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- (71) Applicant: **POLARIS INDUSTRIES INC.** [US/US];
2100 Highway 55, Medina, Minnesota 55340 (US).
- (72) Inventors: **WILLENBRING, Samuel**; c/o 7290 Viking Blvd. NE, Wyoming, Minnesota 55092 (US). **BARTEL, Alix D.**; c/o 50 Prairie Way, Winnipeg, Manitoba R2J 3J8 (CA). **PETERMAN, Jeffrey**; c/o 7290 Viking Blvd. NE, Wyoming, Minnesota 55092 (US). **SWIATKOWSKI, Konrad**; c/o 7290 Viking Blvd. NE, Wyoming, Minnesota 55092 (US). **HENRY, Brandon**; c/o 7290 Viking Blvd. NE, Wyoming, Minnesota 55092 (US).
- (74) Agent: **BUSSE, Timothy J.**; Christensen, Fonder, Dardi & Herbert PLLC, 11322 86th Ave N, Maple Grove, Minnesota 55369 (US).
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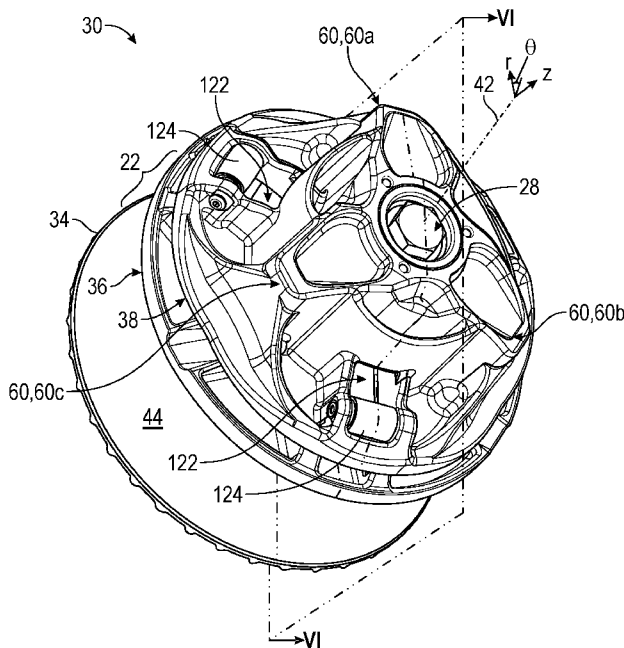


FIG. 3

(57) Abstract: A drive unit for a continuously variable transmission. Tower column portions are formed on a spider assembly with radially extending torque arms mounted to a translating sheave. The tower column portions are arranged with access openings oriented adjacent to and facing the translating sheave to limit flow of debris into the tower column. A baffle may be included that surrounds the spider assembly to further limit the radial inflows. The tower column portions are integrated into the spider assembly for enhanced structural integrity, thereby eliminating the need for separate cover component. Independent sliders may be mounted on opposed tangential faces of the torque arms enabling compensation for differential wear between the sliders even at advanced stages of wear. In some embodiments, the sliders are biased radially outward and into the tower column portions for enhanced contact with the tower column portions.



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DRIVE CLUTCH FOR CONTINUOUSLY VARIABLE TRANSMISSION

BACKGROUND

[0001] Continuously variable transmissions (CVTs) are ubiquitous in the off-road vehicle market (e.g., all-terrain vehicles (ATVs), utility task vehicles (UTVs), and snowmobiles). Such CVTs offer simple operation, wherein the effective transmission gear ratio is continuously adjusted as the rotation rate (RPM) of the drive motor increases and decreases.

[0002] CVTs are prone to accumulation of debris that foul internal adjustment mechanisms as well as the wear of various components that can adversely affect performance, thus requiring maintenance or remedial servicing. Structural failures can also limit the lifetime of the CVT. By nature, CVTs are complex mechanisms, requiring several components. A CVT that mitigates fouling, better tolerates wear of certain components, and provides enhanced structural integrity with fewer assembled components would be welcomed.

SUMMARY

[0003] Various embodiments of the disclosure militate against accumulation of debris in the internal channels of a CVT drive unit, improves the structural integrity of these internal channels, and is designed to tolerate more wear of various sliding components before servicing is required. The design also eliminates the need of a major component required in conventional CVT design for a more compact design with fewer assembly variables.

[0004] Generally, CVTs include a variable driving pulley having a stationary sheave and a translating sheave that define a variable separation distance therebetween based on the rotation rate (e.g., revolutions per minute, or RPM) of the drive pulley. The driving pulley is coupled to a drive shaft using a spider that enables torsion of the variable drive pulley while accommodating the variable separation adjustment of the drive pulley. Conventional CVTs include tower columns that are mounted to the translating sheave that accept torque arms that extend radially (i.e., orthogonal to the drive axis) and are mounted to the spider. The tower

columns are typically structures that protrude axially (i.e., parallel to the drive axis) and are located near the perimeter of the translating sheave and have exposed axial openings at an outboard end of the drive unit. Such conventional designs can generate substantial stress and deflection on the tower columns and drive pulley, particularly under inertial loads at higher rotation rates. In many such conventional CVT clutches, a secondary support structure is required to counter and prevent the adverse effect of these stresses and deflections, adding to the complexity of the design and assembly.

[0005] Various embodiments of the disclosure include tower column portions formed on the spider assembly with the radially extending torque arms being mounted to the translating sheave. This structural relationship is the inverse of conventional CVTs where the tower columns are mounted to the translating sheave and the torque arms are part of the spider. In the disclosed embodiments, the tower column portions are arranged with access openings oriented adjacent to and facing the translating sheave, so that there are no openings to the tower column portions at the outboard end. In this way, the spider assembly acts as a cover that prevents debris from direct axial entry into the tower column portions. Instead, debris entry into the tower column portions is limited to radial inflow through a gap between the spider and the translating sheave. In some embodiments, a baffle is included that surrounds the spider assembly to further limit the radial inflow of debris into the access openings of the tower column portions and may include wiper seals that still further limit debris in flow. The tower column portions also benefit from structure that is integrated into the spider assembly to accommodate the shift weight roller assemblies, thus enhancing the structural integrity of the tower column portions in operation. The enhanced structural integrity negates the need for supporting the tower column portions with a separate cover component and the attendant complexity of manufacturing and assembly for a balanced drive unit.

[0006] Various embodiments of the disclosure include contact sliders that are mounted to torque arms that extend into the tower column portions of the spider assembly. In some embodiments, a pair of such sliders operate independently on opposed tangential faces of the torque arms. The independent action of sliders enable compensation for differential wear between the sliders for enhanced coupling between the torque arms and the tower column portions even at advanced stages of wear. As such, more wear of the sliders can be tolerated for less frequent maintenance requirements. In some embodiments, the sliders are biased radially outward and into the tower column portions for enhanced contact with the tower column portions, particularly at low rotational rates.

[0007] Structurally, various embodiments of a drive unit for a continuously variable transmission are disclosed, comprising a post assembly that defines and is colinear with a drive axis, an axially stationary sheave portion coupled to a first end portion of the post assembly, and a spider assembly affixed to a second end portion of the post assembly. The spider assembly includes a tower portion that defines an axially extending channel extending along and defining a channel axis. The axially extending channel includes a first inner tangential face and a second inner tangential face, each facing tangentially toward the channel axis. A translatable hub assembly is coupled to a mid-portion of the post assembly and includes a translatable hub column colinear with the post assembly about the drive axis, a translatable sheave portion coupled to the translatable hub column, and a torque arm that extends radially outward from the translatable hub column along a torque arm axis and into the axially extending channel of the spider assembly. The torque arm includes a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides the torque arm axis. At least one torque arm slider is coupled to the first outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the at least one torque arm slider engaging the first inner tangential face and the

second inner tangential face of the axially extending channel of the spider assembly for torsional coupling of the spider assembly to the translatable hub assembly about the drive axis.

[0008] The at least one torque arm slider may include a second torque arm slider coupled to the second outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the second torque arm slider engaging the second inner tangential face of the axially extending channel of the spider assembly for torsional coupling of the spider assembly to the translatable hub assembly about the drive axis. In some embodiments, the at least one torque arm slider is a single slider that includes a first single slider portion and a second single slider portion, the first single slider portion engaging the first inner tangential face of the axially extending channel, the second single slider portion engaging the second inner tangential face of the axially extending channel. The first torque arm slider and the second torque arm slider may be separate structures that slide radially along the torque arm independent of each other.

[0009] In some embodiments, the translatable sheave portion is actuated along the drive axis by a plurality of shift weights that centrifugally act against the spider assembly for motivation of the translatable sheave portion toward the axially stationary sheave portion, the plurality of shift weights being uniformly distributed about the drive axis. Each of the plurality of shift weights may be pivotally mounted to the translatable hub assembly to rotate against the spider assembly in response to rotation of the drive unit about the drive axis. In some embodiments, engagement of the first torque arm slider and the second torque arm slider with the axially extending channel of the spider assembly imparts sufficient torsional stiffness on the drive unit about the drive axis to isolate the plurality of shift weights from tangential torsional loads. The spider assembly may include a plurality of rollers, each oriented to

engage a respective one of the plurality of shift weights during the motivation of the translatable sheave portion toward the axially stationary sheave portion.

[0010] The axially extending channel may include one or more wear shims that contact the first torque arm slider and the second torque arm slider. In some embodiments, the axially extending channel is one of a plurality of axially extending channels defined by the spider assembly, the plurality of axially extending channels being uniformly distributed about the drive axis.

[0011] In some embodiments, the translatable hub assembly includes a biasing element disposed between the translatable hub column and the first torque arm slider to bias the first torque arm slider radially outward along the torque arm so that the first torque arm slider contacts the axially extending channel of the spider assembly. The translatable hub assembly may define a pocket proximate a base of the torque arm, the biasing element being disposed within the pocket. The biasing element may include a coil spring. In some embodiments, the first torque arm slider and the second torque arm slider do not physically contact each other.

[0012] In some embodiments, a baffle surrounds an outer periphery of the spider assembly, the baffle being shaped and dimensioned to define a peripheral clearance about the outer periphery. The peripheral clearance about the outer periphery may be substantially uniform. A wiper seal may be disposed between and contacting both the translatable hub assembly and the baffle. In some embodiments, the wiper seal is seated in a gland defined by the spider assembly. The baffle may include a plurality of projections that extend radially outward for movement of air. In some embodiments, the baffle is mounted to the translatable hub assembly, the baffle extending axially in a distal direction away from the translatable sheave portion to surround the outer periphery. In some embodiments, the baffle is registered against the translatable sheave portion. In some embodiments, the spider assembly includes a

skirt portion that extends axially in the distal direction from the outer periphery, the skirt portion extending parallel to the baffle and defining the peripheral clearance therebetween.

[0013] In various embodiments of the disclosure, a drive unit for a continuously variable transmission comprises a tower defining an axially extending channel that defines and extends along a channel axis, the axially extending channel including a first inner tangential face and a second inner tangential face, each of the first inner tangential face and the second inner tangential face facing tangentially toward the channel axis. A torque arm extends radially along a torque arm axis and into the axially extending channel of the tower, the torque arm including a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides the torque arm axis. A first torque arm slider is coupled to the first outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the first torque arm slider engaging the first inner tangential face of the axially extending channel for coupling of the tower to the torque arm. A second torque arm slider is coupled to the second outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the second torque arm slider engaging the second inner tangential face of the axially extending channel for coupling of the tower to the torque arm. The first torque arm slider and the second torque arm slider are separate structures that slide radially along the torque arm independent of each other.

[0014] In some embodiments, the tower is integral to a spider assembly, the spider assembly being axially and rotationally affixed to a post assembly that defines and is colinear with a drive axis. The tower and the spider assembly may be unitary, the torque arm and the translatable hub column may be unitary, and the torque arm, the translatable hub column, and the axially moveable sheave portion may be unitary.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0015] FIG. 1 is a schematic of a continuously variable transmission (CVT) in an idle configuration according to an embodiment of the disclosure;
- [0016] FIG. 2 is a schematic of the CVT of FIG. 1 in an overdrive configuration according to an embodiment of the disclosure;
- [0017] FIG. 3 is a perspective view of a drive unit for the CVT in the idle configuration of FIG. 1 according to an embodiment of the disclosure;
- [0018] FIG. 4 is a perspective, partially exploded view of the drive unit of FIG. 3 according to an embodiment of the disclosure;
- [0019] FIG. 5 is an exploded sectional view of the drive unit of FIG. 3 according to an embodiment of the disclosure;
- [0020] FIG. 6 is a sectional view of the drive unit at plane VI-VI of FIG. 3 according to an embodiment of the disclosure;
- [0021] FIG. 7 is a perspective sectional view of a post assembly of the drive unit of FIG. 3 according to an embodiment of the disclosure;
- [0022] FIG. 8 is a sectional view of a translatable hub assembly for the drive unit of FIG. 3 according to an embodiment of the disclosure;
- [0023] FIG. 9 is an exploded perspective sectional view of the translatable hub assembly of FIG. 8 according to an embodiment of the disclosure;
- [0024] FIG. 10 is a front perspective view of a pair of torque arm sliders for the drive unit of FIG. 3 according to an embodiment of the disclosure;
- [0025] FIG. 11 is a rear plan view of the torque arm sliders of FIG. 10 according to an embodiment of the disclosure;
- [0026] FIG. 12 is a front perspective view of single slider assembly for the drive unit of FIG. 3 according to an embodiment of the disclosure;

[0027] FIG. 13 is a rear plan view of the single slider assembly of FIG. 12 according to an embodiment of the disclosure;

[0028] FIG. 14 is a sectional view of the paired torque arm sliders of FIG. 10 mounted to a torque arm according to an embodiment of the disclosure;

[0029] FIG. 15 is an enlarged perspective view of the paired torque arm sliders of FIG. 10 partially assembled on a translatable hub assembly of the drive unit of FIG. 3 according to an embodiment of the disclosure;

[0030] FIG. 16 is a sectional view of a spider assembly and drive shaft for the drive unit of FIG. 3 according to an embodiment of the disclosure;

[0031] FIG. 17 is a perspective view of the spider assembly and drive shaft of FIG. 16 according to an embodiment of the disclosure;

[0032] FIG. 18 is a perspective sectional view of a drive unit having a baffle according to an embodiment of the disclosure;

[0033] FIG. 19 is a perspective cutaway view of a drive unit having a baffle and skirt according to an embodiment of the disclosure;

[0034] FIG. 20 is an enlarged view of the cutaway section at inset XX of FIG. 19 according to an embodiment of the disclosure;

[0035] FIG. 21 is an enlarged partial perspective view at inset XXI of FIG. 18 with a wiper seal added thereto according to an embodiment of the disclosure;

[0036] FIG. 22 is an enlarged partial perspective view at inset XXII of FIG. 20 with a wiper seal added thereto according to an embodiment of the disclosure;

[0037] FIG. 23 is a sectional view of the drive unit of FIG. 3 in an overdrive configuration according to an embodiment of the disclosure; and

[0038] FIGS. 24 through 29C are conceptual diagrams illustrating an example drive unit for a CVT according to embodiments of the disclosure.

DETAILED DESCRIPTION

[0039] Referring to FIGS. 1 and 2, a schematic of a continuously variable transmission 20 is depicted according to an embodiment of the disclosure. The continuously variable transmission 20 includes a drive pulley 22 and a driven pulley 24 connected by a drive belt 26, the drive belt having a width W . The drive pulley 22 is coupled to a drive shaft 28 via a drive unit 30, the drive shaft 28 being driven by a motor or engine 32, for example, of an all-terrain vehicle (ATV), utility task vehicle (UTV), or snowmobile. The drive unit 30 includes the drive pulley 22, which is effectuated by cooperation between a post assembly 34 and a translatable hub assembly 36. The drive unit 30 also includes a spider assembly 38 that is affixed to the drive shaft 28. The drive unit 30 is depicted in an idle configuration (FIG. 1), wherein the drive belt 26 may be sufficiently loose so that rotation of the drive pulley does not transfer to a rotation of the driven pulley 24 or otherwise rotates the driven pulley at a low rotation rate. The drive unit 30 is also depicted in an overdrive configuration 31 (FIG. 2), wherein the drive belt 26 is fully extended by the drive pulley 22 into the driven pulley 24 for a maximum rotational speed of the driven pulley 24. The drive belt 26 defines a minimum outer belt radius R_0 about the drive axis 42 in the idle configuration 29 and a maximum outer belt radius R_1 in the overdrive configuration 31.

[0040] Referring to FIGS. 3 through 6, the drive unit 30 for the continuously variable transmission 20 is depicted in greater detail according to an embodiment of the disclosure. The post assembly 34 defines and is colinear with a drive axis 42 of the drive unit 30 and includes an axially stationary sheave portion 44 of the drive pulley 22. The translatable hub assembly 36 is coupled to the post assembly 34 in a way that permits translation in the axial directions (i.e., parallel to the drive axis 42). The spider assembly 38 is affixed to a distal end portion 46 of the post assembly 34.

