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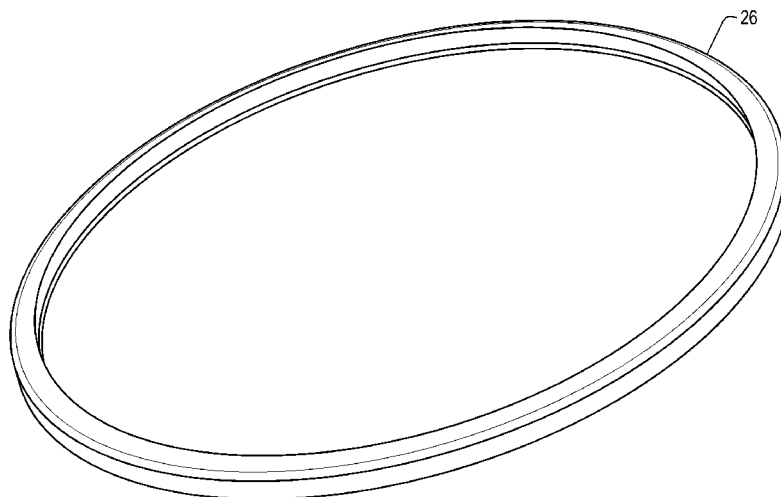


Fig. 9

(57) Abstract: An air spring for a vehicle suspension has an upper structure, a lower structure, and a flexible sleeve, which together define a spring chamber. The flexible sleeve has at least one bead wire (26) within its upper end and/or its lower end. The bead wire (26) has a cross-section that defines a quadrilateral having two acute angles and two obtuse angles. The quadrilateral may be a parallelogram, a rhombus, an obtuse trapezoid, or a scalene trapezoid. The cross section of the bead wire (26) better allows the molded material of the flexible sleeve to remain flat against the bead wire (26) during the molding process, minimizes the need for rubber filler, and prevents the inclusion of trapped air pockets. This improves the sealing ability of the end of the flexible sleeve or bellows against the upper structure or lower structure.



SOLID EXTRUDED BEAD WIRE FOR A AIR SPRING

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to bead wires used in air spring systems, and, more particularly, to air springs used in vehicle suspensions.

2. Description of the Related Art

[0002] Air spring systems are commonly used in vehicle suspensions, truck cab mountings, and seat suspensions, particularly in heavy vehicles such as over the road trucks and tractors. They are also used in other applications, such as railroad vehicles, agricultural vehicles, industrial vehicles, and occasionally in other machinery having moving or vibrating parts. Such air spring systems typically have large load carrying capacity while retaining excellent isolation of the vehicle or its suspended components from road or rail vibration and harshness due to the compressibility of the air within the air springs.

[0003] Construction of air springs for use in air spring systems typically involves the use of a bellows and a lower piston. The bellows is made up of a flexible sleeve that is typically attached to a top bead plate and to a lower end closure, which lower end closure is then attached to the lower piston. The top bead plate, the flexible sleeve, and the lower end closure together define a spring chamber, which changes in volume as the lower piston articulates, causing the flexible sleeve to roll over itself forming a rolling lobe. The lower piston of the air spring is generally mounted to a vehicle suspension member, such as a trailing arm. In the case of railroad vehicles, the lower piston of the air spring is generally mounted to the bogie frame. The top bead plate is usually attached to some other part of the vehicle structure, such as a mount attached to the vehicle frame. As the vehicle travels, the vehicle suspension including the air spring articulates

to absorb road or rail variations and unevenness without transmitting excessive vibration and harshness to the structure of the vehicle. In this way, the air spring provides support of the vehicle mass and load via the frame, suspension, and axles, while providing the necessary isolation from road or rail vibration and harshness.

[0004] Often, the flexible sleeve of the bellows terminates on either end with a bead wire that is molded into the flexible sleeve, so that the bead wire provides structural strength to the bellows, allowing it to be securely attached to the air spring assembly. In some cases, the flexible sleeve is attached to the air spring assembly using a crimp, such as when the top bead plate is crimped over the upper end of the flexible sleeve containing a bead wire. In this case, the bead wire and its surrounding molded rubber bellows material is mechanically locked within the crimp. In other cases, the flexible sleeve is attached to the air spring assembly by being clamped between two other components, such as when the lower end closure and the top of the lower piston are each provided with a recess to receive the end of the flexible sleeve having the bead wire. In this case, the bead wire and its surrounding molded rubber bellows material is mechanically locked between the lower end closure and the top of the lower piston.

[0005] In other arrangements, the end of the flexible sleeve containing the bead wire is pressed over part of the lower piston, lower end closure, or top bead plate, so that it is retained in place by the tension within the circular bead wire. This tension within the bead wire results in compression of the rubber molded bellows material against the lower piston, lower end closure, or top bead plate, which provides a necessary part of the air seal between the flexible sleeve and the lower piston, lower end closure, or top bead plate. It is known to use a bead wire that is square in cross-section in order to increase the area of rubber molded bellows material that is compressed against the lower piston, lower end closure, or top bead plate. One consequence of a bead wire having such a square cross-sectional shape is that the molded bellows material and

fabric ply cords tend to exhibit point stresses near the relatively sharp corners of the square shape of the bead wire. This can result in fatigue and cracking of the flexible sleeve at these locations.

[0006] Another consequence of a bead wire having such a square cross-sectional shape is that the fabric plies of the molded bellows material are sometimes unable to remain fully flat against the bead wire during the molding process due to the fabric plies having to wrap around two consecutive sharp corners. Failure of the fabric plies of the molded bellows material to lie flat against the bead wire during the molding process often results in the inclusion of trapped air pockets, which may compromise the sealing ability of the end of the flexible sleeve against the lower piston, lower end closure, or top bead plate. In order to compensate, it is known to use rubber filler between the bead wire and the molded bellows material, which requires additional expensive steps in the process of producing the flexible sleeve.

SUMMARY OF THE INVENTION

[0007] Embodiments of the present invention provide a bead wire for an air spring. The bead wire may be molded into or bonded with the flexible sleeve or bellows of the air spring.

