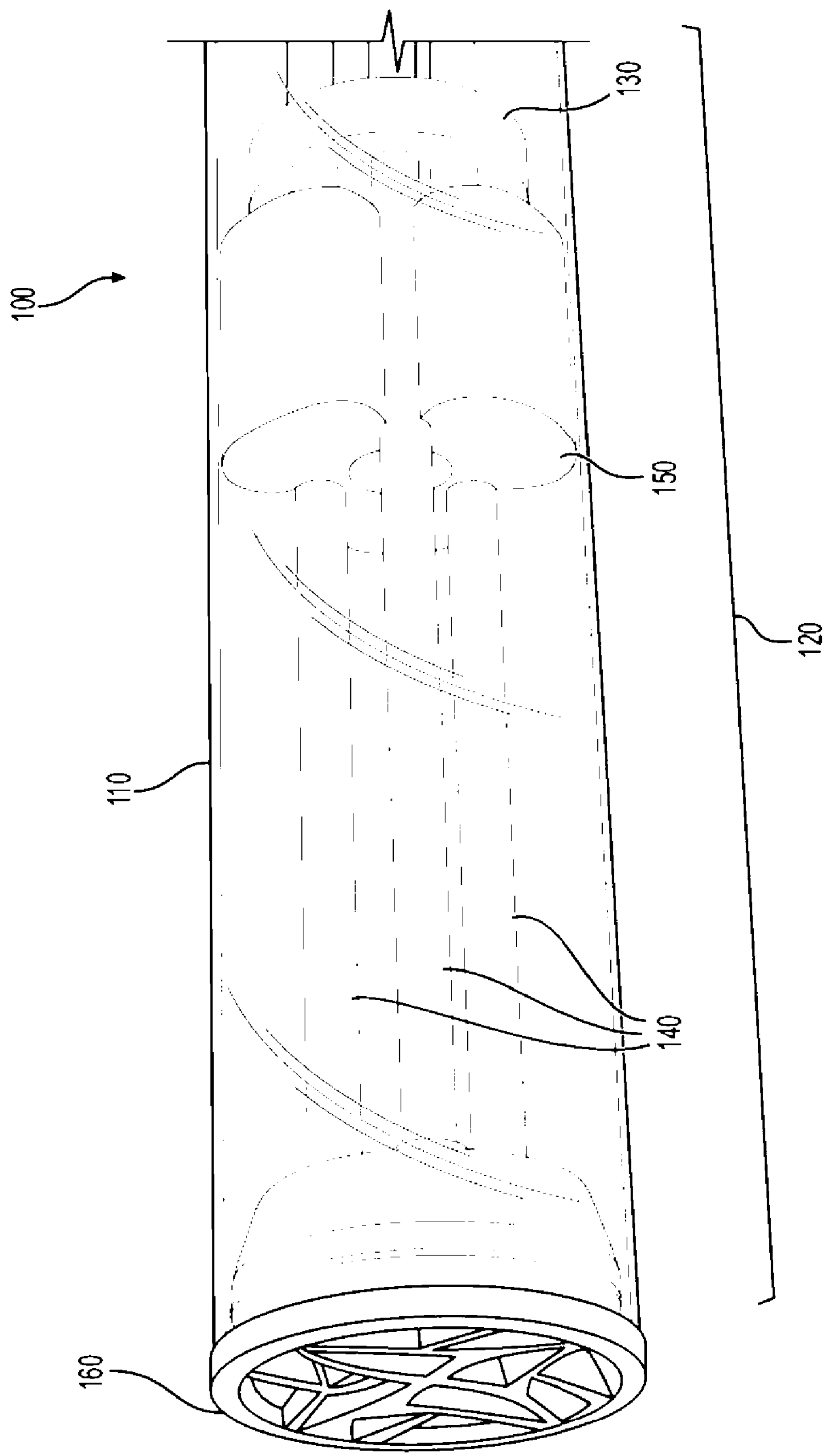


FIG. 1

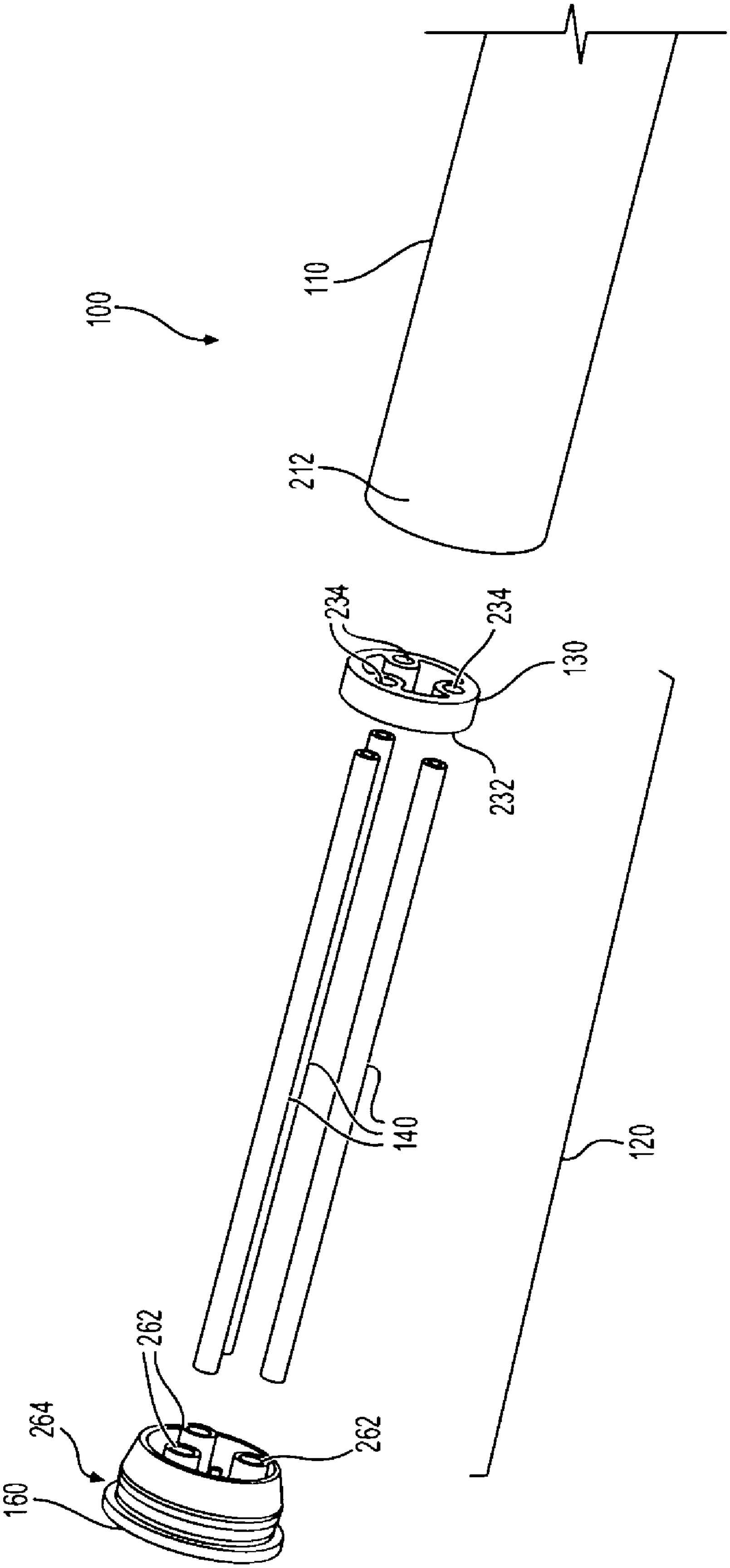


FIG. 2

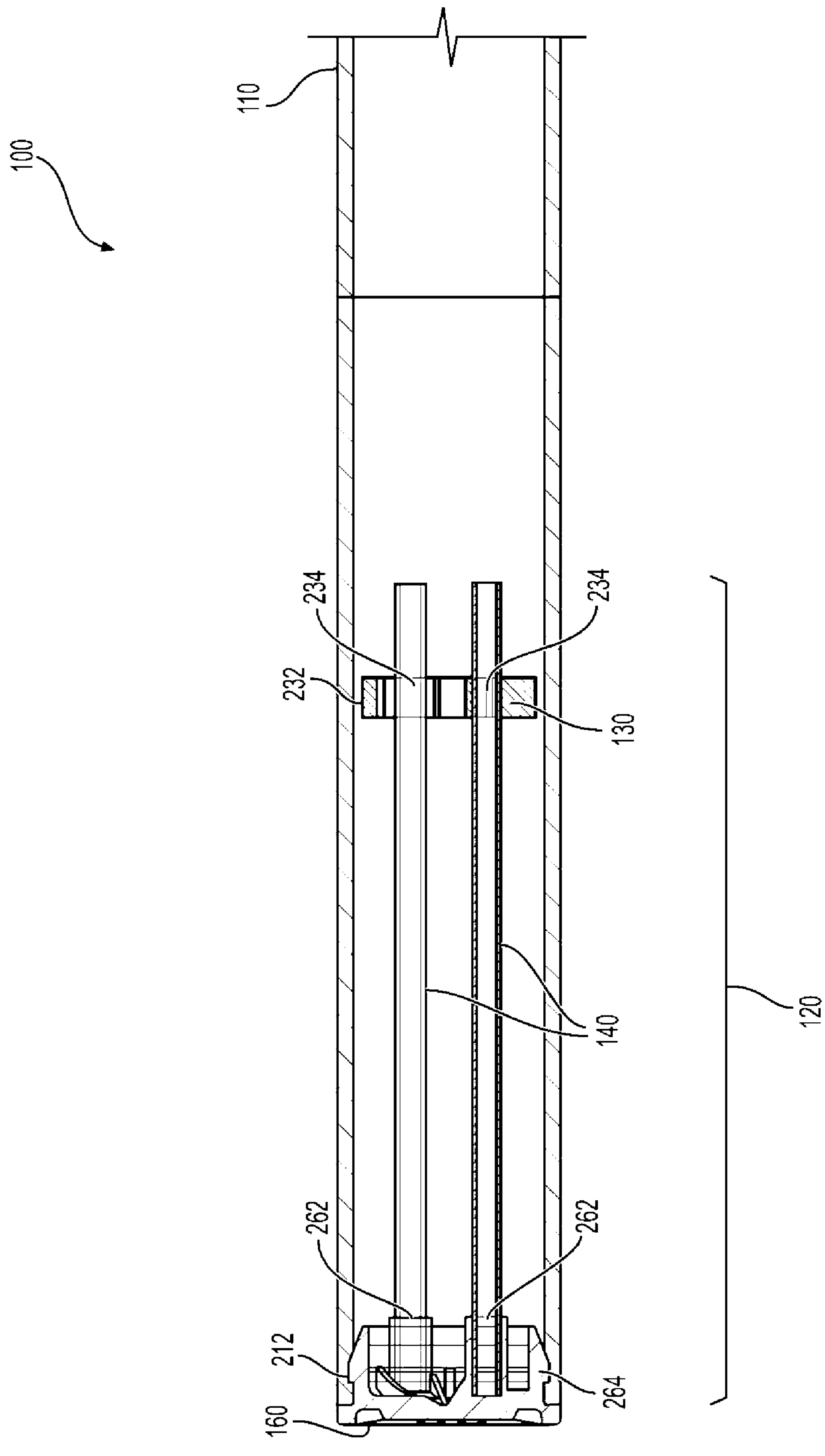


FIG. 3

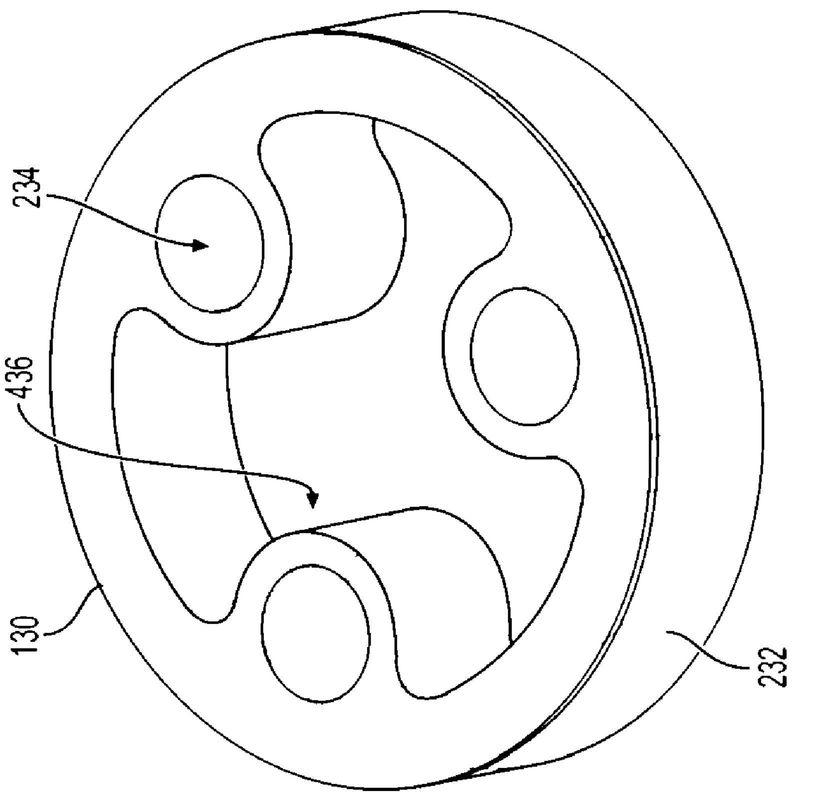


FIG. 4B