[0041] The spider assembly 38 includes a tower column portion 60 that defines an axially extending channel 62 extending along a channel axis 64, the axially extending channel 62 including a first inner tangential face 66 and a second inner tangential face 68 that face tangentially toward the channel axis 64. The translatable hub assembly 36 includes a hub column 80, a translatable sheave portion 82 of the drive pulley 22, and a torque arm 84. The hub column 80 includes an inner wall portion 86 that defines a through-passage 88 that surrounds and is colinear with the post assembly 34 about the drive axis 42. The translatable sheave portion 82 is coupled to and extends radially outward from the hub column 80 to an outer perimeter 90. The torque arm 84 extends radially outward from the hub column 80 along a torque arm axis 92 and into the axially extending channel 62 of the spider assembly 38. In some embodiments, there are a plurality of the torque arms 84 (identified individually as torque arms 84a, 84b, and 84c in the drawings) that correspond to and are in radial alignment with a plurality of axially extending channels 62 (identified individually as axially extending channels 62a, 62b, and 62c) defined by a plurality of tower column portions 60 (identified individually as tower column portions 60a, 60b, and 60c) the spider assembly 38. Each torque arm 84 includes a first outer tangential portion 94 and a second outer tangential portion 96 disposed on opposed tangential sides of the torque arm axis 92.

[0042] In some embodiments, the translatable hub assembly 36 includes first and second torque arm sliders 110 and 112 that are coupled to the first and second outer tangential portions 94 and 96, respectively, of the torque arm 84 to permit translation along the torque arm 84 in radial directions. The first and second torque arm sliders 110 and 112 may engage the first and second inner tangential faces 66 and 68, respectively, of the axially extending channel 62 of the spider assembly 38. In some embodiments, one or more wear shims 72 are inserted into the tower column portion 60 to line the axially extending channel 62 for contact with the first and second torque arm sliders 110 and 112, or alternatively for contact with the

first and second single slider portions 116 and 118 of the single slider assembly 114. The wear shims 72 may be affixed to the spider assembly 38 with fasteners 74.

[0043] The first and second torque arm sliders 110 and 112 may be separate structures that slide radially along the torque arm 84 and independent of each other. In some embodiments, the first and second torque arm sliders 110 and 112 do not contact each other. In some embodiments, the translatable hub assembly 36 includes biasing elements 113 disposed between the hub column 80 and the first and second torque arm sliders 110 and 112.

Alternatively, a single slider assembly 114 may be utilized having first and second single slider portions 116 and 118 that are physically tied together, for example by a common top portion 119. The single slider assembly 114 may also be biased by the one or more biasing elements 113.

[0044] In some embodiments, the translatable sheave portion 82 is actuated along the drive axis 42 by a plurality of shift weights 122 arranged to centrifugally act against the spider assembly for motivation of the translatable sheave portion 82 in a proximal direction 121 (toward the axially stationary sheave portion 44). The plurality of shift weights 122 are uniformly distributed about the drive axis 42. Each of the plurality of shift weights 122 may be pivotally mounted to the translatable hub assembly 36 to rotate towards a distal direction 123 and against the spider assembly in response to rotation of the drive unit 30 about the drive axis 42. In some embodiments, the spider assembly includes a plurality of rollers 124, each being oriented to engage a respective one of the plurality of shift weights 122 during motivation of the translatable sheave portion 82 toward the axially stationary sheave portion 44.

[0045] Functionally, engagement of the slider(s) 110 and 112 or 114 with the axially extending channel 62 of the tower column portion 60 torsionally couples the spider assembly 38 to the translatable hub assembly 36 about the drive axis 42 while enabling the translatable

hub assembly 36 to move parallel to the drive axis 42. Positioning of the translatable hub assembly 36 along the drive axis 42 is established by dynamic interaction between the spider assembly 38 and the shift weights 122 of the translatable hub assembly 36.

[0046] Engagement of the first torque arm slider 110 (or alternatively the first single slider portion 116) and the second torque arm slider 112 (or alternatively the second single slider portion 118) with the wear shim 72 backed by the axially extending channel 62 of the spider assembly 38 generates sufficient torsional rigidity between the spider assembly 38 and the translatable hub assembly 36 of the drive unit 30 to isolate the plurality of shift weights 122 from tangential torsional loads about the drive axis 42. The sufficiency of the torsional rigidity between the first and second torque arm sliders 110 and 112 and the tower column portion 60 may be provided at low rotation rates by the forces generated by the biasing elements 113 to seat the first and second torque arm sliders 110 and 112 against the wear shims 72. The torsional rigidity is enhanced as the rotation rate about the drive axis 42 increases, causing the first and second torque arm sliders 110 and 112 to generate centrifugal forces against the axially extending channel 62.

[0047] Referring to FIG. 7, the post assembly 34 is depicted in greater detail according to an embodiment of the disclosure. The post assembly 34 includes a post 200 having a proximal or first end portion 202 and the distal or second end portion 46, the post 200 being colinear with and defining the drive axis 42. The post 200 defines a through-passage 204 through which the drive shaft 28 passes. The post 200 may include a base shoulder 206 at the first end portion 202. In some embodiments, an outer surface 208 of the post 200 defines a mid-shoulder 212. A tapered profile 214 may be defined at the distal end portion 46.

[0048] In some embodiments, the axially stationary sheave portion 44 is seated against the base shoulder 206 of the post 200 and is secured to the post 200, for example, with a press or shrink fit. The post assembly 34 may include an idle bearing 216 coupled to the post 200

adjacent to or seated within the axially stationary sheave portion 44. The idle bearing 216 defines an outer radius 218.

[0049] Referring to FIGS. 8 and 9 and again to FIG. 6, the translatable hub assembly 36 is depicted in greater detail according to an embodiment of the disclosure. The through-passage 88 of the hub column 80 defines and is colinear with a hub axis 222, which in assembly is in alignment with the drive axis 42 of the drive shaft 28. In some embodiments, the translatable hub assembly 36 includes a proximal centering spacer 224 and a distal centering spacer 226, each disposed at proximal and distal end portions 232 and 234, respectively, of the hub column 80 to axially capture a return element 228 therebetween. The return element 228 may be a coil spring (depicted).

[0050] A proximal bushing 236 is disposed interstitially between the proximal centering spacer 224 and the inner wall 86 of the hub column 80, axially adjacent the idle bearing 216. The proximal bushing 236 may include radial protrusions 238 that seat within corresponding pockets 242 formed at the proximal end portion 232 of the hub column 80. A distal bushing 244 may be disposed within the distal centering spacer 226 for sliding contact with the post 200, thereby permitting translation of the translatable hub assembly 36 in axial directions. The proximal bushing 236 is dimensioned to slide over the proximal centering spacer and the idle bearing. The distal bushing 244 is dimensioned to slide over the outer surface 208 of the post 200. The proximal and distal bushings 236 and 244 may be constructed from polymer or composite materials that provide dry lubrication with the proximal and distal centering spacers 224 and 226, respectively. Examples of bushings 236 and 244 include: metal-polymers such as the DU® bearing manufactured by GGB of Thorofare, New Jersey, USA; filament wound bushings, such as DURALON® bearings manufactured by Rexnord, Inc. of Milwaukee, Wisconsin, U.S.A.; polyimide-based plastic materials, such as VESPEL®

manufactured by Du Pont de Nemours, Inc. of Wilmington, Delaware, USA or TORLON® manufactured by Solvay S.A., Brussels, Belgium.

[0051] The through-passage 88 defines an enlarged radius 252 at the proximal end portion 232 of the hub column 80 that is larger than the outer radius 218 (FIG. 7) of the idle bearing 216 of the post assembly 34. The proximal end portion 232 of the hub column 80 may also define an inner flange 254 at the opening of the through-passage 88, the inner flange 254 extending radially inward relative to the enlarged radius 252.

[0052] In some embodiments, the proximal centering spacer 224 is seated on the mid-shoulder 212 of the post 200 and extends in the proximal direction 121 for contact or near contact with the idle bearing 216 at the proximal end portion 232 of the hub column 80. The proximal centering spacer 224 may include a flange 256 that is offset in the proximal direction 121 from a distal extremity 258 of the proximal centering spacer 224 to define a centering ring 260. The flange 256 and centering ring 260 are dimensioned to receive and center the return element 228. Alternatively, instead of the flange 256 and centering ring 260, a gland (not depicted) akin to an o-ring gland may be formed at the distal extremity 258 of the proximal centering spacer 224 to receive and center the return element 228.

[0053] The distal centering spacer 226 may include an inset collar 262 that depends from an outer flange portion 264 and cooperates with the inner wall 86 of the through-passage 88 to define an annulus 266. The inset collar 262 defines an inner radius 268 about the hub axis 222. In embodiments so equipped, the inner radius 268 is dimensioned to receive the distal bushing 244 (depicted). Alternatively, the inset collar 262 may be machined for a direct sliding fit with the outer surface 208 of the post 200. In some embodiments, the distal centering spacer 226 is provided as an insert 272 that is affixed at the distal end portion 234 of the hub column 80, for example with fasteners 274 that pass through the outer flange

portion 264 (depicted). Alternatively, the distal centering spacer 226 may be unitary with the hub column 80.

[0054] The shift weights 122 may be pivotally mounted to the translatable sheave portion 82 with pivot pins 280 that define tangentially extending pivot axes 278. Each shift weight 122 defines a center of gravity CG that is axially offset relative to the respective pivot axis 278. In some embodiments, each shift weight 122 defines a cam surface 282 that acts against the respective roller 124, the roller 124 acting as a cam follower. Each shift weight 122 may also define a stop portion 284 that engages the sheave portion 82 (e.g., a gusset 286 that protrudes distally). In some embodiments, the annulus 266 defined by the hub column 80 is dimensioned to receive the return element 228.

[0055] Functionally, the idle bearing 216 provides neutral seating for the drive belt 26 of the CVT when in the idle configuration 29 (FIG. 1). In some embodiments, the distance between the sheave portions 44 and 82 are greater than the belt width W (the width of the drive belt 26 in the axial direction) so that the drive belt 26 is in contact with the idle bearing 216 in the idle configuration 29. In some embodiments, the drive belt 26 does not make gripping contact with the sheave portions 44, 82 in the idle configuration 29. The proximal centering spacer 224 is registered against the mid-shoulder 212 of the post 200 so that the return element 228 exerts a return force FR in the distal direction 123, against the distal centering spacer 226, which acts to bias the translatable hub assembly 36 in the distal direction 123. In the idle configuration 29, the axial position of the translatable hub assembly 36 may be established by registration of the distal centering spacer 226 against the spider assembly 38.

[0056] In the idle configuration 29 (i.e., at low or no rotation rate ω about the drive axis 42), the return force FR generated by the return element 228 biases the translatable hub assembly 36 into the spider assembly 38 so that the shift weights 122 are folded radially inward by contact with the rollers 124 (FIG. 6). In some embodiments, the stop portions 284 of the shift

weights 122 engage the translatable sheave portion 82 (e.g., the distally protruding gusset 286) to define the axial position of the spider assembly 38 in the idle configuration.

Accordingly, the axial position of the translatable hub assembly 36 may be established by registration of the distal centering spacer 226 against the spider assembly 38, by registration of the rollers 124 against the folded down shift weights 122, or a combination thereof.

[0057] Referring to FIGS. 10 through 15, the sliders 110, 112, and 114 and the coupling of the biasing elements 113 thereto are depicted in greater detail according to embodiments of the disclosure. The first and second torque arm sliders 110, 112 (FIGS. 10 and 11) each include opposed end portions 292 separated by a side wall 294 and may include a nose portion 296. The side wall 294 defines an outboard surface 298 that defines a tapered angle ϕ toward the torque arm axis 92 in the radially outward direction when the sliders 110 and 112 are assembled on the torque arm 84 (FIG. 14). The end portions 292 and side wall 294 cooperate to define an inner cavity 300 bounded by an orthogonal inner surfaces 302. The first and second torque arm sliders 110, 112 may include centering rings 304 that, when assembled on the torque arm 84, face radially inward to receive or center the biasing elements 113. The nose portion 296 may define an arcuate contour 308 that accommodates passage of a fastener 310 for securing a wear shim 312 to the torque arm 84. When assembled on the torque arm 84, the first and second torque arm sliders 110, 112 may be axially symmetric with respect to the torque arm axis 92 for interchangeability.

[0058] The single slider portions 116, 118 of the single slider assembly 114 (FIGS. 12 and 13) may include some of the same components and attributes as the first and second torque arm sliders 110 and 112, some of which are identified with same-labeled reference characters. A distinction of the single slider assembly 114 is a tie member 314 that physically connects the single slider portions 116 and 118. When assembled on the torque

arm 84, the tie member 314 extends tangentially between the single slider portions 116 and 118.

[0059] In some embodiments, the translatable hub assembly 36 defines sockets 316 proximate a base 318 of each of the torque arms 84, the sockets 316 being dimensioned to receive the biasing elements 113. As such, the biasing elements 113 are captured axially and tangentially by the sockets 312 and radially between the sockets 316 and the torque arm sliders 110, 112 or single slider assemblies 114. Each biasing element 113 may include a coil spring (depicted). The centering rings 304 may help center and secure the biasing elements 113 at desired locations on the first and second torque arm sliders 110, 112 (or single slider portions 116, 118) during operation as well as during assembly of the translatable hub assembly 36.

[0060] Functionally, the enlarged radius 252 of the through-passage 88 at the proximal end portion 232 of the hub column 80 enables the proximal bushing 236 to slide continuously from the proximal centering spacer 224 onto the idle bearing 216 as the drive unit 30 progresses from the idle configuration 29 to the overdrive configuration 31. The seating of the radial protrusions 238 into the pockets 242 (FIG. 9) prevents the proximal bushing 236 from sliding through the through-passage 88 at the proximal end portion 232 of the hub column 80 in operation. Using a continuous flange (not depicted) instead of the radial protrusions 238 would serve the same function. The radial protrusions 238 and pockets 242 also maintain the proximal bushing 236 in a substantially fixed rotational relationship with the hub column 80.

[0061] The inner flange 254 may act to sweep the idle bearing 216 of debris as the translatable hub assembly 36 progresses in the proximal direction 121. The inner flange 254 may also act to prevent the proximal bushing 236 from sliding through the through-passage

88 at the proximal end portion 232 of the hub column 80, for example in embodiments of the proximal centering spacer 224 that do not include the radial protrusions 238 or flange.

[0062] The biasing elements 113 and/or centrifugal forces generated by the rotation rate ω cause the torque arm sliders 110 and 112 (or 114) to impose a radial force vector F_r (FIG. 14) on the opposed inner tangential faces 66 and 68 of the tower column portion 60. The tapered angle ϕ of the outboard surfaces 298 and inner tangential faces 66 and 68 define a normal force component F_n and a parallel force component F_p that are, respectively, normal to and parallel to the outboard surfaces 298. The parallel arrangement between the outboard surfaces 298 and inner tangential faces 66 and 68 enables the parallel force component F_p to urge the first and second torque arm sliders 110, 112 (or first and second single slider portions 116, 118) to translate radially outward along the inner tangential faces 66 and 68 of the tower column portion 60 to seat the torque arm sliders 110 and 112 (or 114) within the axially extending channel 62. The paired first and second torque arm sliders 110, 112 (or first and second single slider portions 116, 118) generate opposed normal force components F_n that securely couple the torque arm 84 to the tower column portion 60.

[0063] For the first and second torque arm sliders 110 and 112, independent translation along the torque arm in the radial directions enables automatic adjustment for compensation of wear, such as depicted at FIG. 14. Over time, the first and second torque arm sliders 110 and 112 may be subject to different levels of wear. Consider that, in operation, the first or second torque arm slider 110 or 112 that is coupled to the outer tangential portion 94 or 96 that rotationally “leads” the torque arm 84 during a torsional loading of the drive unit 30 may tend to be subject to greater contact pressures with the respective inner tangential face 66 or 68 of the axially extending channel 62. In FIG. 14, the slider so depicted for the direction of the rotation rate ω is the second torque arm slider 112, which is coupled to tangential portion 96 of the torque arm 84, which is the forward or “leading” tangential portion of the torque

arm 84 when the drive unit 30 is rotating in the depicted direction of the rotation rate ω .

Because the drive unit 30 tends to operate more often and at higher rotation rates ω in a forward direction of travel for the associated vehicle, the first or second torque arm slider 110 or 112 that leads for forward torque operation may tend to experience more wear than the other “trailing” second or first torque arm slider 112 or 110.

[0064] In FIG. 14, the outboard surface 298 of the second torque arm slider 112 has been subject to more wear than the first torque arm slider 110. Accordingly, the second torque arm slider 112 may seat at a greater radial distance from the drive axis 42 than the first torque arm slider 110. The independent translation also enables better seating of both the first and second torque arm sliders 110 and 112 against the respective first and second inner channel faces 66 and 68 for enhanced contact area and reduced interface pressure.

[0065] The adjustment to wear can compensate for more than just wear on the outboard surface 298. For example, wear on the inner surfaces 302 of the torque arm sliders 110 and 112 (or single slider assembly 114), as well as wear on the inner channel faces 66 and 68 and/or wear shims 72 can also be compensated by the independent translation of the first and second torque arm sliders 110, 112. In another aspect of the independent action of the first and second torque arm sliders 110 and 112, the forward and reverse torque paths of the drive unit 30 are decoupled. That is, the torque path when the rotation of the drive unit 30 is reversed may pass through different elements of the assembly, for example, through first outer tangential portion 94, first torque arm slider 110, and first inner channel face 66 instead of second outer tangential portion 96, second torque arm slider 112, and second inner channel face 68. As such, the independent torque arm sliders 110 and 112 enable equal load sharing of all of the load components so that a given torque arm 84 isn't overloaded in operation.

[0066] The single slider assembly 114 offers a different torsional load dynamic than the first and second torque arm sliders 110 and 112, which may be preferable in some applications.

Because the first and second single slider portions 116 and 118 are tied together, the forward and reverse torque paths of the drive unit 30 are coupled. That is, the single slider assembly 114 acts to center the torque arm 84 within the axially extending channel 62, so that the torsion load passes more equally through both the first and second outer tangential portions 94 and 96, the first and second single slider portions 116 and 118, and the first and second inner channel faces 66 and 68. The centering action also maintains better rotational alignment between the hub assembly 36 and the spider assembly 38 for better alignment of and more uniform contact between the shift weights 122 on the rollers 124.