Embodiments of the bead wire according to present invention may be utilized with a flexible sleeve or bellows that is attached to the air spring assembly using a crimp, or with a flexible sleeve or bellows that is attached to the air spring assembly by being clamped between two other components of the air spring assembly. Alternately, embodiments of the bead wire according to the present invention may be utilized with a flexible sleeve or bellows that is pressed over a part of the air spring assembly so that the flexible sleeve or bellows is retained in place by tension within the circular bead wire. In the latter embodiment, the bead wire may be pressed over a retention feature.

[0008] Embodiments of the present invention provide a bead wire for an air spring that is trapezoidal in cross section with filleted corners, so that the flexible sleeve or bellows material and the reinforcing fabric within the flexible sleeve or bellows is not required to wrap around two consecutive sharp corners. More specifically, the cross section of the bead wire according to embodiments of the present invention may be a trapezoid of the rhombus or parallelogram type. By using a bead wire with a rhombus or parallelogram cross section, the molded material and fabric plies are better able to remain fully flat against the bead wire during the molding process, thereby minimizing the need for rubber filler between the bead wire and the molded bellows material, and preventing the inclusion of trapped air pockets. This improves the sealing ability of the end of the flexible sleeve or bellows against the lower piston, lower end closure, or top bead plate.

[0009] Further embodiments of the present invention may provide a bead wire for an air spring that is of the rhombus or parallelogram type of trapezoid in cross section and that has an obtuse angle near to the corner between the piston and end closure, as well as another obtuse angle opposite from the first obtuse angle. The two adjoining angles of the trapezoid of the rhombus or parallelogram type are therefore acute angles. Embodiments of the present invention may have acute angles with filleted corners that are relatively small in comparison to the filleted corners of the obtuse angles. Still other embodiments of the present invention may provide a bead wire for an air spring that is trapezoidal in cross section without being of the rhombus or parallelogram type, such that the trapezoid is an obtuse trapezoid or even a scalene trapezoid, while still having two opposing corners that are obtuse and two opposing corners that are acute.

[0010] The invention in one form is directed to an air spring for a vehicle suspension. The air spring has an upper structure, a lower structure, and a flexible sleeve with an upper end attached to the upper structure and a lower end attached to the lower structure. The upper structure, the

lower structure, and the flexible sleeve together define a spring chamber. The flexible sleeve has at least one bead wire within its upper end and/or lower end. The at least one bead wire has a cross-section that defines a quadrilateral having two acute angles “A” and two obtuse angles “B.”

[0011] The invention in another form is directed to a bead wire for an air spring for a vehicle suspension. The bead wire has a cross-section that defines a quadrilateral having two acute angles “A” and two obtuse angles “B.”

[0012] The invention in yet another form is directed to a method of manufacturing an air spring for a vehicle suspension. The method includes several steps. The first step is providing an upper structure. The second step is providing a lower structure. The third step is providing a flexible sleeve having an upper end and a lower end. At least one of the upper end and the lower end of the flexible sleeve incorporate at least one bead wire. The at least one bead wire has a cross-section that defines a quadrilateral having two acute angles “A” and two obtuse angles “B.” The fourth step of the method is defining a spring chamber by attaching the upper end of the flexible sleeve to the upper structure and attaching the lower end of the flexible sleeve to the lower structure.

[0013] One advantage of the present invention is that the obtuse angle and the relatively large radius of the bead wire where it adjoins the upper structure or the lower structure allows the molded bellows material and the fabric ply cords to undergo a gentler transition, thereby avoiding separation from the bead wire and eliminating the development of air pockets or the need to use rubber filler material. Another advantage of the present invention is that it avoids fatigue and cracking which results from both the stresses of use of the airspring assembly and from the stresses encountered during manufacturing of the airspring assembly. Yet another advantage of the present invention is that the inward slope of the lower inner surface of the bead

wire further assists the installation of the end of the flexible sleeve over the upper or lower structure.

[0014] Additional features and advantages of the invention will be made apparent from the following detailed description of illustrative embodiments that proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The above-mentioned and other features and advantages of this disclosure, and the manner of attaining them, will become more apparent and the disclosure will be better understood by reference to the following description of an embodiment of the disclosure taken in conjunction with the accompanying drawings, wherein:

[0016] Fig. 1 is a cutaway isometric view of an air spring according to an embodiment of the present invention;

[0017] Fig. 2 is a sectional view of an air spring according to an embodiment of the present invention;

[0018] Fig. 3 is a top view of a bead wire according to an embodiment of the present invention;

[0019] Fig. 4 is an edge view of a bead wire according to an embodiment of the present invention;

[0020] Fig. 5 is a sectional view of a bead wire according to an embodiment of the present invention;

[0021] Fig. 6 is a sectional view of a bead wire engaged with molded bellows material and fabric ply cords according to the prior art;

[0022] Fig. 7 is a partial sectional view of a bead wire according to an embodiment of the present invention;

[0023] Fig. 8 is a sectional view of a bead wire engaged with molded bellows material and fabric ply cords according to an embodiment of the present invention; and

[0024] Fig. 9 is an isometric view of a bead wire according to an embodiment of the present invention.

[0025] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates embodiments of the disclosure, and such exemplifications are not to be construed as limiting the scope of the disclosure in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Referring now to the drawings, and more particularly to Figs. 1 and 2, there is shown an embodiment of an air spring 10 of the present invention. In both Figs. 1 and 2, the air spring 10 is shown in sectional views. The air spring 10 has a bellows 12 made up of a flexible sleeve 14 attached to a top bead plate 16 and to a lower end closure 18. In an alternative embodiment, not shown here, the flexible sleeve 14 may attach directly to the lower piston 24 instead of to the lower end closure 18. In the embodiment shown in Figs. 1 and 2, the top bead plate 16, the flexible sleeve 14, and the lower end closure 18 together define a spring chamber 20. The lower piston 24 partially penetrates into the area of the spring chamber 20, whereby the flexible sleeve 14 folds in upon itself, forming a rolling lobe 22. As this happens, the area defined by the spring chamber 20 gets smaller, compressing the pressurized air therein, and providing a progressive restorative force, so that the air spring 10 provides the necessary load bearing capability while isolating the vehicle or its suspended components (not shown) from road or rail vibration and harshness.

