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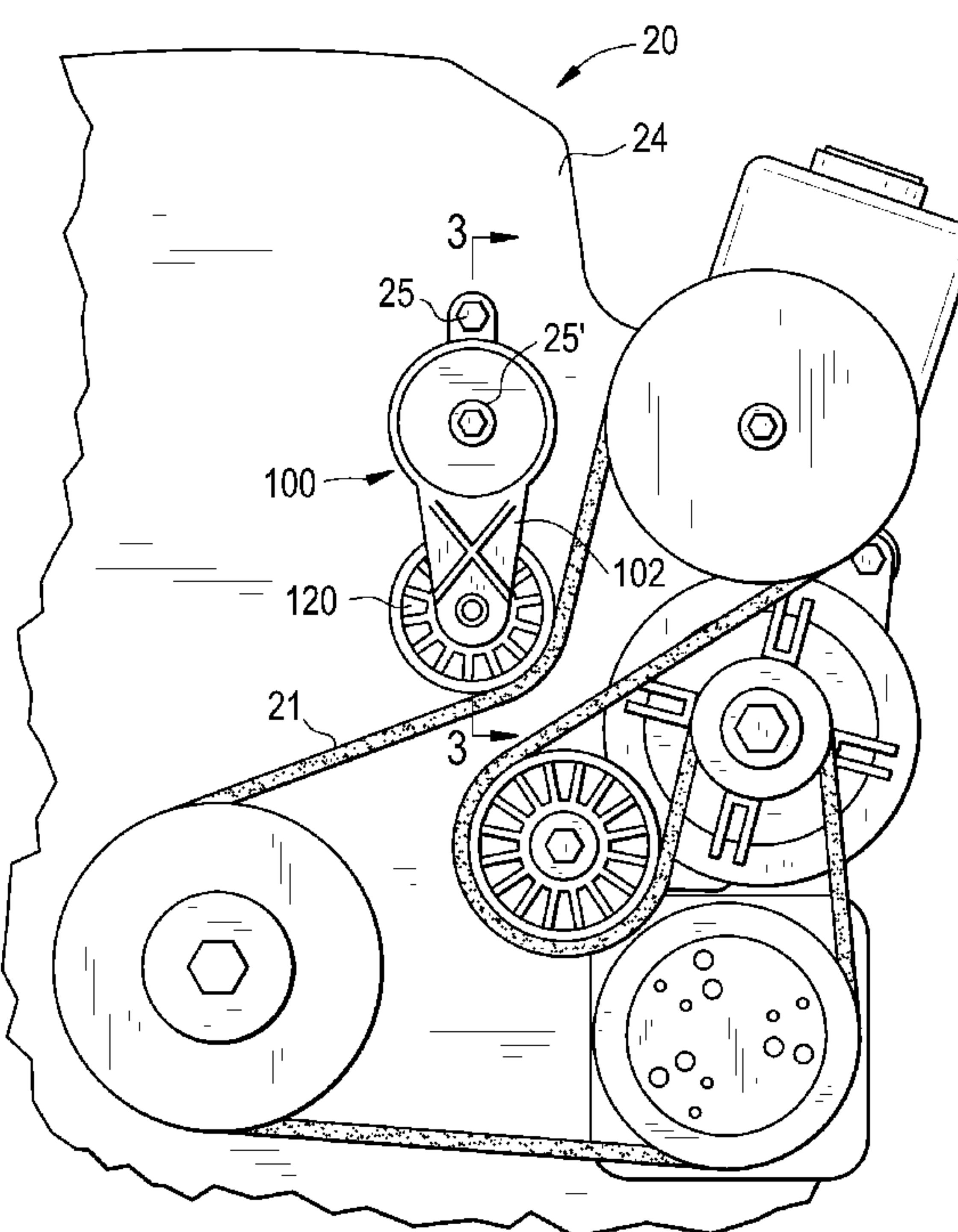
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FROTTEMENT
(54) Title: TENSIONER WITH EXPANDING SPRING FOR RADIAL FRICTIONAL ASYMMETRIC DAMPING

FIG. 1



(57) Abrégé/Abstract:

A tensioner may be part of a power system to tension an endless power transmitting element. The tensioner includes an arm having an arm arbor with a slot therethrough that is rotatable about a first axis, a bushing having a sleeve that includes a cut-out

(57) Abrégé(suite)/Abstract(continued):

and a removable sleeve-segment that has a protrusion thereon, the sleeve-segment being receivable in the cut-out with the protrusion in the slot, and a spring coupled to the arm for rotation of the arm about the first axis into tensioning engagement with a power transmitting element. The spring is positioned where it can radially expand into contact with the protrusion of the bushing, at least the protrusion on the sleeve-segment, as the arm is rotated in a direction opposite the direction of tensioning engagement such that the bushing is urged radially outward relative to the arm arbor to provide frictional damping.

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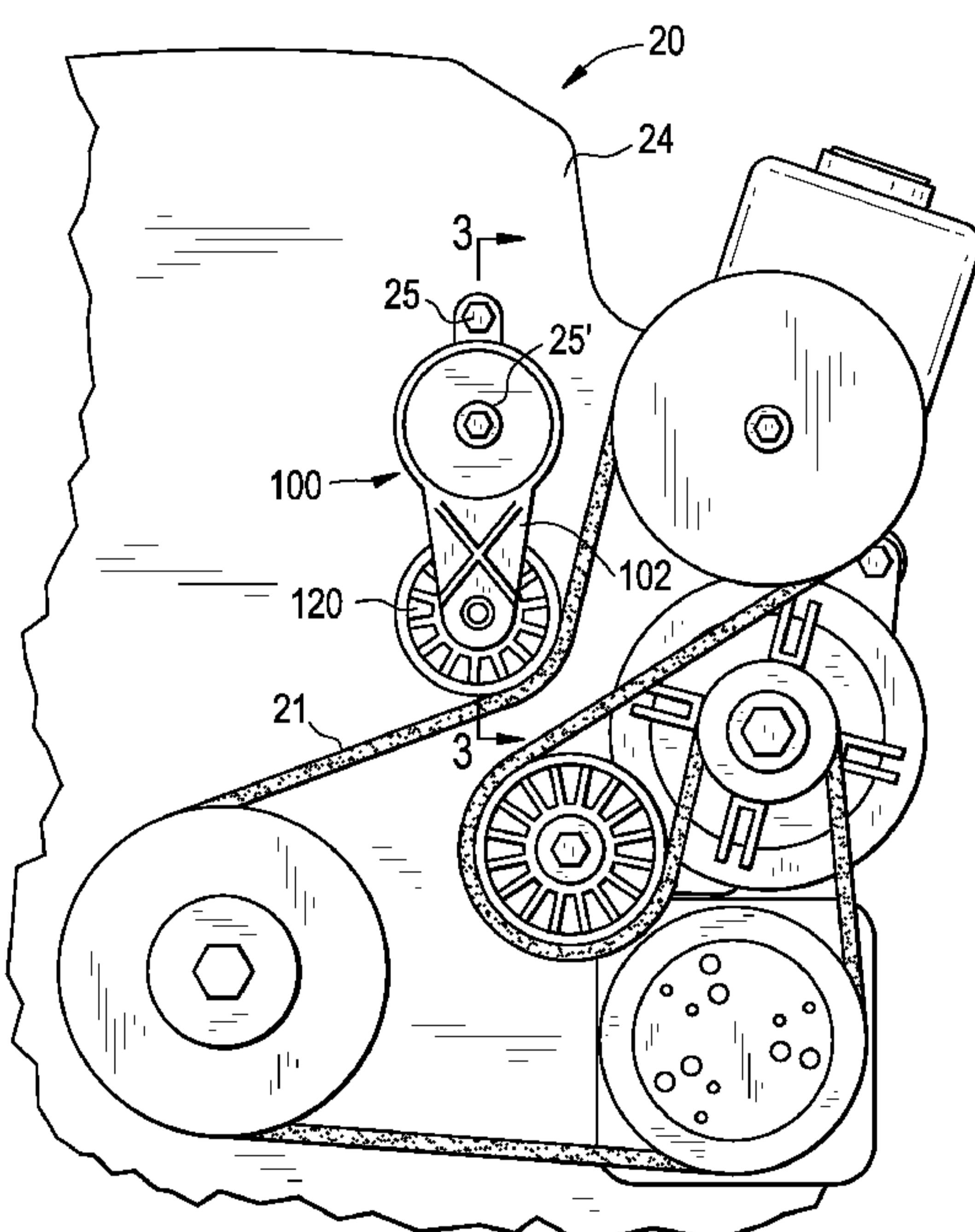
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(54) Title: TENSIONER WITH EXPANDING SPRING FOR RADIAL FRICTIONAL ASYMMETRIC DAMPING

FIG. 1



(57) Abstract: A tensioner may be part of a power system to tension an endless power transmitting element. The tensioner includes an arm having an arm arbor with a slot therethrough that is rotatable about a first axis, a bushing having a sleeve that includes a cut-out and a removable sleeve-segment that has a protrusion thereon, the sleeve-segment being receivable in the cut-out with the protrusion in the slot, and a spring coupled to the arm for rotation of the arm about the first axis into tensioning engagement with a power transmitting element. The spring is positioned where it can radially expand into contact with the protrusion of the bushing, at least the protrusion on the sleeve-segment, as the arm is rotated in a direction opposite the direction of tensioning engagement such that the bushing is urged radially outward relative to the arm arbor to provide frictional damping.