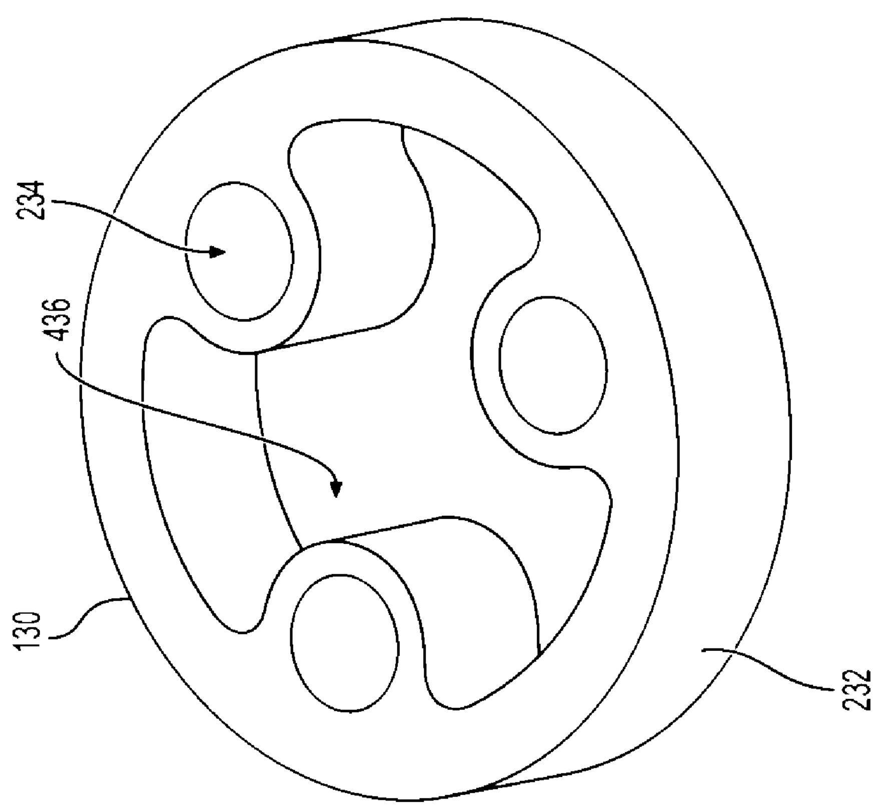


FIG. 4A

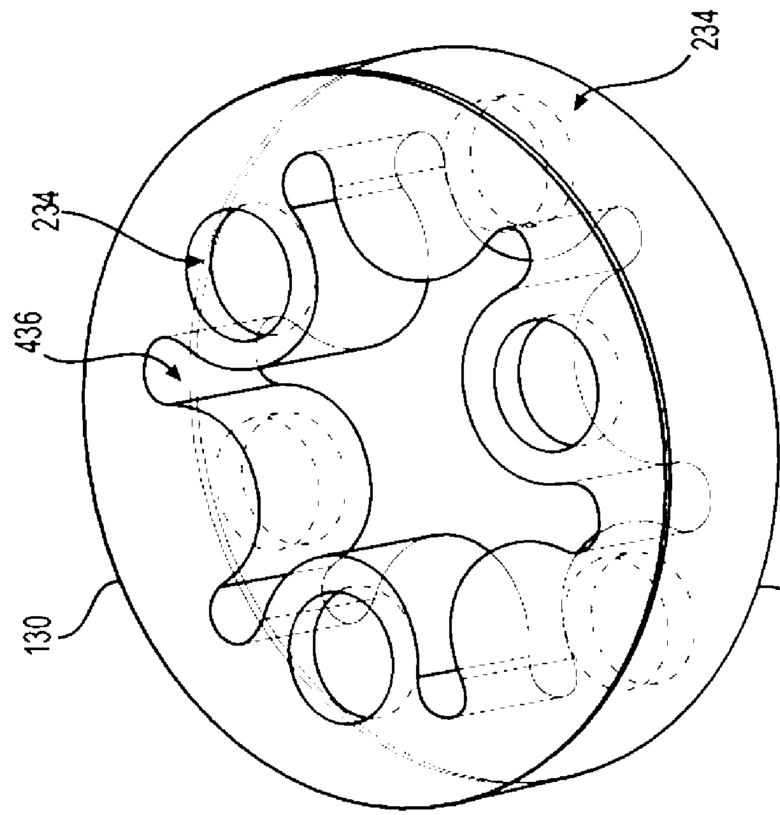


FIG. 4D

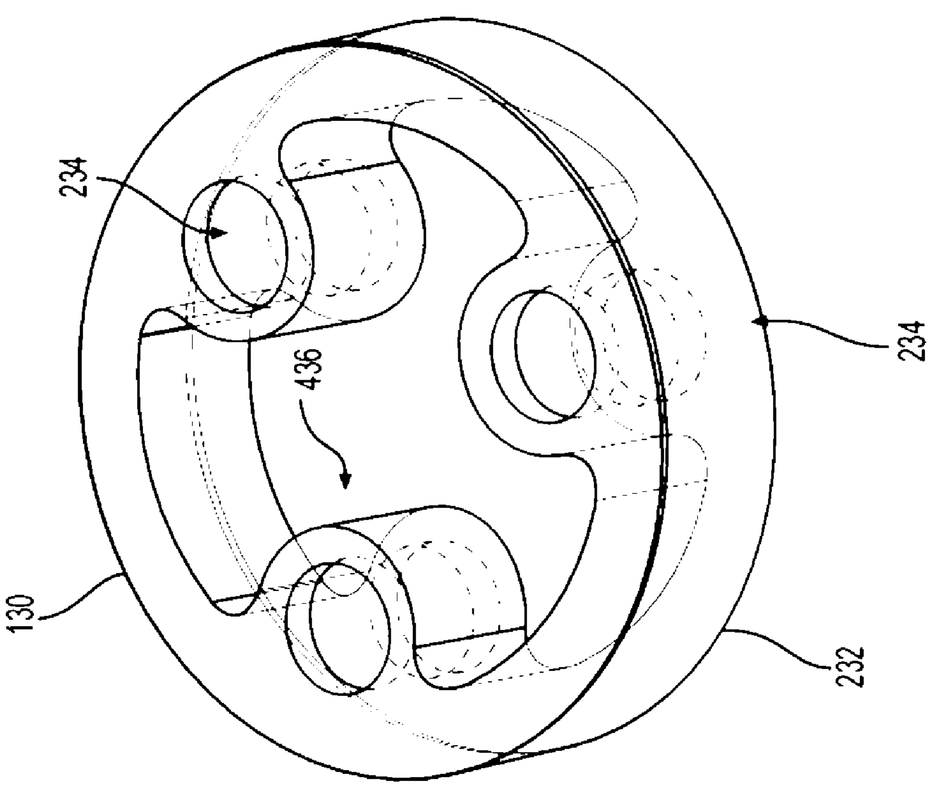
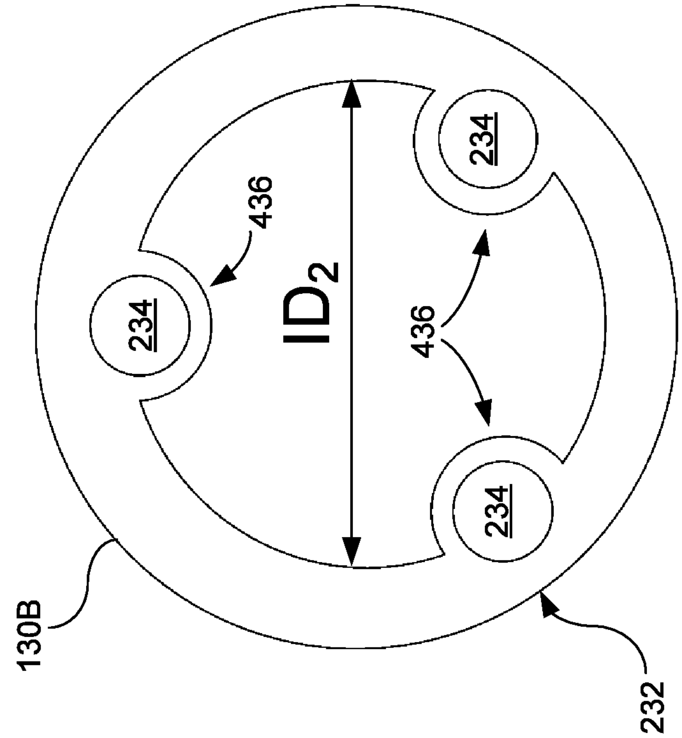
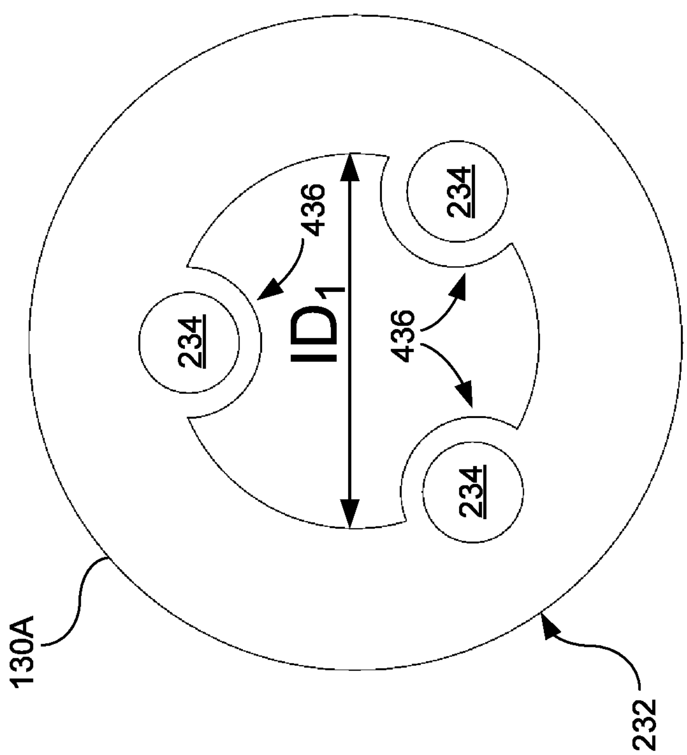