[0027] The flexible sleeve 14 has a bead wire 26 at each end where it attaches to the top bead plate 16 and to the lower end closure 18 or lower piston 24. The bead wire 26 may be molded into the material of the flexible sleeve 14, or the material of the flexible sleeve 14 may be wrapped around the bead wire 26 and bonded. A retention feature 32 may be provided on the top bead plate 16, the lower end closure 18, or on the lower piston 24, as applicable. During installation of the flexible sleeve 14, the ends of the flexible sleeve 14 containing the bead wire 26 may be pressed onto the top bead plate 16, the lower end closure 18, or on the lower piston 24, as applicable. In the embodiment having the retention feature 32, the bead wire 26 may be required to stretch slightly to pass over the retention feature 32, thereby more securely retaining the end of the flexible sleeve 14 on the top bead plate 16, the lower end closure 18, or on the lower piston 24. In this way, the end of the flexible sleeve 14 containing the bead wire 26 “snaps on” to the lower piston 24, lower end closure 18, or top bead plate 16, as applicable.

[0028] Turning now to Figs. 3, 4, and 5, an embodiment of the present invention, a bead wire 26 for a flexible sleeve 14 of an air spring 10 is shown. The bead wire has an improved cross-sectional shape, being in the form of a parallelogram having filleted corners. Fig. 3 shows the bead wire 26 in a top view and Fig. 4 shows the bead wire 26 in a side view. Fig. 5 is a section view of the bead wire 26 along section lines A-A.

[0029] Turning now to Figs. 7 and 8, the bead wire 26 is shown in cross section detail, with and without the molded bellows material 28 and fabric ply cords 30. As shown in these figures, the bead wire 26 cross-section defines a parallelogram having two opposing filleted corners defined by acute angles “A,” and two opposing filleted corners defined by obtuse angles “B.” The fillet radii a' of the acute angles A are relatively small in comparison to the fillet radii b' of the obtuse angles B. By way of non-limiting example, the acute angles A may be 70° and the obtuse angles B may be 110° . By way of further non-limiting example, the fillet radii b' of the

obtuse angles B may be six or seven times larger than the fillet radii a' of the acute angles A. By way of further non-limiting example, the fillet radii a' of the acute angles A may be 0.02" and the fillet radii b' of the obtuse angles B may be 0.13" as applied to a bead wire 26 that measures 0.375" from inside to outside surface and 0.352" from lower to upper surface.

[0030] While a bead wire 26 having a cross-section that defines a parallelogram is illustrated, i.e. – a quadrilateral having opposite sides that are parallel and having opposite sides that are of the same length as each other as measured to the vertices of the corners, other similar quadrilaterals are contemplated as being within the scope of the invention, provided that the quadrilateral has two opposing corners that are acute and two opposing corners that are obtuse. Specifically, the bead wire 26 may have a cross-section that defines a rhombus, i.e. – a quadrilateral having opposite sides that are parallel and having sides that are all the same length as each other as measured to the vertices of the corners, again having two opposing corners that are acute and two opposing corners that are obtuse. The bead wire 26 may have a cross-section that defines an obtuse trapezoid, i.e. – a quadrilateral having only two opposite sides that are parallel, again having two opposing corners that are acute and two opposing corners that are obtuse. The bead wire 26 may have a cross-section that defines a scalene trapezoid, i.e. – a quadrilateral having no sides that are parallel, but again having two opposing corners that are acute and two opposing corners that are obtuse.

[0031] Fig. 8 shows the bead wire 26 of the flexible sleeve 14 installed over the lower end closure 18 against the top of the lower piston 24. An alternative embodiment may provide for the bead wire 26 of the flexible sleeve 14 being installed over part of the lower piston 24 itself. Molded bellows material 28 and fabric ply cords 30 of the flexible sleeve 14 wrap around the bead wire 26. The obtuse angle B and large radius b' allows the molded bellows material 28 and fabric ply cords 30 to undergo a gentler transition in the corner between the lower end closure 18

and the top of the lower piston 24. The obtuse angle B and large radius b' are located on the inside downward corner of the bead wire 26 as installed over the lower end closure 18 against the top of the lower piston 24. As installed over the top bead plate 16, the obtuse angle B and large radius b' would be located on the inside upward corner of the bead wire 26. The inward slope of the lower surface of the bead wire 26 further assists the installation of the end of the flexible sleeve 14 over the top bead plate 16, the lower end closure 18, or the lower piston 24, as applicable, especially when the top bead plate 16, the lower end closure 18, or the lower piston 24 is provided with a retention feature 32.

[0032] Comparing now Fig. 8 to Fig. 6, Fig. 6 shows an embodiment of the prior art using a square bead wire 50. The molded bellows material 52 and the fabric ply cords 54 tend to separate from the square bead wire 50 where it interfaces with the lower end closure 18 when the square bead wire shape is used. This tends to cause an air pocket 56 to develop, which often requires the manufacturer to include a rubber filler material 58 in order to maintain sufficient contact pressure between the end of the flexible sleeve 14 and the lower end closure 18 to prevent leaks. Furthermore, the lower inner corner of the square bead wire 50 forces the molded bellows material 52 and the fabric ply cords 54 to make a sharp transition, which may result in fatigue and cracking of the bellows material 52 and the fabric ply cords 54.

[0033] In contrast, the obtuse angle B and large radius b' allows the molded bellows material 28 and fabric ply cords 30 to undergo a gentler transition in the corner between the lower end closure 18 and the top of the lower piston 24 when the bead wire 26 having a cross-section that defines a parallelogram, rhombus, obtuse trapezoid, or scalene trapezoid according to an embodiment of the present invention is used. This gentler transition eliminates the tendency of an air pocket to develop, so that the use of a rubber filler material is not required, and eliminates the fatigue and cracking of the molded bellows material 28 and the fabric ply cords 30.