[0067] The first and second torque arm sliders 110, 112 and single slider assembly 114 may be fabricated from, for example, polyether ether ketone (PEEK) blended with about 15% to 30% carbon-reinforced polymers and about 15% polytetrafluoroethylene (PTFE). Other materials of fabrication include blends of PEEK, PFTE, and glass-filled polymers, or polyamides or polyimides such as VESPEL® or TORLON®. For example, first and second torque arm sliders 110, 112 may include a polyamide, a polyimide, a polyamide imide, VESLEP®, or TORLON®. In some examples, a material of first and second torque arm sliders 110, 112 may be selected for operability under compression pressures within a range from about 5 mega-Pascals (MPa) to 30 MPa.

[0068] Referring to FIGS. 16 and 17 and again to FIG. 4, the spider assembly 38 is depicted in greater detail according to an embodiment of the disclosure. The spider assembly 38 includes a housing 330 having an end portion 332, a side portion 334, and a proximal face 335. The end portion 332 defines a through-port 336 configured to receive and mate with a fitting 338 to secure the spider assembly 38 in a fixed axial and rotational relationship with the post assembly 34. In some embodiments, the fitting 338 mates with the tapered profile 214 of the second end portion 46 of the post 200, for example by threaded engagement, press fit, or pins. The fitting 338 is configured for receiving and coupling with

the drive shaft 28, which may provide the primary coupling between the drive unit 30 and the drive shaft 28. In some embodiments, the drive shaft is a fastener or bolt, such as a clutch bolt 339 that attaches and affixes the drive clutch to the engine crankshaft. The side portion 334 extends axially from the end portion 332 to an outer periphery 340 that, in assembly, surrounds the post assembly 34. The through-port 336 defines and is colinear about a housing axis 342 that, in assembly, is aligned with the drive axis 42.

[0069] The housing 330 includes a plurality of the tower column portions 60 that define a plurality of the axially extending channels 62 uniformly distributed about the housing axis 342. The channels 62 may each be closed at the end portion 332 of the housing 330 and define an open end 344 at the proximal face 335. The housing 330 of the spider assembly 38 may also define a plurality of roller receptacles 346, each securing a respective one of the plurality of rollers 124 mounted therein and each extending over a respective one of the shift weights 122 that are mounted to the translatable hub assembly 36 for rotation about roller axes 348. In some embodiments, the outer periphery 334 surrounds and is continuous about the tower column portions 60 and the roller receptacles 346.

[0070] Functionally, the tower column portions 60 are integrated into the spider assembly 38. This inverts the relationship of various conventional CVT clutches where the tower column portion extend directly from a drive pulley. Such conventional designs can generate substantial additional stress and deflection on the tower columns and drive pulley, particularly at higher rotation rates. In many such conventional CVT clutches, a secondary support structure is required to counter and prevent the adverse effect of these stresses and deflections, adding to the complexity of the design and assembly. Integration of the of the tower column portions 60 into the spider assembly 38 eliminates that additional stresses and associated deflections that would be imparted on the drive pulley 22 in conventional designs. The continuity of the outer periphery 340 about the tower column portions 60 and roller

receptacles 346 of the housing 330 serves the same function as a secondary support structure in conventional designs, i.e., limiting radial deflection of the tower column portions 60 to maintain axial alignment of the axially extending channels 62.

[0071] Suspended debris such as airborne particulates and fragments tend to flow axially around the drive unit 30. The housing 330, with the closed end and side portions 332 and 334, tends to shroud the translatable sheave portion 82 and the open end 344 of the axially extending channels 62, thereby limiting flow of debris into the axially extending channels 62 of the tower column portions 60. The distal bushing 244 is also contained within both the hub assembly 36 and the spider assembly 38 for reduced exposure to debris.

[0072] Referring to FIGS. 18 through 20, baffle assemblies 350 mounted to the drive unit 30 are depicted according to an embodiment of the disclosure. The baffle assemblies 350 depicted herein are referred to individually as baffle assembly 350a and 350b. The baffle assembly 350a includes a baffle 352a that extends in the distal direction 123 from the outer perimeter 90 of the translatable sheave portion 82 to surround the outer periphery 340 of the spider assembly 38. The baffle 352a is in a fixed axial and rotational relationship with the translatable hub assembly 36 and may be unitary with the translatable sheave portion 82. In some embodiments, the baffle 352a extends to an axial length 354 that surrounds the spider assembly 38 in the overdrive (fully extended) configuration 31. A peripheral clearance 356 is defined between the baffle 352a and the outer periphery 340 of the spider assembly 38. In some embodiments, the peripheral clearance 356 is in a range from 1 millimeter to 8 millimeters inclusive. In some embodiments, the peripheral clearance 356 is in a range from 2 millimeters to 4 millimeters inclusive. The peripheral clearance 356 may be substantially uniform.

[0073] Functionally, the baffle assembly 350 reduces fouling of the axially extending channels 62 of the tower column portions by inhibiting debris from flowing radially inward

between the outer periphery 340 of the spider assembly 38 and the outer perimeter 90 of the translatable sheave portion 44. Entry of debris between the translatable hub assembly 36 and the spider assembly 38 is limited to the peripheral clearance 356. By defining the axial length 354 of the baffle 352a sufficient to surround the spider assembly 38 in the overdrive configuration 31, the baffle assembly 350a functions to limit debris entry across the axial operating range of the drive unit 30, from the idle configuration 29 to the overdrive configuration 31.

[0074] The baffle assembly 350b includes a baffle 352b that is registered against and extends distally from the translatable sheave portion 82. The baffle 352b may be shaped to surround a substantially non-circular perimeter of a spider assembly 38b. In the depicted embodiment, the baffle 352b includes radial juts 358 that trace around the roller receptacles 346, with radially inset arcuate segments 362 extending between radial juts 358. The baffle 352b may be anchored to the translatable hub assembly 36 at the radial juts 358, for example by extension of the pivot pins 280 of the shift weights 122 through radial juts 358.

[0075] In some embodiments, the spider assembly 38b includes a skirt portion 364 that extends in the distal direction 123 from the outer periphery 340 and parallel to the baffle 352b. The peripheral clearance 356 may be maintained between the baffle 352 and the skirt portion 364 over the axial length 34 of the skirt portion 364 to define an annular channel 366 therebetween. In some embodiments, a distal edge 368 of the baffle 352b and a distal edge 372 of the skirt portion 364 and are in substantially axial alignment when the drive unit is in the idle configuration 29. The baffle assembly 350b may include a plurality of projections 374 that extend radially outward from the baffle 352. The skirt portion 364 and attendant annular channel 366 thereby defined may also be implemented with the baffle assembly 350a.

[0076] Functionally, the baffle assembly 350b provides an example of surrounding a spider assembly 38 that has substantially non-circular radial profile. The annular channel 366

further restricts inflow of debris. The skirt portion 364 may also inhibit radially inward flows as the translatable hub assembly 36 is translates in the proximal direction 121, thereby exposing the skirt portion 364. The plurality of projections 374 may act to propel air radially outward, further militating against radially inward flows.

[0077] Referring to FIGS. 21 and 22, wiper seals 376 are depicted according to embodiments of the invention. The wiper seals 376 are arranged to bridge the peripheral clearance 356 for contact with both the translatable hub assembly 36 and the spider assembly 38. In some embodiments, the wiper seal 376 is disposed at the outer periphery 340 of the spider assembly 38 as depicted in FIG. 21. For embodiments that include the skirt portion 364, the wiper seal 376 may be disposed at the outer periphery 340, or at an axial location along the skirt portion 364 as depicted in FIG. 22. The wiper seals 376 define a cross-section 378 and may be disposed in a gland 380 defined on the spider assembly 38. The wiper seal 376 may be pre-formed to follow a non-circular radial profile, such as depicted at FIG. 19.

[0078] The cross-sections 378 of the wiper seals 376 may define different shapes, for example circular or oval shaped (cross-section 378a of FIG. 21) or a polygonal shape (cross-section 378b of FIG. 22, depicting a pentagonal shape). The cross-sections 378 may be hollow (e.g., FIG. 21) or solid (e.g., FIG. 22). In some embodiments, polygonal cross-sections 378b are oriented so that a corner of the shape contacts the baffle 352, 352b. The cross-sections 378 depicted herein are referred to individually by a letter suffix (e.g., “cross-section 378a”). Other non-depicted cross-sections 378 are contemplated, for example, lip or shaft seals.

[0079] Functionally, the wiper seal 376 provides an additional barrier against passage of debris into the interior of the spider assembly 38. The axial translation of the translatable hub assembly 36 relative to the spider assembly 38 can act to wipe the baffle 352 of the baffle assembly 350 to remove debris therefrom. The contact pressure generated against

translatable hub assembly 36 and the spider assembly 38 by the wiper seal 376 can be tailored by the construction and sizing of the wiper seal 376. For example, lighter contact pressures may be effected by the use of softer materials for the wiper seal 376, dimensioning the cross-section 378 for less interference, the use of a hollow cross-section 378, and/or reduced contact areas such as provided by a corner of a polygonal cross-section 378b or a lip structure. Higher contact pressures may be effected by the use of harder materials, dimensioning the cross-section 378 for greater interference, the use of a solid cross-section 378, and/or increased contact areas such as provided by the flat of a polygonal cross-section 378.

[0080] Referring to FIG. 23, the overdrive configuration 31 for the drive unit 30 is depicted according to an embodiment of the disclosure. As the rotation rate ω of the drive unit 30 about the drive axis 42 increases, rotational inertia acts on each of the shift weights 122 to generate a centrifugal force FC that is centered at the respective center of gravity CG. The centrifugal forces FC cause the shift weights 122 to rotate radially outward about the tangentially extending pivot axes 278, thereby exerting actuation forces FA on the rollers 124. The actuation forces FA include axial force components FZ that act counter the return force FR of the return element 228 to translate the translatable hub assembly 36 in the proximal direction 121. The proximal translation of the translatable hub assembly 36 compresses the return element 228 between the proximal and distal centering spacers 224 and 226, thereby increasing the magnitude of the return force FR. The proximal translation may also cause the proximal bushing 236 to slide onto the idle bearing 216.

[0081] At a given rotation rate ω , the summation of the axial force components FZ generated by the shift weights 122 act to overcome various resistance forces that resist axial translation of the translatable hub assembly 36 relative to the spider assembly 38. The resistance forces include the biasing of the return element 228, the friction between the first and second torque

arm sliders 110 and 112 and the axially extending channels 62 of the tower column portions 60, and the friction between the bushings 236 and 244 and the post assembly 34.

Overcoming these and other resistance forces causes the translatable hub assembly 36 and the attendant translatable sheave portion 82 to translate axially toward the axially stationary sheave portion 44, thereby defining a gap δ that is equal to the belt width W at a radial distance $R1$ from the drive axis 42. As such, the drive belt 26 is pushed radially outward by the contraction between the sheave portions 44 and 82 so that the drive belt 26 defines an outer belt radius at the radial distance $R1$, which is greater than the minimum outer belt radius $R0$ of the idle configuration 29. The increase of the radial distance from $R0$ to $R1$ pulls the belt 26 closer toward the driven shaft of the driven pulley 24 to increase the rotation rate of the driven pulley 24 (FIG. 2).

[0082] FIGS. 24 through 29C are conceptual diagrams illustrating an example drive unit 430 for a CVT according to embodiments of the disclosure. Drive unit 430 and the components thereof may be the same or substantially similar to drive unit 30 and the components thereof describe above in reference to FIGS. 3 through 23, except for the differences described herein. For example, drive unit 430 includes a post assembly 434 having an axially stationary sheave portion 444 and a translatable hub assembly 436 having a translatable sheave portion 482, which define a drive pulley 422, and a spider assembly 438 affixed to a distal end portion 446 post assembly 434. Translatable hub assembly 436 further includes a hub column 480 and two or more torque arms, e.g., torque arm 484. Spider assembly 438 includes a plurality of shift weights 423 and corresponding rollers 425.

[0083] In some examples, translatable sheave portion 482 may define a plurality of recesses 483. Plurality of recesses 483 may include respective balance zones configured for balancing a weight of translatable sheave portion 482 by removal material or addition of material (e.g., weights). In some examples, plurality of recesses 483 may be evenly or nearly evenly

positioned around a circumference of translatable sheave portion 482, which may reduce or eliminate exclusion zones that cannot be used for balancing translatable sheave portion 482. In this way, compared to translatable sheave portions without the plurality of recesses 483, translatable sheave portion 482 may be easier to balance.

[0084] As illustrated in FIGS. 27 and 28, torque arm 484 extends radially outward from hub column 480 along a torque arm axis 492 and into the axially extending channel 462 of the spider assembly 438. Each torque arm 484 includes a first outer tangential portion 494 and a second outer tangential portion 496 disposed on opposed tangential sides of the torque arm axis 492. First and second outer tangential portions 494 and 496 define respective slider channels 495 and 497. Slider channels 495 and 497 are configured to receive in sliding engagement first and second torque arm sliders 510 and 512. First and second torque arm slider 510 and 512 are independent of each other, i.e., do not contact or connect with one another. In some examples, translatable hub assembly 436 may include biasing elements, such as coil springs or the like, configured to urge respective first and second torque arm sliders 510 and 51 radially outward and, optionally, axially outward.

[0085] During operation, first torque arm slider 510 may transmit torque T from spider 438, via wear shim 472, to torque arm 484. As such, first torque arm slider 510 may be referred to as a leading slider. The transmission of torque enables translatable hub assembly 436 to rotate with post assembly 434.

[0086] The transmission of torque results in a compressive force (i.e., pressure) on surfaces first torque arm slider 510. As such, at least first torque arm slider 510 is configured to withstand a compressive force with in a range from about 5 MPa to about 30 MPa. Second torque arm slider 512, referred to as a trailing slider, may not transmit torque from spider 438 to torque arm 484, as illustrated by the gap G . Hence, second torque arm slider 512 may be subject to less compressive force during operation compared to first torque arm slider 510.

[0087] In some examples, a material of first and second torque arm sliders 510, 512 may be selected to withstand the compressive forces within a range from about 5 MPa to about 30 MPa. For example, a material of first and second torque arm sliders 510, 512 may include one or more of a polyamide, a polyimide, a polyamide imide, a polyetheretherketone, VESPEL®, or TORLON®.

[0088] Also, during operation, the rotation of translatable hub assembly 436 imparts a centripetal force C on first torque slider 510. A similar centripetal force may be imparted on second torque arm slider 512. In some examples, a magnitude of centripetal force C may be controlled, at least in part, by selecting a mass of first torque arm slide 510 and/or second torque arm slider 512. In some examples, a mass of first and second torque arm sliders 510, 512 may be within a range from about 4.6 grams (g) to about 2.0 g, or about 2.5 g.

[0089] In some examples, the mass of torque arm sliders 510, 512 may be selected based on performance characteristics of the drive unit 430. This is because the operating speed, i.e., revolutions per minute (RPM), contributed to the centripetal force exerted by torque sliders 510, 512 on wear shim 472. For example, a snowmobile having higher average engine speeds (i.e., RPM) and/or drive unit speeds may benefit from a reduced torque arm slider mass compared to a UVT or an ATV that may operate with an relatively lower average engine speed and/or drive unit speed. As an example, when implemented in a UTV or ATV, torque arm sliders 510, 512 may have a mass of about 2.5 g and, when implemented in a snowmobile, may have a mass of about 2.0 g.

[0090] The centripetal force C results in a friction (also referred to as a drag force) between first torque arm slider 510 and wear shim 472. Hence, the friction may be controlled by controlling centripetal force C . Additionally, the friction may be further controlled by selecting an shape of first torque arm slider 510.

[0091] As illustrated in FIGS. 29A through 29C, first torque arm slider 510 extends from a first end 524 to a second end 526 and defines a first angled surface 520 (hereinafter, face 520) and a second flat surface 522 (hereinafter flat, 522) each opposing a base surface 525. First torque arms slider 510 defines a width W and a maximum height H (hereinafter, height H). The width W may be within a range from about 5 millimeters (mm) to about 15 mm, such as about 10 mm. The height H may be within a range from about 10 mm to about 20 mm, such as about 15 mm.

[0092] Base surface 525 may extend along length L . The overall length L of first torque arm slider 510 may be within a range from about 10 mm to about 50 mm, such as with in a range from about 15 mm to about 30 mm, such as about 18 mm. In other examples, length L may be less than 15 mm or greater than 50 mm.

[0093] Each of face 520 and flat 522 may have a respective length L_A and L_F , respectively. Length L_A of face 520 may be within a range from about 6 mm to about 40 mm, such as about 12 mm. Length L_F of flat 522 may be with in a range from about 4 mm to about 20 mm, such as about 6 mm.

[0094] The dimensions of face 520 and flat 522 are configured to withstand a threshold pressure, such as a pressure within a range from about 5 MPa to about 30 MPa. For example, an area defined by face 520 and flat 522 may be configured to withstand pressures within a range from about 5 MPa to about 30 MPa or, in some example, greater than about 30 MPa. Moreover, face 520 may be configured to withstand more pressure than flat 522.

[0095] In some examples, a height H of first torque arm slider 510 is a function of the threshold pressure. That is, a torque arm slider having a greater height H may withstand a greater pressure relative to a torque arm slider having a lesser height H .