FIG. 4C



234
234
234
436
436
ID_2
130B
232

FIG. 5B



234
234
234
436
436
ID_1
130A
232

FIG. 5A

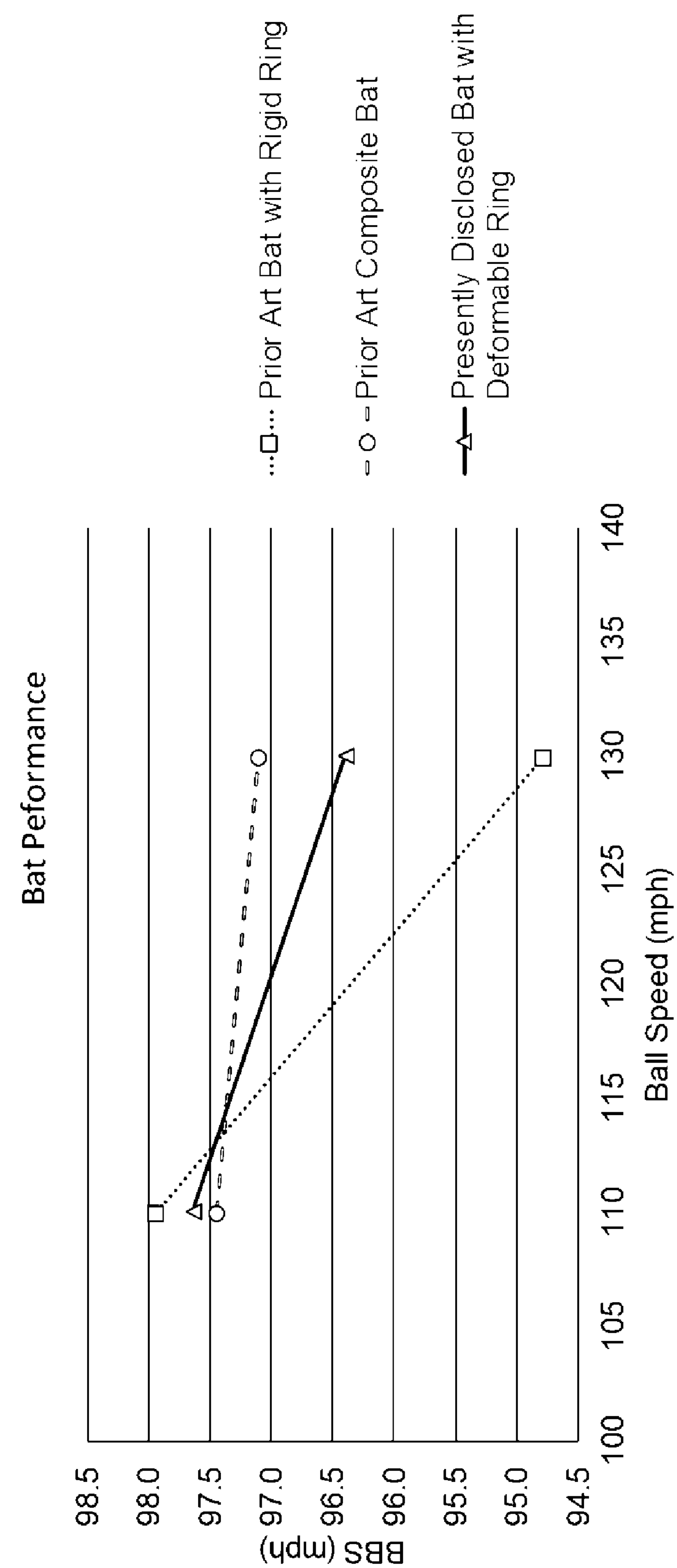
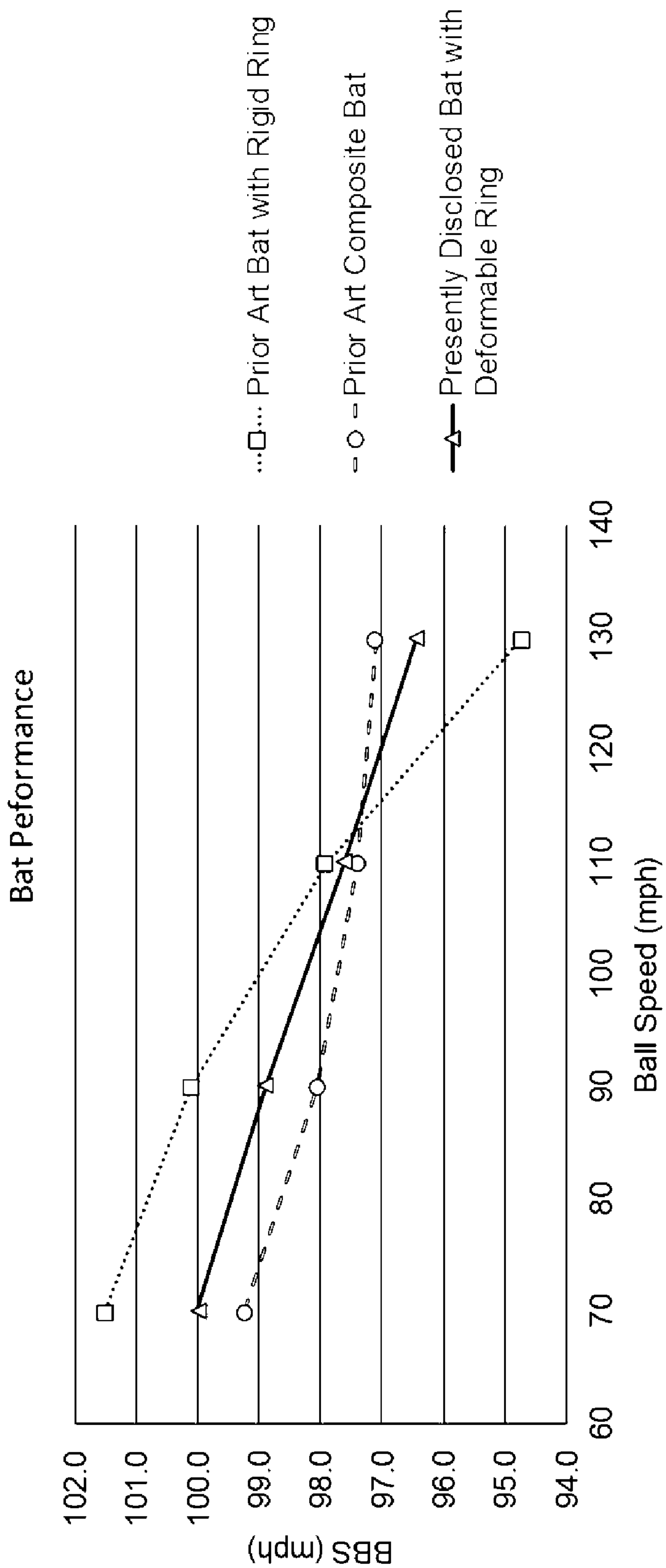

Bat Peformance
BBS (mph)
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
94.5
100
105
110
115
120
125
130
135
140
Ball Speed (mph)
Prior Art Bat with Rigid Ring
Prior Art Composite Bat
Presently Disclosed Bat with Deformable Ring

FIG. 6A



Bat Peformance
BBS (mph)
102.0
101.0
100.0
99.0
98.0
97.0
96.0
95.0
94.0
60
70
80
90
100
110
120
130
140
Ball Speed (mph)
Prior Art Bat with Rigid Ring
Prior Art Composite Bat
Presently Disclosed Bat with Deformable Ring

FIG. 6B

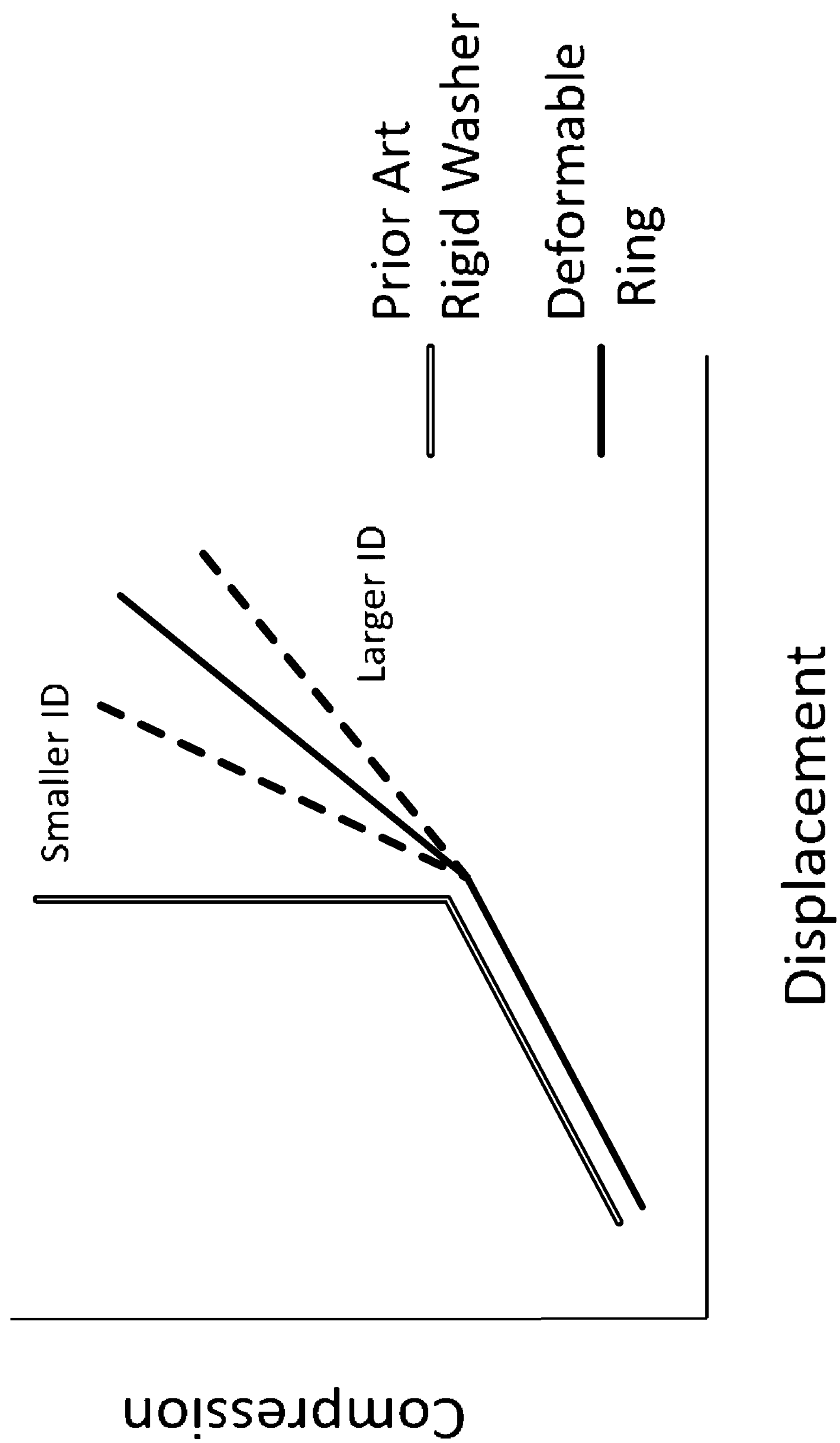

Prior Art Rigid Washer
Deformable Ring
Smaller ID
Larger ID
Displacement
Compression

FIG. 7

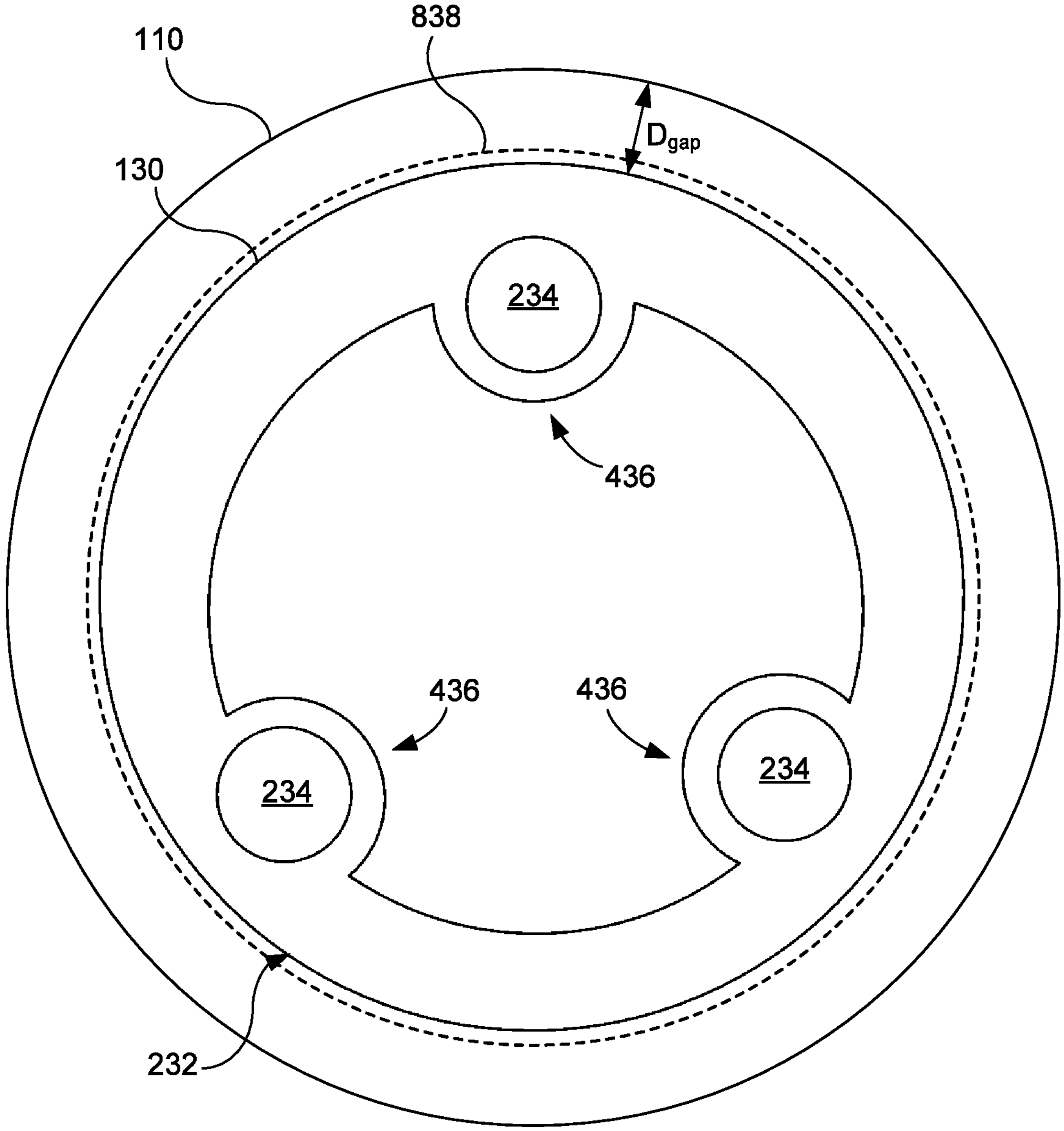
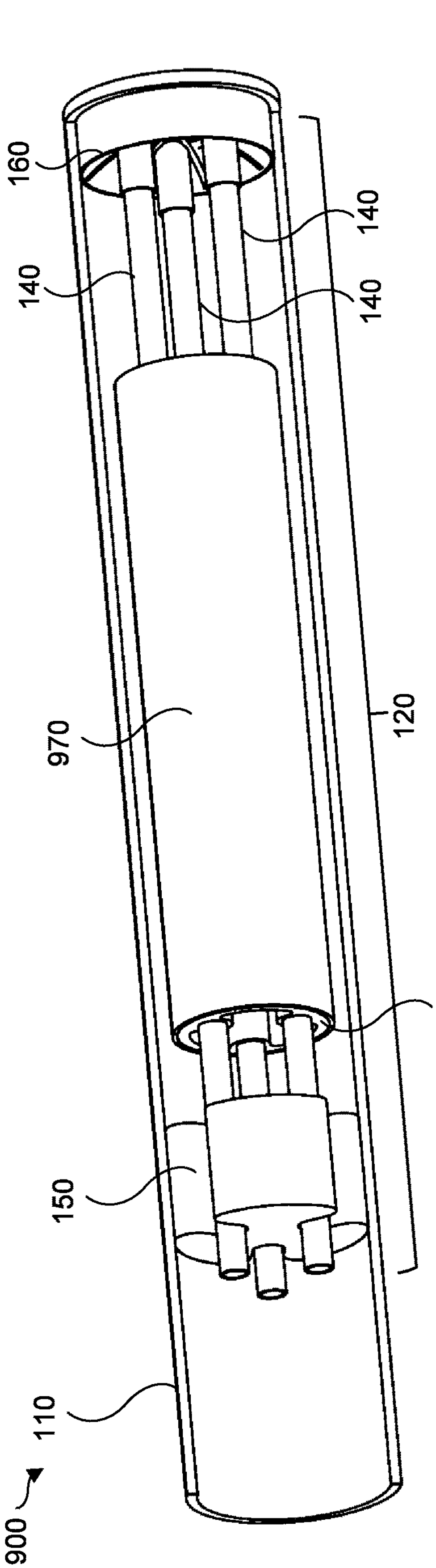