[0034] Note that the bead wire 26 having a cross-section that defines a parallelogram, rhombus, obtuse trapezoid, or scalene trapezoid according to an embodiment of the present invention may be formed using any appropriate process, such as extrusion, stamping, roll forming, casting, and etcetera. Further, the bead wire may be made of any suitable material, such as steel or other ferrous or non-ferrous metal, as well as synthetic materials such as plastic or composites.

[0035] Fig. 9 shows an embodiment of a bead wire according to the present invention.

[0036] While this invention has been described with respect to at least one embodiment, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. An air spring for a vehicle suspension, comprising:
 - an upper structure;
 - a lower structure;
 - a flexible sleeve having an upper end attached to said upper structure and having a lower end attached to said lower structure;
 - said upper structure, said lower structure, and said flexible sleeve defining a spring chamber;
 - said flexible sleeve being provided with at least one bead wire within at least one of said upper end and said lower end; and
 - said at least one bead wire having a cross-section that defines a quadrilateral having two acute angles A and two obtuse angles B.
2. The air spring of claim 1, wherein:
 - said at least one bead wire having a cross-section that further defines one of:
 - a parallelogram;
 - a rhombus;
 - an obtuse trapezoid; and
 - a scalene trapezoid.

3. The air spring of claim 1, wherein:

said at least one bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, said second fillet radii b' being between about 6 and about 7 times greater than said first fillet radii a' .

4. The air spring of claim 1, wherein:

said at least one bead wire being molded into said flexible sleeve.

5. The air spring of claim 1, wherein:

at least one of said upper structure and said lower structure being further provided with a retention feature.

6. The air spring of claim 1, wherein:

said upper structure further comprising a bead plate;

said lower structure further comprising a lower piston;

said upper end of said flexible sleeve being attached to said bead plate; and

said lower end of said flexible sleeve being attached to said lower piston.

7. The air spring of claim 1, wherein:

said upper structure further comprising a bead plate;

said lower structure further comprising a lower piston and a lower end closure;

said upper end of said flexible sleeve being attached to said bead plate; and

said lower end of said flexible sleeve being attached to said lower end closure.

8. The air spring of claim 1, wherein:

one of said obtuse angles of said at least one bead wire being positioned adjacent to a corner defined by a portion of one of said upper structure and said lower structure which is encircled by one of said upper end and said lower end, respectively, of said flexible sleeve and by a portion of one of said upper structure and said lower structure which is adjoined by one of said upper end and said lower end, respectively, of said flexible sleeve.

9. A bead wire for an air spring for a vehicle suspension, wherein:

said bead wire having a cross-section that defines a quadrilateral having two acute angles A and two obtuse angles B.

10. The bead wire of claim 9, wherein:

said bead wire having a cross-section that further defines one of:

a parallelogram;

a rhombus;

an obtuse trapezoid; and

a scalene trapezoid.

11. The bead wire of claim 9, wherein:

said bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, said second fillet radii b' being between about 6 and about 7 times greater than said first fillet radii a' .

12. A method of manufacturing an air spring for a vehicle suspension, comprising the steps of:

providing an upper structure;

providing a lower structure;

providing a flexible sleeve having an upper end and a lower end, at least one of said upper end and said lower end of said flexible sleeve incorporating at least one bead wire, said at least one bead wire having a cross-section that defines a quadrilateral having two acute angles A and two obtuse angles B; and

defining a spring chamber by attaching said upper end of said flexible sleeve to said upper structure and attaching said lower end of said flexible sleeve to said lower structure.

13. The method of claim 12, wherein:

said at least one bead wire having a cross-section that further defines one of:

a parallelogram;

a rhombus;

an obtuse trapezoid; and

a scalene trapezoid.

14. The method of claim 12, wherein:

said at least one bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, said second fillet radii b' being between about 6 and about 7 times greater than said first fillet radii a' .

15. The method of claim 12, further comprising the step of:
molding said at least one bead wire into at least one of said upper end and said lower end of said flexible sleeve.

16. The method of claim 12, further comprising the step of:
providing at least one of said upper structure and said lower structure with a retention feature.

17. The method of claim 12, wherein:
said upper structure further comprising a bead plate;
said lower structure further comprising a lower piston;
said upper end of said flexible sleeve being attached to said bead plate; and
said lower end of said flexible sleeve being attached to said lower piston.

18. The method of claim 12, wherein:
said upper structure further comprising a bead plate;
said lower structure further comprising a lower piston and a lower end closure;
said upper end of said flexible sleeve being attached to said bead plate; and
said lower end of said flexible sleeve being attached to said lower end closure.

19. The method of claim 12, further comprising the step of:

positioning one of said obtuse angles of said at least one bead wire adjacent to a corner defined by a portion of one of said upper structure and said lower structure which is encircled by one of said upper end and said lower end, respectively, of said flexible sleeve and by a portion of one of said upper structure and said lower structure which is adjoined by one of said upper end and said lower end, respectively, of said flexible sleeve.

AMENDED CLAIMS

received by the International Bureau on 25 May 2017 (25.05.2017).

1. (currently amended) An air spring for a vehicle suspension, comprising:

an upper structure; a lower structure; a flexible sleeve having an upper end attached to said upper structure and having a lower end attached to said lower structure; said upper structure, said lower structure, and said flexible sleeve defining a spring chamber; said flexible sleeve being provided with at least one bead wire within at least one of said upper end and said lower end; and said at least one bead wire having a cross-section that defines a quadrilateral having two acute angles A and two obtuse angles B, wherein said at least one bead wire having a crosssection that further defines one of:

a parallelogram; a

rhombus; an obtuse

trapezoid; and a scalene

trapezoid.

3. (original) The air spring of claim 1, wherein:

said at least one bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, ~~said second fillet radii b' being between about 6 and about 7 times greater than~~ said first fillet radii a' .

4. (original) The air spring of claim 1, wherein:

said at least one bead wire being molded into said flexible sleeve.

