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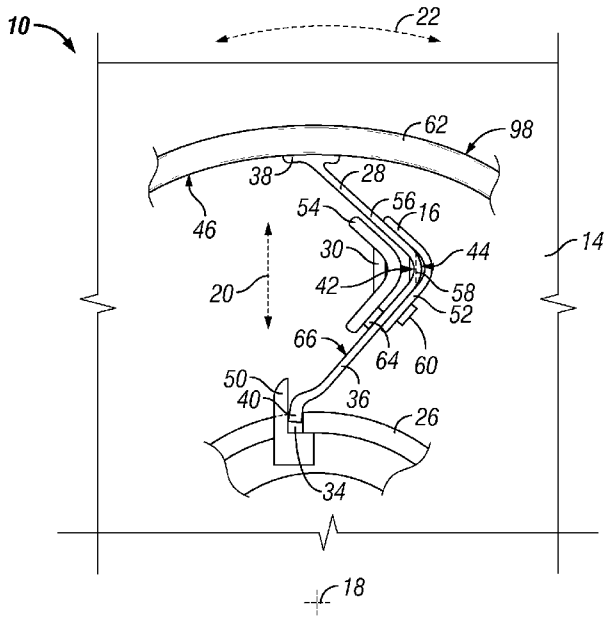


FIG. 11

(57) Abstract: An apparatus for assembling a non-pneumatic tire is provided that includes a plurality of ramped elements (16) that each have a ramped surface (30) oriented at an angle relative to a longitudinal direction. A hub (26) that has a plurality of receiving features (34), a shear band (62), and a plurality of spokes (28) that are attached to the shear band (62) that are spaced from the central axis in a radial direction are also included. The spokes each have a body that is disposed between an outward radial end of the spoke and an inward radial end of the spoke. Movement of the spokes relative to the ramped elements in the longitudinal direction causes the spokes to engage the ramped surfaces and be elongated in the radial direction, and for the inward radial ends of the spokes to be received by the receiving features.

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STATIC FIXTURE FOR SPOKE TO HUB ATTACHMENT FOR A NON-PNEUMATIC TIRE

FIELD OF THE INVENTION

[0001] The subject matter of the present invention relates to fixtures for the production of non-pneumatic tires. More particularly, the present application involves a fixture that includes ramped elements that are statically positioned in the fixture and are engaged by moving spokes that in turn are pre-tensioned by the ramped elements and aligned into receiving portions of the hub of the non-pneumatic tire.

BACKGROUND OF THE INVENTION

[0002] Non-pneumatic tires are those that do not require air. These tires instead feature a hub that is mounted onto a wheel of a vehicle, and a series of spokes that extend radially outward from the hub. The spokes can be attached to a shear band that includes tread of the tire. The spokes can be arranged and manufactured in a number of ways. Further, any number of spokes can be used in the design of non-pneumatic tires. However, when large numbers of spokes are used manufacturing problems arise. The large numbers of spokes require the spokes be positioned close to one another, and in these instances the spokes cannot be formed with the shear band as part of a complete assembly. For a non-pneumatic tire to be constructed in a uniform manner, the circumferential and lateral precision of location of the spokes should be within 0.2 millimeters. Further, variations in spokes to spoke flange thicknesses exist in the manufacture of spokes, which also should be taken into account in any subsequent assembly process. It may be desirable to impart pretension onto the spokes of the non-pneumatic tire so that the assembled product has a degree of spoke pretension. The assembly of the non-pneumatic tire must likewise be executed in order to introduce this pretension.

[0003] One way of assembling a non-pneumatic tire involves placing components within a fixture and stretching the spokes to the hub through the use of an actuated device that causes the fixture to move to urge the spokes to the hub. The actuated device holds the spokes against the hub for a desired amount of time to cause connection through curing. This time may be from 10-30 minutes and ties up the fixture for this amount of time. Due to the various manufacturing challenges associated with the production of non-pneumatic tires, a mechanism for addressing and improving upon issues associated with their production would be beneficial.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0005] Fig. 1 is a side view of a non-pneumatic tire.

[0006] Fig. 2 is a perspective view with a portion cut away to show the assembly of the apparatus.

[0007] Fig. 3 is a perspective view of a hub.

[0008] Fig. 4 is a perspective view of a ramped element.

[0009] Fig. 5 is a front view of a portion of the ramped element of Fig. 4.

[0010] Fig. 6 is a back view of the portion of the ramped element of Fig. 4.

[0011] Fig. 7 is a side view of the portion of the ramped element of Fig. 4.

[0012] Fig. 8 is a top view of the portion of the ramped element of Fig. 4.

[0013] Fig. 9 is a side view of a portion of the apparatus with the spoke not yet in engagement with the ramped element.

[0014] Fig. 10 is a front view of Fig. 9.

[0015] Fig. 11 is a side view of a portion of the apparatus with the spoke in engagement with a ramped surface of the ramped element.

[0016] Fig. 12 is a side view of Fig. 11.

[0017] Fig. 13 is a perspective view of a portion of the apparatus with the spokes in engagement with ramped surfaces of the ramped element.

[0018] Fig. 14 is a perspective view of Fig. 13 from a different angle.

[0019] Fig. 15 is a side view of a portion of the apparatus with the spoke inserted into the receiving feature of the hub.

[0020] Fig. 16 is a front view of Fig. 15.

[0021] Fig. 17 is a front view of a section of the non-pneumatic tire with a securement mechanism that is adhesion.

[0022] Fig. 18 is a front view of a section of the non-pneumatic tire with a securement mechanism that is a keyed interference fit.

[0023] The use of identical or similar reference numerals in different figures denotes identical or similar features.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Reference will now be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, and not meant as a limitation of the invention. For example, features illustrated or described as part of one embodiment can be used with another embodiment to yield still a third embodiment. It is intended that the present invention include these and other modifications and variations.

[0025] The present invention provides for an apparatus 10 that is used in the construction of a non-pneumatic tire 12. A hub 26 is first placed inside a fixture and a shear band 62 with a series of attached spokes 28 are pressed into it. The shear band 62 and spokes 28 are placed into the fixture that has a series of ramped elements 16 distributed around a central axis 18 in a circumferential direction 22. Each of the ramped elements 16 has a ramped surface 30. The shear band 62 and attached spokes 28 are moved in relation to the ramped elements 16 and engagement and movement of the spokes 28 along the ramped surfaces 32 causes the spokes 28 to be stretched in the radial direction 20. The inward radial ends 40 of the spokes 28 are aligned with receiving features 34 of the hub 26 and are received therewith. The inward radial ends 40 are attached to the hub 26 at the receving features 34 through adhesive and/or a mechanical connection in order to effect attachment of the spokes 28 to the hub 26 with a desired amount of pretension. This assembly does not require actuation of the ramped elements 16 to effect assembly, but instead utilizes movement of the spokes 28 relative to the base 14, hub 26, and ramped elements 16.

[0026] Fig. 1 shows a non-pneumatic tire 12 in accordance with one exemplary embodiment. The non-pneumatic tire 12 has an axis 102 at its center, and the radial direction 20 extends from the axis 102. Tread 98 is located on the outer exterior of a shear band 62 and extends all the way around the non-pneumatic tire 12 in the circumferential direction 22. The shear band 62 is located inward in the radial direction 20 from the tread 98 and likewise extends 360 degrees around the axis 102 in the circumferential direction 22. A series of spokes 28 engage the shear band 62 and extend inward in the radial direction 20 from the shear band 62 to a hub 26 of the non-pneumatic tire 12. Any number of spokes 28 can be present, and their cross-sectional shape can be different from that shown. In some embodiments, from 64-80 spokes 28 are present in the non-pneumatic tire 12. The hub 26 is located inward from the spokes 28 in the radial direction 20 and can be mounted onto a wheel of the vehicle. The spokes 28 at the top of the non-pneumatic tire 12 are in tension, and the spokes 28 at the bottom are in compression as

the non-pneumatic tire 12 rests on the ground 100 and as the non-pneumatic tire 12 turns in normal operation of the vehicle.

[0027] Fig. 2 shows the apparatus 10 in cut away view and in a configuration in which the spokes 28 are not in engagement with the ramped elements 16. A base 14 supports various components of the apparatus 10 such as the hub 26, spoke to hub guide 50, and ramped elements 16. The base 14 can include plates, columns, or any other structure needed to support the various components of the apparatus 10. The shear band 62 and spokes 28 could be supported by the base 14, or may be supported by a separate member that moves these elements 62, 28 in relation to other components of the apparatus 10. An aperture can extend through the center of the base 14 at the central axis 18, or it may be solid in other exemplary embodiments. The hub 26 is supported by the base 14 and may rest thereon or can be clamped onto the base 14. The hub 26 is positioned so that is central axis is coaxial with the central axis 18 of the ramped elements 16. A series of spoke to hub guides 50 are positioned adjacent the hub 26 in the longitudinal direction 24. There may be some overlap of the spoke to hub guides 50 and the hub 26 in the radial direction 20. The spoke to hub guides 50 may be mounted to the base 14 and free from engagement with the hub 26, or the spoke to hub guides 50 can be in contact with the hub 26. The spoke to hub guides 50 can extend all the way around the central axis 18 in the circumferential direction 22 and may be provided in a number equal to the number of spokes 28 that are to be incorporated into the non-pneumatic tire 12.