FIG. 8



160
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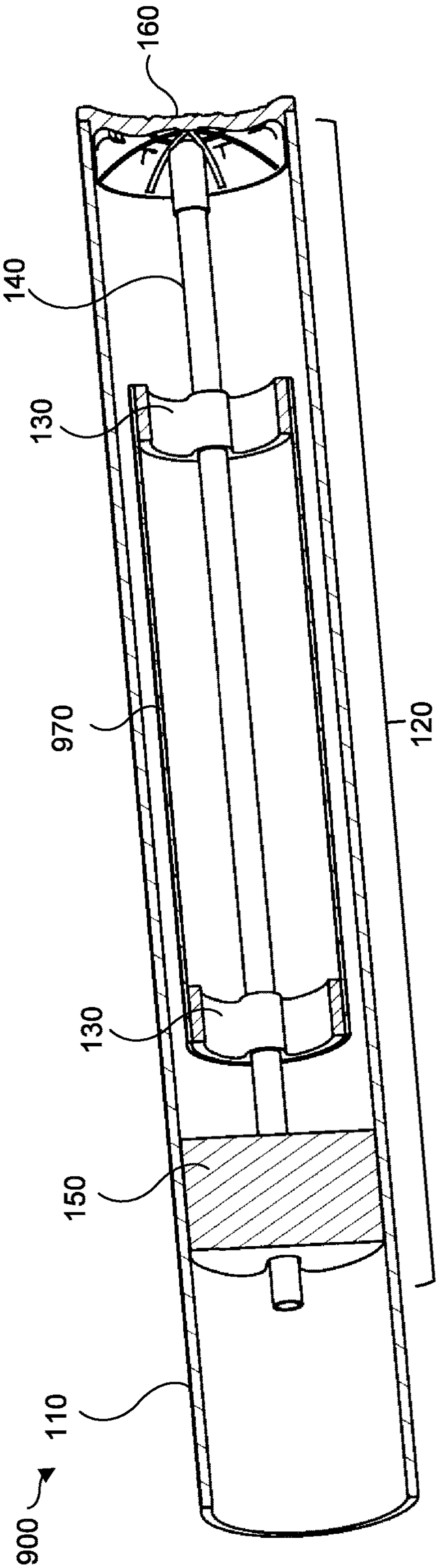
FIG. 9A



160
140
130
970
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130
150
110
900