5. (original) The air spring of claim 1, wherein:
at least one of said upper structure and said lower structure being further provided with a retention feature.
6. (original) The air spring of claim 1, wherein: said upper structure further comprising a bead plate; said lower structure further comprising a lower piston; said upper end of said flexible sleeve being attached to said bead plate; and said lower end of said flexible sleeve being attached to said lower piston.
7. (original) The air spring of claim 1, wherein: said upper structure further comprising a bead plate; said lower structure further comprising a lower piston and a lower end closure; said upper end of said flexible sleeve being attached to said bead plate; and said lower end of said flexible sleeve being attached to said lower end closure.
8. (original) The air spring of claim 1, wherein:
one of said obtuse angles of said at least one bead wire being positioned adjacent to a corner defined by a portion of one of said upper structure and said lower structure which is encircled by one of said upper end and said lower end, respectively, of said flexible sleeve and by a portion of one of said upper structure and said lower structure which is adjoined by one of said upper end and said lower end, respectively, of said flexible sleeve.
9. (currently amended) A bead wire for an air spring for a vehicle suspension, wherein:

said bead wire having a cross-section that defines a quadrilateral having filleted corners, two acute angles A and two obtuse angles B.

10. (original) The bead wire of claim 9, wherein:

said bead wire having a cross-section that further defines one of:

a parallelogram; a

rhombus; an obtuse

trapezoid; and a scalene

trapezoid.

11. (original) The bead wire of claim 9, wherein:

said bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, said second fillet radii b' being between about 6 and about 7 times greater than said first fillet radii a' .

12. (currently amended) A method of manufacturing an air spring for a vehicle suspension, comprising the steps of:

providing an upper structure; providing

a lower structure; providing a flexible

sleeve having an upper end and a lower

end, at least one of said upper end and

said lower end of said flexible sleeve

incorporating at least one bead wire,

said at least one bead wire having a cross-section that defines a quadrilateral having two acute angles A and two obtuse angles B; and defining a spring chamber by attaching said upper end of said flexible sleeve to said upper structure and attaching said lower end of said flexible sleeve to said lower structure, wherein said at least one bead wire having a cross-section that further defines one of:

a parallelogram; a rhombus; an obtuse trapezoid; and a scalene trapezoid.

14. (original) The method of claim 12, wherein:

said at least one bead wire further having a cross-section with first fillet radii a' between the edges defining said acute angles A and second fillet radii b' between the edges defining said obtuse angles B, ~~said second fillet radii b' being between about 6 and about 7 times greater than~~ said first fillet radii a' .

15. (original) The method of claim 12, further comprising the step of:

molding said at least one bead wire into at least one of said upper end and said lower end of said flexible sleeve.

16. (original) The method of claim 12, further comprising the step of:
providing at least one of said upper structure and said lower structure with a retention feature.
17. (original) The method of claim 12, wherein: said upper structure further comprising a bead plate; said lower structure further comprising a lower piston; said upper end of said flexible sleeve being attached to said bead plate; and said lower end of said flexible sleeve being attached to said lower piston.
18. (original) The method of claim 12, wherein: said upper structure further comprising a bead plate; said lower structure further comprising a lower piston and a lower end closure; said upper end of said flexible sleeve being attached to said bead plate; and said lower end of said flexible sleeve being attached to said lower end closure.
19. (original) The method of claim 12, further comprising the step of:
positioning one of said obtuse angles of said at least one bead wire adjacent to a corner defined by a portion of one of said upper structure and said lower structure which is encircled by ~~one of said upper end and said lower end, respectively, of said flexible sleeve and by a portion~~
of one of said upper structure and said lower structure which is adjoined by one of said upper end and said lower end, respectively, of said flexible sleeve.