[0028] A series of ramped elements 16 extend from the base 14 and are located outward from the spoke to hub guides 50 and the hub 26 in the radial direction 20. The ramped elements 16 are separated from one another in the circumferential direction 22 about the central axis 18 and are provided in the same number as the number of spokes 28 that are to be incorporated into the non-pneumatic tire 12. The ramped elements 16 could extend along the entire combined lengths of the hub 26 and the spoke to hub guides 50 in the longitudinal direction 24. The ramped elements 16 may be in engagement with the spoke to hub guides 50 or could be separated from the spoke to hub guides 50 and free from engagement therewith. The spokes 28 and shear band 62 are attached to one another before interaction with the ramped elements 16, spoke to hub guides 50, and hub 26. The shear band 62 is located outward from the ramped elements 16, hub 26, and spoke to hub guides 50 in the radial direction 20. The spokes 28 are located outward from the hub 26 in the radial direction 20 before attachment to the hub 26. The spokes 28 may overlap the ramped element 16 in the radial direction 20 in Fig. 2.

[0029] The shear band 62 and spokes 28 are acted upon by a press plate 68 that is in turn acted upon by a hydraulic cylinder, air bladder, or mechanical linkage (not shown) that functions to apply force to the press plate 68 to in turn push the shear band 62 and spokes 28 relative to the ramped elements 16, hub 26, and spoke to hub guides 50. The force 70 applied by the press plate 68 is in the longitudinal direction 24. The press plate 68 can be varied so that it does not have a central section, but is instead a ring that applies force 70 to the shear band 62 and/or spokes 28. The press plate 68 may be mounted onto the shear band 62 and spokes 28 or could simply engage these two components 28, 62 without being directly attached thereto. The press plate 68 may also be capable of reversing its motion in the longitudinal direction 24 so that after the non-pneumatic tire 12 has been assembled the press plate 68 pulls the non-pneumatic tire 12 out of the apparatus 10, or otherwise opens to allow access to and subsequent removal of the non-pneumatic tire 12 from the apparatus 10.

[0030] Fig. 3 shows the hub 26 being a ring shaped object with an aperture through its center. The hub 26 is symmetrical in configuration and features a pair of inner flanges and an exterior surface. A plurality of receiving features 34 are defined on the outer surface of the hub 26. The receiving features 34 receive the inner radial ends 40 of the spokes 28 and form an attachment location between the spokes 28 and the hub 26. The receiving features 34 may be arranged in a variety of different manners. As shown, the receiving features 34 are slots that are in the exterior surface and extend in the longitudinal direction 24. The slots do not have a component of extension in the circumferential direction 22 but instead extend only in the longitudinal direction 24. The slots have a square cross-sectional shape and are evenly spaced in the circumferential direction 22. The number of slots present are the same as the number of spokes 28 to be incorporated into the non-pneumatic tire 12. The slots making up the receiving features 34 may be different from those shown and described in accordance with other exemplary embodiments.

[0031] Once exemplary embodiment of the ramped element 16 is shown in Fig. 4. The ramped element 16 includes a ramped surface 30 for use in stretching the spokes 28. The ramped element 16 can be made out of a single piece, or as is the case in the embodiment of Fig. 4 is made out of a first component 72 and a second component 74 that are first formed and then subsequently attached to one another. The second component 74 is an elongated L shaped member made of steel. Although described as L shaped, in some embodiments the legs of the second component 74 may be the same lengths as one another. Nested within the L shaped first component is the second component 74 that features the ramped surface 30. The first component

72 is made of steel and is shown in different views with reference to Figs. 5-8. The first component 72 has an upper surface that has a convex shape, and a flat bottom surface that extends along a portion of the length of the first component 72 in the longitudinal direction 24. The bottom surface then extends from the flat bottom portion at an angle to the front of the first component 72. The angle 32 of orientation is shown from the side and is measured as being the angle between the ramped surface 30 and the longitudinal direction 24. The angle 32 may be from 3 degrees to 20 degrees, from 20-45 degrees, or up to 75 degrees, or greater than 0 degrees in accordance with various exemplary embodiments. The ramped surface 30 can be a flat surface oriented at an angle different from the flat bottom surface of the first component 72. The first and second components 72, 74 can be attached to one another through welding, adhesion, mechanical fasteners, or may be integrally formed with one another. When assembled, the flat bottom surface of the first component 72 and the ramped surface 30 are visible, and the convex upper surface of the first component 72 is nested within the second component 74 and is not visible.

[0032] Figs. 9 and 10 show a portion of the apparatus 10 in which only a first spoke 56 of the plurality of spokes 28, and in which only a first ramped element 52 and a second ramped element 54 of the plurality of ramped elements 16 are shown. The first spoke 56 has an outward radial end 38 that is connected to an inner surface 46 of the shear band 62, and this connection may be made in a previous process before the apparatus 10 functions to connect the first spoke 56 to the hub 26. The first spoke 56 has a body 36 that extends in the radial direction 20. The outward radial end 38 is on one side of the body 36, and the inward radial end 40 is on the opposite side of the body 36 in the radial direction. The body 36 has a concave surface 42 and an oppositely disposed convex surface 44. The body 36 may be described as being V shaped. However, it is to be understood that the body 36 need not have the concave 42 and convex 44 surfaces in other arrangements. The first spoke 56 has a flat surface 66 on the same side as the concave surface 42 that extends to the inward radial end 40.

[0033] The body 36 is located so as to be aligned between the first ramped element 52 and the second ramped element 54 in the circumferential direction 22. In the arrangement shown, the concave surface 42 and the convex surface 44 are both located so as to be aligned between the first and second ramped elements 52 and 54. The first spoke 56 may be free from engagement with the first and second ramped elements 52 and 54 in the arrangement of Figs. 9 and 10. The first spoke 56 is oriented in the radial direction 20 so as to be at the same radial position as the ramped surface 58 of the first ramped element 52. The ramped surfaces 30, 58 are

located further from the base 14 section from which the ramped elements 52, 54 extend than are portions of the ramped elements 52, 54 that do not feature a sloped surface.

[0034] A single one of the spoke to hub guides 50 of the apparatus 10 is also shown and it is located adjacent the hub 26. The spoke to hub guide 50 has a flange that extends in the radial direction 20 with one section that is farther from the hub 26 in the longitudinal direction 24 having a greater extent in the radial direction 20 from the central axis 18 than the second closer to the hub 26 in the longitudinal direction 24. The spoke to hub guides 50 may engage the hub 26 or can be spaced slightly from the hub 26 in the longitudinal direction 24 and not touch the hub 26. Although not shown, the base 14 can engage and support the spoke to hub guides 50. The hub 26 includes the receiving features 34, and the spoke to hub guide 50 is oriented with respect to the receiving feature 34 in the circumferential direction 22 and radial direction 20 so as not to block the front opening of the receiving feature 34. The spoke to hub guide 50 is spaced from the first spoke 56 and the first and second ramped elements 52, 54 and is not in contact with these components 52, 54 and 56.

[0035] Force 70 applied from the press plate 68 or from other components will cause the first spoke 56 and attached shear band 62 to move in the longitudinal direction 24 relative to the spoke to hub guide 50, the first ramped element 52, and the second ramped element 54. Figs. 11 and 12 show the orientation of the apparatus 10 after the first spoke 56 and the shear band 62 have moved some degree in the longitudinal direction 24 toward the ramped elements 52, 54. The body 36 of the first spoke 56 engages the ramped surface 58 of the first ramped element 52. The orientation of the first ramped surface 58 is at the aforementioned angle 32 to the longitudinal direction 24 and this angled surface 58 causes the body 36 to deflect in the circumferential direction 22. The first spoke 56 is rigidly attached at the outward radial end 38 and this area does not change positions upon engagement with the first ramped surface 58. However, the V shaped body 36 will flatten upon engagement with the first ramped surface 58 that will in turn cause the body 36 to extend in the radial direction 20. The body 36 will flatten out in the circumferential direction 22 upon engagement with the ramped surface 58. Engagement with the ramped surface 58 will thus cause the body 36 to move both in the radial and circumferential directions 20 and 22. The middle section of the body 36 will tend to deform and the outer radial ends of the spokes 28 will move more in the radial direction 20.

[0036] The convex surface 44 may be deformed upon engagement so that it engages the first ramped element 52. In a similar manner, the flat surface 66 of the body 36 that is inward in the radial direction 20 from the concave surface 42 will move in the circumferential direction 22

upon engagement of the body 36 with the ramped surface 58. In order to keep the flat surface 66 at a desired orientation relative to the receiving feature 34, the second ramped element 54 is provided with a body guide member 64 on the side of the second ramped element 54 that directly faces the concave surface 42 of the body 36. The body guide member 64 extends outward from the surface of the second ramped element 54 that is closest to the concave surface 42. The flat surface 66 engages the body guide member 64 when the body 36 engages the ramped surface 58, and the body guide member 64 functions to keep the body 36 from flexing too far in the circumferential direction 22 so that it will be in alignment with the receiving features 34. The remainder of the ramped elements 16 also have body guide members 60 disposed onto one of their surfaces in order to help maintain the correct alignment of the spoke 28 upon spoke 28 deflection.