FIG. 9B

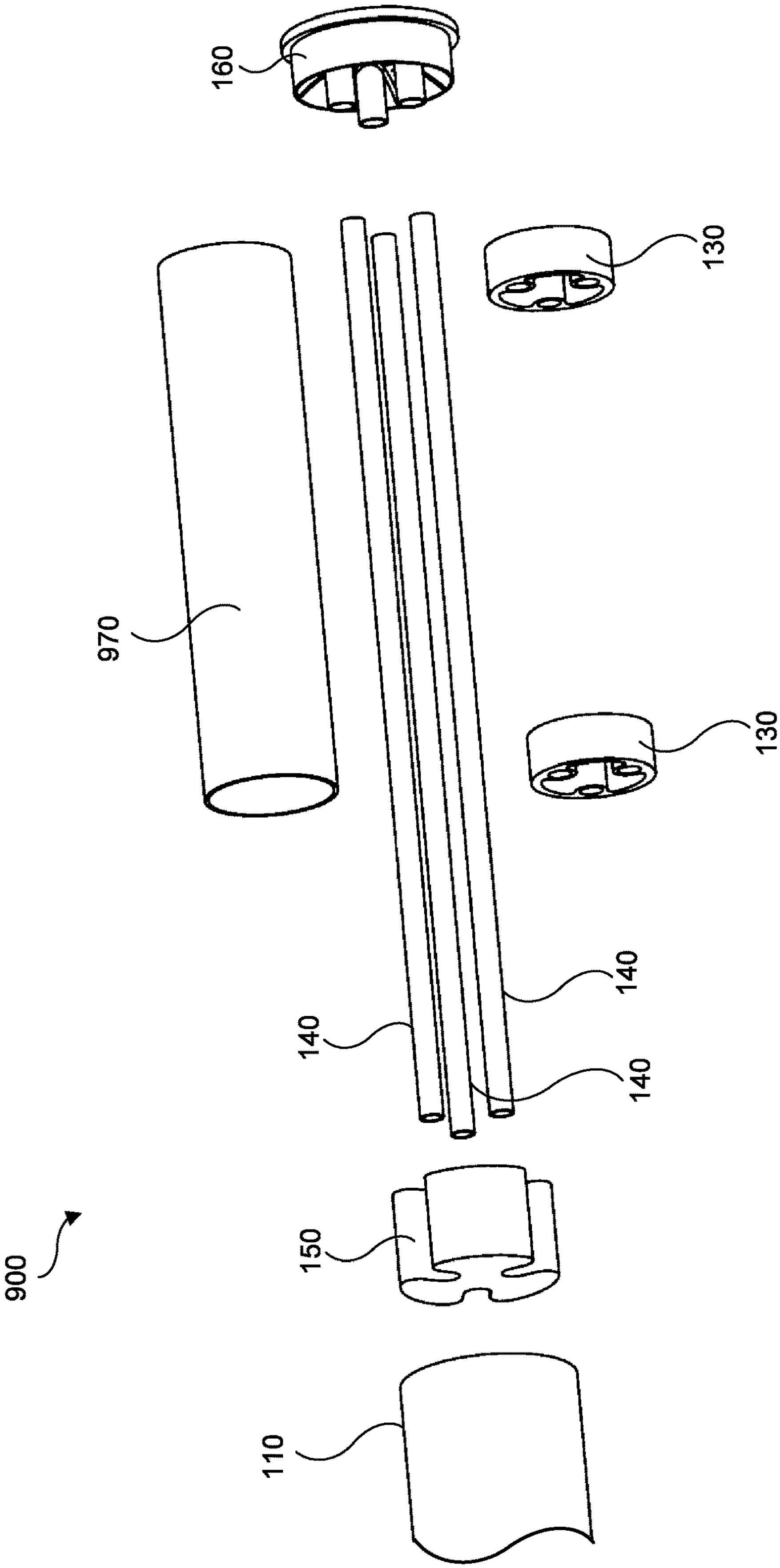

FIG. 10

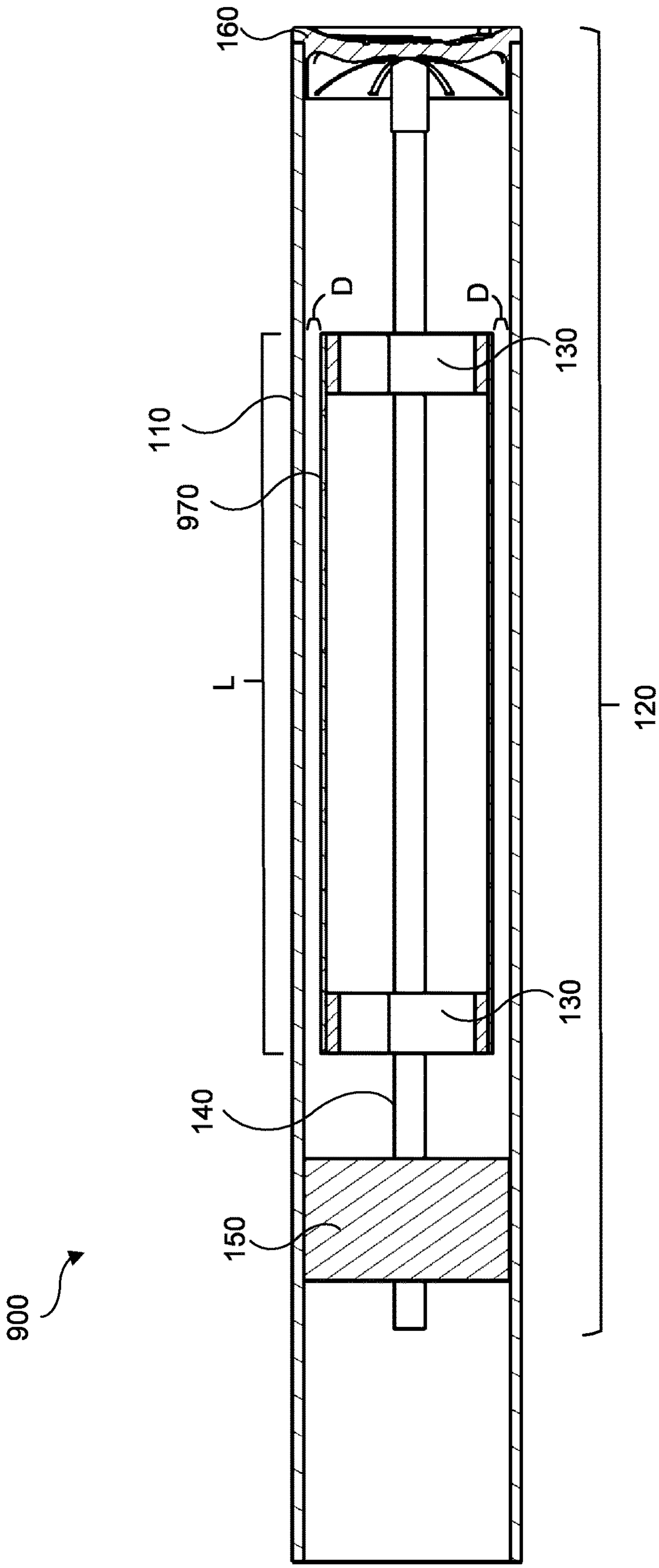

FIG. 11

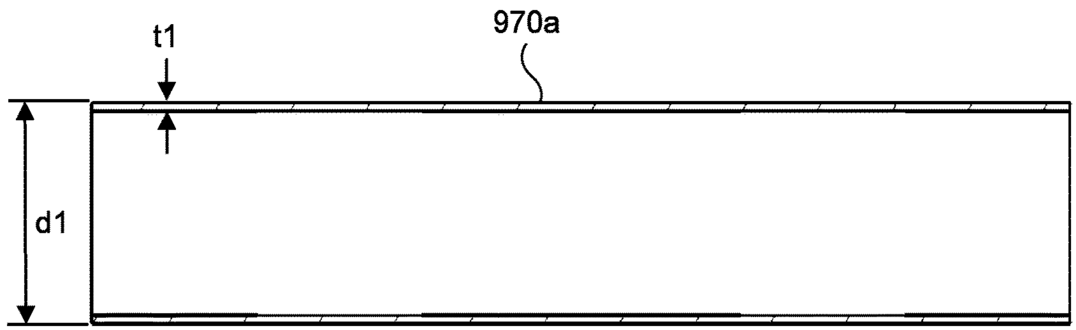

FIG. 12A

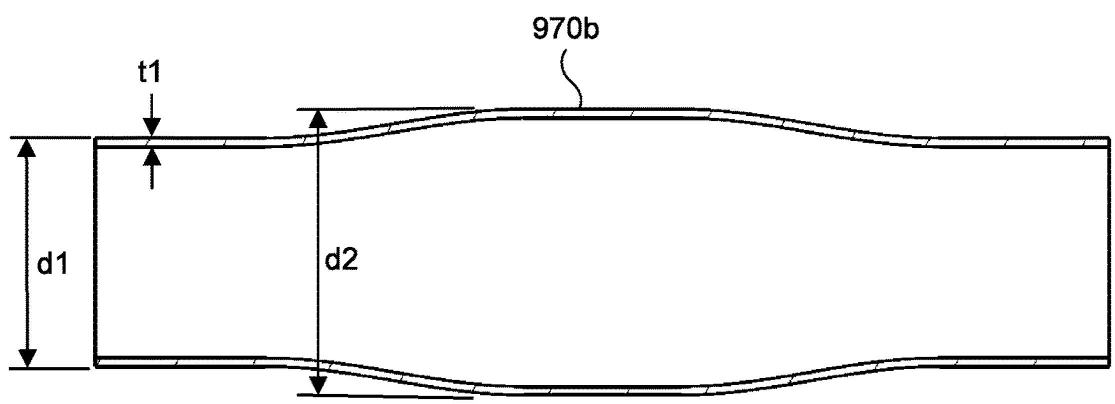

FIG. 12B

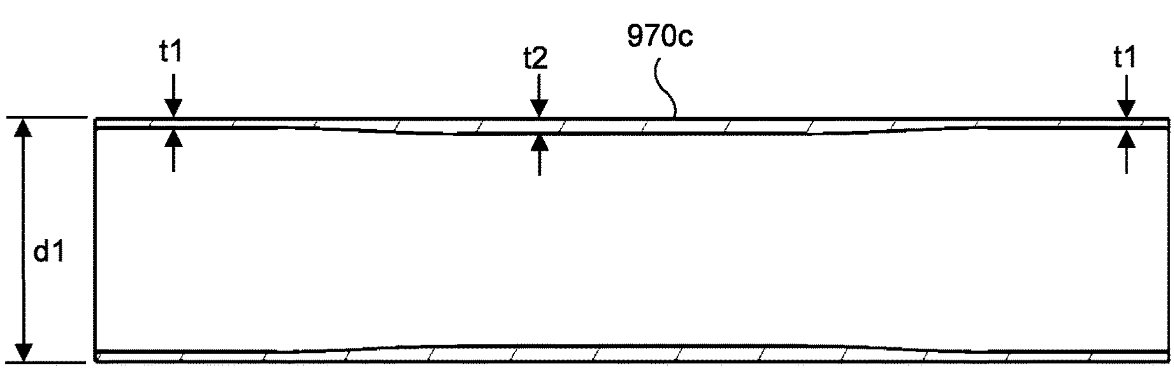

FIG. 12C

BAT SYSTEM WITH PERFORMANCE LIMITING STRUCTURE AND METHODS OF MAKING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 17/223,126, filed 6 Apr. 2021 (Now U.S. Pat. No. 11,524,215), which is a continuation-in-part of U.S. patent application Ser. No. 16/661,208, filed 23 Oct. 2019 (Now U.S. Pat. No. 10,967,235), which claims priority under 35 U.S.C. § 119 to U.S. Provisional Patent Application No. 62/749,759, filed on 24 Oct. 2018 and entitled "Bat System with Performance Limiting Structure and Methods of Making Same," the contents of which are hereby incorporated by reference in their entirety.

BACKGROUND

Generally, the performance of a bat is related to the efficiency with which the bat can impart force to a ball upon impact. Bat manufacturers often evaluate a bat's coefficient of restitution (COR) to measure its performance. Previously, bat manufacturers typically sought to improve the performance of bats to achieve an increased COR. Today, however, bat manufacturers are typically concerned with manufacturing bats that provide the greatest performance possible but without exceeding maximum performance metrics of various leagues and other organized forms of play.

Generally, increased deformation experienced by a bat upon impact with a ball corresponds to an increased COR of the bat. Some existing bat designs aim to prevent a bat from exceeding an imposed COR limit by limiting deformation of the bat upon impact of the bat with a ball. For example, U.S. Pat. No. 8,632,428 to Burger describes a bat that includes a central tube positioned coaxially within the barrel and one or more rigid, "washer-shaped" restriction members to limit the deformation of the bat upon impact with a ball. The washer-shaped restriction members have an outer diameter that is less than the inner diameter of the barrel, such that the barrel is able to deform until the inner wall of the barrel contacts the washer-shaped restriction members. By controlling the amount of possible deformation, it is thus possible to control the amount of deformation experienced by a bat at impact, and thus, limit the maximum COR provided by the bat.

While such a design may sufficiently limit the maximum COR provided by a bat, the bat's performance at lower impact forces may be unnecessarily reduced. That is, at lower forces (e.g., lower swing speed or lower ball speed), deformation of the bat does not need to be limited to prevent the bat from exceeding the maximum COR limit, but the high rigidity and incompressibility of a washer-shaped restriction member would likely prevent deformation of the bat's barrel even at lower forces such that performance of the bat at the lower forces is unnecessarily reduced. More particularly, such a bat may perform substantially differently within three ranges of ball speed. At low speed impacts (e.g., a low speed range), only the barrel may flex. At higher speeds (e.g., a medium speed range), a single side of the barrel (e.g., the portion of the barrel impacting the ball) may engage the washer-shaped restriction member, and at still higher speeds (e.g., a high speed range), two sides of the barrel (e.g., the portion of the barrel impacting the ball and the portion of the barrel directly opposite the impact location) may engage the washer-shaped restriction member. For

impacts in the high speed range, the incompressible nature of the washer-shaped restriction member may prevent flex of the washer-shaped restriction member and of the barrel system, as a whole, which can be detrimental to bat performance, particularly at high-force impacts (e.g., impacts with a ball in the high speed range).

What is needed, therefore, is a bat designed to maximize performance within a given set of guidelines at high impact forces while simultaneously maximizing absolute performance of the bat at lower impact forces. It is to such a bat that embodiments of the present invention are primarily directed.

SUMMARY

Embodiments of the present invention relate to a baseball or softball bat having a hollow barrel and one or more deformable rings suspending within the hollow barrel by a plurality of rods positioned longitudinally within the hollow barrel. Each of the plurality of rods can be offset from a central axis of the hollow barrel by a common radius, and the deformable ring can have a substantially circular outer wall that has a diameter less than an inner diameter of the hollow barrel. The deformable ring can also have a plurality of holes positioned equidistantly about a circumference corresponding to the common radius, with each hole at least partially receiving a rod of the three or more rods. Thus, the deformable ring can be positioned such that it is in coaxial alignment with the hollow barrel when the bat is at rest. Embodiments can also include an end cap that has holes extending partially therethrough, with each end cap hole at least partially receiving an end of a rod.

According the disclosed technology, a bat can include a hollow barrel and an internal assembly disposed within the hollow barrel. The internal assembly can comprise a plurality of rigid rods disposed longitudinally within the hollow barrel, an alignment insert, a deformable ring, and an end cap. The alignment insert can have an outer diameter approximately equal to an inner diameter of the hollow barrel and a plurality of through-holes that are each (i) axially extending through the alignment insert, (ii) offset from a central axis of the alignment insert by a common radius and positioned such that the plurality of through-holes is disposed equidistantly along a circumference corresponding to the common radius, and (iii) configured to receive a portion of a corresponding rigid rod. The deformable ring can comprise an outer wall having an outer diameter smaller than the inner diameter of the hollow barrel and a plurality of holes disposed equidistantly about the circumference corresponding to the common radius. Each hole of the deformable ring can be configured to at least partially receive a corresponding rigid rod. The end cap can be configured to insert into an end of the hollow barrel, and the end cap can have a plurality of recesses disposed equidistantly about the circumference corresponding to the common radius. Each recess can be configured to receive an end of a corresponding rigid rod. The end cap and the alignment insert can be configured to maintain the plurality of rigid rods in a predetermined configuration when the bat is at rest. The predetermined configuration can correspond to each of the plurality of rigid rods being parallel. The plurality of rigid rods can be configured to maintain the deformable ring in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, each point along the outer wall of the deformable ring is disposed a predetermined gap distance from an inner surface of the hollow barrel.

The hollow barrel can be configured to flex inwardly responsive to receiving force from an impact with an object such that the inner surface of the hollow barrel contacts the outer wall of the deformable ring.

The hollow barrel can be configured to transfer at least some of the force from the impact to the deformable ring. The deformable ring can be configured to at least partially deform from an original shape to a deformed shaped upon receiving at least some of the force from the impact, and the deformable ring can be configured to return from the deformed shape to the original shape.

The deformable ring can be configured to transfer a rebound force to the hollow barrel as the deformable ring returns from the deformed shape to the original shape.

The alignment insert can have a plurality of lobes.

The alignment insert can comprise EVA foam.

The bat can comprise a plurality of deformable rings.

The deformable ring can comprise aluminum.

The deformable ring can comprise a plurality of inner lobes. Each of the plurality of holes of the deformable ring can be at least partially disposed within a corresponding inner lobe of the plurality of inner lobes.

The deformable ring can comprise a hollow inner portion.

At least some of the plurality of rigid rods can comprise carbon.

At least some of the plurality of rigid rods can be hollow.

At least some of the plurality of rigid rods can be substantially solid.

The end cap can comprise a protrusion configured to at least partially insert into a notch of the hollow barrel. The notch can be disposed on an interior wall of the hollow barrel proximate a distal end of the hollow barrel. The protrusion and notch can be configured to interlock.

According to the disclosed technology, a method for manufacturing a bat can comprise providing a hollow barrel and assembling an internal assembly. Assembling the internal assembly can include inserting each of a plurality of rigid rods into a corresponding through-hole of a plurality of through-holes in an alignment insert having an outer diameter approximately equal to an inner diameter of the hollow barrel. Each of the plurality of through-holes can be axially extending through the alignment insert and can be offset from a central axis of the alignment insert by a common radius and positioned such that the plurality of through-holes is disposed equidistantly along a circumference corresponding to the common radius. Assembling the internal assembly can include inserting each of the plurality of rigid rods into a corresponding hole of a plurality of holes in a deformable ring comprising an outer wall that has an outer diameter smaller than the inner diameter of the hollow barrel. The plurality of holes can be disposed equidistantly about the circumference corresponding to the common radius. Assembling the internal assembly can include inserting an end of each of the plurality of rigid rods into a corresponding recess of a plurality of recesses in an end cap. The plurality of recesses in the end cap can be disposed equidistantly about the circumference corresponding to the common radius. Assembling the internal assembly can include inserting the end cap into an end of the hollow barrel.

Assembling the internal assembly can comprise positioning the plurality of rigid rods such that the plurality of rigid rods is in a predetermined configuration when the bat is at rest. The predetermined configuration can correspond to each of the plurality of rigid rods being parallel.

Assembling the internal assembly can comprise positioning the deformable ring in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, each point along the outer wall of the deformable ring is disposed a predetermined gap distance from an inner surface of the hollow barrel.

The disclosed technology can include a bat which has a hollow barrel and an internal assembly configured to resist deformation of the hollow barrel. The internal assembly can include a rod disposed longitudinally in the hollow barrel, a ring attached to the rod, a deformable sleeve disposed around the ring and extending longitudinally in the hollow barrel. The sleeve can include an outer diameter smaller than an inner diameter of the hollow barrel. The bat can include an end cap attached to an end of the hollow barrel and having a recess configured to receive an end of the rod. The rod can be configured to maintain the deformable sleeve in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, the sleeve is disposed a predetermined gap distance from an inner surface of the hollow barrel.

Responsive to receiving force from an impact with an object, the hollow barrel can be configured to flex inwardly such that the inner surface of the hollow barrel contacts the deformable sleeve.

The hollow barrel can be configured to transfer at least some of the force from the impact to the deformable sleeve. The deformable sleeve can be configured to at least partially deform from an original shape to a deformed shaped upon receiving the at least some of the force from the impact and return from the deformed shape to the original shape.

The deformable sleeve can be further configured to transfer a rebound force to the hollow barrel as the deformable sleeve returns from the deformed shape to the original shape.

The ring can be a deformable ring and the hollow barrel can be configured to transfer at least some of the force from the impact to the deformable ring. The deformable ring can be configured to at least partially deform from an original shape to a deformed shaped upon receiving the at least some of the force from the impact and return from the deformed shape to the original shape.

The ring can be a first ring and the internal assembly can further include a second ring. The second ring can be attached to the rod and spaced a distance from the first ring. The sleeve can extend between the first ring and the second ring.

The sleeve can include a first outer diameter proximate the first ring and proximate the second ring and a second outer diameter between the first ring and the second ring. The second outer diameter can be greater than the first outer diameter. The second outer diameter can be less than the first outer diameter. The sleeve can include a first thickness proximate the first ring and proximate the second ring and a second thickness between the first ring and the second ring. The second thickness can be greater than the first thickness. The second thickness can be less than the first thickness.

The sleeve can comprise a composite material.

The internal assembly can further comprise an alignment insert comprising an outer diameter approximately equal to the inner diameter of the hollow barrel and a lobe configured to receive a portion of the rod.

The bat can further include a plurality of rods. The ring can comprise a plurality of holes. Each hole of the plurality of holes can be configured to at least partially receive a respective rod of the plurality of rods.

The bat can have a central axis and the ring can have a central axis aligned with the central axis of the bat. The plurality of holes of the ring can be disposed equidistantly about a circumference corresponding to a radial distance from the central axis of the bat.

The end cap can further comprise a plurality of recesses configured to at least partially receive an end of a respective rod of the plurality of rods. The end cap can have a central axis aligned with the central axis of the bat and the plurality of recesses of the end cap can be disposed equidistantly about a circumference corresponding to a radial distance from the central axis of the bat.