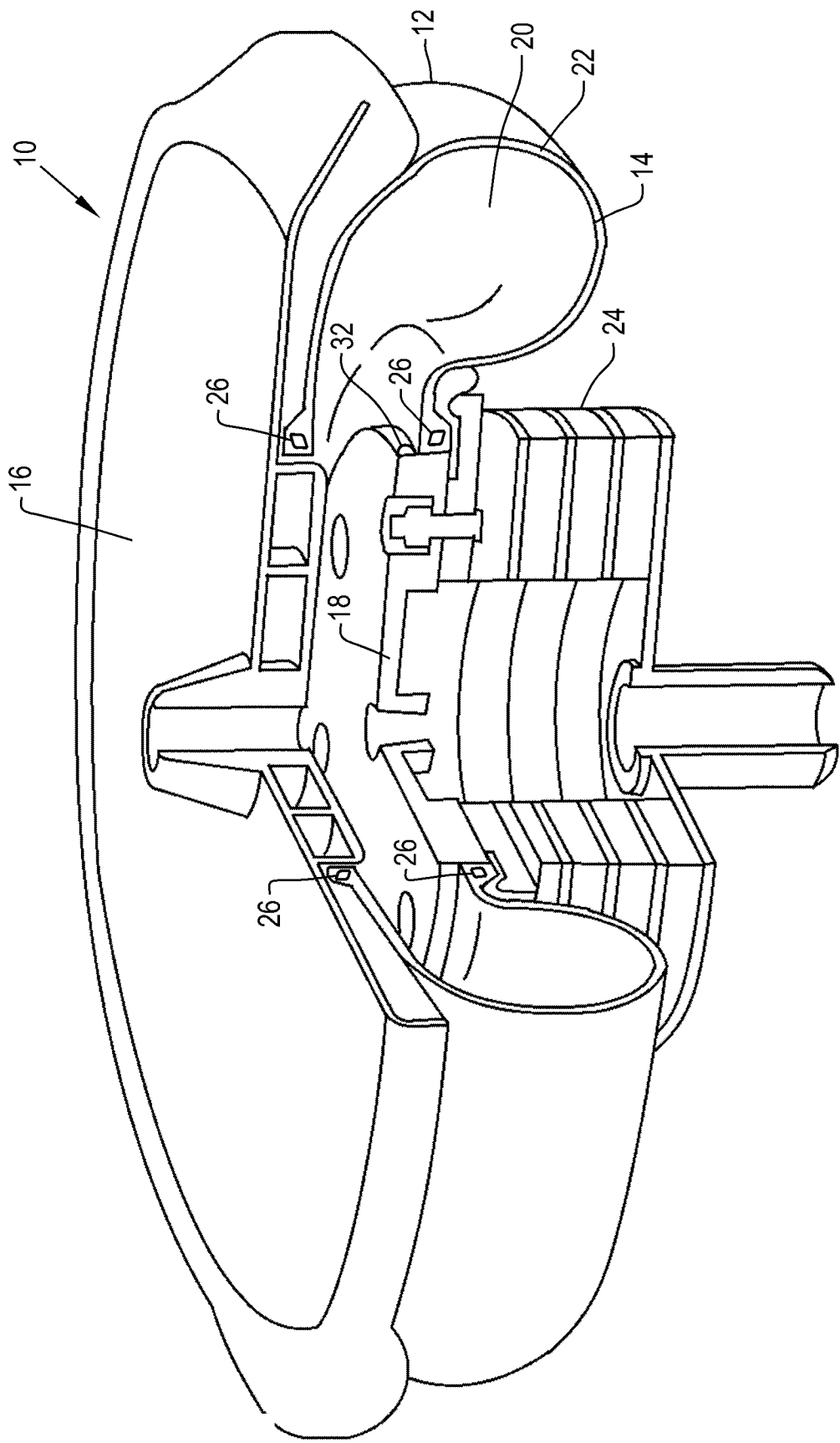


Fig. 1

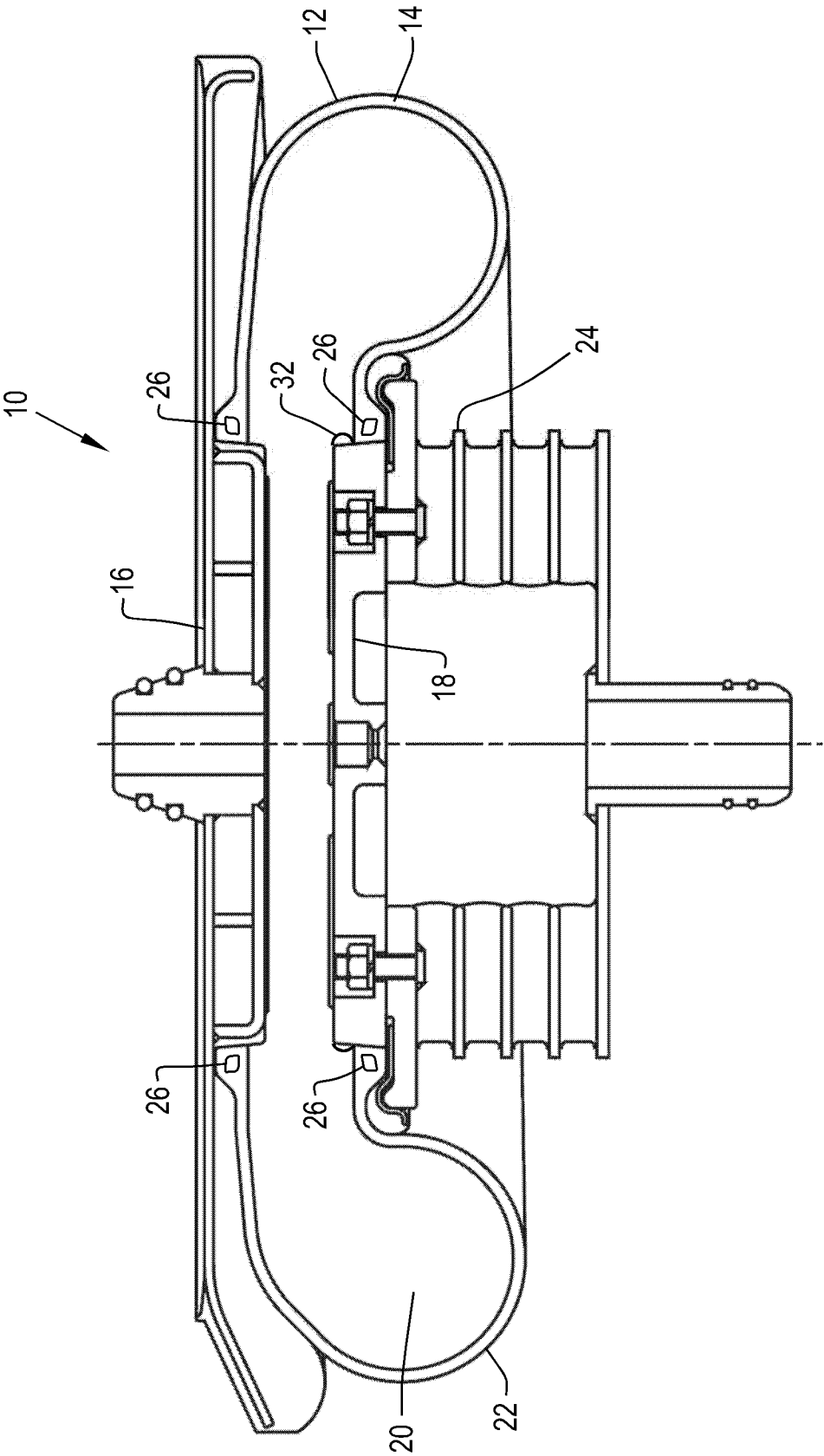


Fig. 2

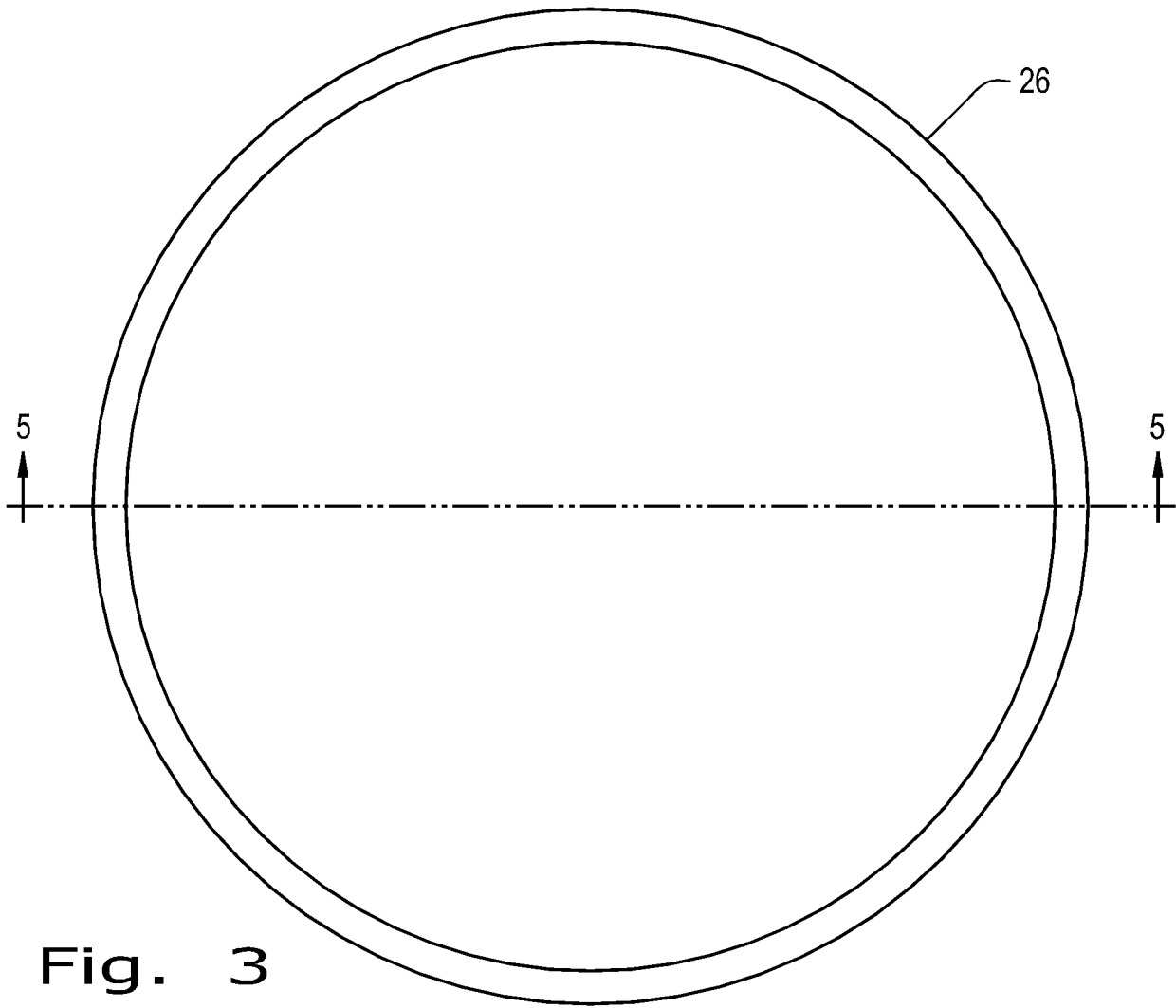