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TENSIONER WITH EXPANDING SPRING FOR RADIAL FRICTIONAL ASYMMETRIC DAMPING

Related Applications

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 12/874,797 filed September 2, 2010, the entire contents of which are hereby incorporated by reference.

Technical Field

[0002] The present invention relates generally to tensioners and more particularly to an asymmetrically damped tensioner utilizing an expanding spring to provide radial friction-damping.

Background

[0003] It is common for a tensioner such as a belt tensioner to have a means to dampen movement of the tensioner arm caused by belt tension fluctuation. The required magnitude of this damping depends on many drive factors including geometry, accessory loads, accessory inertia, engine duty cycle and others. For instance, drive systems that have higher torsional input or certain transient dynamic conditions may require higher damping to sufficiently control tensioner movement. Although higher damping is very effective at controlling arm movement, it can also be detrimental to other critical tensioner functions (e.g. slow or no response to slack belt conditions). In addition, variation or change in damping that occur as a result of manufacturing variation, operating temperature and component break-in or wear can also cause the tensioner to be unresponsive.

[0004] Timing belt systems have benefited from the use of asymmetric damping to address this problem. An asymmetrically damped tensioner provides damping when additional belt tension is encountered, but is free to respond to slack belt conditions. Although asymmetric functionality may not be required for all other front end accessory drive tensioners, the potential for increased service life, solving other transient dynamic system problems including belt slip, or simply making the tensioner less sensitive to damping variation make it a desirable design option.

[0005] Many belt tensioner damping mechanisms that utilize frictional damping use axial forces to move components of the tensioner to create the frictional force that does the damping. These designs tend to require a means to contain the axial force and some components of the belt tensioner must be more robust to withstand the axial force over the lifetime of the tensioner.

Summary

[0006] One aspect of the disclosed tensioners is a tensioner embodiment where the radial damping force can be contained within a support wall rather than relying on joints. The radial damping is preferably asymmetric.

[0007] In one embodiment, a tensioner is disclosed that may be part of a power system where the tensioner provides tension to an endless power transmitting element such as a belt, chain, or other continuous loop. The tensioner has an arm that is rotatable about a first axis and includes an arm arbor having a slot therethrough, a bushing having a sleeve that includes a cut-out and a removable sleeve-segment receivable in the cut-out, the bushing having a protrusion at least on the sleeve-segment, the protrusion being positioned adjacent the arm arbor with the protrusion in the arm arbor's slot, and a spring coupled to the arm urging the arm to rotate about the first axis into tensioning engagement with a power transmitting element. The spring is positioned where it can radially expand into contact with the protrusion of the bushing as the arm is rotated in a direction opposite the direction of tensioning engagement such that the bushing is urged radially outward relative to the arm arbor to provide frictional damping.

[0008] In another embodiment, the tensioner includes a support member housing the spring, the arm arbor, and the bushing with the bushing adjacent the support member and the arm arbor between the spring and the bushing. Accordingly, when the spring is expanded radially it urges the bushing into frictional engagement with the support member to provide the frictional damping.

[0009] The bushing may include a longitudinal slit therethrough that allows radial expansion of the bushing in response to the radially expansion of the spring. In one embodiment, the bushing includes a substantially cylindrical sleeve that has the longitudinal slit therein and has at least one protrusion on its inner surface. The bushing may also have a flange extending outward from one end of its sleeve.

[0010] The arm arbor of the arm preferably has a fixed diameter such that the arm arbor does not respond to the radial expansion of the spring. Instead, just the bushing is expanded radially by the expanding spring. The tensioner may also include a cap enclosing the spring within the tensioner.

[0011] In one embodiment, the arm includes a pulley rotatably mounted about a second axis, the second axis being spaced from and parallel to the first axis.

Brief Description of the Drawing

[0012] FIG. 1 is a front view of an engine which utilizes an embodiment of a tensioner.

[0013] FIG. 2 is an exploded perspective view of an embodiment of a tensioner.

[0014] FIG. 3 is a side, cross-sectional view of the tensioner of FIG. 1 taken along line 3-3.

[0015] FIG. 4 is a cross-sectional view of the tensioner of FIG. 3 taken along line 4-4.

[0016] FIG. 5 is a cross-sectional view of an embodiment of a tensioner showing the underside of the cap connected to the arm, pivot shaft, and spring.

[0017] FIG. 6 is a side, bottom perspective view of the cap of FIG. 5.

[0018] FIG. 7 is an exploded perspective view of another embodiment of a tensioner.

[0019] FIG. 8 is an assembled side view of the tensioner of FIG. 7.

[0020] FIG. 9 is an exploded bottom perspective view of the tensioner of FIG. 8 without the support member.

[0021] FIG. 10 is a cross-sectional top view of the assembled tensioner of FIG. 8 taken along line 10-10.

Detailed Description

[0022] The following detailed description will illustrate the general principles of the invention, examples of which are additionally illustrated in the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0023] The damping mechanism and tensioner disclosed herein provide an asymmetric frictional damper. The tensioner is typically part of a power system where the tensioner provides tension to an endless power transmitting element such as a belt, chain, or other continuous loop that are in a system driven by at least one source and that may also drive an accessory. The power transmitting element and the tensioner operate in concert with the tensioner providing tension to the endless power transmitting element as needed and responding to dynamic conditions thereof.

[0024] Referring now to FIG. 1, an engine is generally indicated by the reference numeral 20 and utilizes an endless power transmitting element 21 for driving a plurality of driven accessories as is well known in the art. The belt tensioner of this invention, generally designated as 100, is utilized to provide a tensioning force on the endless power transmitting element 21. The endless power transmission element 21 may be of any suitable type known in the art. The tensioner 100 is configured to be fixed to a mounting bracket or support structure 24 of the engine 20 by a plurality of fasteners 25. The fasteners may be bolts, screws, welds, or any other suitable fastener known in the art that will hold the tensioner in place during operation of the engine. The mounting bracket or supporting structure 24 may be of any configuration and include any number of openings for receiving the fasteners 25.

[0025] Tensioning a slack endless power transmitting element with the tensioner disclosed herein is unusual in that it is the winding of an unwound spring that operates to rotate the arm of the tensioner to provide tension, which will be referred to herein as the tensioning direction **T**. In the opposite direction, referred to herein as the winding direction **W**, the tensioner arm may be considered to be winding in response to a prevailing force of the endless power transmitting element which is tightening in the span where the tensioner resides; however, uncharacteristically for tensioners, the winding of the tensioner arm corresponds to an unwinding of the spring within the disclosed tensioners.

[0026] The winding of the tensioner may have some potentially undesirable effects upon the drive system's intended function. To mitigate these undesirable effects it may be helpful

to have a damper or damping mechanism, for example a frictional damper, incorporated in the tensioner to resist the movement of the power transmitting element, without adversely affecting rotation of the tensioner, in particular its arm to tension the power transmitting element. This kind of frictional damping is generally known as asymmetric damping, and in the tensioners disclosed herein the unwinding of the spring provides such damping. The unwinding of the spring expands its coils outward, enlarging its coil diameter, which is herein utilized to provide the asymmetric friction damping by having the spring act upon another component of the tensioner in that the spring urges into frictional engagement with another surface.

[0027] Referring to FIGS. 2-3 and FIGS. 7-8, the tensioners 100 and 100' disclosed herein provide asymmetric frictional damping to the movement of an arm 102 through the expansion of spring 106 as it is unwound in response to a belt load or other prevailing force of the endless power transmitting element which is tightening in the span where the tensioner resides. The spring 106 transfers an outwardly directed force, a radial force, from its expanding coils to a bushing 108 to urge the bushing 108 (FIGS. 2-3) or bushing 108' (FIGS. 7) into frictional engagement with an interior surface 146 of a support member 114 that houses at least part of the spring 106 and bushing 108, 108' such that substantial frictional damping is applied to the belt tensioner in the winding direction **W**. As explained above, the winding direction occurs when increasing tension causes the endless power transmitting element to lift the tensioner arm in a direction away therefrom. The tensioner resists rotating in the winding direction **W** with a frictional damping force, but does not substantially resist movement of the tensioner arm toward the belt with the same frictional damping force.

[0028] Unique to the construction of the tensioners disclosed herein is the use of the radially expanding spring where the radial expansion provides the force to urge parts into frictional engagement to provide damping and the radially expanded, i.e., unwound, spring then applies a torsional force to apply torque to the tensioner arm to rotate the tensioner arm in the tensioning direction **T**, i.e., toward the power transmitting element.

[0029] The tensioner's application of radial force, rather than axial force, allows some of the components to be made from less costly materials as the components and joints do not need to be as robust as they would to withstand axial forces. The absence of axial forces allows some components to be made thinner, which can reduce the weight of the tensioner

and the cost. Any radial forces that exist in the tensioner can be contained effortlessly within the support member of the belt tensioner.

[0030] The tensioners 100 and 100' of FIGS. 2-6 and 7-10, respectively, contain many of the same or similar components. The components will be described in detail with respect to tensioner 100 of FIGS. 2-6, but the description is equally applicable to tensioner 100' of FIGS. 7-10 for the same reference numbers. One difference between the tensioners 100 and 100' is the configuration of the bushings 108' (FIG. 7) and 108 (FIG. 2).

[0031] Turning now to FIGS. 2-6, the tensioner 100 includes a tensioner arm 102 rotatable about a first axis **A** in the tensioning direction **T** and in the winding direction **W** opposite the tensioning direction as shown in FIG. 3, a spring 106, a bushing 108, a support member 114, and a cap 118. The arm 102 includes a pulley 120 rotatably mounted to its first end 130 for rotation about a second axis **B** that is spaced from and parallel to the first axis **A**. The pulley 120 may be coupled to the arm 102 with a pulley bolt 122 or other fastener and may include a dust cover 124.