The bat can further include an alignment insert comprising an outer diameter approximately equal to the inner diameter of the hollow barrel and a plurality of lobes. Each lobe can be configured to at least partially receive a respective rod of the plurality of rods. Each of the plurality of lobes of the alignment insert can be offset from a central axis of the alignment insert by a radial distance. The plurality of lobes of the alignment insert can be disposed equidistantly along a circumference corresponding to the radial distance.

The disclosed technology can include an internal assembly for a bat comprising a rod, a deformable ring attached to the rod, and a deformable sleeve disposed around the deformable ring and configured to extend longitudinally in a hollow barrel of the bat. The sleeve can have an outer diameter smaller than an inner diameter of the hollow barrel. The rod can be configured to maintain the deformable sleeve in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, the sleeve is disposed a predetermined gap distance from an inner surface of the hollow barrel.

The ring can be a first ring and the internal assembly can further comprise a second ring. The second ring can be attached to the rod and spaced a distance from the first ring. The sleeve can extend between the first ring and the second ring. The internal assembly can further comprise an alignment insert comprising an outer diameter approximately equal to an inner diameter of a hollow barrel of the bat and a lobe configured to at least partially receive a portion of the rod.

These and other objects, features and advantages of the present invention will become more apparent upon reading the following specification in conjunction with the accompanying drawing figures.

BRIEF DESCRIPTION OF THE FIGURES

Reference will now be made to the accompanying figures, which are not necessarily drawn to scale, and wherein:

FIG. **1** is an isometric view of a bat with the barrel depicted as transparent for clarity, according to some embodiments of the disclosed technology;

FIG. **2** is an exploded view of a bat, according to some embodiments of the disclosed technology;

FIG. **3** is a partial cross-sectional side view of a bat, according to some embodiments of the disclosed technology;

FIG. **4**A is an isometric view of a deformable ring, according to some embodiments of the disclosed technology;

FIG. **4**B is a wireframe drawing of the deformable ring depicted in FIG. **4**A, according to some embodiments of the disclosed technology;

FIG. **4**C is a wireframe drawing of a deformable ring, according to some embodiments of the disclosed technology;

FIG. **4**D is a wireframe drawing of a deformable ring, according to some embodiments of the disclosed technology;

FIG. **5**A is a cross-section of a deformable ring, according to some embodiments of the disclosed technology;

FIG. **5**B is a cross-section of a deformable ring, according to some embodiments of the disclosed technology;

FIG. **6**A is a graph illustrating performance of a bat incorporating an embodiment of the presently disclosed technology as compared to that of two prior art bats;

FIG. **6**B is a graph illustrating performance of a bat incorporating an embodiment of the presently disclosed technology as compared to that of two prior art bats;

FIG. **7** is a graph illustrating a comparison of the compression and displacement of a prior art rigid washer and a deformable ring, according to some embodiments of the disclosed technology;

FIG. **8** is a cross-section of a deformable ring within a hollow barrel, according to some embodiments of the disclosed technology;

FIG. **9**A is an isometric view of another bat with the barrel shown as a cutaway for clarity, according to some embodiments of the disclosed technology;

FIG. **9**B is an isometric view of the bat with the barrel and internal assembly shown as a cross-section for clarity, according to some embodiments of the disclosed technology;

FIG. **10** is an exploded view of a bat, according to some embodiments of the disclosed technology;

FIG. **11** is a cross-sectional side view of a bat, according to some embodiments of the disclosed technology; and

FIGS. **12**A-**12**C illustrate various cross-sectional views of a sleeve of a bat, according to some embodiments of the disclosed technology.

DETAILED DESCRIPTION

Throughout this disclosure, certain example embodiments are described in relation to bats including a plurality of rods and a deformable ring. Some embodiments of the disclosed technology will be described more fully hereinafter with reference to the accompanying drawings. This disclosed technology may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. The components described hereinafter as making up various elements of the disclosed technology are intended to be illustrative and not restrictive. Many suitable components that would perform the same or similar functions as components described herein are intended to be embraced within the scope of the disclosed electronic devices and methods. Such other components not described herein may include, but are not limited to, for example, components developed after development of the disclosed technology.

In the following description, numerous specific details are set forth. But it is to be understood that embodiments of the disclosed technology may be practiced without these specific details. In other instances, well-known methods, structures, and techniques have not been shown in detail in order not to obscure an understanding of this description. References to "one embodiment," "an embodiment," "example embodiment," "some embodiments," "certain embodiments," "various embodiments," etc., indicate that the embodiment(s) of the disclosed technology so described may include a particular feature, structure, or characteristic, but not every embodiment necessarily includes the particular feature, structure, or characteristic. Further, repeated use of the phrase "in one embodiment" does not necessarily refer to the same embodiment, although it may.

Throughout the specification and the claims, the following terms take at least the meanings explicitly associated herein, unless the context clearly dictates otherwise. The term “or” is intended to mean an inclusive “or.” Further, the terms “a,” “an,” and “the” are intended to mean one or more unless specified otherwise or clear from the context to be directed to a singular form.

Unless otherwise specified, the use of the ordinal adjectives “first,” “second,” “third,” etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described should be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

According to some embodiments, the disclosed technology relates to a bat, such as baseball bat or a softball bat. In some embodiments, the bat can include a hollow barrel and an internal assembly that is configured to resist deformation of the hollow barrel, especially deformation of the hollow barrel upon impact with a ball, for example. In certain embodiments, the internal assembly can be configured to resist, but not entirely prevent, deformation of the bat upon contact the hollow barrel’s inner wall with an outer edge or surface of the deformable ring. In certain embodiments, the internal assembly can include a deformable ring that is suspended within the hollow barrel by a plurality of rods that extend longitudinally within the hollow barrel.

FIG. **1** is an isometric view of a bat **100** according to some embodiments of the disclosed technology. The bat **100** can include a barrel **110**, which is depicted as transparent in FIG. **1** to clearly show the internal components of the bat **100**. In some embodiments, the bat **100** can include an internal assembly **120**, which can include one or more deformable rings **130** and a plurality or rods **140**. The deformable ring(s) **130** can be configured to limit (but not prevent) barrel flex at comparatively high impact forces while still allowing the barrel **110** to freely flex at comparatively low impact forces. In certain embodiments, a deformable ring **130** can be placed at a location along the length of the barrel **110** corresponding to the peak performance of the bat **100**, or the bat’s “sweet spot.” While some embodiments may include a single deformable ring **130**, other embodiments can include two, three, four, five, six, or more deformable rings **130**. Increasing the number of deformable rings **130** can provide a more constant control of deformation of the hollow barrel **110** upon impact with a ball, but increasing the number deformable rings **130** can also increase the overall weight of the bat **100**, which can negatively impact performance of the bat **100**. To provide uniformity of deformation about the exterior diameter of the bat **100**, some embodiments can include three or more rods **140**. For example, some embodiments can include three, four, five, six, or more rods **140**. Similar to the number of deformable rings **130** used, an increased number of rods **140** can provide increased positional securely of the deformable ring **130**, but increasing the number of rods **140** can increase the overall weight of the bat **100**, which may negatively impact the performance of the bat **100**. Accordingly, some embodiments can include as few as two rods **140**, which can reduce the overall weight of the bat **100**, but may do so at the cost of uniformity of deformation about the exterior diameter of the bat **100**. Some embodiments can also include an alignment insert **150**, which can provide limited or no effect on the deformation of the hollow barrel **110**. According to some embodiments, the rods **140** can be solid. In some embodiments, the rods **140** can be substantially hollow, such as is depicted in FIG. **2**. According to some embodiments, the rods **140** can comprise carbon tubes. In certain embodiments, the rods **140** can comprise metal, resin, carbon, glass fibers, or some mixture thereof. In some embodiments, each rod **140** can have a diameter in the range of approximately 1 mm to approximately 50 mm. For example, some embodiments can include rods **140** having a diameter in the range of approximately 5 mm to approximately 30 mm.

In some embodiments, the alignment insert **150** can have a shape that mirrors the interior shape of the hollow barrel **110**. For example, the alignment insert **150** can have a substantially cylindrical shape. Alternately, the alignment insert **150** can have a frustoconical shape. The alignment insert **150** can have an exterior diameter that is substantially equal to the interior diameter of the hollow barrel **110**. The alignment insert **150** can include a plurality of holes or lobes extending axially therethrough. Each hole of the alignment insert **150** can be positioned at a common radius from a center of the alignment insert **150**, and in certain embodiments, the holes can be positioned equidistantly about a circumference corresponding to this common radius. Each hole of the alignment insert **150** can be dimensioned to receive a corresponding rod **140**. The alignment insert **150** can include a plurality of axially extending slits, and each slit can align with a corresponding hole of the alignment insert **150**. Thus, each hole of the alignment insert **150** can be configured to receive a rod **140** through the slit such that each rod **140** is passed through a slit and into a corresponding hole in a radially inward direction.

The alignment insert **150** can have other shapes. For example, the alignment insert **150** can have a plurality of lobes formed between adjacent niches, such as is shown in FIG. **1**. Each niche can correspond to a rod **140** of the internal assembly **120**, and each niche can be configured to receive at least a portion of the corresponding rod **140**. Regardless of the shape, in some embodiments, the alignment insert **150** can be configured to substantially maintain the rods **140** in a predetermined alignment and/or position. In addition, the alignment insert **150** can also provide subjective benefits regarding the sound of the bat **100** striking a ball (i.e., the ball-striking sound of a bat **100** with an alignment insert **150** can be more pleasing to a general audience than the ball-striking sound of a bat **100** without an alignment insert **150**). In some embodiments, the alignment insert **150** can comprise a light yet sturdy material. In some embodiments, the alignment insert **150** can comprise a polymer, copolymer, and/or foam, such as EVA foam. The alignment insert **150** can include a central hole (e.g., as shown in FIG. **1**), which can reduce the weight of the alignment insert **150** (and thus the overall weight of the bat **100**). The central hole can be dimensioned such that weight is reduced without negatively impacting the necessary rigidity of the alignment insert **150** that is required to maintain the rods **140** in alignment with other components of the internal assembly **120** and/or other components of the bat **100**. Certain embodiments can exclude the alignment insert **150**. In some embodiments, the bat **100** can include an end cap **160**. As discussed more fully below, in some embodiments, the end cap **160** can be configured to fit securely into a distal end of the barrel **110** and can be configured to receive an end of each of a plurality of rods **140** and maintain the end of each rod **140** in a predetermined alignment and/or position.

Referring to FIG. **2**, the deformable ring **130** can include a circular outer wall **232** and a plurality of holes **234**, where each hole **234** is configured to at least partially receive a rod **140**. In some embodiments, the circular outer wall **232** has an outer diameter that is less than an inner diameter of the hollow barrel **110** such that, upon impact of the hollow barrel **110** with a ball, the hollow barrel **110** is permitted to deform a predetermined amount or a predetermined distance before contacting the circular outer wall **232** of the deformable ring **130**. According to some embodiments, the deformable ring **130** is configured to at least partially deform upon receiving force from the impact of the hollow barrel **110** with a ball via contact of the hollow barrel **110** with the circular outer wall **232** of the deformable ring **130**. In some embodiments, the deformable ring **130** can be configured to return to its original shape subsequent to deforming.

According to certain embodiments, the deformable ring **130** can include one or more holes **234** that extend entirely through the deformable ring **130**. Each hole **234** can be located in a corresponding inner lobe **436** of the deformable ring **130** (e.g., as shown in FIGS. **4A-4D**). In some embodiments, each hole **234** of the deformable ring **130** can be positioned at a common radius from a center of the deformable ring **130**, and in certain embodiments, the holes **234** can be positioned equidistantly about a circumference corresponding to this common radius. The positions of the holes **234** of the deformable ring **130** can correspond to, and align with, the holes of the alignment insert **150**. It should be understood that the circumference corresponding to the common radius does not necessarily correspond to a circumference of the circular outer wall **232**. In some embodiments, when the holes **234** receive the rods **140**, the deformable ring **130** can be positioned such that it is suspended within the hollow barrel, and in coaxial alignment with the hollow barrel **110**, when the bat **100** is at rest (e.g., when the bat **100** is not striking a ball). As will be discussed more fully below, because the outer diameter of the deformable ring **130** (i.e., the diameter of the circular outer wall **232**) can be less than the internal diameter of the portion of the hollow barrel **110** adjacent to the deformable ring **130**, a gap can be formed between the deformable ring **130** and the hollow barrel **110**.

In some embodiments, the end cap **160** can include a number of holes **262** that extend partially into the end cap **160**. In some embodiments, each hole **262** can correspond to a rod **140**. As shown in FIGS. **2** and **3**, in some embodiments, the end cap **160** can include multiple protrusions extending from an inner surface of the end cap **160** with each protrusion including a partial hole **262**. This can permit the end cap **160** to comprise a relatively lower amount of material, which can decrease the overall weight of the bat **100**.