[0037] Upon engagement with the ramped surface 58, the inward radial end 40 will tend to deflect or curl in the circumferential direction 22 past the receiving feature 34. The spoke to hub guide 50 extends beyond the receiving feature 34 outward in the radial direction 20 and will engage the inward radial end 40 and prevent it from moving past in the circumferential direction 22. Extension of the body 36 in the radial direction 20 will cause the inward radial end 40 to be forced down against a circumferentially extending surface of the spoke to hub guide 50. The spoke 28 has some degree of flexibility to it, and portions of the inward radial end 40 will lie flat against the circumferentially extending surface of the spoke to hub guide 50, while other portions of the inward radial end 40 inward in the radial direction 20 will be bent or bowed upwards and out of engagement with the circumferentially extending surface of the spoke to hub guide 50. The surfaces of the spoke to hub guide 50 are aligned with respect to the receiving feature 34 so that the inward radial end 40 is aligned with the front opening of the receiving feature 34.

[0038] Figs. 13 and 14 show the apparatus 10 in a similar configuration as in Figs. 10 and 11 in which the spokes 28 are moved relative to the ramped elements 16 so that the leading edge of the spokes 28 are on the ramped surfaces 30. The views in Figs. 13 and 14 show a plurality of the spokes 28, guides 50, and more ramped elements 16 than in were shown in Figs. 10 and 11. It is to be understood that any number of these components 16, 28, and 50 can be provided about the apparatus 10 and they may all be configured in the same manner as one another so that it is unnecessary to show and describe every one. Engagement of the spokes 28 with the ramped surfaces 30 cause the spokes 28 to exhibit some degree of bending or twisting so that they elongate in the radial direction 20, and twist and move in the circumferential direction 22. The ramped elements 16 may themselves deflect somewhat in the radial 20 and circumferential

directions 22 upon the spokes 28 engaging them and exerting forces thereon. The shear band 62 does not move in the radial direction 20 as the ramped surfaces 30 are engaged by the spokes 28. The inward radial ends 40 engage the spoke to hub guides 50 in this orientation and their forward ends are located flat on the upper surface of the spoke to hub guides 50, while their tailing ends are curved outwards in the radial direction 20. Upon deflection, the spokes 28 may engage both ramped elements 16 immediately adjacent the spoke 28 on opposite sides of the spoke 28 in the circumferential direction 22. In some instances, the body 36 outward in the radial direction 20 on the same side as the concave surface 42 engages the second ramped element 54, and the body 36 inward in the radial direction 20 on the same side as the concave surface 42 engages the body guide member 64 of the same second ramped element 54. The body 36 will also on the opposite side at the convex surface 44 will engage the first ramped element 52 either at the convex surface 44, or inward and outward in the radial direction 20 on opposite sides of the convex surface 44.

[0039] Continued movement of the spokes 28 and shear band 62 in the longitudinal direction 24 will cause the remainder of the inward radial ends 40 to be placed flat onto the upper surface of the spoke to hub guides 50, and the spokes 28 will all be stretched in the radial direction 20 and thus pre-tensioned. The upper surfaces of the spoke to hub guides 50 are at the same distance in the radial direction 20 from the central axis 18 as are the bottoms of the receiving features 34 that are slots in the illustrated embodiment. The leading sides of the inward radial ends 40 are moved into the receiving features 34, and at this point the ramped surfaces 30 end and the ramped elements 16 that are engaged at this point in the longitudinal direction 24 are not ramped. The ramped elements 16 from this point all the way to the base 14 in the longitudinal direction 24 are not ramped and are all located at the same consistent position in the circumferential direction 22. Figs. 15 and 16 show the spokes 28 completely inserted into the receiving features 34 and completely out of engagement with the ramped surfaces 30 and with the spoke to hub guides 50. The first spoke 56 is still in engagement with both the first and second ramped elements 52, 54.

[0040] The slot making up the receiving feature 34 is open at a longitudinal end and at the upper radial end. The inward radial end 40 will tend to be retained into the receiving feature 34 due to its stretching and tendency to contract by moving in the circumferential direction 22. A keyed arrangement can be molded or formed into the receiving features 34 and inward radial ends 40 to further contain the inward radial ends 40 within the receiving features 34. In some exemplary embodiments, a securement mechanism 48 can be used to permanently affix the inward radial ends 40 to the receiving features 34. The securement mechanism 48 is shown in

Fig. 17 as being adhesive 104 that is applied to the terminal inward radial ends of the spokes 28. The inward radial ends 40 with applied adhesive 104 is inserted into the receiving features 34 and engagement with the adhesive 104 to the hub 26 causes secure attachment. The adhesive 104 could alternatively be applied first to the receiving features 34 and not on the inward radial ends 40. Still further, adhesive 104 could be applied to both the receiving features 34 and the inward radial ends 40 to secure attachment.

[0041] Fig. 18 shows another arrangement of the securement mechanism 48 in which the inward radial end 40 does not completely fill the void of the receiving feature 34. The securement mechanism 48 is a key 106 that is press fit into the receiving feature 34 and creates an interference fit with the inward radial end 40. This interference fit functions to retain the inward radial end 40 to the hub 26. The key 106 could be variously arranged, and need not be located inward of the inward radial end 40 in the radial direction 20. In other instances, the key 106 may be on either side of the inward radial end 40 in the circumferential direction 22. Other types of securement mechanisms 48 can be used to effect attachment of the receiving features 34 to the spokes 28 in other embodiments. Still further, it is to be understood that in some arrangements securement mechanisms 48 are not necessary, and in other arrangements the receiving features 34 need not be slots, but could instead be simply lines of adhesive 104, interlocking tabs, or projections that fit within or onto features of the spokes 28. Although described as applying the securement mechanism 48 when the spokes 28 and hub 26 are in the apparatus 10, the securement mechanism 48 may be applied once these components 26, 28 have been removed from the apparatus 10. The receiving features 34 allow for a connection with the spokes 28 that removes the need of having an actuated fixture stretch the spoke 28 into engagement with the hub 26 and hold the spoke 28 against the hub 26 until adhesive has cured or set or until some other type of permanent connection is established. The receiving feature 34 of the hub 26 itself holds the spoke 28 end in place. This attachment may be permanent, or is at least secure enough to allow the hub 26 and held spokes 28 to be removed from the fixture for subsequent permanent attachment by the securement mechanism 48 outside of the fixture, or in some cases within the fixture if desired. Although described as being adhesive 104 or a key 106, other types of securement mechanisms 48 are possible such as crimping or mechanical fasteners.

[0042] After the spokes 28 are received by the receiving features 34 to cause connection to the hub 26, the press plate 68 may be reversed in motion in the longitudinal direction 24 or otherwise lifted off to allow access to the interior of the apparatus 10. The spokes 28, hub 26, and/or shear band 62 can be grasped and pulled or pushed to effect movement of the combined

elements out of the apparatus 10. A press plate installed below the fixture could in some instances be used to push the assembled spokes 28, hub 26 and shear band 62 out of the fixture assembly of the ramped elements 16 and spoke to hub guides 50. The spokes 28 and attached hub 26 are moved in the longitudinal direction 24 opposite to the direction previously described extending from Figs. 9-16. As the spokes 28 are connected to the hub 26, the spokes 28 may not engage the ramped surfaces 30 upon removal of the spokes 28 and hub 26 from the ramped elements 16, base 14, and spoke to hub guides 50. The assembled non-pneumatic tire 12 has spokes 28 that are pre-tensioned from the aforementioned assembly process. The non-pneumatic tire 12 can be removed immediately after assembly so that the fixture can be reintegrated back into the production line. Once removed, a new shear band 62 with attached spokes 28 can be attached to a new hub 26 according to the described method.

[0043] The present apparatus 10 may function by having the ramped elements 16 and spoke to hub guides 50 remain fixed relative to the base 14 so that they are not actuated relative to the base 14. Although they may move relative to the base 14 by having the spokes 28 forced against them, they are not actuated relative to the base 14. The apparatus 10 may not use a cam or air bladder to move the spokes 28 relative to the base 14 or ramped elements 16.

[0044] While the present subject matter has been described in detail with respect to specific embodiments and methods thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing may readily produce alterations to, variations of, and equivalents to such embodiments. Accordingly, the scope of the present disclosure is by way of example rather than by way of limitation, and the subject disclosure does not preclude inclusion of such modifications, variations and/or additions to the present subject matter as would be readily apparent to one of ordinary skill in the art.