[0032] The arm 102 includes, at its second end 132, an arm arbor 104 extending from the arm about the first axis **A**. The arm arbor 104 may include a sleeve 152 that has an open first end 154 and a partial bottom 117 that defines an open second end 156 that has a smaller opening compared to the first end 154. In one embodiment, the sleeve 152 is generally cylindrical and defines a housing 150 that may receive the spring 106. Within the sleeve 152 one or more slots 116 are present that extend therethrough, i.e., the slots are open from the exterior surface of the arm arbor 104 into its interior. Upon assembly, the first end 154 of the sleeve 152 may be closed by the cap 118 and the second end 156 may be closed by the support member 114. The cap 118 and support member 114 may enclose the other components of the tensioner, for example, the spring 106, the arm arbor 104, and the bushing 108, and protect them from contaminants.

[0033] In one embodiment, the arm arbor 104 includes two slots 116, more preferably as shown in FIG. 2, three slots 116, but is not limited to any particular number of slots. The slots 116 may be positioned equally distant apart about the arm arbor 114, which is advantageous to distribute the force exerted by the expanding spring 106 more uniformly onto the bushing 108. In one embodiment, the slots 116 may extend through the sleeve 152. The slots 116 may be any shape and/or configuration that allows the protrusions 110 of the

bushing to extend into the cavity 143 defined by the sleeve 152 for contact with spring 106 as it expands.

[0034] As best seen in FIG. 3, the slots 116 may extend through the sleeve 152 and into the partial bottom 117. The portion of the slots 116 in the partial bottom 117 only extend partially radially, inward into the partial bottom 117, such that the partial bottom 117 is circumferentially discontinuous at its outer periphery and circumferentially continuous at its inner periphery. The inner periphery being the edge closest to the first axis A. The circumferentially continuous inner periphery helps stabilize or provide rigidity to the open second end 156 of the sleeve 152 and provides the arm arbor 114 with fixed dimensions. In one embodiment, the sleeve 152 is substantially cylindrical and has a fixed diameter.

[0035] The partial bottom 117, as best seen in FIG. 4, includes an abutment feature 180 positioned within the interior of the sleeve 152. The abutment feature 180 receives the first end 107 of the spring 106. Accordingly, when the arm arbor 104 rotates with the arm 102, the abutment feature 180 urges the spring 106 to unwind and radially expand its diameter. In one embodiment, the abutment feature 180 is a partition or protrusion that provides a generally planar surface for a generally flat cut end of the spring 106 to abut thereagainst in direct contact. In another embodiment, the abutment feature 180 may be a sleeve, a bracket, a recess, or other receptacle that the spring end 107 fits into to connect the spring to the arm arbor 104 for movement therewith.

[0036] In one embodiment, the abutment feature 180 may be a ramping feature, which depending on the ramp direction, could either increase or decrease the outward expansion of the spring. One of skill in the art will appreciate that the shape and/or contour of the abutment feature 180 may be such that the tensioner could have asymmetric or progressive damping.

[0037] The second end 132 of the arm 102 may also include a flange 158 about the periphery where the arm arbor 104 connects to the arm 102. The flange 158, upon assembly of the tensioner 100, may seat upon flange 115 of the support member 114. Extending from flange 158 there may be a tab 140 projecting outward that may act as a stop to limit the rotational movement of the arm 102 about first axis A when the tab 140 contacts a stop, for example, stop 142 on the support member 114 and/or tab 136 on the cap 118.

[0038] The arm arbor 104 is received in the cavity 143 of the support member 114. The support member 114 has a closed end 160 and an open end 162 and includes a pivot shaft 144 that extends from the closed end 160 into the cavity 143 and about which the arm arbor 104 rotates. The support member 114 may facilitate mounting the tensioner 100 in place relative to an endless power transmitting element. In one embodiment, the pivot shaft 144 is generally centrally positioned within the cavity 143 and has an axially extending opening 145 or bore that may receive a bolt, screw, pin, or other fastener 25' (shown in FIG. 1) to hold the assembled belt tensioner together and/or to mount the tensioner to a surface relative to an endless power transmitting element. The support member 114 may also receive and/or house at least part of the bushing 108 and spring 106.

[0039] In one embodiment, the support member 114 may include an upper rim 115 or flange extending outward about the periphery of the open end 162 of the cavity 143 and a stop 142 projecting outward from the exterior wall thereof proximate to the open end 162 or as an extension of the flange 115. In one embodiment, the support member 114 may also include a positioning pin 147 on the exterior surface of the closed end 160 of the cavity 143 that is receivable in a receptacle that may be provided on the mounting bracket or supporting structure 24 of the engine 20.

[0040] As shown in FIGS. 2-3, a bushing 108 is positioned or positionable between the arm arbor 104 and the interior surface 146 of the support member 114 and is adjacent the exterior surface of the arm arbor 104. The bushing 108 includes a sleeve 119 having a first open end 170 and a second open end 172 and one or more protrusions 110 extending from the sleeve's interior surface 168 toward the first axis A. In one embodiment, the sleeve 119 is generally cylindrical. The number of protrusions 110 preferably matches the number of slots 116 in the arm arbor 104 such that the bushing 108 is mateable with the arm arbor 104 with its protrusions 110 received in the slots 116. Accordingly, the protrusions 110 are shaped to mate with the slots 116 of the arm arbor 104. The protrusions 110 are also dimensioned such that they extend through the arm arbor 104 into its interior cavity 143 and are accessible to or by the spring 106 as it expands upon unwinding.

[0041] The bushing 108 may also include a flange 113 extending outward from one end of the sleeve 119, for example, from the first open end 170. In the embodiment of FIGS. 2-3, the bushing 108 includes a slit 112 therethrough extending from the first open end 170 to the second open end 172. The slit 112 enables the bushing 108 to expand radially in response to

the expansion of the spring 106 as it unwinds. In an alternate embodiment, the bushing 108 may be generally elastic.

[0042] Spring 106 is seated within cavity 143 of the support member 114 with its coils juxtaposed to the protrusions 110 of the bushing 108. Accordingly, when the arm 102 rotates in response to belt loading or other prevailing force of the endless power transmitting element which is tightening in the span where the tensioner resides, the spring 106 will unwind, increasing the coil diameter, and radially expand its coils into the protrusions 110 of the bushing 108 thereby directing the bushing 108 radially outward relative to the arm arbor 104, which remains stationary, and into frictional engagement with the interior surface of the support member 114. When the belt loading or other prevailing force of the power transmitting element dissipates, the torque built up in the spring 106 as a result of its unwound state urges the tensioner arm 102 to rotate in the tensioning direction **T** as the spring returns to its wound state. Accordingly, the spring 106 is coupled to the tensioner arm 102 such that the spring provides the torque to urge the tensioner arm in the tensioning direction **T**.

[0043] The spring 106 is a torsional spring of any shape and/or configuration. In one embodiment, the torsional spring is a round-wire spring. In another embodiment, the torsional spring may be a square or rectangular spring or a square or rectangular coil spring. In another embodiment, the torsional spring is a flatwire spring. One of skill in the art will appreciate that to these various torsional springs may require alternate spring end engagement points within the tensioner to provide secure attachments so that the spring winds and unwinds appropriately to bias the arm.

[0044] The spring 106 preferably has a first end 107 coupling the spring 106 to the tensioner arm 102, in particular to the arm arbor 104, and a second end 109 coupling the spring 106 to the cap 118. The first end 107 of spring 106, as discussed above, abuts against or is received in a first abutment feature 180 of the tensioner arm 102, best seen in FIG. 4, to couple the tensioner arm 102 to the spring 106 so that rotation of the tensioner arm 102 in the winding direction **W** unwinds the spring and thereby radially expands the diameter of the spring's coils. Thereafter, the torque of the unwound expanded spring 106 can rotate the tensioner arm 102 in the tensioning direction **T** to tension a power transmitting element when the force lifting the tensioner arm in the winding direction **W** is reduced. As the spring 106 uses its torque to rotate the arm 102, the spring 106 winds back toward its original position

thereby reducing and/or removing the radial force from the protrusions 110 of the bushing 108 such that reduced or substantially no frictional damping to resist rotation of the tensioner arm toward the belt occurs. The damping of the tensioner 100 is asymmetric.

[0045] The second end 109 of spring 106 is likewise abutted against or received in a second abutment feature (item 182 in FIG. 5) located in the cap 118. The second abutment feature in the cap 118 may be the same as or different from the first abutment feature 180. It is preferable that the second end 109 of the spring is stationary, i.e., held stationary by the cap 118, which is stationary relative to the arm 102. Accordingly, the second abutment feature in the cap 118 should be configured to hold the second end 109 of the spring 106 stationary.

[0046] The cap 118 of FIGS. 1-3 includes a generally centrally located bore 134 for receiving a fastener 25' such as a bolt, screw, rivet, or other fastener for securing the cap to the tensioner. The bore 134 may be countersunk into the upper surface 135 of the cap to receive the head of the fastener. The cap 118 may also include a tab 136 extending outward therefrom. The tab 136 may be L-shaped and comprise an arm 138 extending generally horizontally outward from the outer periphery of the cap 118 and a flange 139 generally extending vertically down from the end of the arm 138 opposite the periphery of the cap. On the underside 137 of the cap, a second abutment feature for receiving one end of the spring 106 may be formed therein or thereon. A track 192 may be recessed into the underside 137 of the cap for receiving the spring 106 and may define at least part of the abutment feature and extend away therefrom. The track 192 preferably matches the curvature or shape of the spring 106. In one embodiment, the cap 118 may include more than one tab 136 and the tabs may fix the cap 118 to the arm 102 and/or the support member 114.