Similar to the holes **234** of the deformable ring **130**, in some embodiments, each hole **262** of the end cap **160** can be positioned at a common radius from a center of the end cap **160**, and in certain embodiments, the holes **234** can be positioned equidistantly about a circumference corresponding to this common radius. In certain embodiments, the common radius with respect to the deformable ring **130** can be substantially equal to the common radius with respect to the end cap **160** and/or the holes **234** of the deformable ring **130** such that each rod **140** is substantially parallel to one another. In some embodiments, the common radius with respect to the deformable ring **130** can be smaller than the common radius with respect to the end cap **160** such that each rod **140** increasingly extends radially outward as the rod **140** extends longitudinally from the deformable ring **130** toward the end cap **160**; in some embodiments, this configuration can provide rods **140** that are substantially parallel to an outer wall of the hollow barrel **110** if the hollow barrel **110** increases in outer diameter from a proximate end to a distal end, but it should be understood that such a configuration of the rods **140** is not limited to embodiments in which the diameter of the hollow barrel **110** changes.

In certain embodiments, the end cap **160** can also include a protrusion **264**, which can correspond to a notch **212** located proximate the distal end of the hollow barrel **110**. In some embodiments, the end cap **160** can be permanently attached to the hollow barrel **110**. In certain embodiments, the end cap can be attached to the hollow barrel with an adhesive, such as a glue or epoxy. In certain embodiments, the end cap **160** can be detachably attachable to the hollow barrel **110**. Embodiments including a detachably attachable end cap **160** can permit multiple internal assemblies **120** and end caps **160** to be inserted into a single hollow barrel **110**, which can enable a single bat **100** to be used in multiple leagues governed by rules requiring differing maximum performance metrics of bats. Thus, it should be appreciated that various components of the internal assembly **120**, the end cap **160**, and/or any combination thereof are herein contemplated as being provided separately from all other structures discussed herein. For example, it is contemplated that various embodiments of the deformable ring **130** can be provided separately from all other components discussed herein.

As shown throughout the figures, the designs disclosed herein utilize multiple rods **140** as opposed to a single tube or rod (e.g., located along the central axis of the barrel **110**). Such designs can permit the deformable ring **130** to be more evenly displaced within the barrel **110** (i.e., translational movement of the deformable ring **130** within the barrel **110**) at impact. Such even displacement of the deformable ring **130** can facilitate decreased performance restriction (e.g., as opposed to a rigid washer design) for all but the high-speed impacts (e.g., impacts at a sufficient force to cause the barrel **110** to flex inward at the impact location such that the interior wall of the barrel **110** near the impact location contacts the deformable ring **130** and causes the deformable ring **130** to contact the interior wall of the barrel **110** opposite the impact location). Thus, such designs can limit the flex of the barrel **110** (and COR of the bat **100**) at high-speed impacts, while permitting free flexing of the barrel **110** at lower speeds and thus maximizing performance of the bat **100** at lower speeds.

FIGS. **4A** and **4B** more clearly depict the deformable ring **130** according to some embodiments, along with the circular outer wall **232** and holes **234**. In some embodiments, one or more of the holes **234** can extend only partially into the deformable ring **130** such that only an end of a rod can extend into the hole **234**. Some embodiments can include a combination of complete (i.e., formed fully through the deformable ring **130**) and partial (i.e., formed only partially through the deformable ring **130**) holes **234**. Referring to FIGS. **4C** and **4D**, in certain embodiments, the deformable ring can include one or more holes **234** that extends partially into a first side (e.g., a top side) of the deformable ring **130** and can include one or more holes **234** that extends partially into a second side (e.g., a bottom side) of the deformable ring **130** such that an end of a first rod **140** can be inserted into the first side of the deformable ring **130** and an end of a second rod **140** can be inserted into the second side of the deformable ring **130**. In some embodiments, a given pair of rods **140** on opposite sides of the deformable ring **130** (e.g., the first rod **140** inserted into the first side of the deformable ring **130** and the second rod **140** inserted into the second side of the deformable ring **130**) can be axially aligned with respect to one another, such as shown in FIG. **4C**. In certain embodiments, one or more of the rods **140** on opposite sides of the deformable ring **130** can be axially offset with respect to one another, such as shown in FIG. **4D**.

Referring to FIGS. **5A** and **5B**, in some embodiments, a plurality of deformable rings **130** can be provided, and according to some embodiments, the outer diameter of each deformable ring **130** is the same. Thus, each of the plurality of deformable rings **130** can be used with the same hollow barrel **110**. In some embodiments, the diameters of the holes **234** can be different from deformable ring **130** such that rods **140** of differing diameters can be used, which can influence the deformability of the deformable ring **130**. In certain embodiments, the diameters of the holes **234** can be the same among all deformable rings **130** such that the same rods **140** can be used for all deformable rings **130**. In some embodiments, the inner diameter of the deformable rings **130** can be adjusted to provide differing rigidities and thus differing deformability of the hollow barrel **110**, ultimately resulting in differing performance characteristics of the bat **100**. For example, FIG. **5**A depicts a deformable ring **130**A having an outer diameter and an inner diameter ID', and FIG. **5**B depicts a deformable ring **130**B having the same outer diameter as deformable ring **130**A and having an inner diameter ID_2, which is greater than the inner diameter Di of deformable ring **130**A. Because deformable rings **130**A and **130**B have the same outer diameter and because deformable ring **130**A has an inner diameter Di less than the inner diameter ID_2 of deformable ring **130**B, deformable ring **130**A has a greater wall thickness than that of deformable ring **130**B. Accordingly, deformable ring **130**A is more rigid, and thus less deformable, than deformable ring **130**B.

In some embodiments, the deformable ring **130** can have a thickness (e.g., height) in the range of approximately 1 mm (approximately 0.04 inch) to approximately 50 mm (approximately 2 inches). For example, in some embodiments, the deformable ring **130** can have a thickness (e.g., height) in the range of approximately 1 mm (approximately 0.04 inch) to approximately 20 mm (approximately 0.8 inch). In certain embodiments, the deformable ring **130** can have a radial thickness (e.g., the smallest thickness of a sidewall of the deformable ring) in the range of approximately 1 mm (approximately 0.04 inch) to approximately 50 mm (approximately 2 inches). For example, in some embodiments, the deformable ring **130** can have a radial thickness in the range of approximately 5 mm (approximately 0.2 inch) to approximately 30 mm (approximately 1.2 inches). In some embodiments, the deformable ring can comprise one or more metals (e.g., aluminum), resin, one or more composite materials, one or more plastics (e.g., nylon), any combination thereof, or any other appropriate material(s).

FIGS. **6**A and **6**B are graphs depicting the performance of three types of bats: a prior art bat having a rigid, washer-shaped ring, a prior art composite bat lacking any sort of internal ring structure, and a bat comprising the presently disclosed technology. As can be seen, the presently disclosed bat provides a batted ball speed that is higher than the normal composite bat and nearly as high as the bat including the washer-shaped ring at lower speeds and provides a batted ball speed that is higher than the bat including the washer-shaped ring and nearly as high as the normal composite bat at medium speeds. And at higher speeds, the presently disclosed bat provides a batted ball speed that is much higher than the bat including the washer-shaped ring. Thus, the presently disclosed can increase bat performance at a target force (e.g., to conform with controlling rules and regulations) while maintaining a high level of performance at forces beyond the target force. The increased overall performance of bats using a deformable ring **130** can be at least partly attributable to the unique balance of compression and displacement afforded by the disclosed technology. Referring to FIG. **7**, a rigid washer of a prior art bat can be displaced within the bat as the bat barrel is compressed only until the rigid washer is in contact with both the impact side and opposite side of the barrel, at which time no further displacement is possible. In contrast, the deformable ring **130** of the disclosed technology can displace similarly but is also able to deform after contacting both the impact side and opposite side of the barrel. As can also be seen from FIG. **7**, the degree of compression of the deformable ring **130** can be altered based on the inner diameter of the deformable ring **130** (assuming a constant outer diameter). Stated otherwise, the thickness of the deformable ring's **130** outer wall can affect the degree of compression of the deformable ring **130**.

As shown in FIG. **8**, the deformable ring **130** can be suspended within the hollow barrel **110** such that a gap is formed between the circular outer wall **232** of the deformable ring **130** and the interior surface of the hollow barrel **110**. The magnitude of this gap (i.e., distance D_{gap}) can be altered to achieve a predetermined performance at various batted ball speeds. As will be appreciated, the outer surface of the deformable ring **130** and/or the inner surface of the barrel **110** may not be perfectly circular due to manufacturing limitations or other reasons. Thus, the gap distance D_{gap} can refer to an average gap distance D_{gap} between the outer surface of the deformable ring **130** and the inner surface of the barrel **110**.

Optionally, a compressible material **838** can be attached or affixed to the outer wall **232** of the deformable ring **130**. The compressible material **838** can help to reduce or eliminate vibrations that can cause an undesirable sound (e.g., a rattling sound) that may occur when the deformable ring **130** contacts the inner surface of the barrel **110**. The compressible material **838** can be or include a fabric (e.g., felt), a foam (e.g., a low-density polyurethane foam), or any other compressible material. As will be appreciated, the compressible material **838** can be highly compressible such that it can dampen, reduce, and/or remove audible rattling without inhibiting the benefits of the deformable ring **130** as described herein. The compressible material **838** can be attached or affixed to the outer wall **232** of the deformable ring **130** via adhesive (e.g., glue, epoxy, tape) or any type of attachment device. As a non-limiting example, the compressible material **838** can be a tape (e.g., a felt tape, a foam tape) and can be adhered to the outer wall **232** of the deformable ring **130**. Alternatively or in addition, a compressible material **838** can be attached or affixed to the inner surface of the barrel **110**. The compressible material **838** can have a thickness that is less than the gap distance D_{gap} such that a gap exists between the compressible material **838** and the inner surface of the barrel **110** (if the compressible material **838** is attached to the outer wall **232** of the deformable ring **130**) or between the compressible material **838** and the outer wall **232** of the deformable ring **130** (if the compressible material **838** is attached to the inner surface of the barrel **110**). Alternatively, the compressible material **838** can have a thickness that is approximately equal to the gap distance D_{gap}. Further, while the compressible material **838** has heretofore been described as being attached to the outer wall **232** of the deformable ring **130** and/or the inner surface of the barrel **110**, it is contemplated that the compressible material **838** can be simply disposed between the deformable ring **130** and the barrel **110**. For example, the compressible material **838** can have a thickness that approximately equal to or greater than (e.g., slightly greater than) the gap distance D_{gap} such that the compressible material can be retained between the deformable ring **130** and the barrel **110** via friction forces and/or slight compression of the compressible material **838**. Regardless of its positioning, the compressible material **838** can be positioned such that it prevents direct contact between the deformable ring **130** and the barrel **110**.

Table 1 below refers to data resulting from experiments conducted using examples of the disclosed technology, including two samples having rings of differing wall thickness and the same outer diameter (i.e., having differing inner diameters) and three samples having different outer diameters. Each sample was tested with the same hollow barrel **110**, such that the difference between the inner diameter of the hollow barrel **110** and the outer diameter of each sample deformable ring **130** results in a corresponding gap distance D_{gap}. The barrel **110** used in testing these samples had an inner diameter of approximately 50 mm (approximately 2 inches). Thus, as an example, the gap distance D_{gap} for Sample A, which included a ring **130** having an outer diameter of 36 mm (approximately 1.4 inches), was approximately 7 mm (approximately 0.28 inches) (i.e., (50 mm outer diameter of barrel **110**—36 mm outer diameter of deformable ring **130**)÷2=7 mm D_{gap} for Sample A). The force values of Table 1 refer how much force was required to compress the barrel **110** of each sample a constant, predetermined amount. For the purposes of these experiments, the predetermined displacement resulting from the compression of the barrel **110** was 0.050±0.001 inch (1.3±0.025 mm). Ring wall thickness refers to the difference between the deformable ring's **130** outer diameter and largest inner diameter (see, e.g., FIGS. **5**A and **5**B), ring height refers to the height of thickness of each deformable ring **130**, and ring location refers to the position of each deformable ring **130** with respect to the cap end of the barrel of the bat (i.e., each of the samples was located at a position 7 inches from the cap end of the barrel **110**). Each sample was tested using a robotic batter at a low speed, a medium speed, and a high speed.

TABLE 1

Sample	Force (lbf)	Ring Outer Diameter (mm)	Ring Wall Thickness (mm)	Ring Height (mm)	Ring Location (in)
A	255	36	4.0	10.0	7.0
B	251	40	4.5	10.0	7.0
C	249	44	5.0	10.0	7.0
D	250	40	3.0	10.0	7.0

Table 2 below shows the batted ball speed resulting from impacts of some of the above sample bats with balls traveling at three different speeds prior to impact: low speed (55 km/h (approximately 34 mph)), medium speed (80 km/h (approximately 50 mph)), and high speed (125 km/h (approximately 78 mph)). To determine the batted ball speed in this data, a swing robot was used for testing (not a bat cannon), and the exit velocity of ball was then measured. As can be seen from the data, there is little difference between the performances of Samples A, B, and C at the low and medium speeds. At the high speed, however, the biggest gap resulted in the best performance. This could be because contact between the barrel **110** and the deformable ring **130** is comparatively delayed, thus permitting the barrel **110** to flex farther and also spring back farther.