WHAT IS CLAIMED IS:

1. An apparatus for assembling a non-pneumatic tire, comprising:

a base;

a plurality of ramped elements that extend from the base and that are disposed about a central axis in a circumferential direction, wherein the central axis extends in a longitudinal direction, wherein the ramped elements each have a ramped surface that is oriented at an angle relative to the longitudinal direction;

a hub that has a plurality of receiving features;

a shear band; and

a plurality of spokes that are attached to the shear band and are spaced from the central axis in a radial direction, wherein the spokes each have a body that is disposed between an outward radial end of the spoke and an inward radial end of the spoke, wherein movement of the spokes relative to the ramped elements in the longitudinal direction causes the spokes to engage the ramped surfaces and be elongated in the radial direction, wherein the inward radial ends of the spokes are received by the receiving features upon additional movement of the spokes relative to the ramped elements in the longitudinal direction.

2. The apparatus as set forth in claim 1, wherein the bodies of the spokes have a concave surface and an oppositely disposed convex surface, wherein the convex surface of the body engages the ramped surface.

3. The apparatus as set forth in claims 1 or 2, wherein during elongation of the bodies of the spokes the outer radial ends of the spokes remain fixed on an inner surface of the shear band and do not move, and wherein during elongation of the bodies of the spokes the inner radial ends move closer to the central axis in the radial direction.

4. The apparatus as set forth in any one of claims 1-3, wherein from 64 to 80 spokes are present, and wherein from 64 to 80 ramped elements are present.

5. The apparatus as set forth in any one of claims 1-4, wherein the receiving features are slots that extend in the longitudinal direction, wherein the inner radial ends are located within the

slots upon the additional movement of the spokes relative to the ramped elements in the longitudinal direction.

6. The apparatus as set forth in claim 5, wherein the inner radial ends are secured within the slots by a securement mechanism selected from the group consisting of adhesive, crimping, and a keyed interference fit.

7. The apparatus as set forth in any one of claims 1-6, wherein the elongation of the spokes upon the movement of the spokes relative to the ramped elements in the longitudinal direction resulting in engagement with the ramped surfaces is maintained after the receiving of the inward radial ends of the spokes by the receiving features to result in the spokes being pre-tensioned.

8. The apparatus as set forth in any one of claims 1-7, further comprising a plurality of spoke to hub guides that are located radially inward from the ramped elements, wherein upon the elongation of the spokes upon movement of the spokes relative to the ramped elements in the longitudinal direction resulting in engagement with the ramped surfaces the inward radial ends of the spokes engage the spoke to hub guides and are prevented from moving past the spoke to hub guides in the circumferential direction.

9. The apparatus as set forth in claim 8, wherein the spoke to hub guides extend from the base, and wherein the spoke to hub guides are spaced from the ramped elements and are not in engagement with the ramped elements.

10. The apparatus as set forth in any one of claims 1-9, wherein each one of the ramped elements is disposed between adjacent spokes in the circumferential direction.

11. The apparatus as set forth in any one of claims 1-10, wherein the plurality of ramped elements has a first ramped element and a second ramped element, wherein the first ramped element is next to the second ramped element in the circumferential direction, wherein a first spoke of the plurality of spokes is disposed between the first ramped element and the second ramped element in the circumferential direction, wherein the first spoke engages the ramped surface of the first ramped element and engages the second ramped element when the first spoke

moves relative to the first and second ramped elements in the longitudinal direction when the first spoke is elongated in the radial direction.

12. The apparatus as set forth in claim 11, wherein the plurality of ramped elements each have a body guide member, wherein the body guide member of the second ramped element engages the first spoke when the first spoke engages the ramped surface of the first ramped element when the first spoke moves relative to the first and second ramped elements in the longitudinal direction when the first spoke is elongated in the radial direction, wherein the body guide member limits movement of the body of the first spoke in the circumferential direction.

13. The apparatus as set forth in any one of claims 11 or 12, wherein the body of the first spoke has a convex surface that engages the ramped surface of the first ramped element, and wherein the body of the first spoke has a flat surface on an opposite side of the body from the convex surface, and wherein the flat surface of the body of the first spoke engages the second ramped element.

14. The apparatus as set forth in any one of claims 1-13, further comprising a press plate that engages the shear band, wherein force applied to the press plate causes the movement of the spokes relative to the ramped elements in the longitudinal direction which causes the spokes to engage the ramped surfaces and be elongated in the radial direction.

15. The apparatus as set forth in any one of claim 14, wherein the only force applied to the ramped elements is via the force transmitted through the press plate.