[0047] In another embodiment, illustrated in FIGS. 5-6, the cap, generally designated as 118', has a splined attachment to the pivot shaft 144. The pivot shaft 144 has splined end 186 opposite the pivot shaft's junction to the closed end 160 of the cavity 143 and a bore 145. The splined end 186 provides a mating connection between the support member 114 and cap 118'. To mate with the splined end 186, the cap 118' has a knob 188 comprising an internal configuration of alternating ridges 194 and recesses 196. The cap 118' is held stationary by the knob's 188 connection to the splined end 186 of the pivot shaft 144.

[0048] The cap 118' may include a generally centrally located bore 134' that is positioned through the center of the knob 188. The cap 118' may also include a track 192' recessed into

the underside 137' thereof. The track 192' is shaped to match the shape of the torsional spring 106, in particular, the portion of the spring that includes the second end 109 of the spring 106 and at least part of the first coil extending therefrom. The track 192' may also define part of the abutment feature 182 against which the cut end of the second end 109 of the spring is in direction contact therewith. The track 192' may have a protrusion 190 extending therein proximal the second end 109 of the spring 106 to aide in maintaining the second end 109 in place in the cap.

[0049] The second abutment feature 182 may be similar to that described above.

[0050] Referring to FIGS. 7-8, the tensioner 100' includes a tensioner arm 102 rotatable about a first axis **A** in the tensioning direction **T** and in the winding direction **W** opposite the tensioning direction as shown in FIG. 7, a spring 106, a support member 114, and a cap 118 as described above. The arm 102 may also include a pulley 120 rotatably mounted to its first end 130 for rotation about a second axis **B** that is spaced from and parallel to the first axis **A**. The pulley 120 may be coupled to the arm 102 with a pulley bolt 122 or other fastener and may include a dust cover 124. Tensioner 100' includes a bushing 108' that during operation provides frictional asymmetric damping in response to the radially expansion of the coils of spring 106.

[0051] Bushing 108' is similar to bushing 108 (FIG. 2) in that bushing 108' includes a sleeve 119 having a first open end 170 and a second open end 172 and one or more protrusions 110 extending from the sleeve's interior surface 168 toward the first axis **A**. In one embodiment, the sleeve 119 is generally cylindrical and the number of protrusions 110 matches the number of slots 116 in the arm arbor 104 such that the bushing 108' is mateable with the arm arbor 104 with its protrusions 110 received in the slots 116.

[0052] Bushing 108', as shown in FIGS. 7 and 9, is different from bushing 108 (FIG. 2) by the inclusion of a cut-out 204 in the sleeve 119 and a removable sleeve-segment 202 that is receivable in the cut-out 204. The cut-out 204 is an opening in the sleeve 119. In one embodiment, the cut-out 204 is formed from the second end 172 of the sleeve toward the first end 170 and results in a discontinuous second end 172 that appears generally C-shaped from a bottom end view and a generally continuous first end 170 that appears generally circular-shaped from a top end view. The cut-out 204 may be any desired size and shape. In one embodiment, the cut-out 204 is generally U-shaped. In another embodiment, the cut-out 204

may form three sides within sleeve 119, two vertical sides 212, 214 and a header 216 connecting the vertical sides 212, 214.

[0053] The removable sleeve-segment 202 can be formed from the piece of the sleeve removed when making the cut-out 204 or can be formed independent thereof. The removable sleeve-segment 202 should be shaped such that it fits within the cut-out 204. The fit should be relatively intimate in proximity with the two units fitting substantially matched to one another. This is for simplicity; but, other variations are feasible. At least one of the protrusions 110 is located on the interior surface of the removable sleeve-segment 202, generally identified as protrusion 210, and projects inward toward the first Axis A.

[0054] As shown in FIGS. 9-10, the protrusions 110, 210 are shaped to mate with the slots 116 of the arm arbor 104 and may be dimensioned such that they extend through the arm arbor 104 into its interior cavity 143 and are accessible to or by the spring 106 as it expands upon unwinding. For the protrusions 110, 210 to mate with the slots 116, bushing 108' is positioned or positionable adjacent the exterior surface of the arm arbor 104 and, as shown in FIG. 10, may be positioned between the arm arbor 104 and the interior surface 146 of the support member 114. Also, as shown in FIG. 10, the spring 106 may be in direct contact with one or more of the protrusions 110, 210.

[0055] The removable sleeve-segment 202 with its protrusion 210 in contact with spring 106 is movable radially outward for frictional damping as the spring's coils expand upon movement of the tensioner arm 102 in the winding direction **W**, which unwinds the spring and thereby radially expands the diameter of the spring's coils. Bushing 108' is expandable radially outward as a whole by action of the expanding spring coils against protrusions 110 and 210.

[0056] The sleeve-segment 202 permits a physical separation to match the functional separation of alignment control and damping control. The single-unit design of FIGS. 2-6 takes advantage of the relative flexibility of the single component bushing 108, preferably of a plastic, to act as a single, cost effective, rotary alignment pivot and a flexing radial damping element with inherently smooth surface pressure transitions along the radial arc of the bushing's outer diameter. The design in FIGS. 7-10, having the two component bushing 108', allows dissimilar materials to be used for the removable sleeve-segment 202 and sleeve 119. This allows for customizing the two functions of the bushing damper — damping and pivot

alignment, perhaps allowing one to be "premium" without driving the cost of the other.

Another potential benefit of the two component bushing 108' is that damping may start to wear or the pivot may start to wear without negatively affecting damping. Also, this design may allow damping control up or down via pressure or coefficient of friction changes, without affecting the pivot feature.

[0057] The bushing 108' may also include a flange 113 extending outward from one end of the sleeve 119, for example, from the first open end 170. As shown in FIGS. 7 and 9, bushing 108' may include a slit 112 therethrough extending from the first open end 170 to the second open end 172. The slit 112 enables the bushing 108' to expand radially in response to the expansion of the spring 106 as it unwinds. In an alternate embodiment, the bushing 108' may be generally elastic.

[0058] As shown in FIG. 9, the arm 102 may include a tab 240 extending downward from the underside of flange 158 toward the support member 114. Tab 240 may act as a stop to limit the rotational movement of the arm 102 about the first axis A. In one embodiment, tab 240 may come into contact with stop 142 on the support member 114 to limit the rotation of the arm. Tab 240 may be positioned on flange 158 such that the tab 240 is between the arm arbor 104 and the first end of the arm 130 where the pulley 120 is mounted.

[0059] The embodiments of this invention shown in the drawing and described above are exemplary of numerous embodiments that may be made within the scope of the appended claims. It is contemplated that numerous other configurations of the tensioner may be created taking advantage of the disclosed approach. In short, it is the applicant's intention that the scope of the patent issuing herefrom will be limited only by the scope of the appended claims.

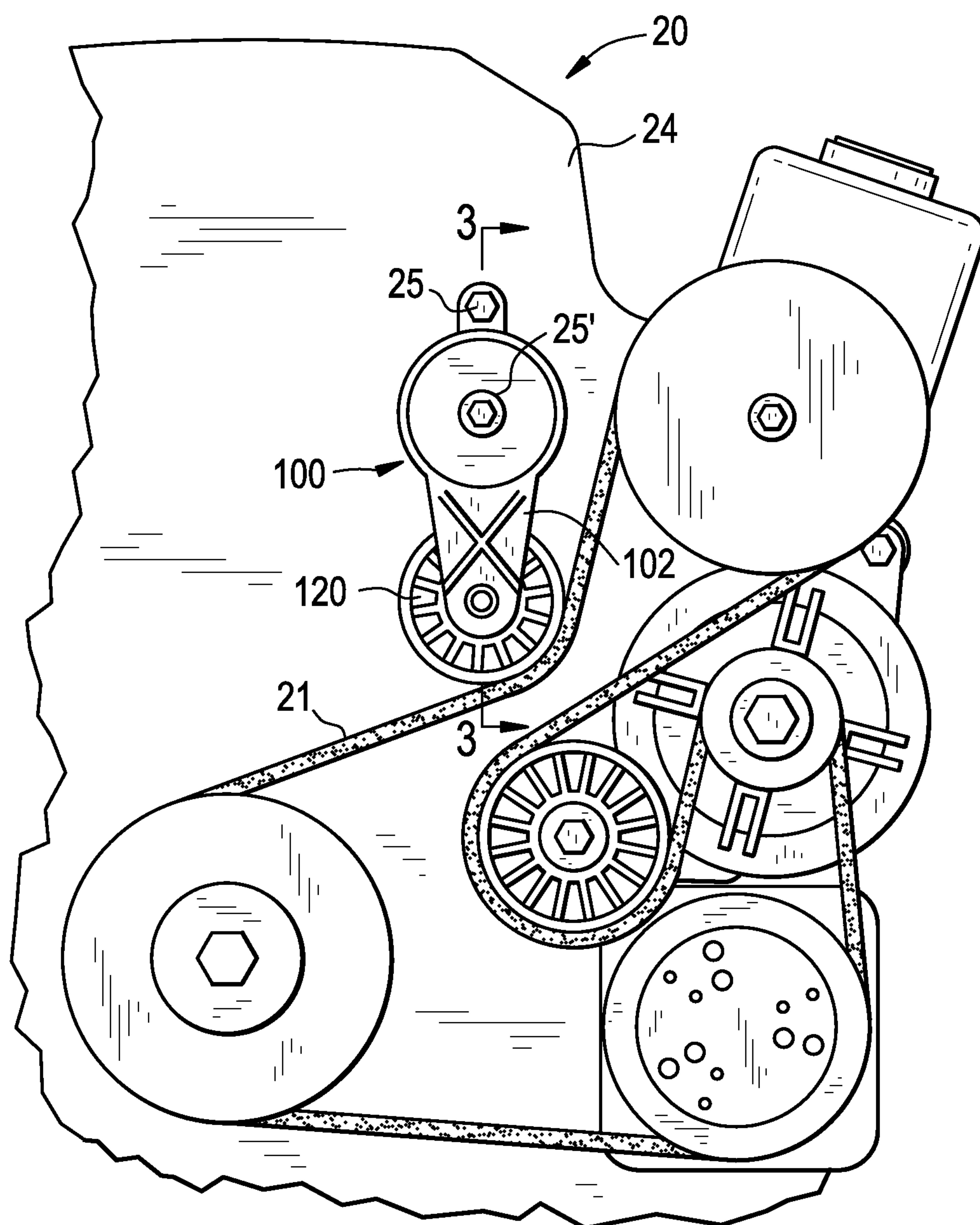
[0060] What is claimed is:

1. A tensioner comprising:
 - an arm rotatable about a first axis, the arm comprising an arm arbor having a slot through a portion thereof;
 - a bushing comprising a sleeve having a cut-out and a removable sleeve-segment receivable in the cut-out, the bushing having a protrusion at least on the sleeve-segment, the protrusion being positioned adjacent the arm arbor with the protrusion received in the slot thereof;
 - a spring coupled to the arm urging the arm to rotate about the first axis into tensioning engagement with an endless power transmitting element, the spring being positioned to radially expand into contact with the protrusion of the bushing as the arm is rotated in a direction opposite the direction of tensioning engagement such that the bushing is urged radially outward relative to the arm arbor to provide frictional damping.
2. The tensioner of claim 1 wherein the bushing includes a longitudinal slit therethrough that allows radial expansion thereof.
3. The tensioner of claim 2 wherein the sleeve of the bushing further comprises at least one protrusion thereon that is received in a second slot of the arm arbor.
4. The tensioner of claim 3 wherein the sleeve of the bushing is substantially cylindrical.
5. The tensioner of claim 2 wherein the arm arbor has a fixed diameter.
6. The tensioner of claim 1 wherein the arm includes a pulley rotatably mounted about a second axis, the second axis being spaced from and parallel to the first axis.
7. The tensioner of claim 1 further comprising a support member housing the spring, the arm arbor, and the bushing with the bushing adjacent the support member and the arm arbor between the spring and the bushing.
8. The tensioner of claim 7 wherein the radial expansion of the spring urges the bushing into frictional engagement with the support member to provide the frictional damping.
9. The tensioner of claim 7 wherein the support member is stationary and includes a shaft that defines the first axis, wherein the arm is rotatably mounted to the shaft.

10. The tensioner of claim 1 further comprising a cap enclosing the spring within the tensioner.
11. The tensioner of claim 10 wherein the spring has a first end coupled to the arm and a second end coupled to the cap.
12. The tensioner of claim 1 wherein the tensioner provides asymmetric damping.
13. The tensioner of claim 1 wherein the protrusion is dimensioned to extend into the cavity of the arm arbor.
14. The tensioner of claim 1 wherein the arm arbor comprises a generally cylindrical sleeve having an open first end and a partial bottom that defines an open second end that has a smaller opening compared to the first end.
15. The tensioner of claim 14 wherein the slot extends through the sleeve and into the partial bottom such that the bushing may be slide onto the arm arbor.
16. The tensioner of claim 15 wherein the spring is housed within the generally cylindrical sleeve of the arm arbor.
17. The tensioner of claim 16 further comprising a cap enclosing the spring within the arm arbor, the spring having a first end coupled to the arm and a second end coupled to the cap.

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FIG. 1



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FIG. 2

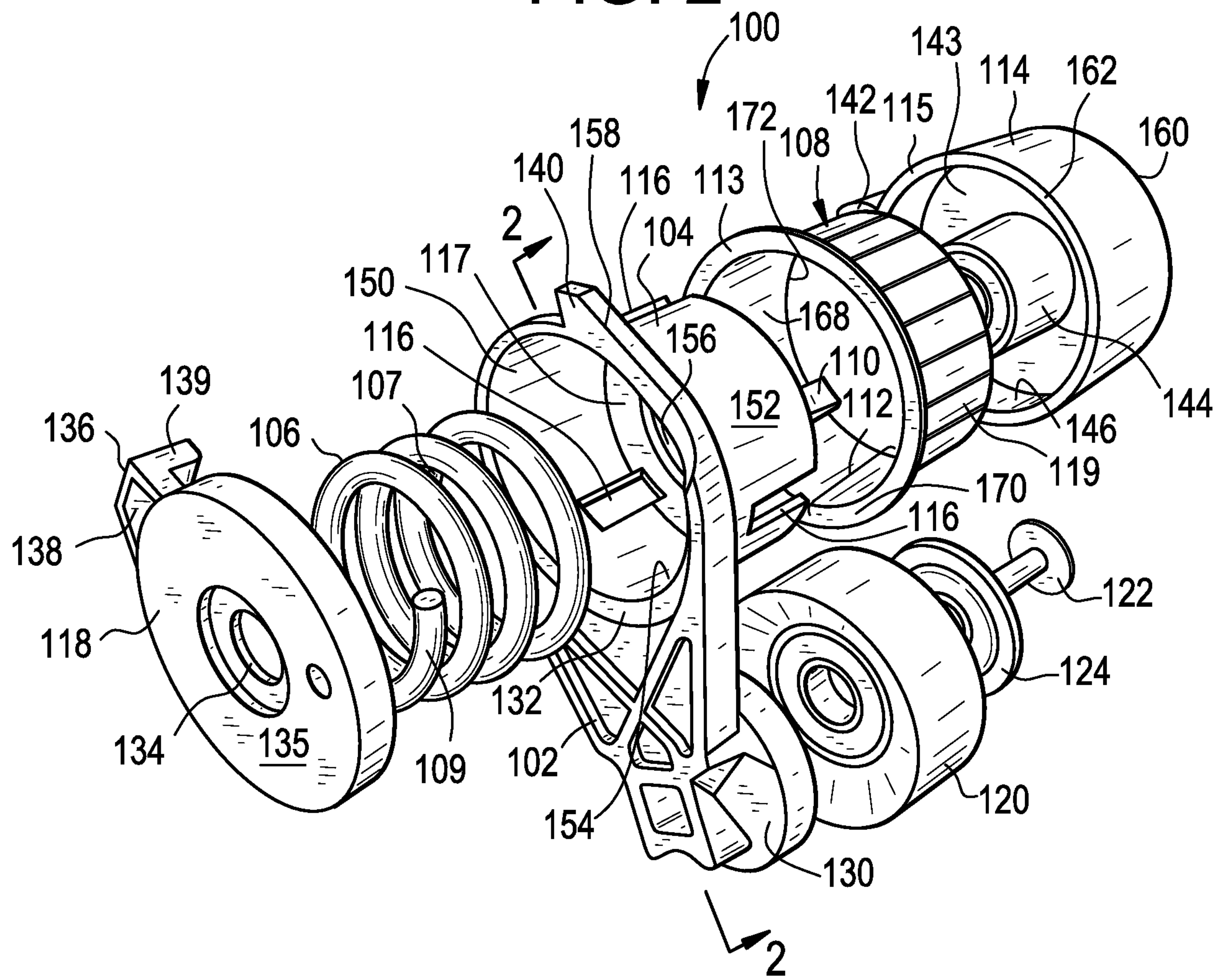
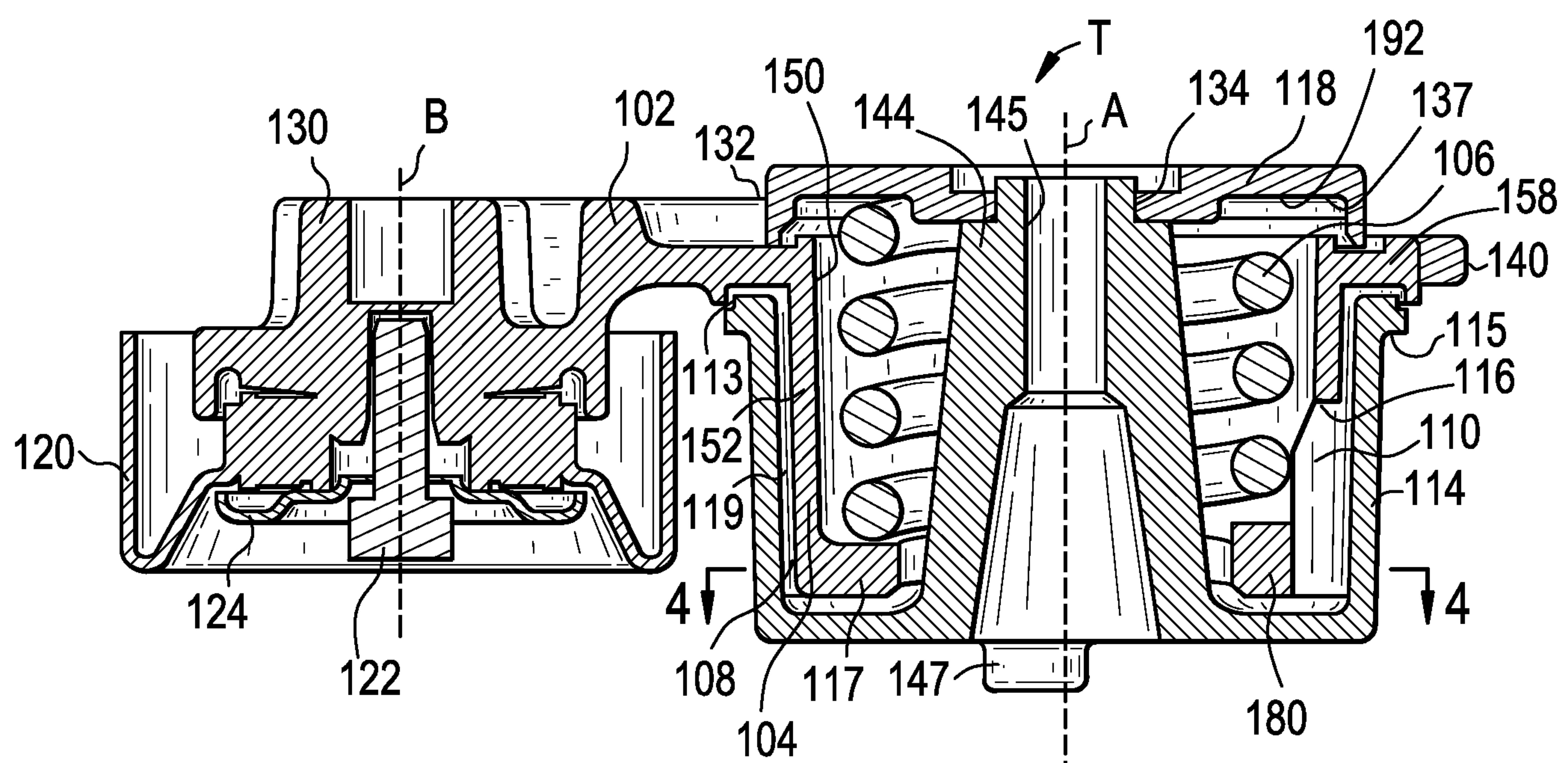