[0096] In some examples, the mass of first torque arm slider 510 may be selected based on a length L . To control the length, material may be removed from a first end 524, second end

526, or both. Alternatively, first torque arm slider may be formed having a shorter length L . When material is removed to reduce mass, other surfaces of first torque arm slider 510 may remain substantially the same compared to heavier sliders, albeit lengths length L_A and/or L_F may be slightly reduced. Additionally, other components of drive unit 430 may be substantially the same, for example, an axial length of torque arm 484 as well as the shape of respective slider channels 495 and 497 may be the same compared to those for relatively heavier sliders. In this way, performance characteristics of drive unit 430 may be controlled by modifying or replacing relatively less expensive components.

[0097] Face 520 is defined by a working angle ω , which may be within a range from about 20-degrees to about 30-degrees relative to a plane defines by flat 522. In some examples, a working angle ω of 20-degrees may result in greater friction compared to a working angle ω of 30-degrees. For example, a working angle ω of 30-degrees may result in about 60% less friction compared to a working angle ω of 20-degrees. Moreover, in some examples, a working angle ω greater than 30-degrees may result in a high frequency motion between first torque arm slider 510 and wear shim 472 or otherwise provide in sufficient torsional rigidity to effectively engage spider 438 with torque translatable hub assembly 436. As discussed above, the working angle ω , like mass, may be selected based on performance characteristics of drive unit 430 at least for the reason to reduce friction.

[0098] Although illustrated as having substantially similar working angles ω , in some examples, first torque arm slider 510 may have a first working angle and second torque arm slider 512 may have a second, different working angle. The difference in working angles may be selected to control performance characteristics of drive unit 430 under predetermined operating conditions, such as low power (e.g., lower RMP), high power (e.g., high RPM), or both.

[0099] Flat 522 extends along a plane that is substantially parallel to torque arm axis 492 (i.e., a plane extending . Flat 522 registers spider 438 (via wear shim 472) with translatable hub assembly 436 (via torque arm slider 510, 512). That is flat 522 is configured to sets an orientation or position of spider 538 relative to translatable hub assembly 436. By registering spider 438 with translatable hub assembly 436, flat 522 may reduce premature wear of wear shim 472, torque arm slider 510, 512, or both resulting from relative movement therebetween or oscillation of forces caused by engine torque oscillations, backlash, acceleration events, or the like. Additionally, or alternatively, flat 522 may reduce a tendency of the engine nominal torque to push first torque arm slider 510 axially inward and second torque arm slider 512 axially outward. As such, flat 522 further improves shift performance and contact between roller and shift weight.

[0100] First torque arm slider 510 includes an optional step 528. Step 528 allows a working radius to provide additional clearance with wear shim 472 as first torque arm slider 510 takes up backlash. Additionally, or alternatively, step 528 may reduce misalignment. For example, (without flat engine nominal torque would push leading slider downward, and trailing slider upward), improves shift performance, and contact between roller and shift weight.

[0101] First torque arm slider 510 also includes optional chamfers 530 and 532. Chamfers 530 and 532 may provide a radius for clearance between a first torque arm slider 510 and slider channel 495.

[0102] Although illustrated as including generally rectilinear surfaces, e.g., a polygonal profile, in some examples, first and second torque arm sliders 510, 512 may include curvilinear surfaces, rounded corners, or both.

[0103] Second torque arm slider 512 may be the same as or substantially similar to first torque arm slider 510 as described above. That is, first torque arm slider 510 and second torque arm slider 512 may be symmetrical.

[0104] In some examples, drive unit 430 includes an optional a one-way clutch member 450. One-way clutch member 450 is configured to reduce inertial impact forces and, optionally, noise resulting from impact forces, caused by clearance, backlash, or both between rotating slidable components. One-way clutch member 450 may be used in place of a back-driving slider or bushing, such as bushing 244 described above.

[0105] Internal combustion engines output a cyclic torque. Hence, drivetrain components experience acceleration and deceleration events, even during contact power output. A CVT of such drivetrain components necessarily has sliding sheaves to change the gear ratio, which requires clearance between selected CVT components. This clearance allows for different velocities between parts and thereby impacts. These impacts create time varying forces which in turn vibrate support structures and create noise. By implementing one-way clutch 450 in such CVT systems, the forward torque in the cycle can be carried by the main driving features, such as splines and one-way clutch 450 can reduce the reverse or negative forces from inertia.

[0106] Alternatively, one-way clutch member 450 may be used in an electronic CVT (eCVT) system or other systems having splines or similar features configured to transmit torque and slide. Such systems or features require have clearance or backlash which contributes to impact forces and thereby noise. Reducing the amount of backlash reduces the force and thereby the noise. For example, a drive force acts on the splines during the torque pulse and one-way clutch 450 resist the inertia of the driven parts on the downstream side of the spline or clearance.

[0107] Various directional terms and expressions herein are derived from the r - θ - z coordinate system depicted at FIG. 3. The r - θ - z coordinate system is of arbitrary origin, with the z -coordinate being colinear with the drive axis 42 of the drive unit 30. “Axial” and its derivative terms refer to directions that are parallel to the z -coordinate. “Radial” and its

derivative terms refer to directions parallel to the r-coordinate. “Tangential” and its derivative terms refer to a direction that is congruent with the θ -coordinate. “Distal” and its derivative terms refers to a direction along the z-coordinate that is away from the base shoulder 206 of the post 200. “Proximal” and its derivative terms refer to a direction that is opposite the distal direction.

[0108] The following clauses illustrate example subject matter described herein:

[0109] Clause 1. A drive unit for a continuously variable transmission, comprising: a post assembly that defines and is colinear with a drive axis; an axially stationary sheave portion coupled to a first end portion of said post assembly; a spider assembly affixed to a second end portion of said post assembly, said spider assembly including a tower portion that defines an axially extending channel extending along and defining a channel axis, said axially extending channel including a first inner tangential face and a second inner tangential face, each facing tangentially toward said channel axis; a translatable hub assembly coupled to a mid-portion of said post assembly, including: a translatable hub column colinear with said post assembly about said drive axis, a translatable sheave portion coupled to said translatable hub column, a torque arm that extends radially outward from said translatable hub column along a torque arm axis and into said axially extending channel of said spider assembly, said torque arm including a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides said torque arm axis; at least one torque arm slider coupled to said first outer tangential portion of said torque arm to permit translation along said torque arm in radial directions, said at least one torque arm slider engaging said first inner tangential face and said second inner tangential face of said axially extending channel of said spider assembly for torsional coupling of said spider assembly to said translatable hub assembly about the drive axis.

[0110] Clause 2. The drive unit of clause 1, wherein said at least one torque arm slider is a single slider that includes a first single slider portion and a second single slider portion, said first single slider portion engaging said first inner tangential face of said axially extending channel, said second single slider portion engaging said second inner tangential face of said axially extending channel.

[0111] Clause 3. The drive unit of clause 1, wherein said at least one torque arm slider includes: a second torque arm slider coupled to said second outer tangential portion of said torque arm to permit translation along said torque arm in radial directions, said second torque arm slider engaging said second inner tangential face of said axially extending channel of said spider assembly for torsional coupling of said spider assembly to said translatable hub assembly about the drive axis.

[0112] Clause 4. The drive unit of clause 1, wherein said first torque arm slider and said second torque arm slider are separate structures that slide radially along said torque arm independent of each other.

[0113] Clause 5. The drive unit of clause 1, comprising a return element coupled to said translatable hub assembly to bias said axially moveable sheave portion away from said axially stationary sheave portion when said drive unit is not rotating.

[0114] Clause 6. The drive unit of clause 1, wherein said translatable sheave portion is actuated along said drive axis by a plurality of shift weights that centrifugally act against said spider assembly for motivation of said translatable sheave portion toward said axially stationary sheave portion, said plurality of shift weights being uniformly distributed about said drive axis.

[0115] Clause 7. The drive unit of clause 6, wherein each of said plurality of shift weights are pivotally mounted to said translatable hub assembly to rotate against said spider assembly in response to rotation of said drive unit about said drive axis.

[0116] Clause 8. The drive unit of clause 6, wherein engagement of said first torque arm slider and said second torque arm slider with said axially extending channel of said spider assembly imparts sufficient torsional stiffness on said drive unit about said drive axis to isolate said plurality of shift weights from tangential torsional loads.

[0117] Clause 9. The drive unit of clause,6 wherein said spider assembly includes a plurality of rollers, each oriented to engage a respective one of said plurality of shift weights during said motivation of said translatable sheave portion toward said axially stationary sheave portion.

[0118] Clause 10. The drive unit of clause,1 wherein said axially extending channel is one of a plurality of axially extending channels defined by said spider assembly, said plurality of axially extending channels being uniformly distributed about said drive axis.

[0119] Clause 11. The drive unit of clause,1 wherein said axially extending channel includes one or more wear shims that contact said first torque arm slider and said second torque arm slider.

[0120] Clause 12. The drive unit of clause 1, wherein said first torque arm slider and said second torque arm slider do not physically contact each other.

[0121] Clause 13. The drive unit of clause 1, wherein said translatable hub assembly includes a biasing element disposed between said translatable hub column and said first torque arm slider to bias said first torque arm slider radially outward along said torque arm so that said first torque arm slider contacts said axially extending channel of said spider assembly.

[0122] Clause 14. The drive unit of clause 13, wherein said translatable hub assembly defines a pocket proximate a base of said torque arm, said biasing element being disposed within said pocket.

[0123] Clause 15. The drive unit of clause 14, wherein said biasing element includes a coil spring.

[0124] Clause 16. The drive unit of clause 1, comprising a baffle that surrounds an outer periphery of said spider assembly, said baffle being shaped and dimensioned to define a peripheral clearance about said outer periphery.

[0125] Clause 17. The drive unit of clause 16, wherein said peripheral clearance about said outer periphery is substantially uniform.

[0126] Clause 18. The drive unit of clause 16, wherein said baffle includes a plurality of projections that extend radially outward for movement of air.

[0127] Clause 19. The drive unit of clause 16, wherein said baffle is mounted to said translatable hub assembly, said baffle extending axially in a distal direction away from said translatable sheave portion to surround said outer periphery.

[0128] Clause 20. The drive unit of clause 19, wherein said baffle is registered against said translatable sheave portion.

[0129] Clause 21. The drive unit of clause 19, wherein said spider assembly includes a skirt portion that extends axially in said distal direction from said outer periphery, said skirt portion extending parallel to said baffle and defining said peripheral clearance therebetween.

[0130] Clause 22. The drive unit of clause 21, wherein a distal edge of said skirt portion and a distal edge of said baffle are in axial alignment when said drive unit is in an idle configuration.

[0131] Clause 23. A drive unit for a continuously variable transmission, comprising: a tower defining an axially extending channel that defines and extends along a channel axis, said axially extending channel including a first inner tangential face and a second inner tangential face, each of said first inner tangential face and said second inner tangential face facing tangentially toward said channel axis; a torque arm that extends radially along a torque arm

axis and into said axially extending channel of said tower, said torque arm including a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides said torque arm axis; a first torque arm slider coupled to said first outer tangential portion of said torque arm to permit translation along said torque arm in radial directions, said first torque arm slider engaging said first inner tangential face of said axially extending channel for coupling of said tower to said torque arm; and a second torque arm slider coupled to said second outer tangential portion of said torque arm to permit translation along said torque arm in radial directions, said second torque arm slider engaging said second inner tangential face of said axially extending channel for coupling of said tower to said torque arm, wherein said first torque arm slider and said second torque arm slider are separate structures that slide radially along said torque arm independent of each other.

[0132] Clause 24. The drive unit of clause 23, wherein said tower is integral to a spider assembly, said spider assembly being axially and rotationally affixed to a post assembly that defines and is colinear with a drive axis.

[0133] Clause 25. The drive unit of clause 24, wherein said tower and said spider assembly are unitary.

[0134] Clause 26. The drive unit of clause 24, wherein said torque arm is integral with a translatable hub assembly coupled to said post assembly to permit translation along said post assembly in axial directions, said translatable hub assembly including: a translatable hub column colinear with said post assembly about said drive axis, and a translatable sheave portion.

[0135] Clause 27. The drive unit of clause 26, wherein said torque arm and said translatable hub column are unitary.

[0136] Clause 28. The drive unit of clause 26, wherein said torque arm, said translatable hub column, and said axially moveable sheave portion are unitary.

[0137] Clause 29. The drive unit of clause 1, comprising a baffle that surrounds an outer periphery of said spider assembly, said baffle being shaped and dimensioned to define a peripheral clearance about said outer periphery.

[0138] Clause 30. The drive unit of clause 29, comprising a wiper seal disposed between and contacting both said translatable hub assembly and said baffle.

[0139] Clause 31. The drive unit of clause 30, wherein said wiper seal is seated in a gland defined by said spider assembly.

[0140] Clause 32. The drive unit of clause 29, wherein said peripheral clearance about said outer periphery is substantially uniform .

[0141] Clause 33. The drive unit of clause 29, wherein said baffle includes a plurality of projections that extend radially outward for movement of air.

[0142] Clause 34. The drive unit of clause 20, wherein said baffle is mounted to said translatable hub assembly, said baffle extending axially in a distal direction away from said translatable sheave portion to surround said outer periphery.

[0143] Clause 35. The drive unit of clause 34, wherein said baffle is registered against said translatable sheave portion.

[0144] Clause 36. The drive unit of clause 34, wherein said spider assembly includes a skirt portion that extends axially in said distal direction from said outer periphery, said skirt portion extending parallel to said baffle and defining said peripheral clearance therebetween.

[0145] Clause 37. The drive unit of clause 36, wherein a distal edge of said skirt portion and a distal edge of said baffle are in axial alignment when said drive unit is in an idle configuration.

[0146] Clause 38. The drive unit of clause 24, comprising: an axially stationary sheave portion coupled to said post assembly; and a return spring coupled to said translatable hub

assembly to bias said axially moveable sheave portion away from said axially stationary sheave portion.

[0147] Clause 39. The drive unit of clause 24, comprising an axially stationary sheave portion coupled to said post assembly, wherein said translatable sheave portion is actuated along said post assembly by a plurality of shift weights that centrifugally act against said spider assembly for motivation of said translatable sheave portion toward said axially stationary sheave portion, said plurality of shift weights being uniformly distributed about said drive axis.

[0148] Clause 40. The drive unit of clause 39, wherein each of said plurality of shift weights are pivotally mounted to said translatable hub assembly to rotate against said spider assembly in response to rotation of said drive unit about said drive axis.

[0149] Clause 41. The drive unit of clause 39, wherein engagement of said first torque arm slider and said second torque arm slider with said axially extending channel of said spider assembly imparts sufficient torsional stiffness on said drive unit about said drive axis to isolate said plurality of shift weights from tangential torsional loads.

[0150] Clause 42. The drive unit of clause 39, wherein said spider assembly includes a plurality of rollers, each being oriented to engage a respective one of said plurality of shift weights during said motivation of said translatable sheave portion toward said axially stationary sheave portion.

[0151] Clause 43. The drive unit of clause 23, wherein said axially extending channel is one of a plurality of axially extending channels defined by said spider assembly, said plurality of axially extending channels being uniformly distributed about said drive axis.

[0152] Clause 44. The drive unit of clause 23, wherein said axially extending channel includes one or more wear shims that contact said first torque arm slider and said second torque arm slider.

[0153] Clause 45. The drive unit of clause 23, wherein said first torque arm slider and said second torque arm slider do not physically contact each other.

[0154] Clause 46. The drive unit of clause 23, wherein said translatable hub assembly includes a biasing element disposed between said translatable hub column and said first torque arm slider to bias said first torque arm slider radially outward along said torque arm so that said first torque arm slider contacts said axially extending channel of said spider assembly.

[0155] Clause 47. The drive unit of clause 46, wherein said translatable hub assembly defines a pocket proximate a base of said torque arm, said biasing element being disposed within said pocket.

[0156] Clause 48. The drive unit of clause 47, wherein said biasing element includes a coil spring.

CLAIMS

What is claimed is:

1. A drive unit for a continuously variable transmission, comprising:
 - a post assembly that defines and is colinear with a drive axis;
 - an axially stationary sheave portion coupled to a first end portion of the post assembly;
 - a spider assembly affixed to a second end portion of the post assembly, the spider assembly including a tower portion that defines an axially extending channel extending along and defining a channel axis, the axially extending channel including a first inner tangential face and a second inner tangential face, each facing tangentially toward the channel axis;
 - a translatable hub assembly coupled to a mid-portion of the post assembly, including
 - a translatable hub column colinear with the post assembly about the drive axis,
 - a translatable sheave portion coupled to the translatable hub column,
 - a torque arm that extends radially outward from the translatable hub column along a torque arm axis and into the axially extending channel of the spider assembly, the torque arm including a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides the torque arm axis;
 - at least one torque arm slider coupled to the first outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the at least one torque arm slider engaging at least one of the first inner tangential face and the second inner tangential face of the axially extending channel of the spider assembly for torsional coupling of the spider assembly to the translatable hub assembly about the drive axis.

2. The drive unit of claim 1, wherein the at least one torque arm slider is a single slider that includes a first single slider portion and a second single slider portion, the first single slider portion engaging the first inner tangential face of the axially extending channel, the second single slider portion engaging the second inner tangential face of the axially extending channel.
3. The drive unit of claim 1, wherein the at least one torque arm slider includes:
 - a first torque arm slider coupled to the first outer tangential portion of the torque arm, the first torque arm slider engaging the first inner tangential face of the axially extending channel of the spider assembly; and
 - a second torque arm slider coupled to the second outer tangential portion of the torque arm, the second torque arm slider engaging the second inner tangential face of the axially extending channel of the spider assembly.
4. The drive unit of claim 3, wherein the first torque arm slider and the second torque arm slider are separate structures that slide radially along the torque arm independent of each other.
5. The drive unit of claim 3, wherein the first outer tangential portion defines a first slider channel configured to receive in radial sliding engagement the first torque arm slider, and wherein the second outer tangential portion defines a second slider channel configured to receive in radial sliding engagement the second torque arm slider.