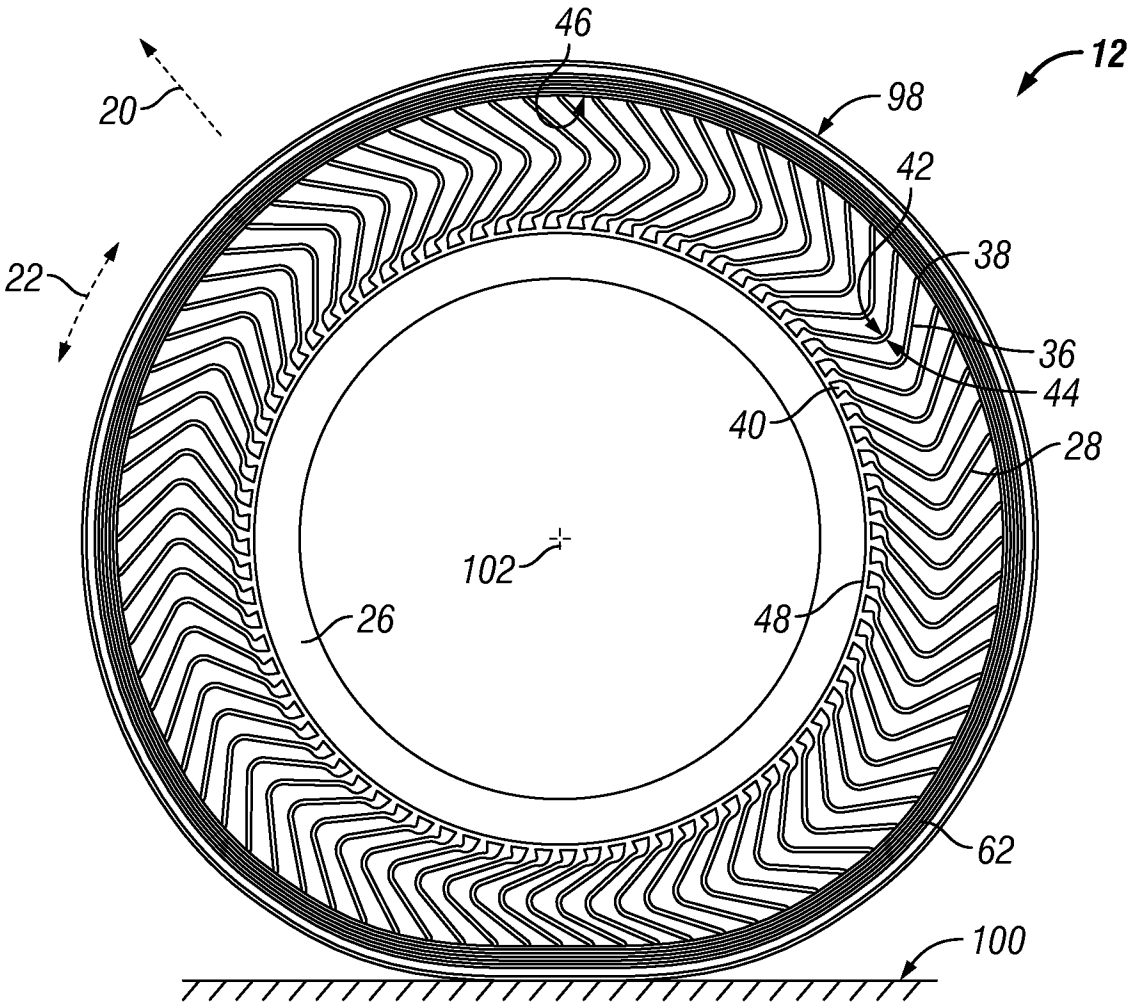


FIG. 1

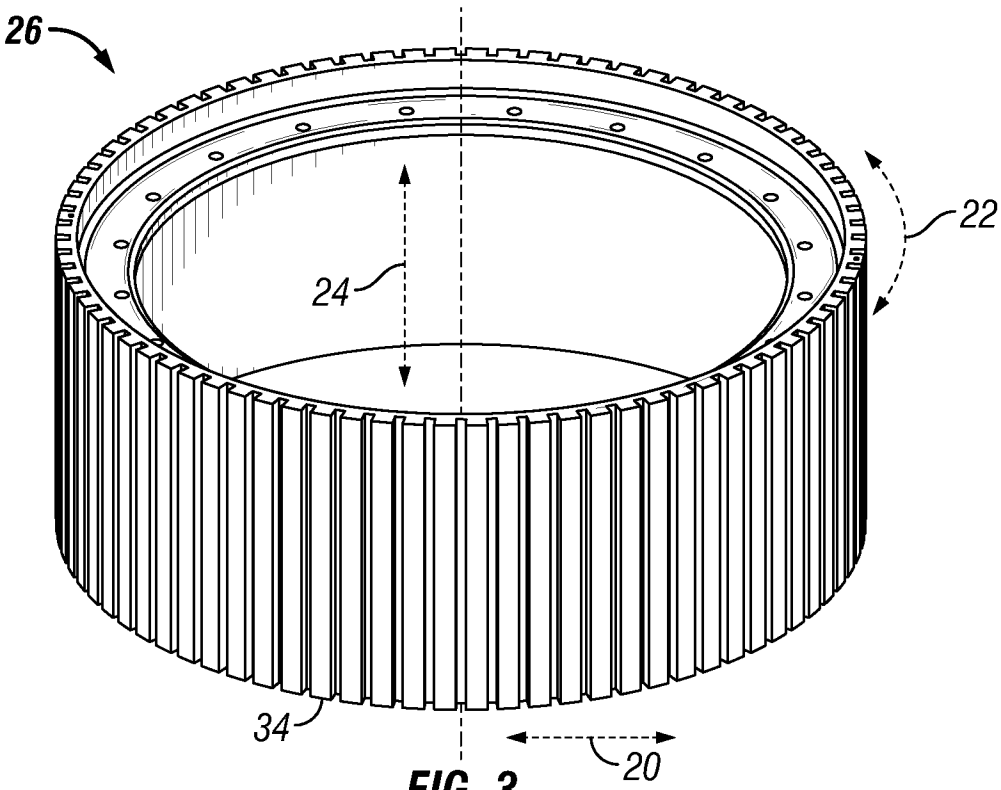


FIG. 3

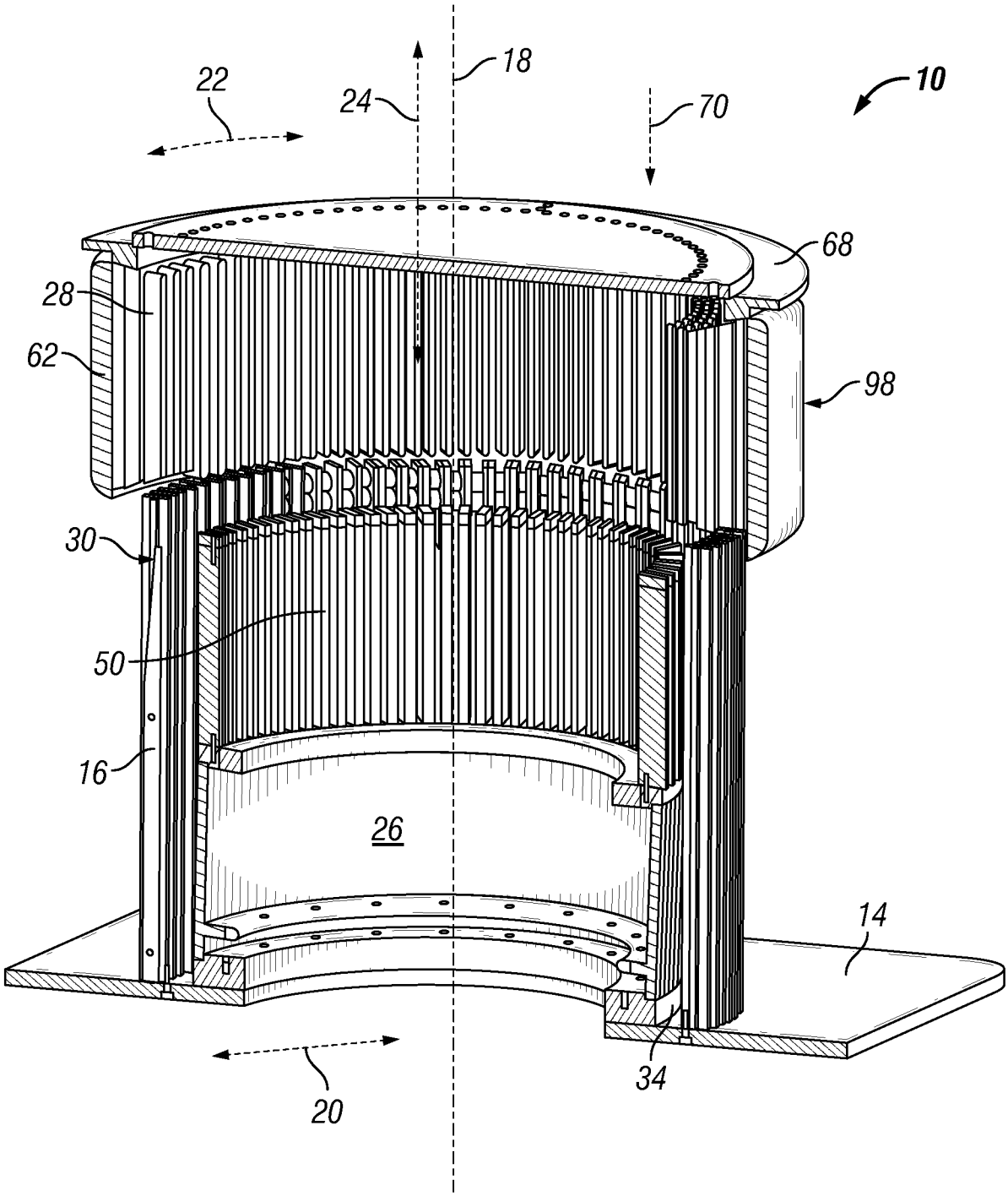


FIG. 2

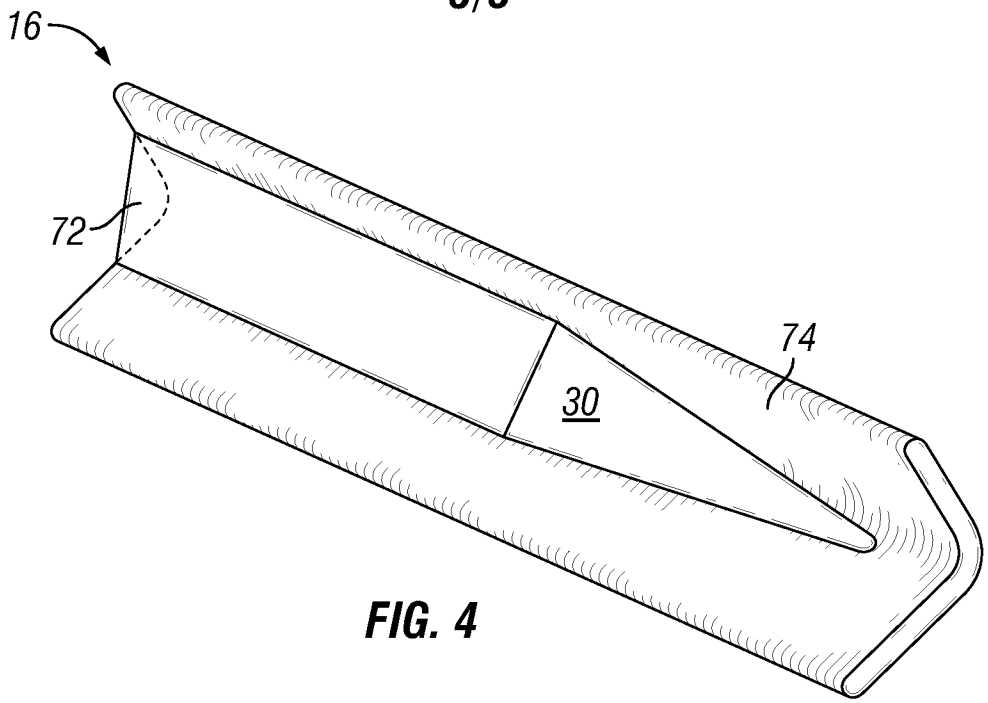


FIG. 4

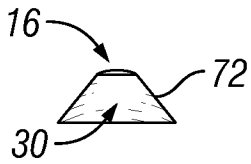


FIG. 5

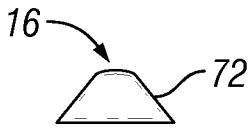


FIG. 6

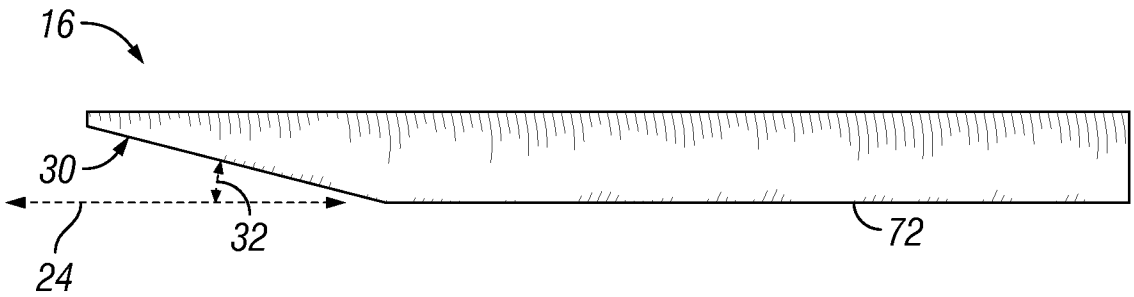


FIG. 7

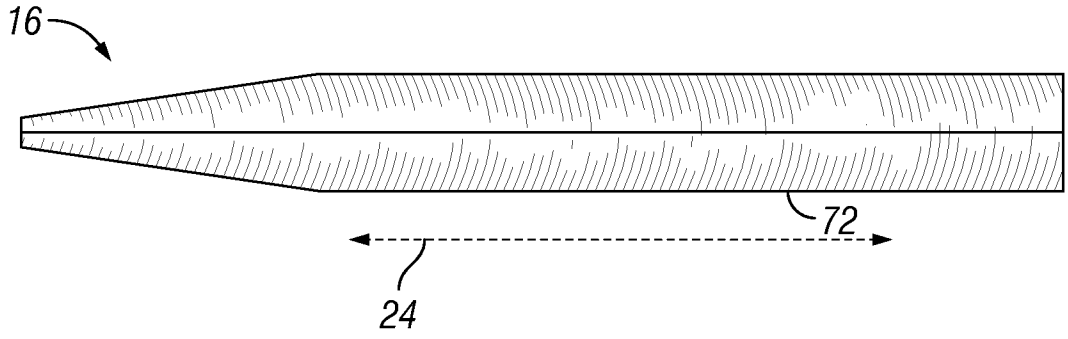


FIG. 8

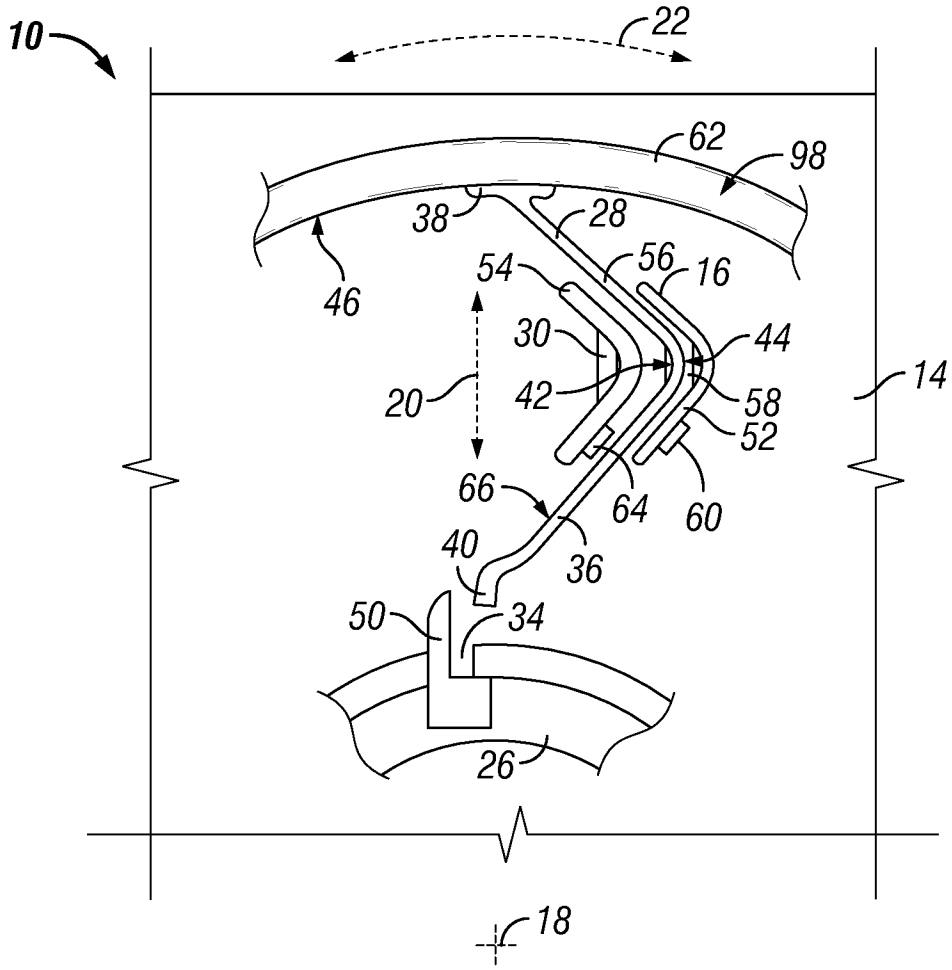

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FIG. 9

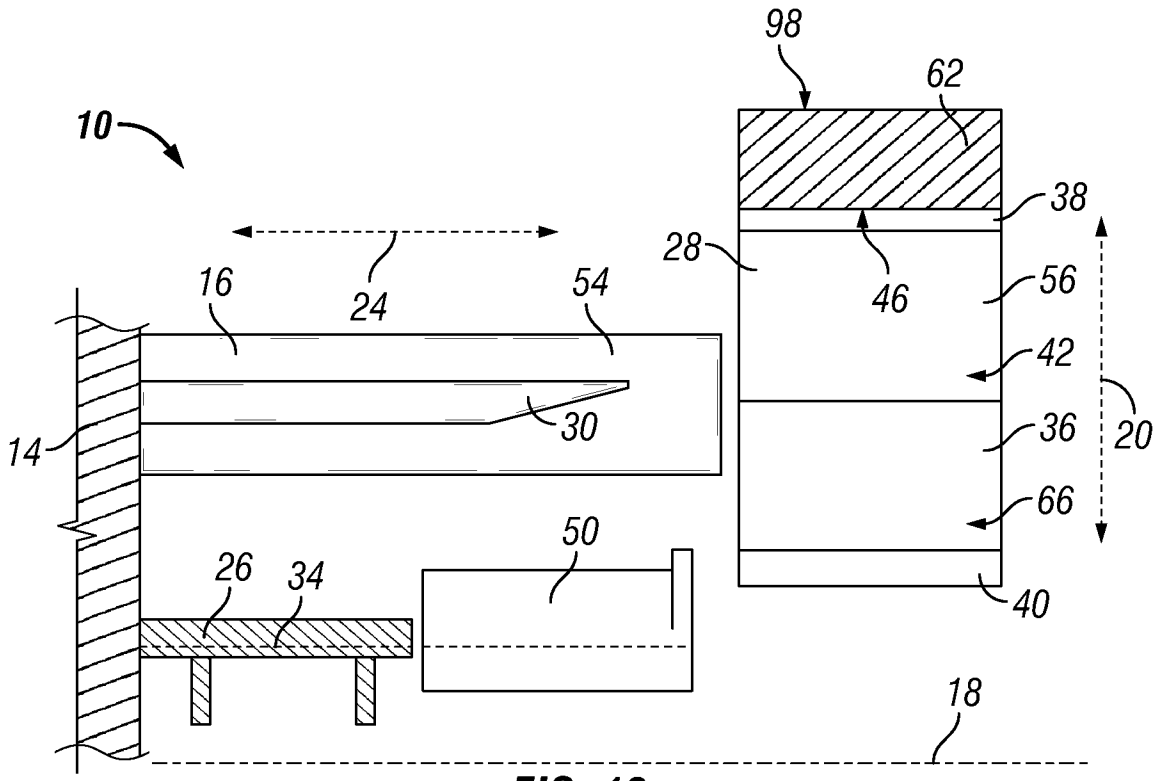

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FIG. 10

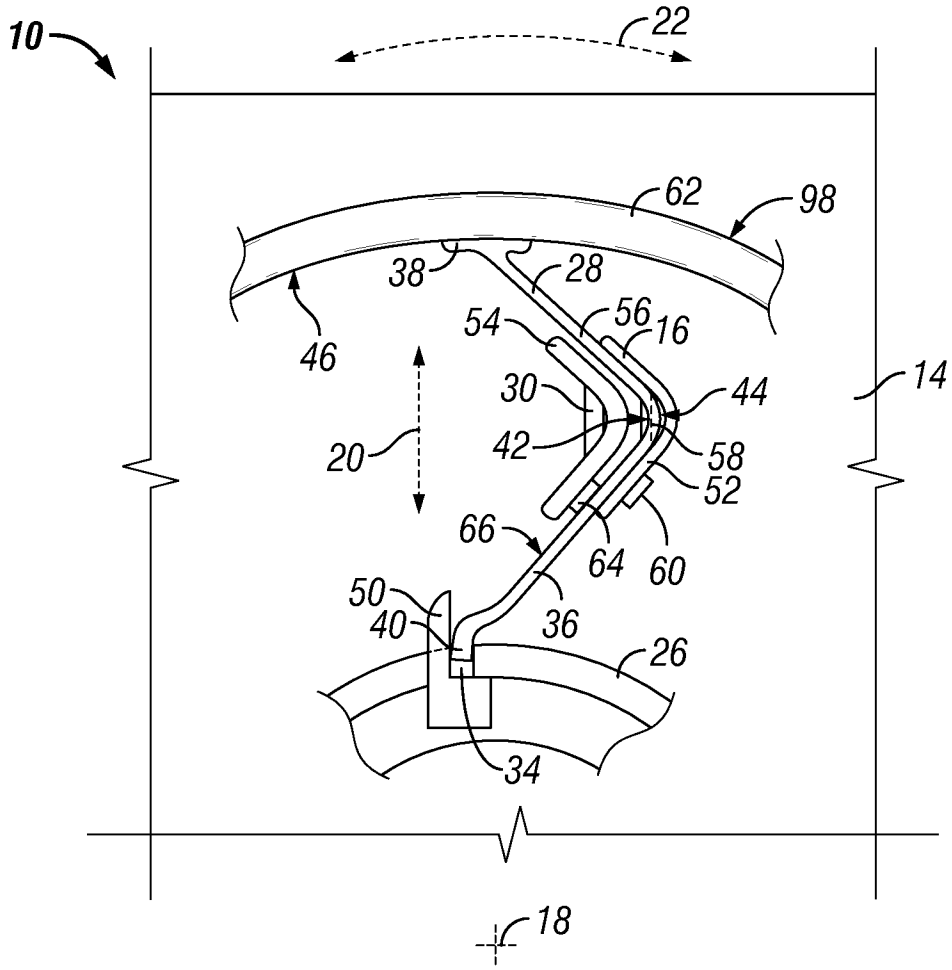

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FIG. 11