FIG. 3



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FIG. 4

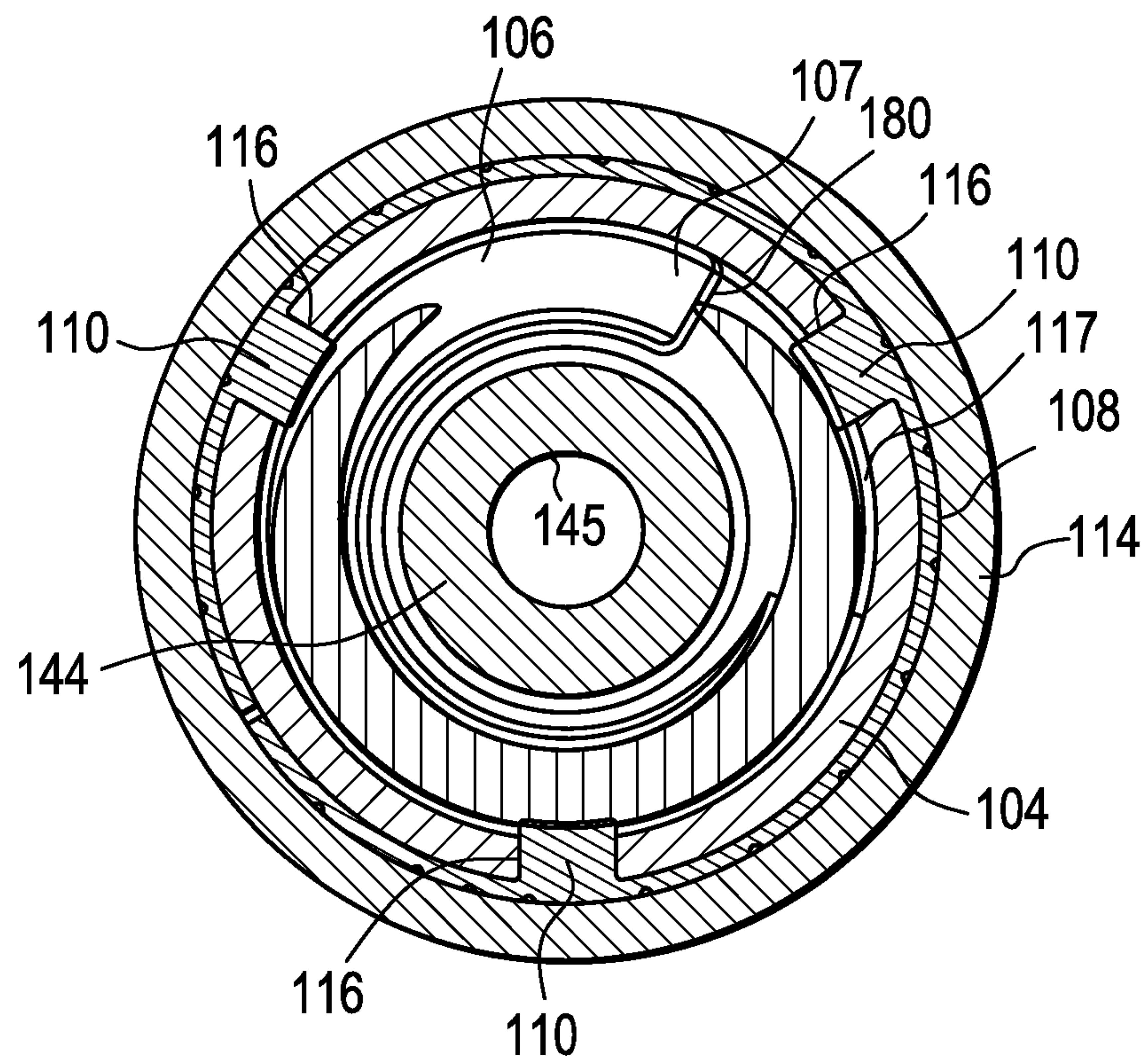
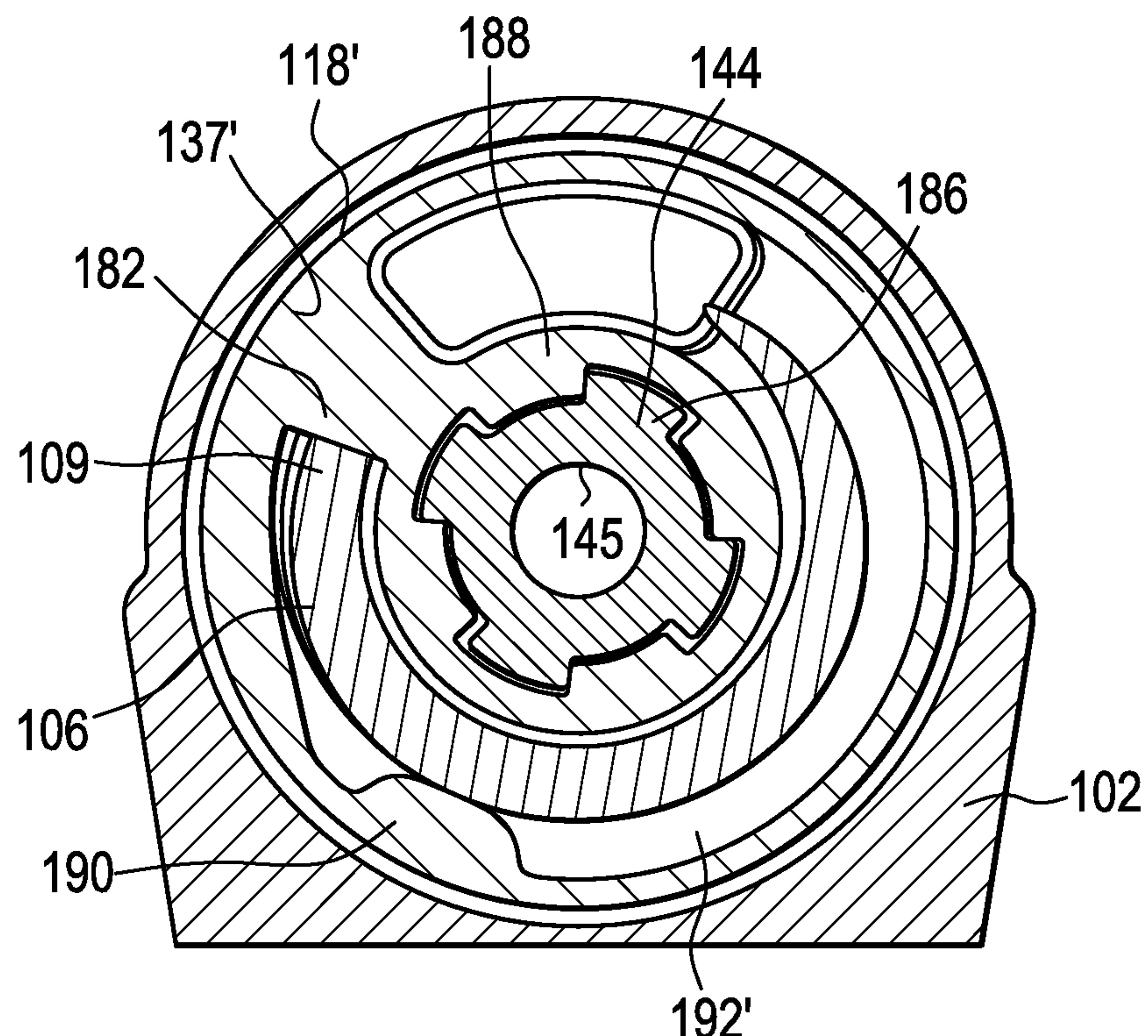
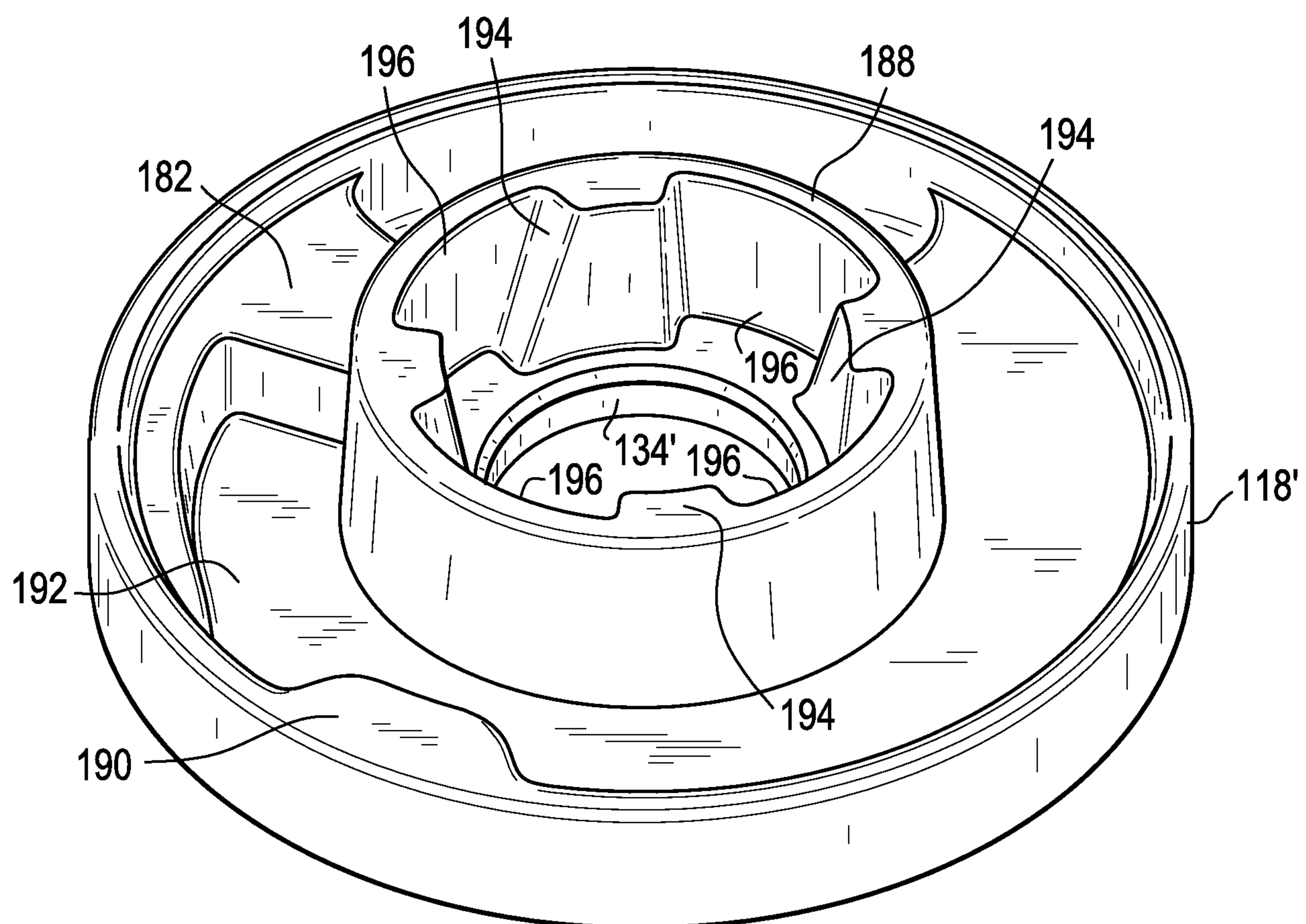