6. The drive unit of claim 3, wherein each of the first torque arm slider and the second torque arm slider comprise a flat surface extending substantially parallel to the torque arm axis and a face surface extending at an angle within a range from approximately 20-degrees to approximately 30-degrees from a plane defined by the flat surface.

7. The drive unit of claim 1, wherein the translatable sheave portion is actuated along the drive axis by a plurality of shift weights that centrifugally act against the spider assembly for motivation of the translatable sheave portion toward the axially stationary sheave portion, the plurality of shift weights being uniformly distributed about the drive axis, and wherein each of the plurality of shift weights are pivotally mounted to the translatable hub assembly to rotate against the spider assembly in response to rotation of the drive unit about the drive axis.

8. The drive unit of claim 7, wherein engagement of the at least one torque arm slider with the axially extending channel of the spider assembly imparts sufficient torsional stiffness on the drive unit about the drive axis to isolate the plurality of shift weights from tangential torsional loads.

9. The drive unit of claim 7, wherein the spider assembly includes a plurality of rollers, each oriented to engage a respective one of the plurality of shift weights during the motivation of the translatable sheave portion toward the axially stationary sheave portion.

10. The drive unit of claim 1, wherein the translatable hub assembly includes a biasing element disposed between the translatable hub column and the first torque arm slider to bias the first torque arm slider radially outward along the torque arm so that the first torque arm slider contacts the axially extending channel of the spider assembly.

11. The drive unit of claim 10, wherein the translatable hub assembly defines a pocket proximate a base of the torque arm, the biasing element being disposed within the pocket.

12. The drive unit of claim 1, comprising a baffle that surrounds an outer periphery of the spider assembly, the baffle being shaped and dimensioned to define a peripheral clearance about the outer periphery, and wherein the baffle includes a plurality of projections that extend radially outward for movement of air.

13. The drive unit of claim 12, wherein the spider assembly includes a skirt portion that extends axially in the distal direction from the outer periphery, the skirt portion extending parallel to the baffle and defining the peripheral clearance therebetween, and wherein a distal edge of the skirt portion and a distal edge of the baffle are in axial alignment when the drive unit is in an idle configuration.

14. A drive unit for a continuously variable transmission, comprising:

a tower defining an axially extending channel that defines and extends along a channel axis, the axially extending channel including a first inner tangential face and a second inner tangential face, each of the first inner tangential face and the second inner tangential face facing tangentially toward the channel axis;

a torque arm that extends radially along a torque arm axis and into the axially extending channel of the tower, the torque arm including a first outer tangential portion and a second outer tangential portion that are disposed on opposed tangential sides the torque arm axis;

a first torque arm slider coupled to the first outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the first torque arm slider engaging the first inner tangential face of the axially extending channel for coupling of the tower to the torque arm; and

a second torque arm slider coupled to the second outer tangential portion of the torque arm to permit translation along the torque arm in radial directions, the second torque arm slider engaging the second inner tangential face of the axially extending channel for coupling of the tower to the torque arm,

wherein the first torque arm slider and the second torque arm slider are separate structures that slide radially along the torque arm independent of each other.

15. The drive unit of claim 14, wherein the tower is integral to a spider assembly, the spider assembly being axially and rotationally affixed to a post assembly that defines and is colinear with a drive axis.

16. The drive unit of claim 14, wherein the torque arm is integral with a translatable hub assembly coupled to the post assembly to permit translation along the post assembly in axial directions, the translatable hub assembly including:

a translatable hub column colinear with the post assembly about the drive axis, and
a translatable sheave portion.

17. A drive unit for a continuously variable transmission, comprising:

a first torque arm slider configured to be received in sliding engagement with both a first inner tangential face of a channel of a tower extending axially and facing toward a channel axis and a first slider channel defined by a first outer tangential portion of a torque arm extending along a torque arm axis, wherein the channel axis is substantially perpendicular to the torque arm axis; and

a second torque arm slider configured to be received in sliding engagement with both a second opposing inner tangential face of the channel of the tower extending axially and facing toward the channel axis and a second slider channel defined by a second opposing outer tangential portion of the torque arm extending along the torque arm axis,

wherein the first torque arm slider and the second torque arm slider are separate structures disposed to couple the tower to the torque arm and permit translation along the torque arm and the channel in radial directions independent of each other.

18. The drive unit of claim 17, wherein each of the first and second torque arm sliders comprise a unitary polymeric structure extending from a first end to a second end and defining a flat surface and a face surface each opposing a base surface, wherein the base surface is received in the respective first and second slider channels of the torque arm, wherein the flat surface and the face surface engage the respective first and second inner tangential faces of the channel of the tower.

19. The drive unit of claim 18, wherein the unitary polymeric structure has a weight within a range from about 2.0 grams (g) to about 4.5 g and comprises at least one of a polyamide, a polyimide, and a polyamide imide.

20. The drive unit of claim 18, wherein the face surface extends at an angle within a range from about 20-degrees to about 30-degrees away from a plane defined by the flat surface, and wherein a maximum height of each of the first and second torque arm sliders is within a range from about 10 millimeters (mm) to about 15 mm.