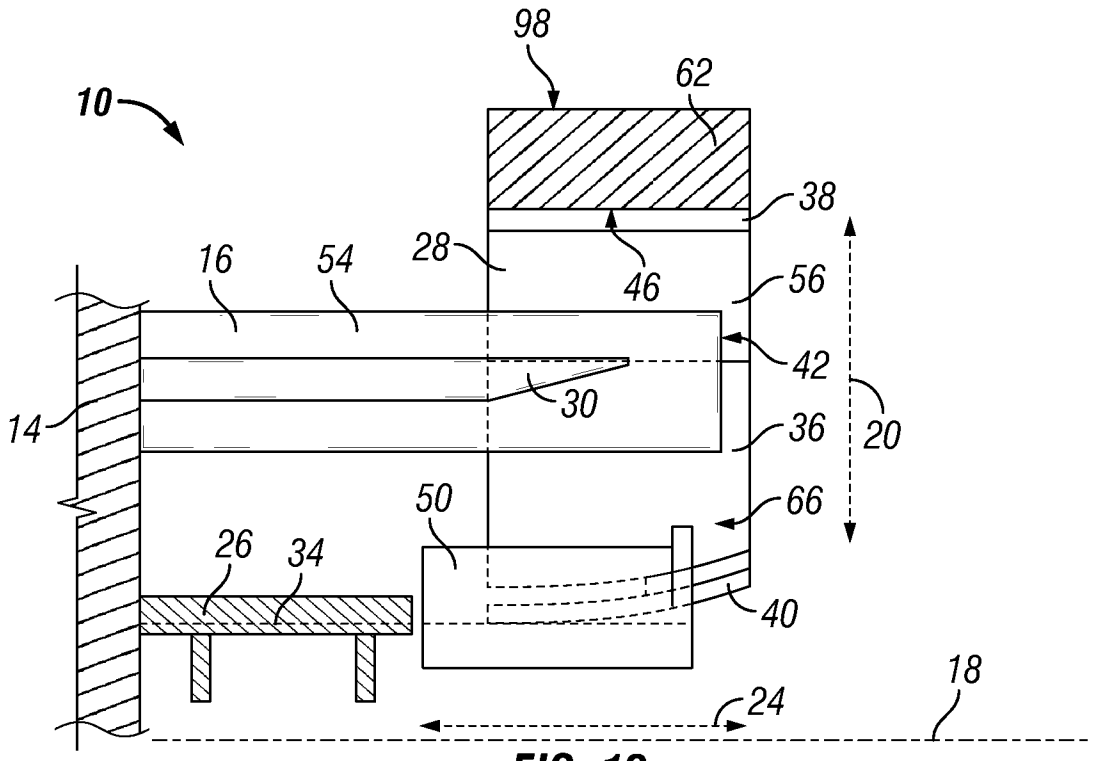

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FIG. 12

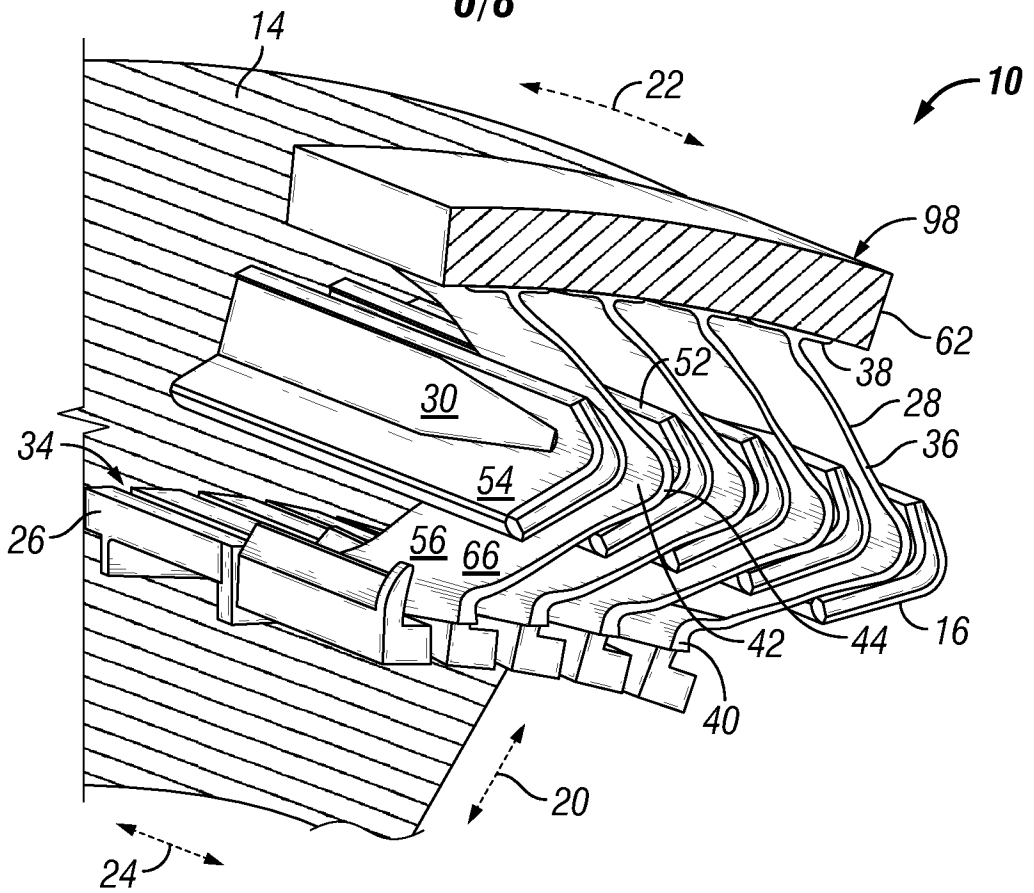

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FIG. 13

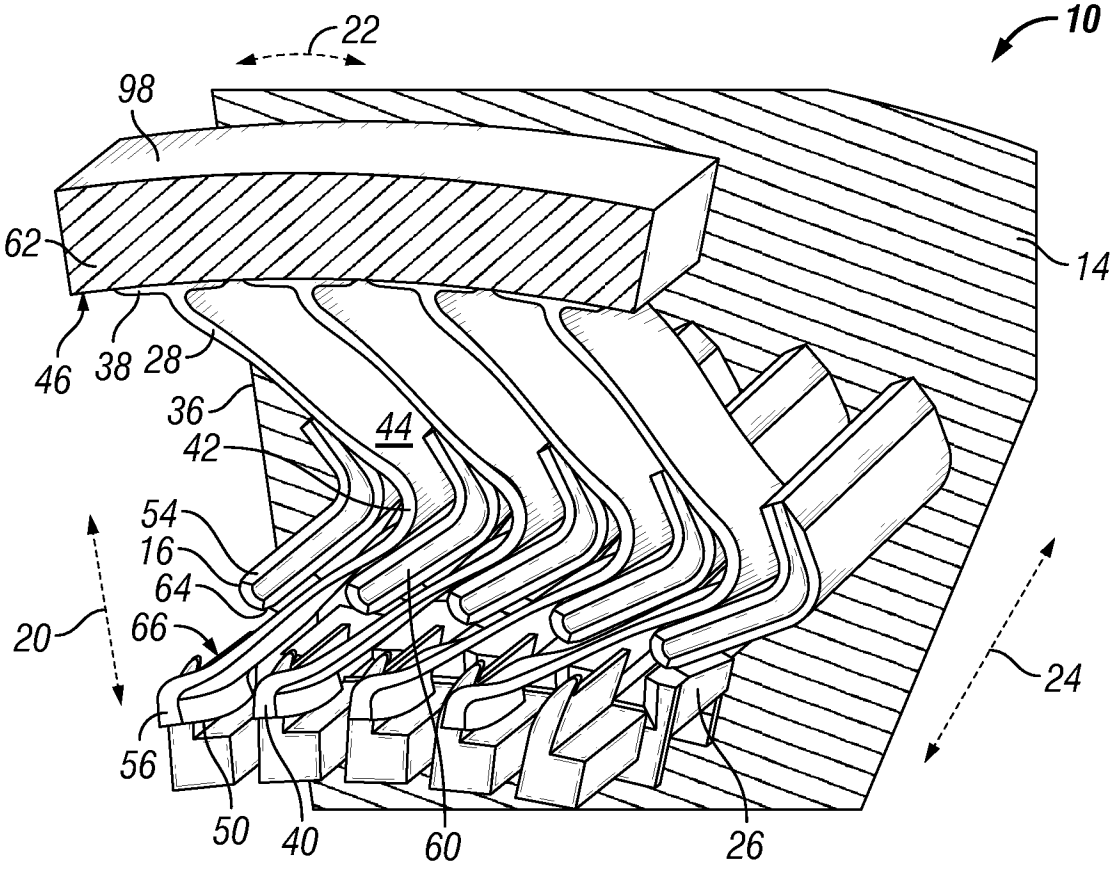

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FIG. 14

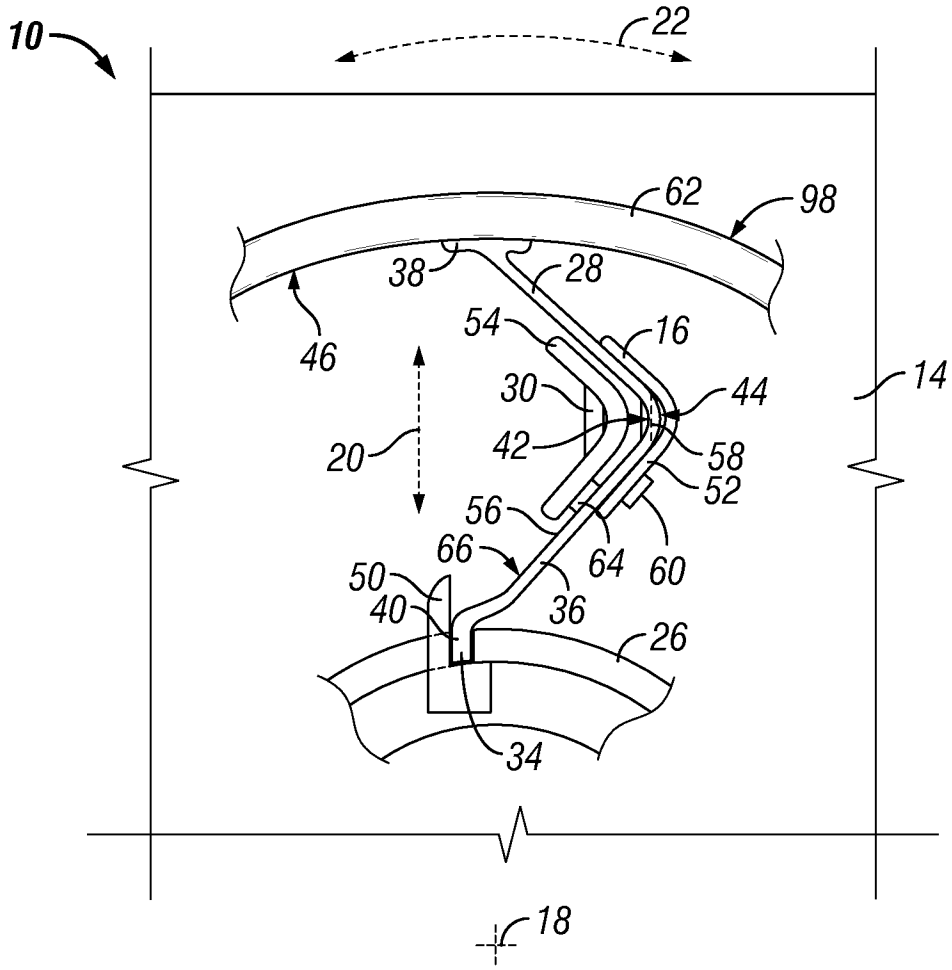

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FIG. 15

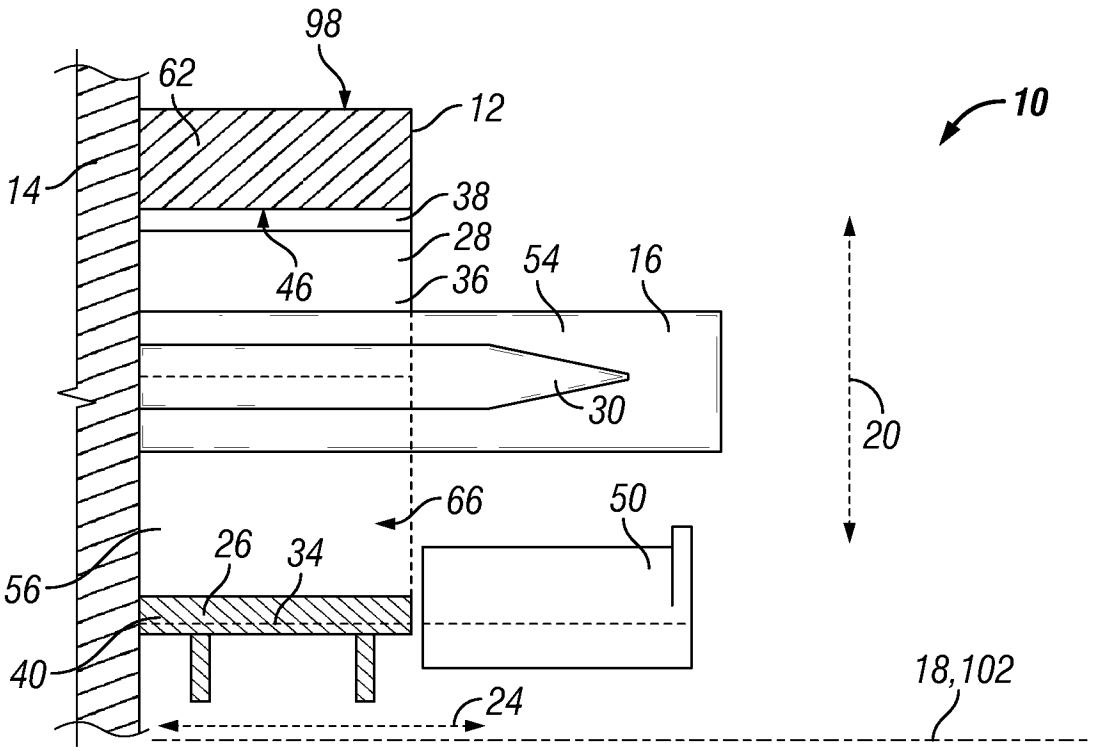

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FIG. 16

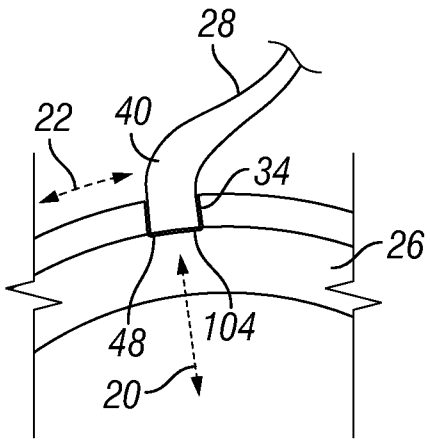


FIG. 17

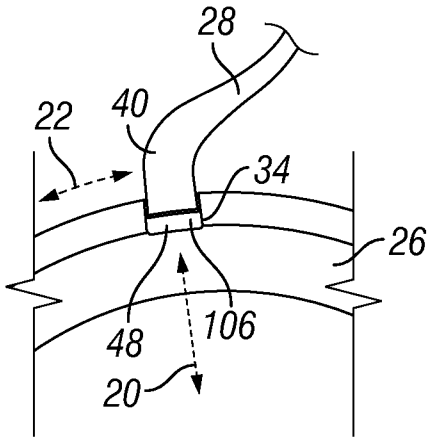


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/069413

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60B31/00
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)
B60B B29D B60C

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.
A	US 103 669 A (SHOGREN AND ADAMS) 31 May 1870 (1870-05-31) page 1; figures 1,2	1-15
A	JP 2011 025759 A (BRIDGESTONE CORP) 10 February 2011 (2011-02-10) paragraphs [0020] - [0034]; figures 1-8	1-15
A	US 2014/070439 A1 (MARTIN KEVIN L [US] ET AL) 13 March 2014 (2014-03-13) paragraphs [0039] - [0045]; figures 1-4	1-15
A	JP H07 96708 A (HAKUHOU KOGYO KK) 11 April 1995 (1995-04-11) paragraphs [0018] - [0029]; figures 1,2	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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

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

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

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

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

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Date of the actual completion of the international search	Date of mailing of the international search report
11 October 2017	20/10/2017

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

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/069413

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 108 233 A (BAER TERRY G ET AL) 22 August 1978 (1978-08-22) column 2, line 5 - column 3, line 44; figures 1-3	1-15

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/069413

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