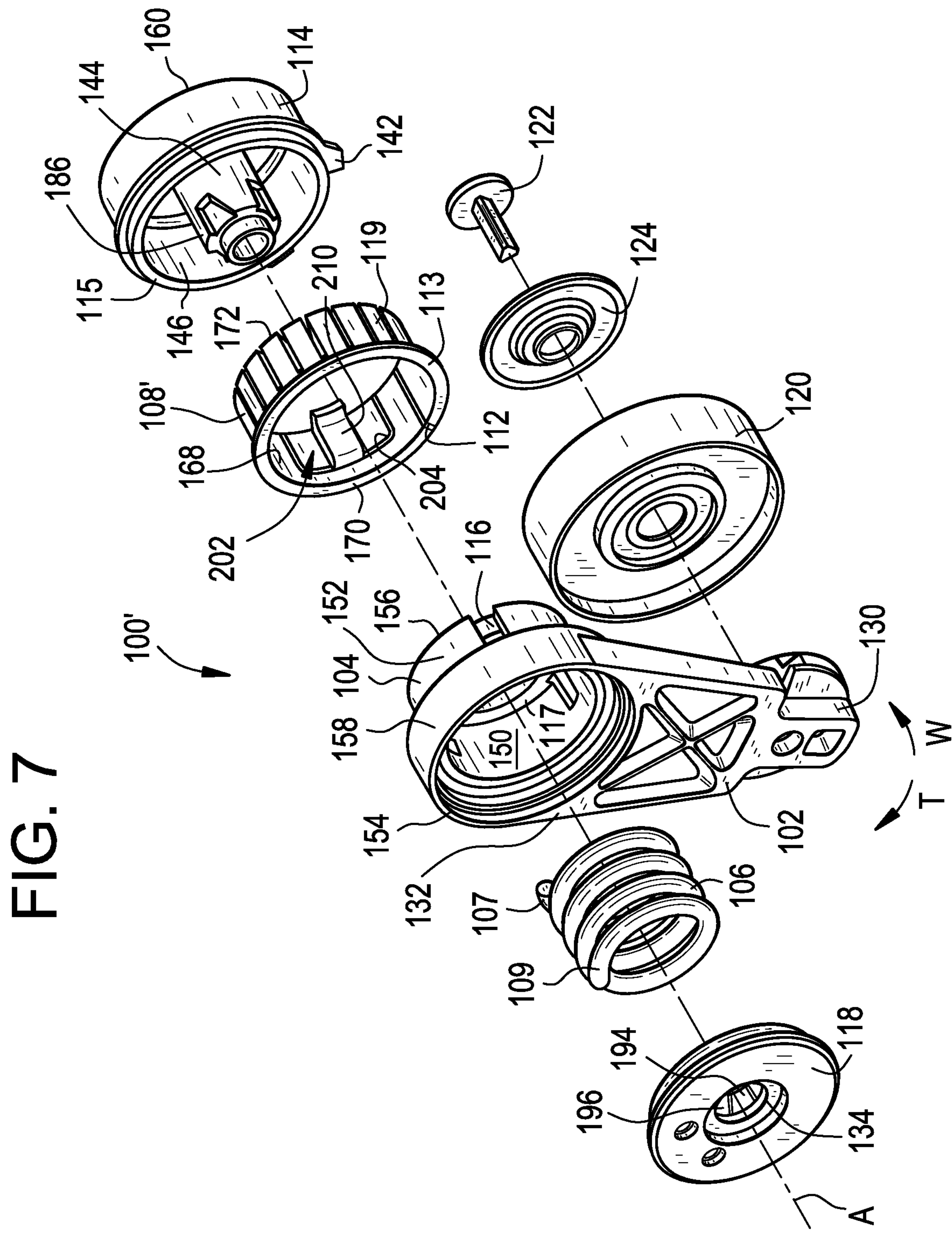
FIG. 5



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FIG. 6





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FIG. 8