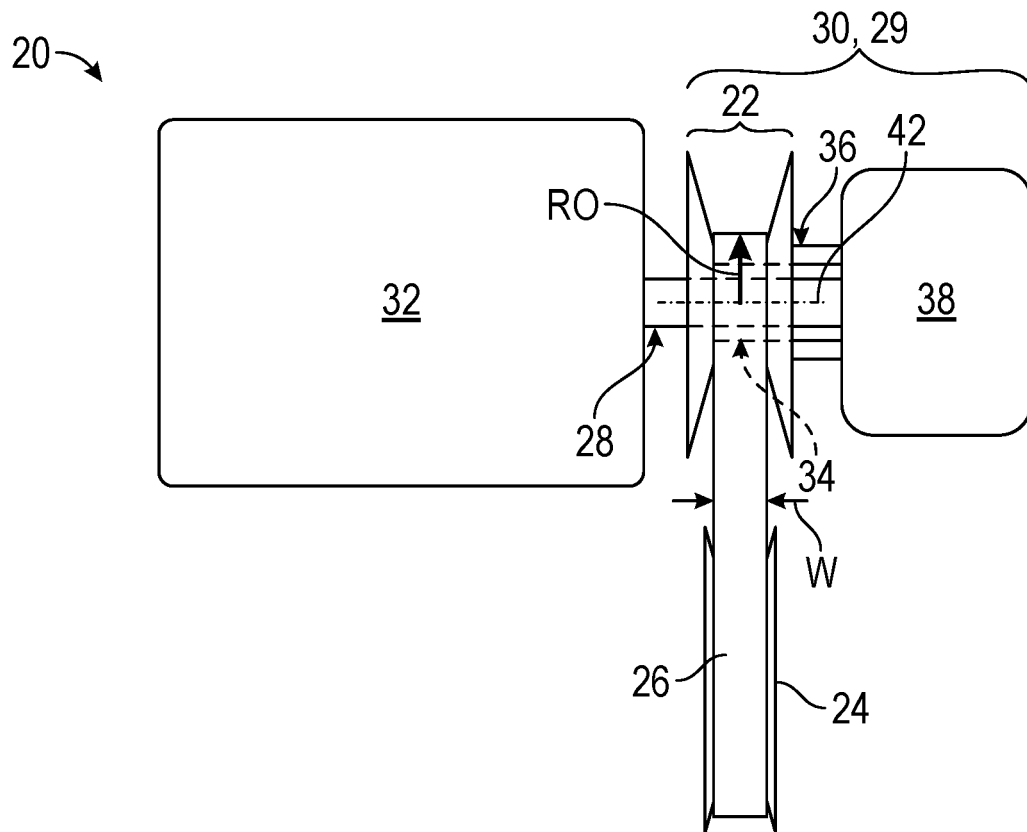


FIG. 1

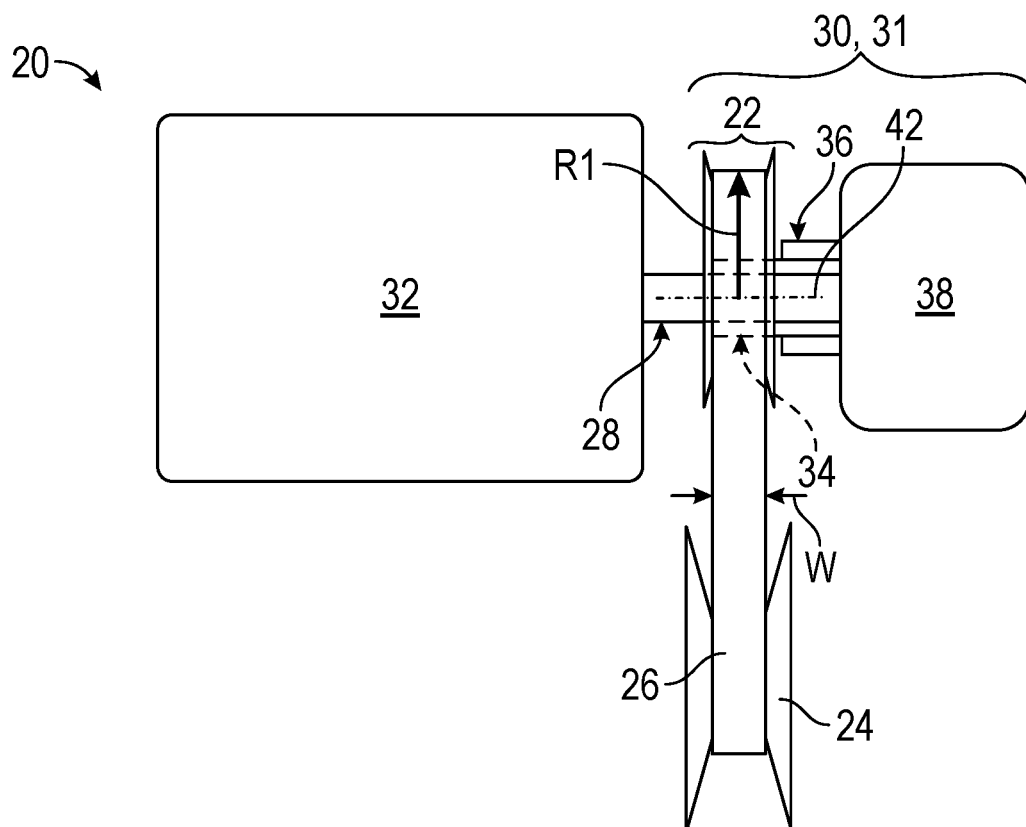


FIG. 2

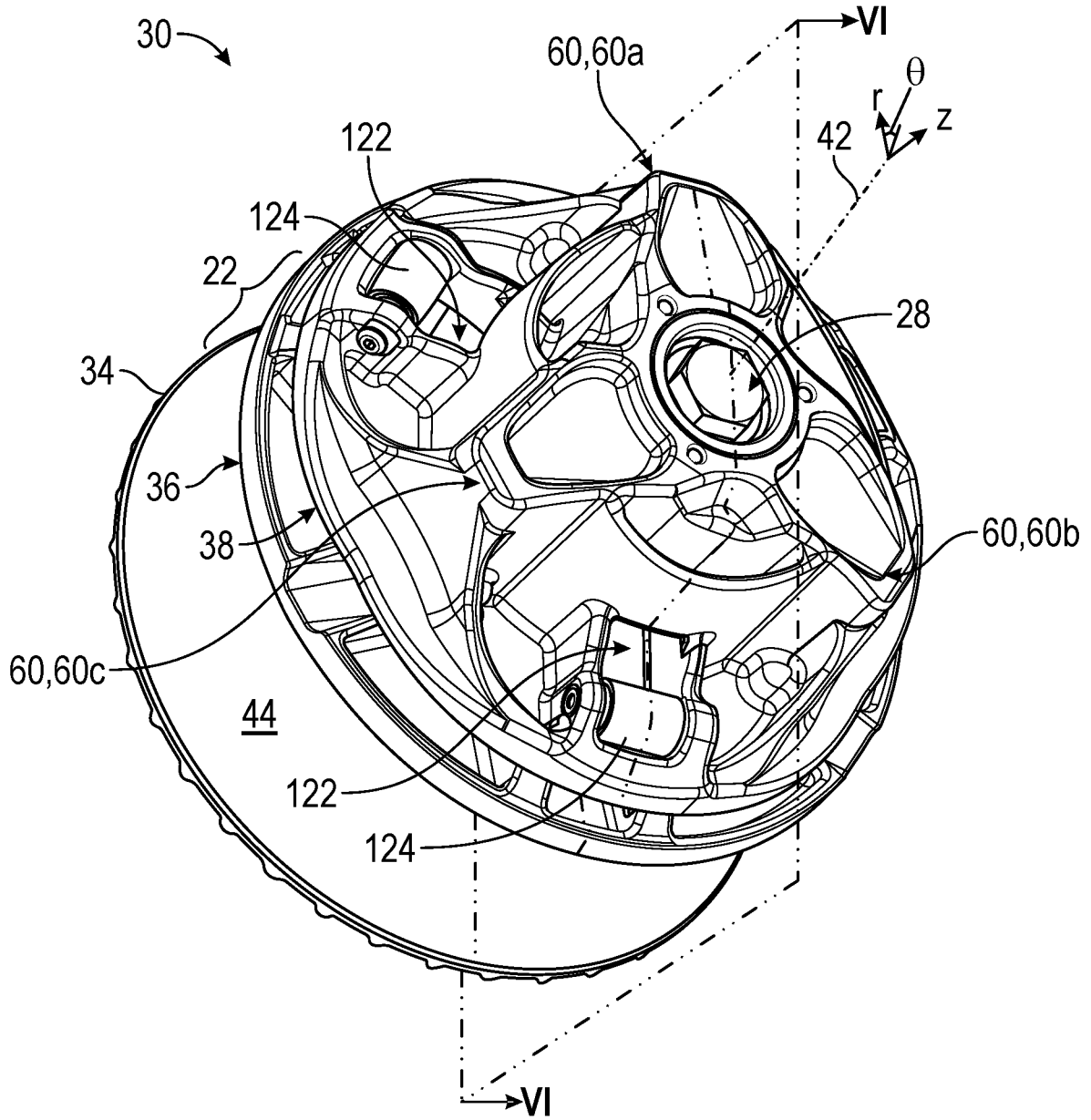


FIG. 3

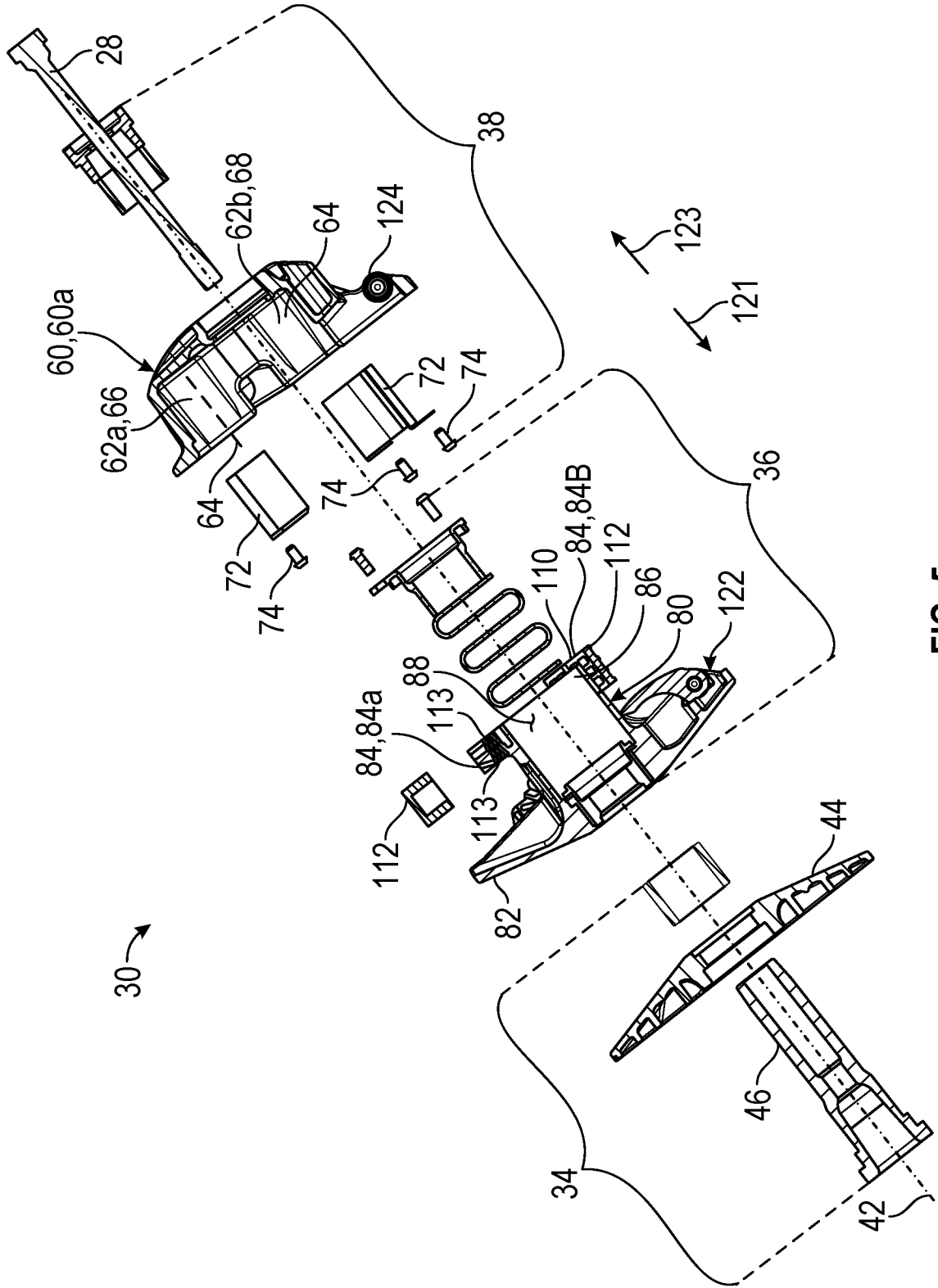


FIG. 5

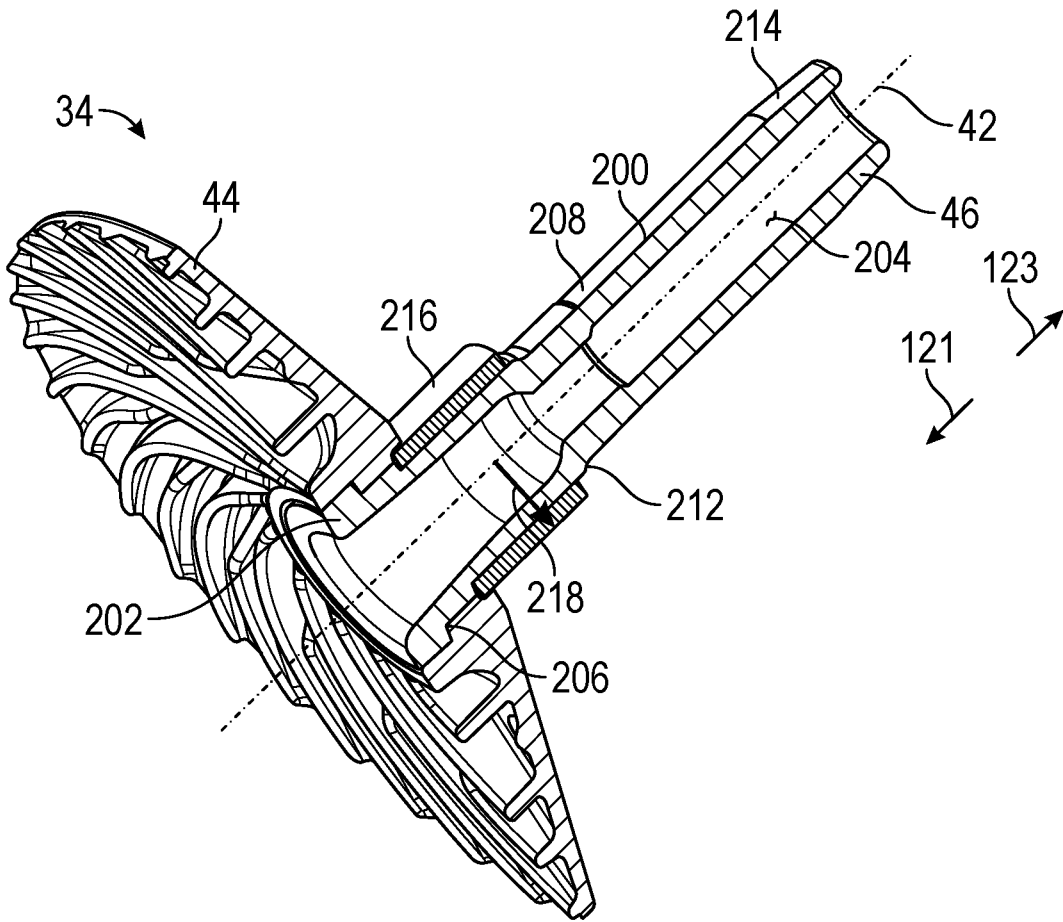


FIG. 7

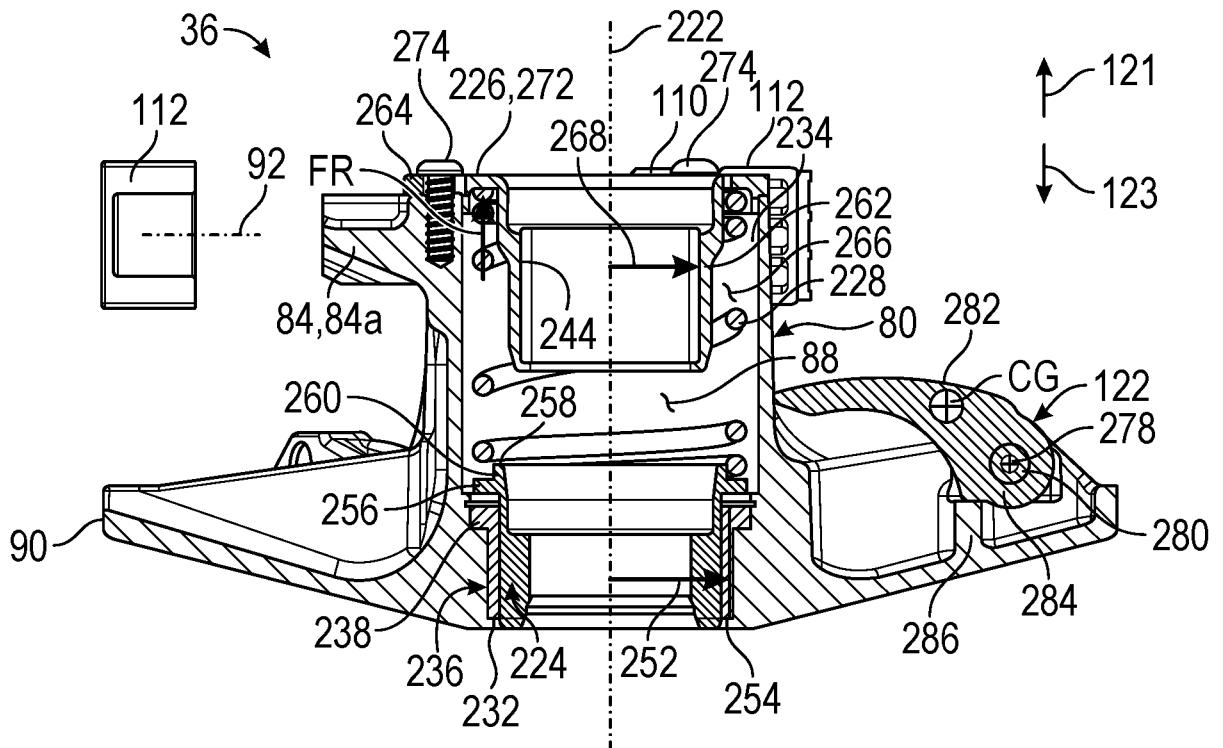


FIG. 8

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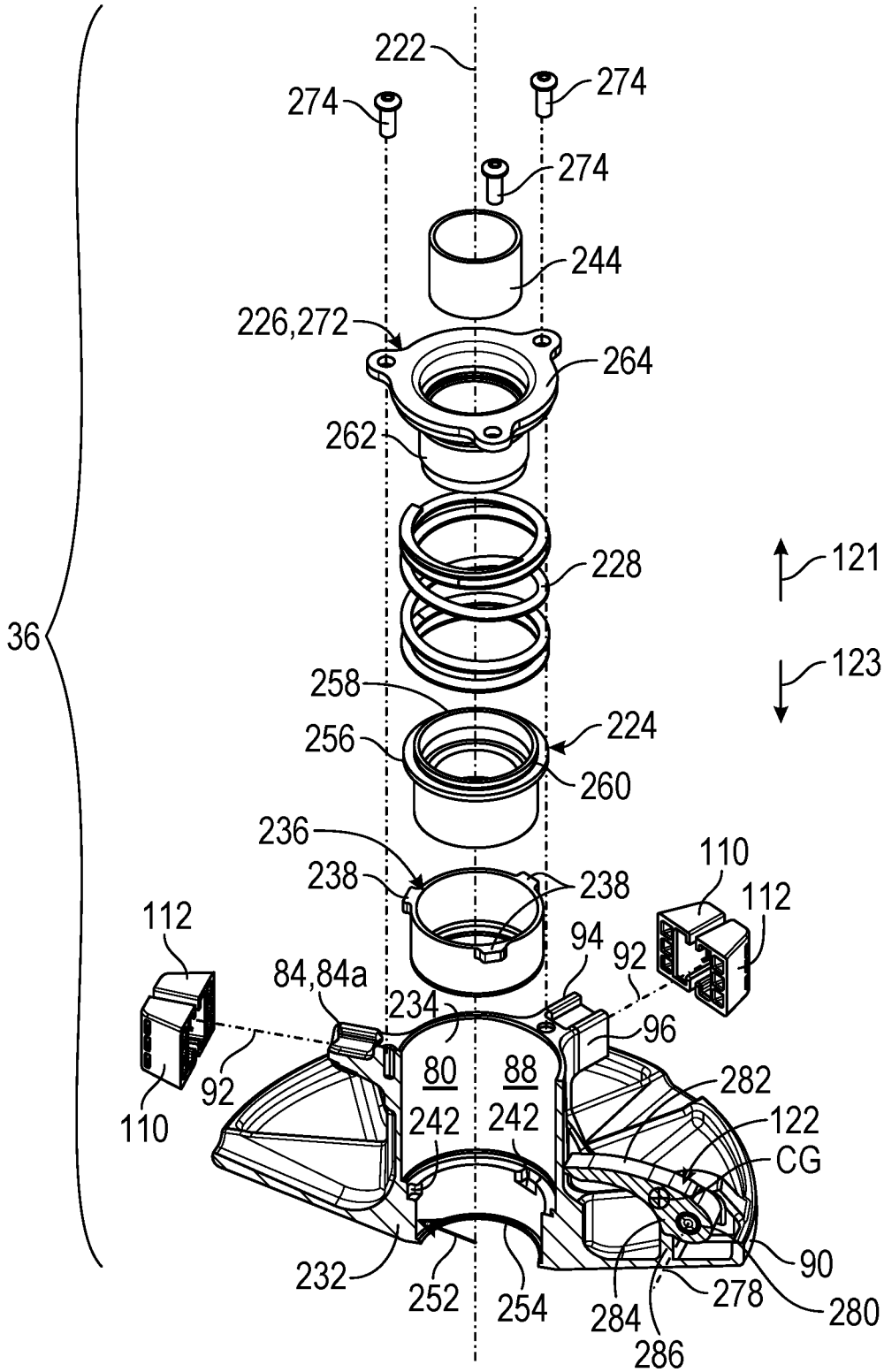


FIG. 9

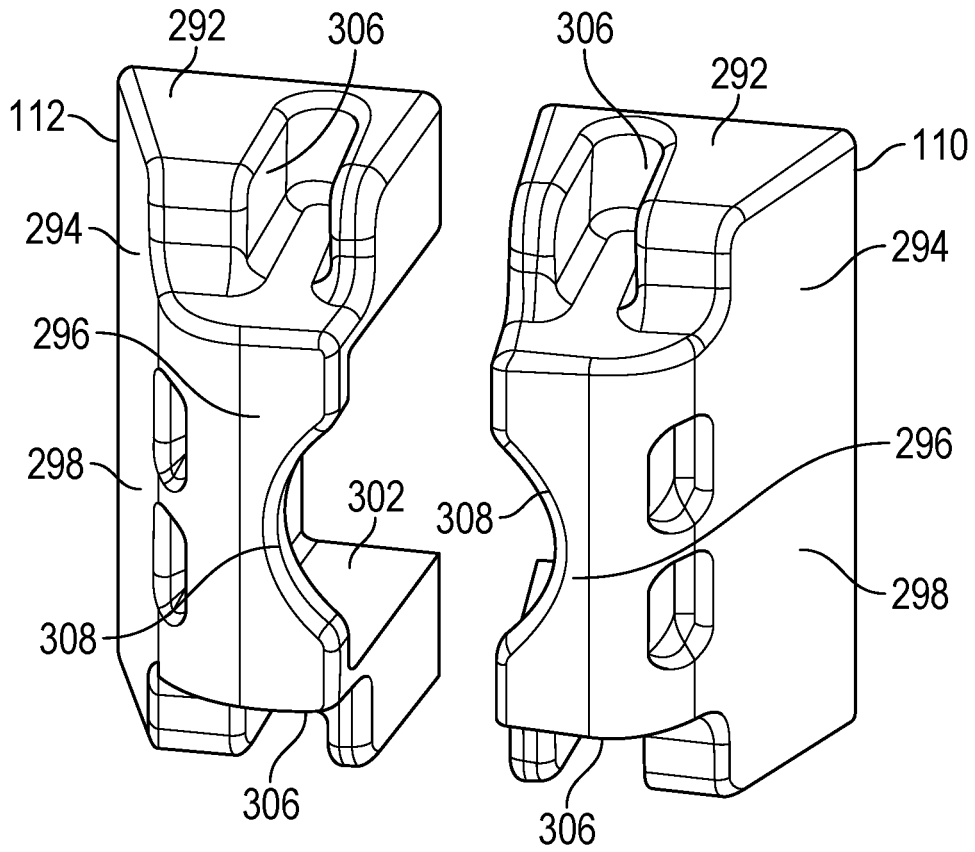


FIG. 10

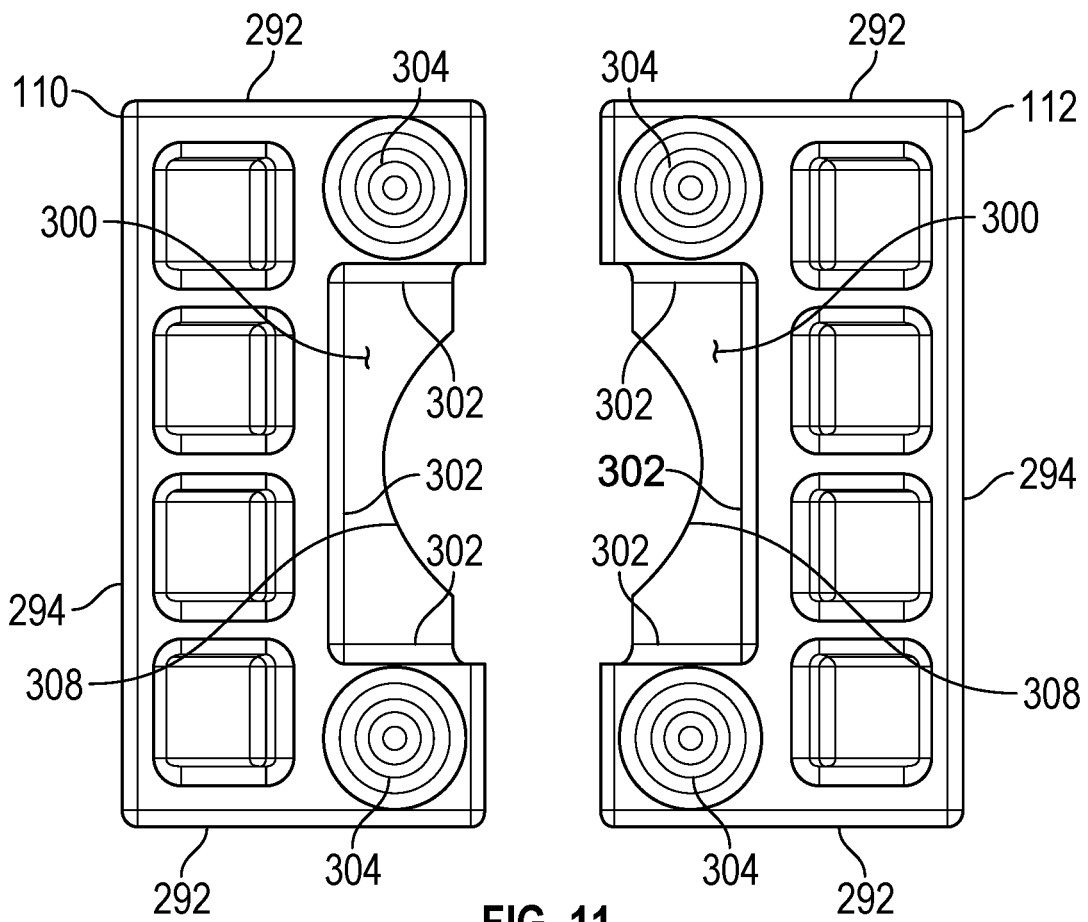


FIG. 11

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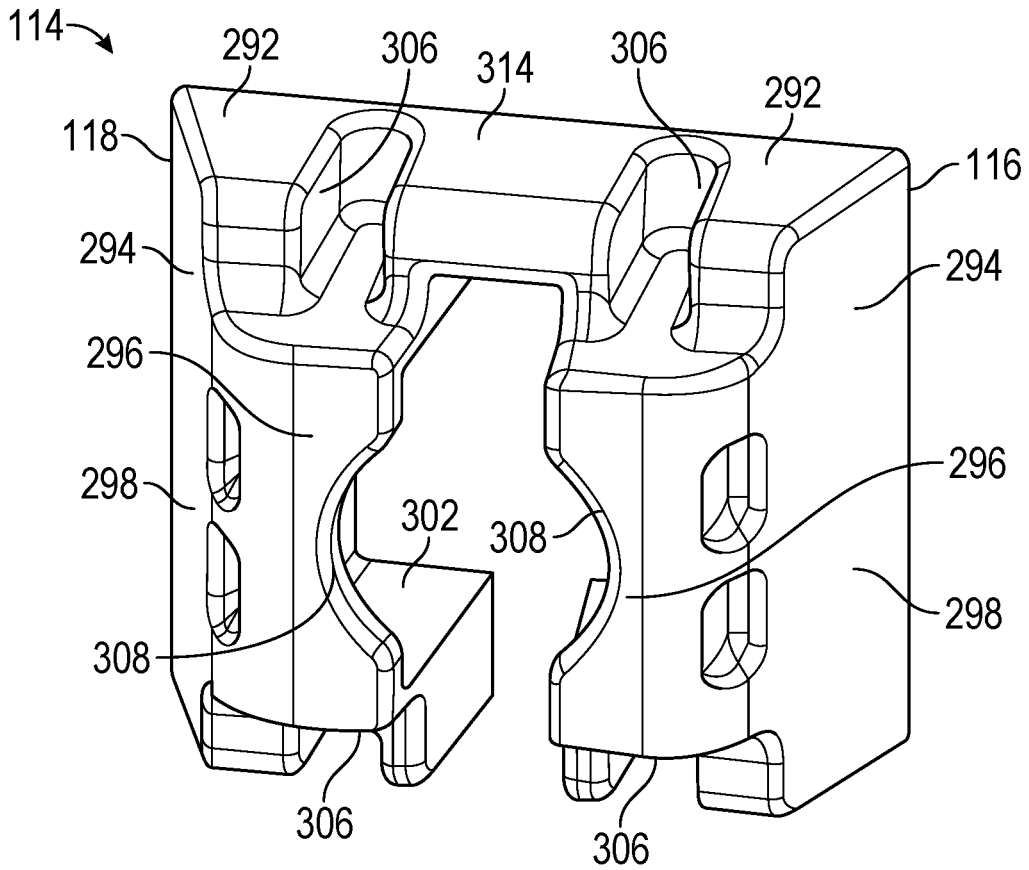