Fig. 3

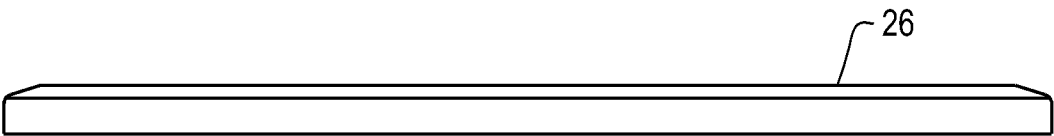


Fig. 4

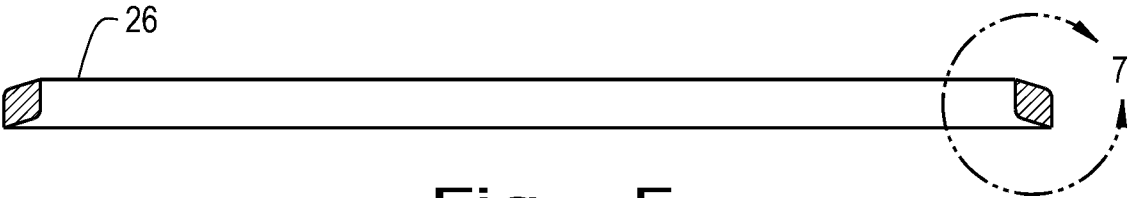
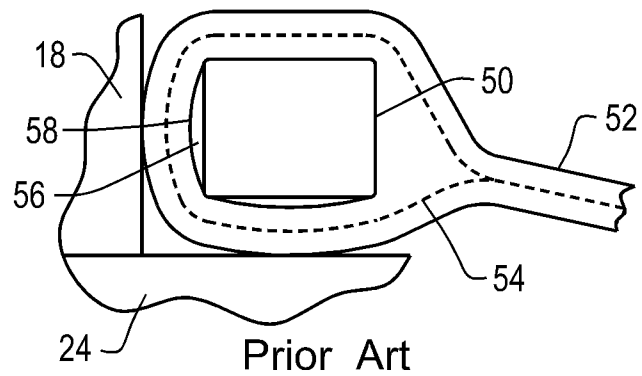