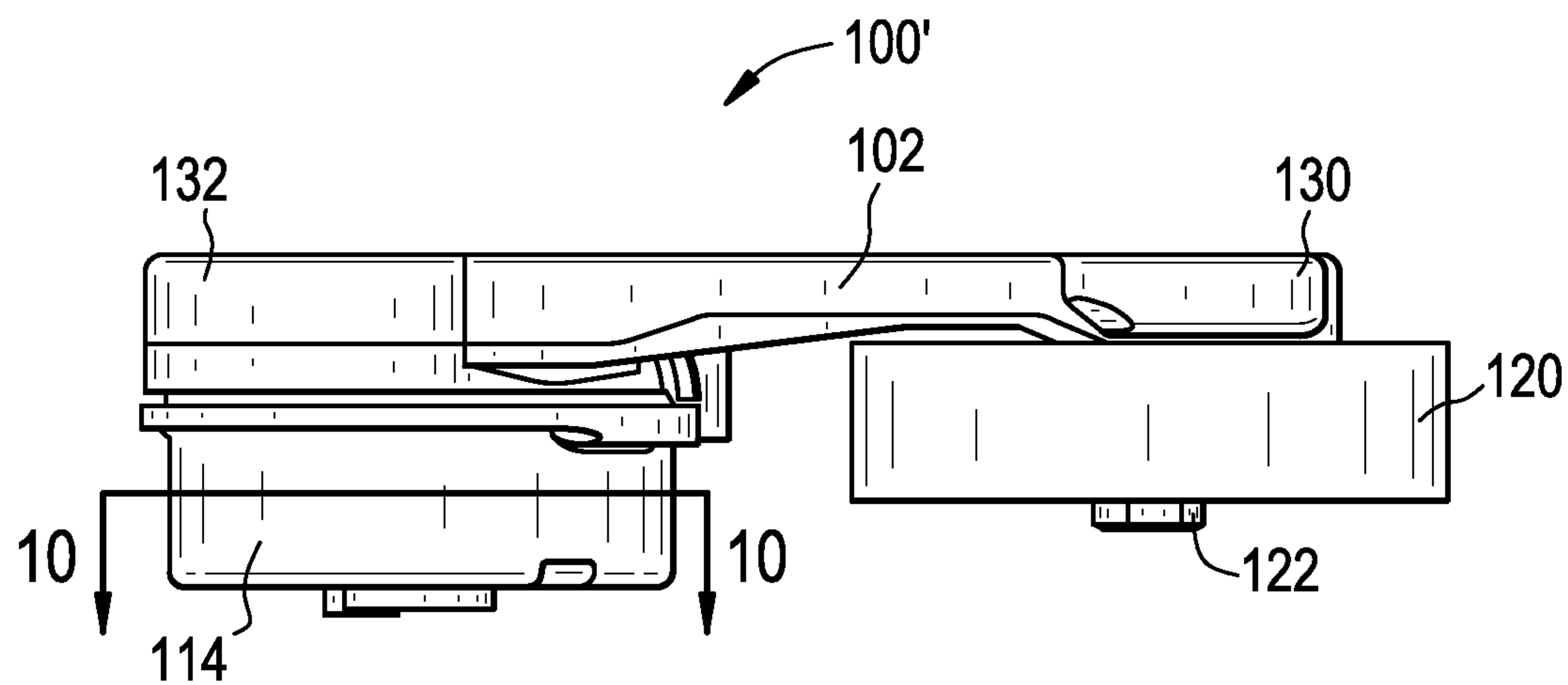
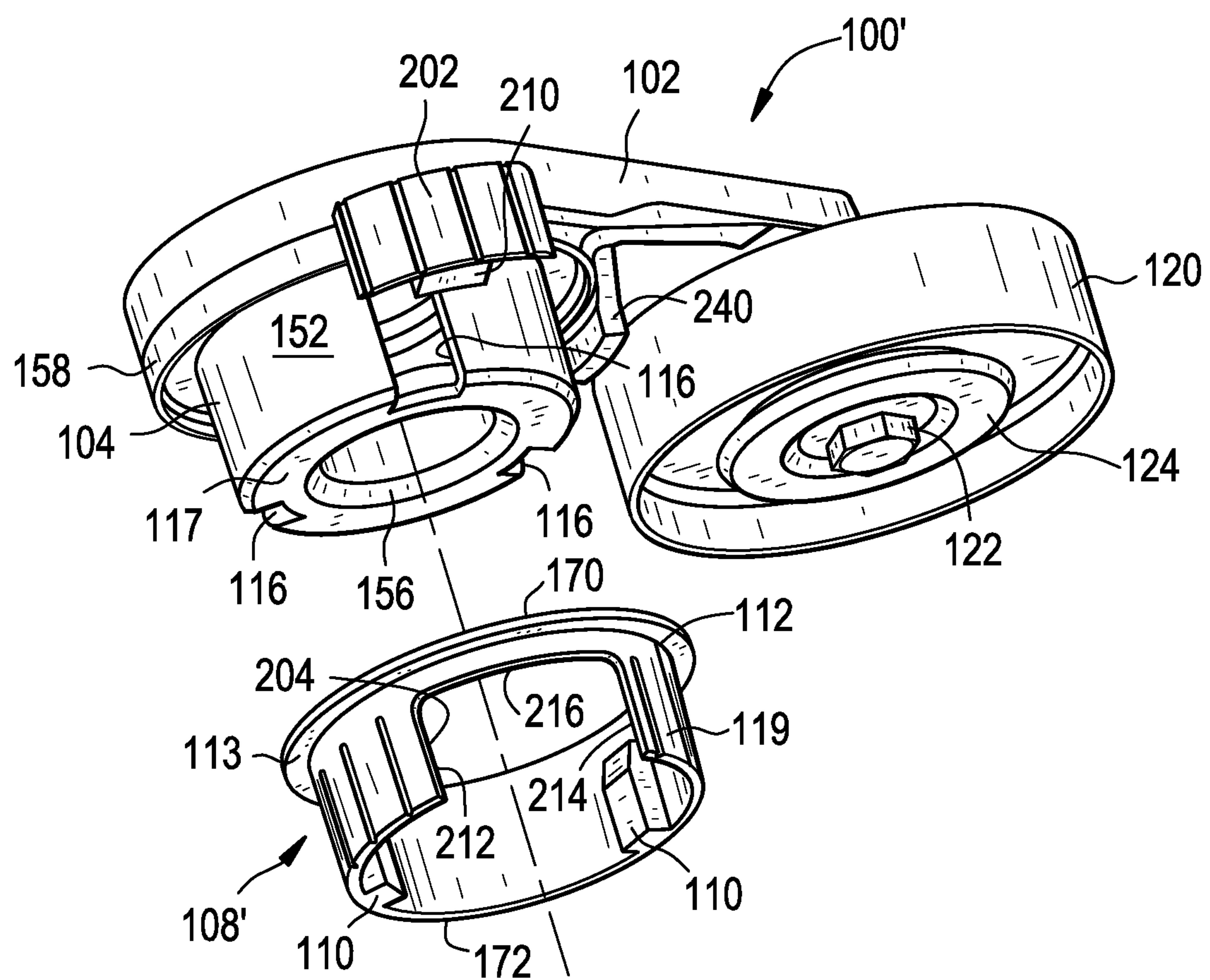


FIG. 9



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FIG. 10

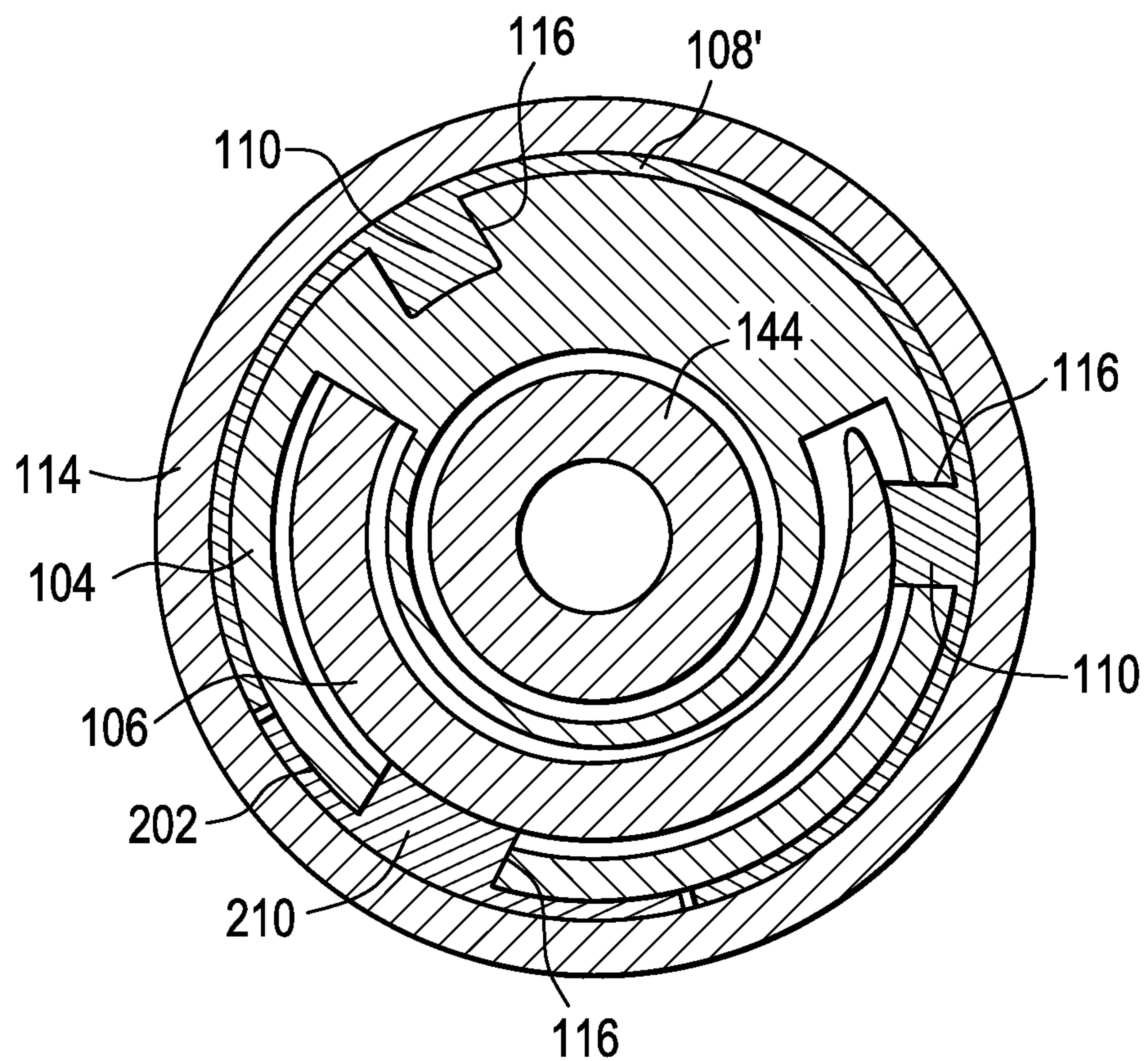


FIG. 1