FIG. 12

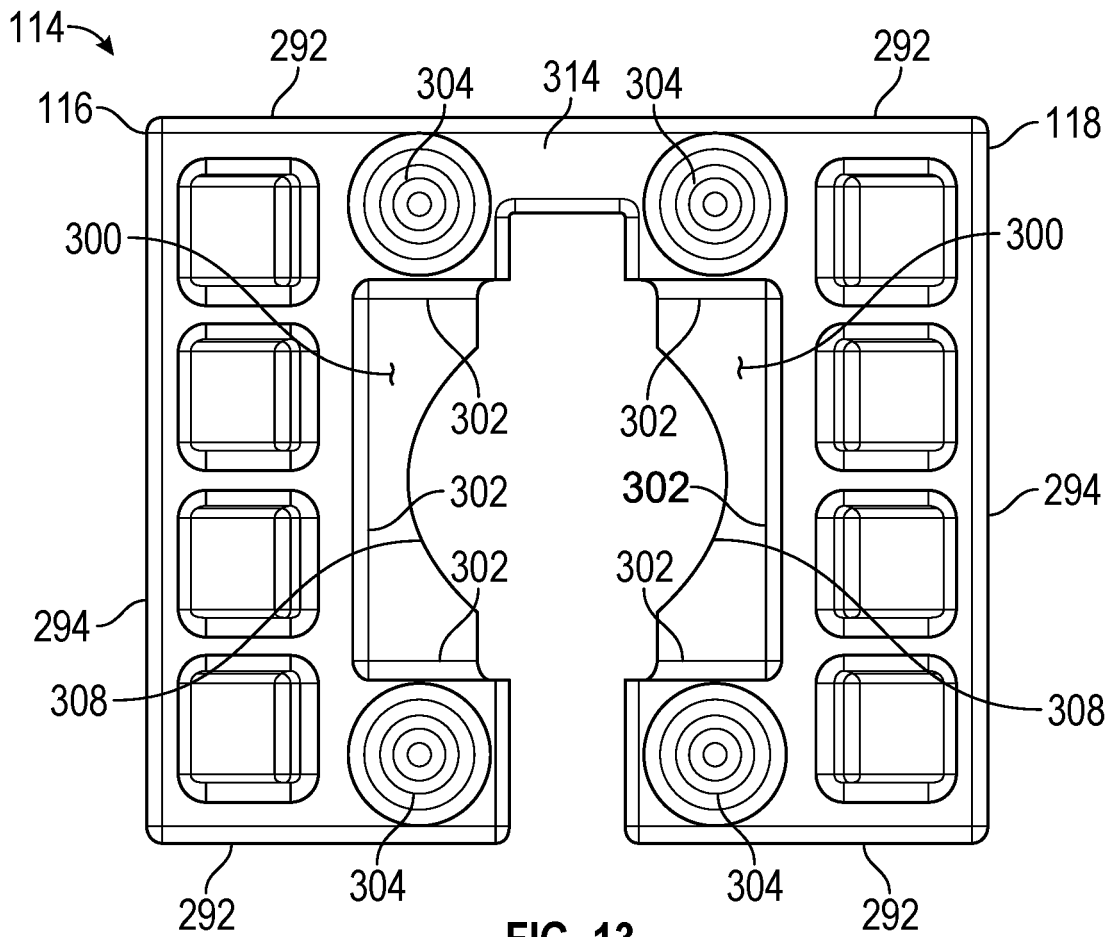


FIG. 13

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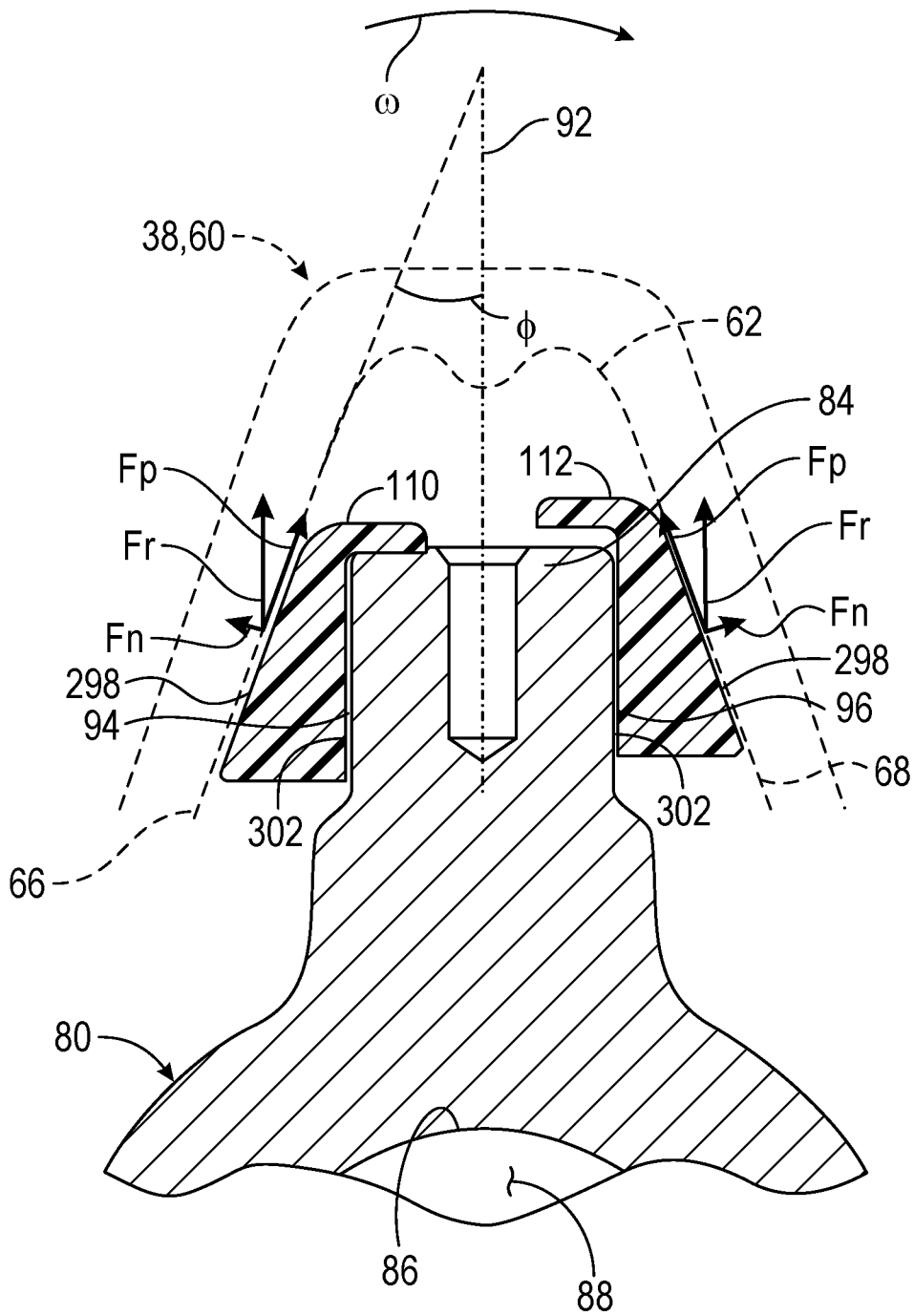