Fig. 5

1/12



Prior Art
Fig. 6

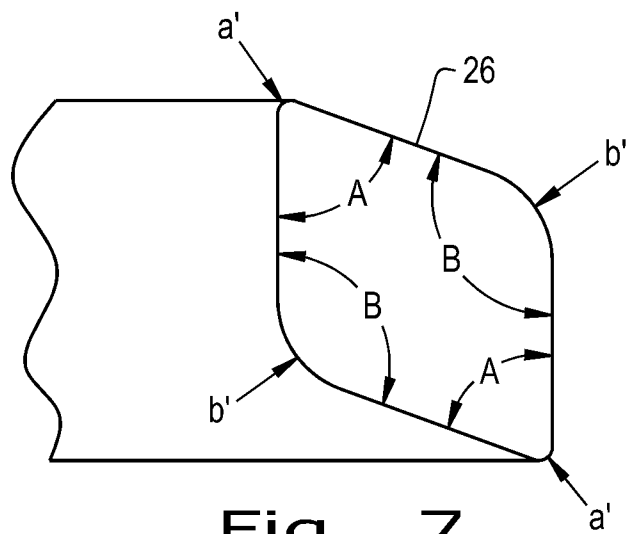


Fig. 7

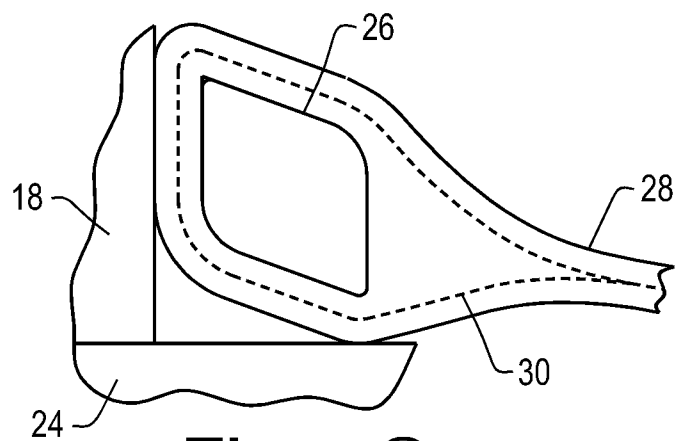


Fig. 8

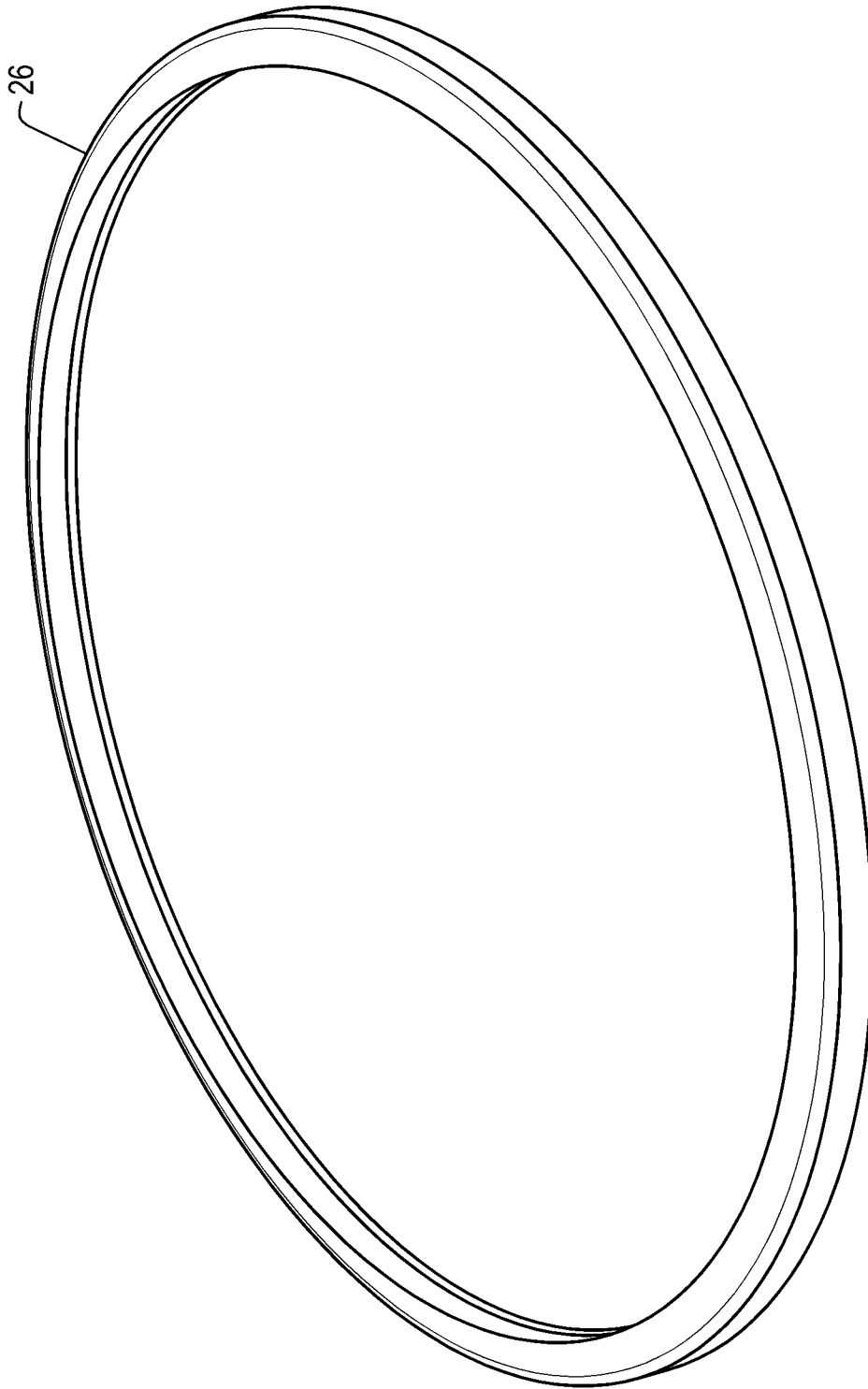


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/013165

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F16F9/04 B60G11/27
 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)
 F16F B60G

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.
X	CN 2 040 455 U (SHENYANG AIRCRAFT IND CO [CN]) 5 July 1989 (1989-07-05)	1-3,6, 8-14,17, 19
Y	figures 1, 3	7,18
X	WO 2012/096996 A1 (FIRESTONE IND PRODUCTS CO LLC [US]; KOESKE PAUL P [US]) 19 July 2012 (2012-07-19)	1,2,4-6, 9,10,12, 13,15-17
Y	figures 1, 2 abstract paragraph [0023] paragraph [0030]	7,18
Y	US 2014/300038 A1 (KITA YOSHIYUKI [JP] ET AL) 9 October 2014 (2014-10-09) figure 7	7,18
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

14 March 2017

Date of mailing of the international search report

10/04/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/013165

C(Continuation). 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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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/013165

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