TABLE 2

Sample	55 km/h	80 km/h	125 km/h
A	49.9	74.2	119.6
B	49.9	74.1	118.1
C	50.1	74.0	118.1

Table 3 below shows the batted ball speed resulting from impacts of some of the above sample bats with balls traveling at three different speeds prior to impact: low speed (55 km/h (approximately 34 mph)), medium speed (80 km/h (approximately 50 mph)), and high speed (105 km/h (approximately 65 mph)). As above, the batted ball speed in this data was determined during testing using a swing robot (not a bat cannon) and measuring the exit velocity of ball. Here, the data seems to indicate that a less stiff deformable ring **130** (e.g., having a thinner wall) provides comparatively increased performance.

TABLE 3

Sample	55 km/h	80 km/h	125 km/h
B	49.9	74.1	97.6
D	50.7	74.3	99.2

Turning now to FIGS. **9**A-**12**C another example of the bat is shown. FIG. **9**A is an isometric view of another bat **900** with the barrel **110** shown as a cutaway for clarity while FIG. **9**B is an isometric view of the bat **900** with the barrel **110** and internal assembly **120** shown as a cross-section for clarity, according to some embodiments of the disclosed technology. The bat **900** can include all of the same features of the bat **100** previously described herein. For example, as shown in FIGS. **9**A-**10**, the bat **900** can include a barrel **110**, an internal structure **120**, and an end cap **160**. The internal structure **120** can include one or more deformable rings **130**, one or more rods **140**, an alignment insert **150**, and a deformable sleeve **970** as shown. Except for the deformable sleeve **970**, the features of each of these components just named can include the same features, functions, properties, etc. previously described above.

As shown in FIGS. **9**A and **9**B, the deformable sleeve **970** can be disposed around the deformable rings **130** and suspended in the barrel **110** via the rods **140**. In some examples, the deformable sleeve **970** can extend between one or more deformable rings **130** and either be attached to the deformable rings **130**, frictionally engaged with the deformable rings **130**, or be detached to the deformable rings **130**.

The deformable sleeve **970** can be configured to deform when a force is applied to it. For example, when the bat **900** is used to hit a ball and the barrel **110** flexes as a result of the impact, the barrel **110** can flex inwardly until it contacts the deformable sleeve **970** and the deformable sleeve **970** can deform as a result of the force. As will be appreciated, the deformable sleeve **970** can be resilient or otherwise spring back into shape thereby transferring some of the energy back to the barrel **110** and subsequently the ball. In this way, the deformable sleeve **970** can act similar to the deformable rings **130**. As will be appreciated, however, rather than being positioned in discrete locations as are the deformable rings **130**, the deformable sleeve **970** can be configured to extend between deformable rings **130** along a greater portion of the barrel **110**. As such, the deformable sleeve **970** can extend a greater distance than the deformable rings **130** alone, thereby increasing the size of the sweet spot on the bat **900** without significantly increasing the weight of the bat **900**.

Because the bat **900** includes a deformable sleeve **970**, the deformable rings **130** can be made from the same flexible materials previously described or be made from more rigid materials. If the deformable rings **130** are made from a flexible material, both the deformable rings **130** and the deformable sleeve **970** can be configured to transfer energy back to the barrel **110** after being compressed by the force applied by contacting a ball.

The deformable sleeve **970** can be made from resilient material including, but not limited to, aluminum, polymers, glass fiber composites, carbon fiber composites, etc. In some examples, the deformable sleeve **970** can be made from carbon fiber composites and/or glass fiber composites having various layup orientations. For example, various layers of the carbon fiber composites and/or glass fiber composites can be layered with the fibers generally being oriented in 0°, 30°, 45°, 60°, and/or 90° angles in relation to a longitudinal direction of the deformable sleeve **970**. As will be appreciated, the number of layers, order of layers, size of fibers, orientation of layers, resin material, etc. will affect the ability of the deformable sleeve **970** to deflect and the force required to deflect the deformable sleeve **970**.

As shown in FIG. **11**, the deformable sleeve **970** can be extend a length L of the barrel **110**. The length L can range between the entire length of the barrel **110** or only a few inches depending on the configuration. In some examples, the sleeve **970** can be configured to extend a length L that is substantially in an area of the bat **900** where a batter is most likely to hit the ball. For example, the sleeve **970** can be disposed in the barrel **110** approximately 3 to 10 inches from the end of the end cap **160** and extend the length of a preferred striking area of the bat **900**. In other examples, the sleeve **970** can be disposed in the barrel **110** approximately 5 to 9 inches from the end cap **160**.

As shown in FIG. **11**, the deformable sleeve **970** can be suspended in the barrel **110** such that a gap having a distance D can be between an outer surface of the deformable sleeve **970** and an inner surface of the barrel **110**. As before, the magnitude of this gap (i.e., distance D) can be altered to achieve a predetermined performance at various batted ball speeds. As will be appreciated, the outer surface of the deformable sleeve **970** and/or the inner surface of the barrel **110** may not be perfectly circular due to manufacturing limitations or other reasons. Thus, the gap distance D can refer to an average gap distance D between the outer surface of the deformable ring **130** and the inner surface of the barrel **110**. The distance D of the gap, for example, can be approximately 0.2 mm (0.00787 inches) to approximately 10 mm (0.394 inches).

FIGS. **12A**-**12C** illustrate various cross-sectional views of a deformable sleeve **970** of the bat **900**, according to some embodiments of the disclosed technology. As shown in FIG. **12A**, the deformable sleeve **970** can have a constant wall thickness t and a constant outer diameter d1 along the length of the deformable sleeve **970**. In other examples, the wall thickness t and the outer diameter d1 can be varied as shown in FIGS. **12B** and **12C**. For example, as shown in FIG. **12B**, the deformable sleeve **970** can have a first outer diameter d1 and a second outer diameter d2 that is greater than the first outer diameter d1. As will be appreciated, increasing the outer diameter of the deformable sleeve **970** means that the barrel **110** of the bat **900** is more likely to contact the portion of the deformable sleeve **970** at the location of the greater second diameter d2 than at the location of the smaller first diameter d1. Thus, the deformable sleeve **970** can be formed to have an increased diameter (d2) at locations where it is desirable for the barrel **110** to contact the deformable sleeve **970** before contacting other portions of the deformable sleeve (e.g., at locations having the first outer diameter d1). In other examples, the second outer diameter d2 can be smaller than the first outer diameter d1 such that the deformable sleeve **970** can be formed to have a decreased diameter (d2) at locations where it is desirable for the barrel **110** to contact the deformable sleeve **970** subsequent to contacting other portions of the deformable sleeve **970** (e.g. at locations having the first outer diameter d1).

As another example, the deformable sleeve **970** can have a varying wall thickness across the length of the deformable sleeve **970**. For example, as shown in FIG. **12C**, the deformable sleeve **970** can have a first wall thickness t1 at a first location and a second wall thickness t2 at a second location. The second wall thickness t2 can be greater than the first wall thickness t1. In other examples, although not shown, it will be appreciated that the second wall thickness t2 can be less than the first wall thickness t1. As will be appreciated, by increasing the wall thickness, the deformable sleeve **970** can be made to be more rigid. Thus, the deformable sleeve **970** can be formed to include a thicker wall in locations where it would be desirable for the bat **900** to have a more rigid or stiff deformable sleeve **970**. Furthermore, the deformable sleeve **970** can include some combination of varying thickness t and outer diameter d to affect the performance of the bat **900** as desired. Furthermore, more than one deformable sleeve **970** can be disposed inside of the barrel **110**. For example, the bat **900** can include multiple deformable sleeves **970** disposed side by side (with or without a space in between) with each deformable sleeve **970** having varying length, thickness, and/or outer diameter as would be preferable for the particular application.

Because the bat **900** includes an inner sleeve **970** that extends some length of the barrel **110**, the bat **900** can exhibit improved sound and feeling as compared to previous designs. For example, the inner sleeve **970** can produce a similar effect to that of the deformable rings **130** but help to reduce the overall vibrations resulting from hitting a ball. Thus, the inner sleeve **970** can produce an impact sound and feel that tends to be more desirable for avid baseball and softball players.

While certain embodiments of the disclosed technology have been described in connection with what is presently considered to be the most practical embodiments, it is to be understood that the disclosed technology is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

This written description uses examples to disclose certain embodiments of the disclosed technology, including the best mode, and also to enable any person skilled in the art to practice certain embodiments of the disclosed technology, including making and using any devices or systems and performing any incorporated methods. The patentable scope of certain embodiments of the disclosed technology is defined in the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A bat comprising:
a hollow barrel;
an internal assembly disposed in the hollow barrel, the internal assembly comprising:
a rod disposed longitudinally in the hollow barrel;
a ring attached to the rod; and
a deformable sleeve disposed around the ring and extending longitudinally in the hollow barrel, the deformable sleeve having an outer diameter smaller than an inner diameter of the hollow barrel;
an end cap attached to an end of the hollow barrel, the end cap having a recess configured to receive an end of the rod,
wherein the rod is configured to maintain the deformable sleeve in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, the deformable sleeve is disposed a predetermined gap distance from an inner surface of the hollow barrel.

2. The bat of claim 1, wherein responsive to receiving force from an impact with an object, the hollow barrel is configured to flex inwardly such that the inner surface of the hollow barrel contacts the deformable sleeve.

3. The bat of claim 2, wherein:
the hollow barrel is configured to transfer at least some of the force from the impact to the deformable sleeve, and
the deformable sleeve is configured to:
at least partially deform from an original shape to a deformed shape upon receiving the at least some of the force from the impact; and
return from the deformed shape to the original shape.

4. The bat of claim 3, wherein the deformable sleeve is further configured to transfer a rebound force to the hollow barrel as the deformable sleeve returns from the deformed shape to the original shape.

5. The bat of claim 3, wherein:
the ring is a deformable ring,
the hollow barrel is configured to transfer at least some of the force from the impact to the deformable ring, and
the deformable ring is configured to:
at least partially deform from an original shape to a deformed shaped upon receiving the at least some of the force from the impact; and
return from the deformed shape to the original shape.

6. The bat of claim 1, wherein the ring is a first ring and the internal assembly further comprises a second ring, the second ring being attached to the rod and spaced a distance from the first ring, and
wherein the deformable sleeve extends between the first ring and the second ring.

7. The bat of claim 6, wherein the deformable sleeve comprises a first outer diameter proximate the first ring and proximate the second ring and a second outer diameter between the first ring and the second ring, the second outer diameter being greater than the first outer diameter.

8. The bat of claim 6, wherein the deformable sleeve comprises a first outer diameter proximate the first ring and proximate the second ring and a second outer diameter between the first ring and the second ring, the second outer diameter being less than the first outer diameter.

9. The bat of claim 6, wherein the deformable sleeve comprises a first thickness proximate the first ring and proximate the second ring and a second thickness between the first ring and the second ring, the second thickness being greater than the first thickness.

10. The bat of claim 6, wherein the deformable sleeve comprises a first thickness proximate the first ring and proximate the second ring and a second thickness between the first ring and the second ring, the second thickness being less than the first thickness.

11. The bat of claim 1, wherein the internal assembly further comprise an alignment insert comprising:
an outer diameter approximately equal to the inner diameter of the hollow barrel; and
a lobe configured to receive a portion of the rod.

12. The bat of claim 1 further comprising a plurality of rods, wherein the ring comprises a plurality of holes, each hole of the plurality of holes being configured to at least partially receive a respective rod of the plurality of rods.

13. The bat of claim 12, wherein:
the bat has a central axis;
the ring has a central axis aligned with the central axis of the bat, and
the plurality of holes of the ring is disposed equidistantly about a circumference corresponding to a radial distance from the central axis of the bat.

14. The bat of claim 12, wherein the end cap further comprises a plurality of recesses configured to at least partially receive an end of a respective rod of the plurality of rods.

15. The bat of claim 14, wherein:
the end cap has a central axis aligned with the central axis of the bat, and
the plurality of recesses of the end cap is disposed equidistantly about a circumference corresponding to a radial distance from the central axis of the bat.

16. The bat of claim 12 further comprising an alignment insert comprising:
an outer diameter approximately equal to the inner diameter of the hollow barrel; and
a plurality of lobes, each lobe configured to at least partially receive a respective rod of the plurality of rods.

17. The bat of claim 16, wherein each of the plurality of lobes of the alignment insert is offset from a central axis of the alignment insert by a radial distance.

18. An internal assembly for a bat comprising:
a rod;
a ring attached to the rod; and
a deformable sleeve disposed around the ring and configured to extend longitudinally in a hollow barrel of the bat, the deformable sleeve having an outer diameter smaller than an inner diameter of the hollow barrel, wherein the rod is configured to maintain the deformable sleeve in a predetermined suspended position within the hollow barrel such that, when the bat is at rest, the deformable sleeve is disposed a predetermined gap distance from an inner surface of the hollow barrel.

19. The internal assembly of claim 18, wherein the ring is a first ring and the internal assembly further comprises a second ring, the second ring being attached to the rod and spaced a distance from the first ring, and
wherein the deformable sleeve extends between the first ring and the second ring.

20. The internal assembly of claim **19** further comprising an alignment insert comprising:

an outer diameter approximately equal to an inner diameter of a hollow barrel of the bat; and

a lobe configured to at least partially receive a portion of the rod.

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