FIG. 14

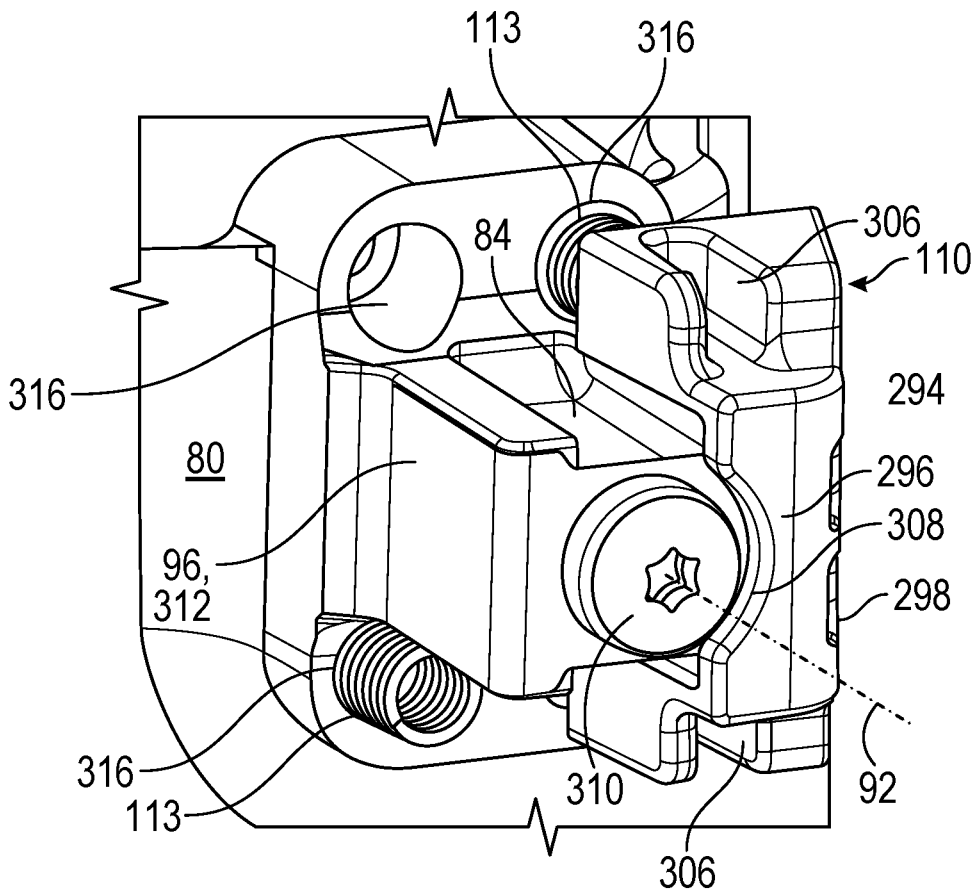


FIG. 15

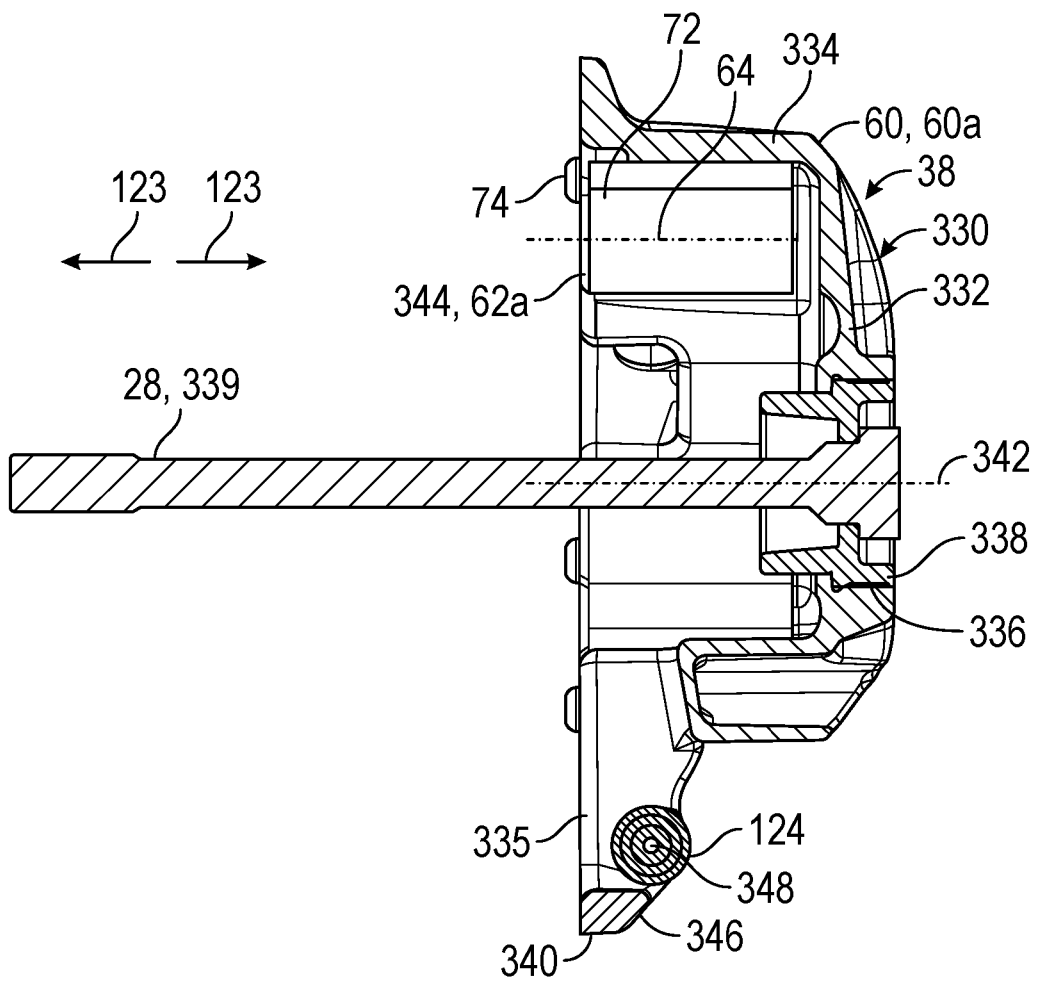


FIG. 16

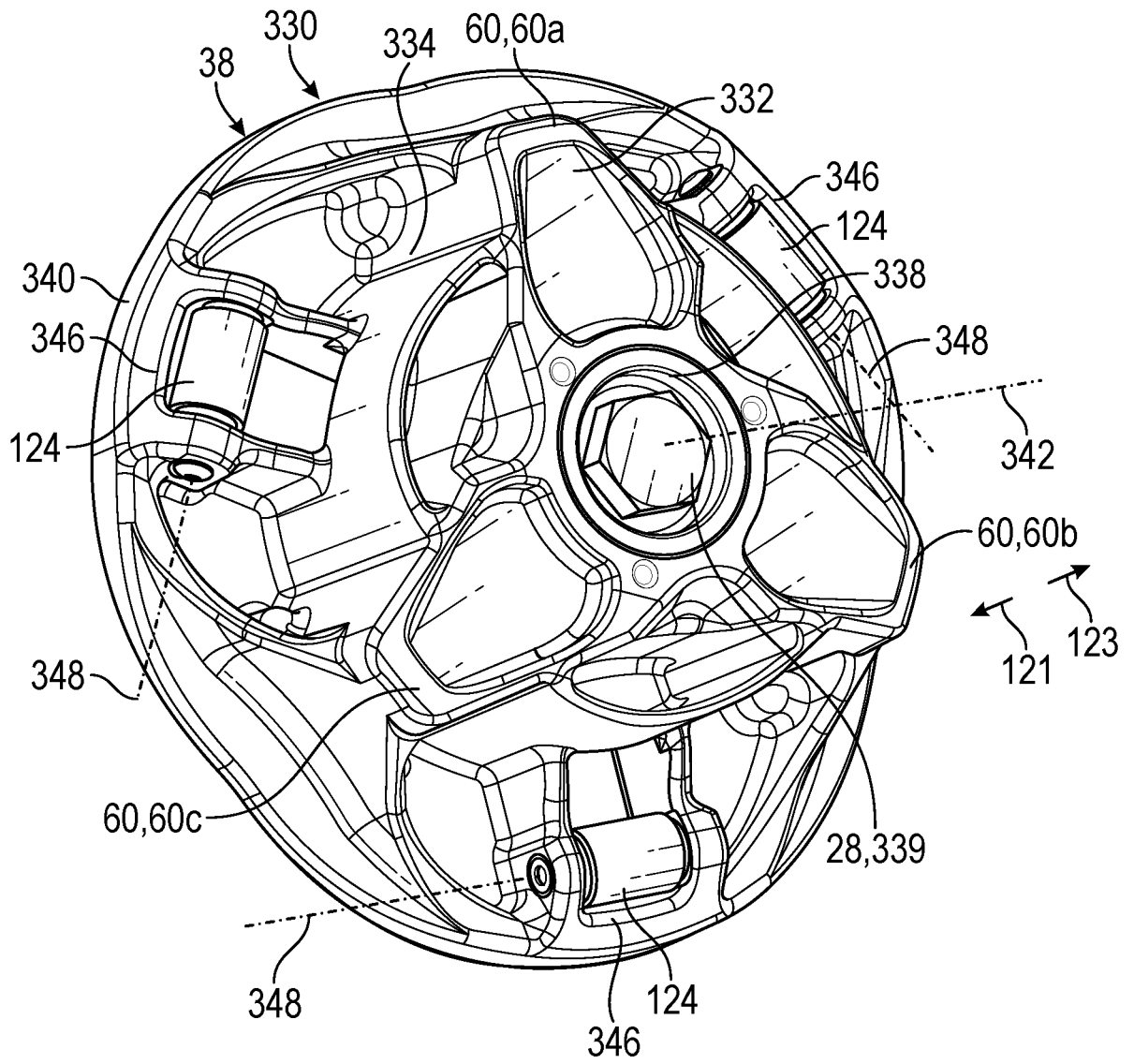


FIG. 17

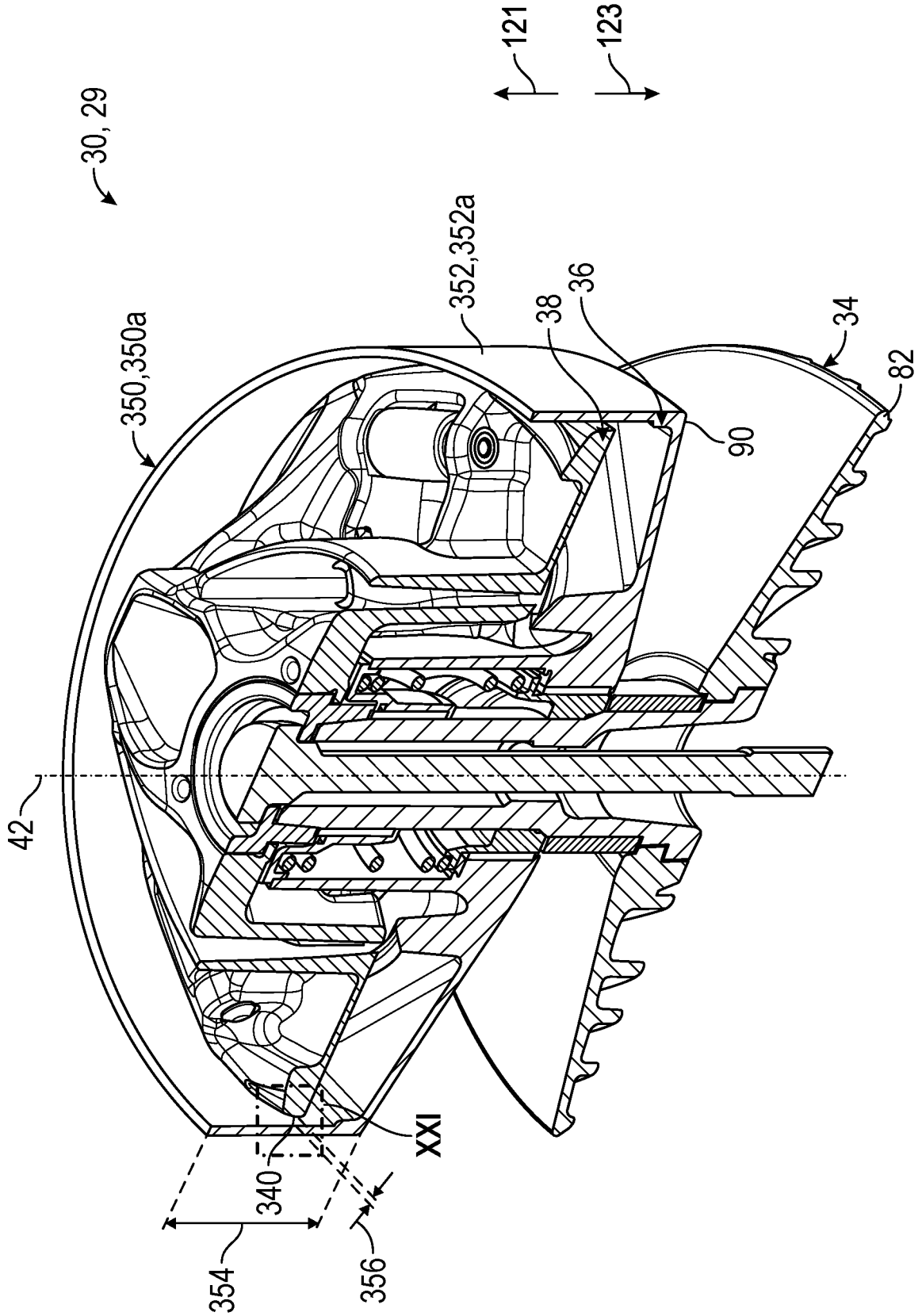


FIG. 18

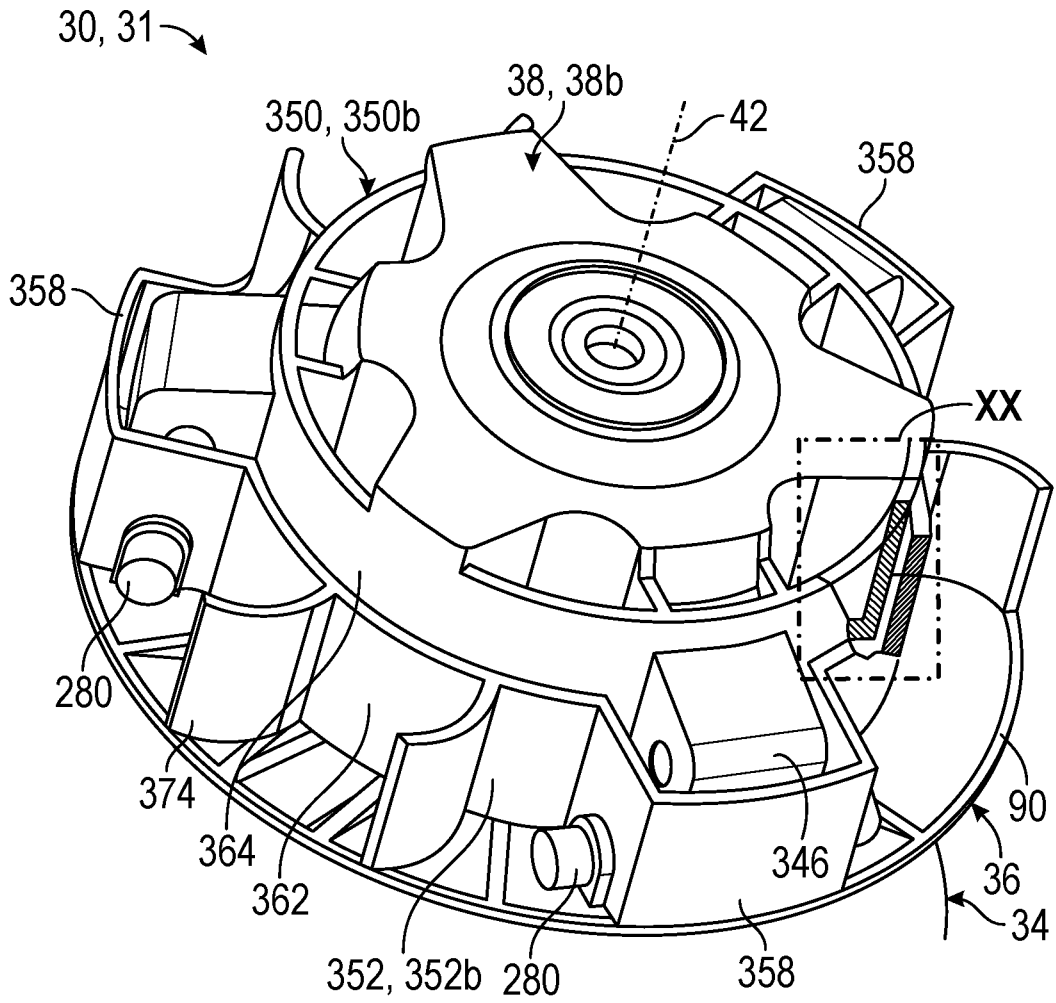


FIG. 19

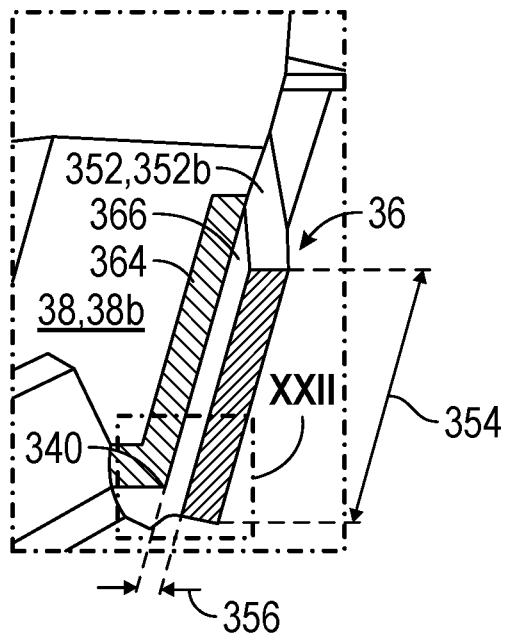


FIG. 20

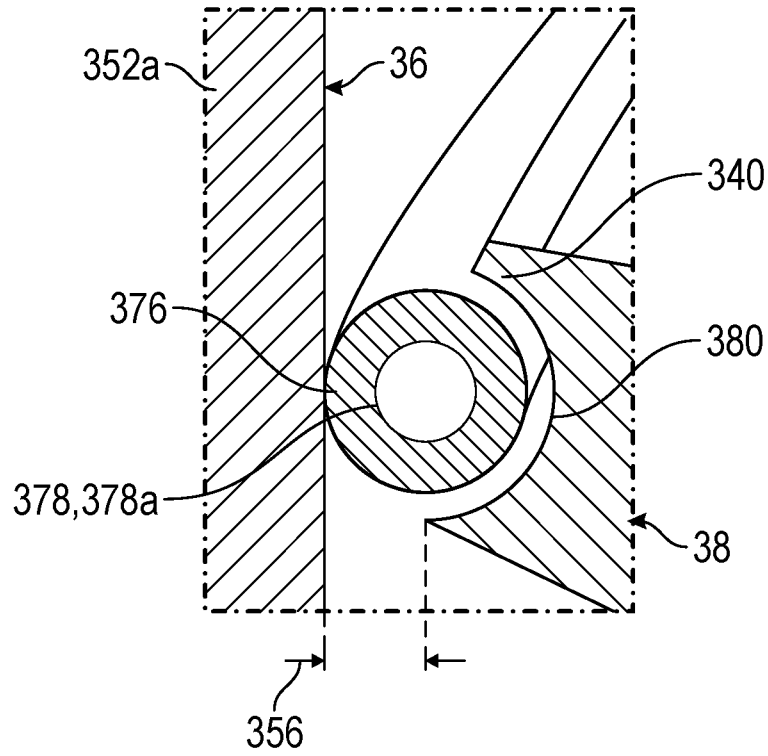


FIG. 21

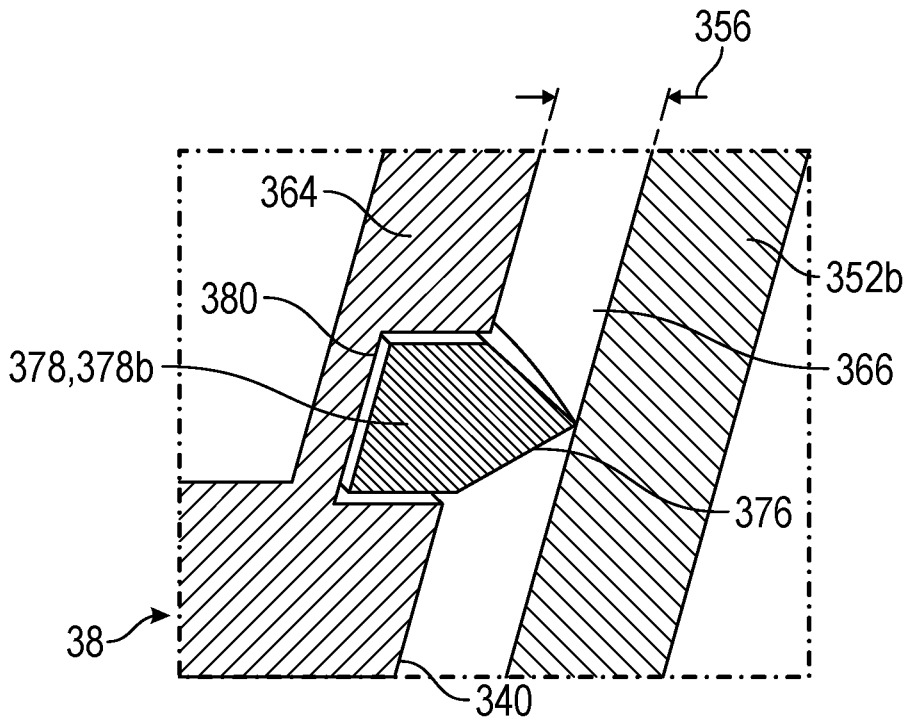


FIG. 22

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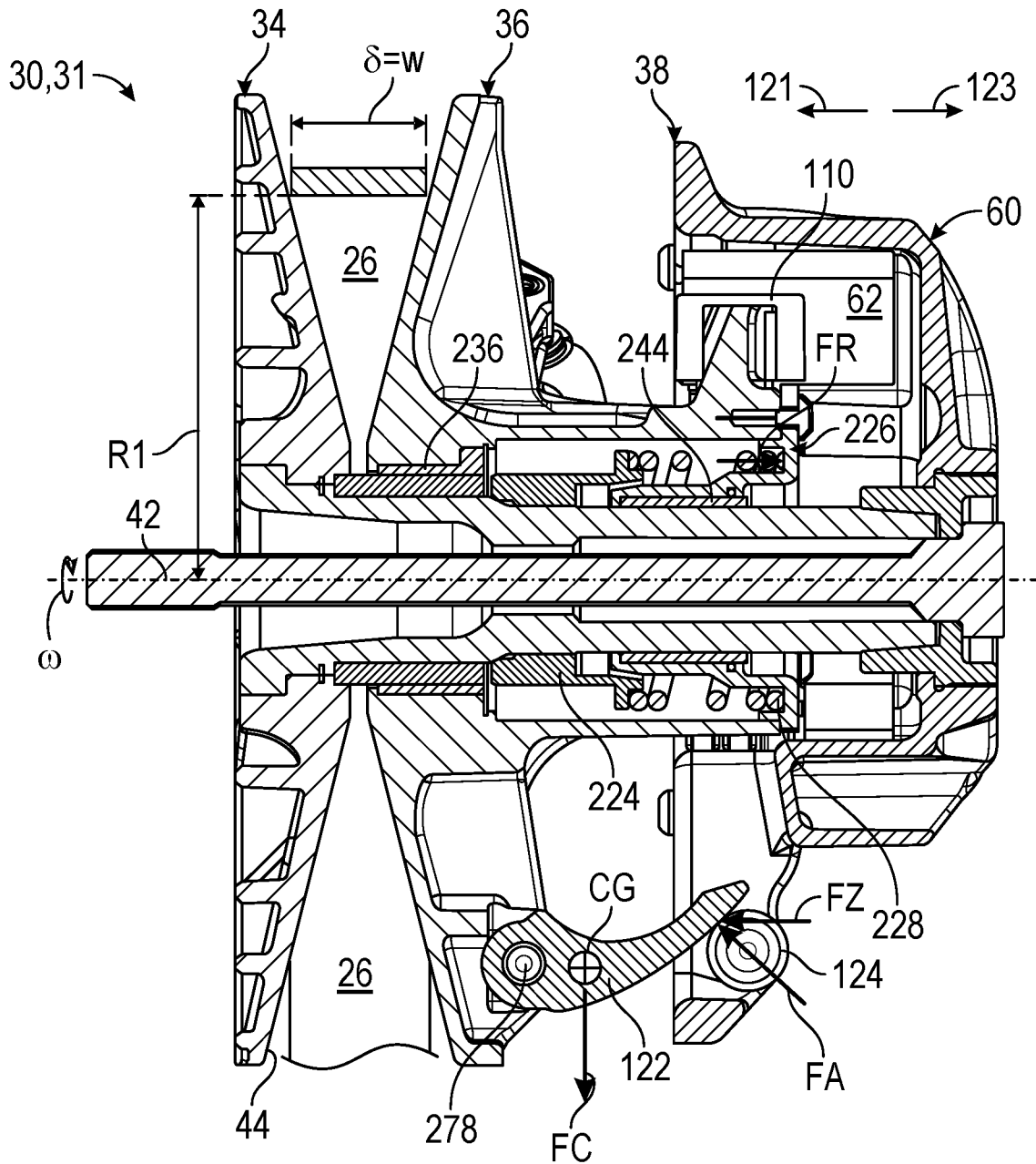


FIG. 23

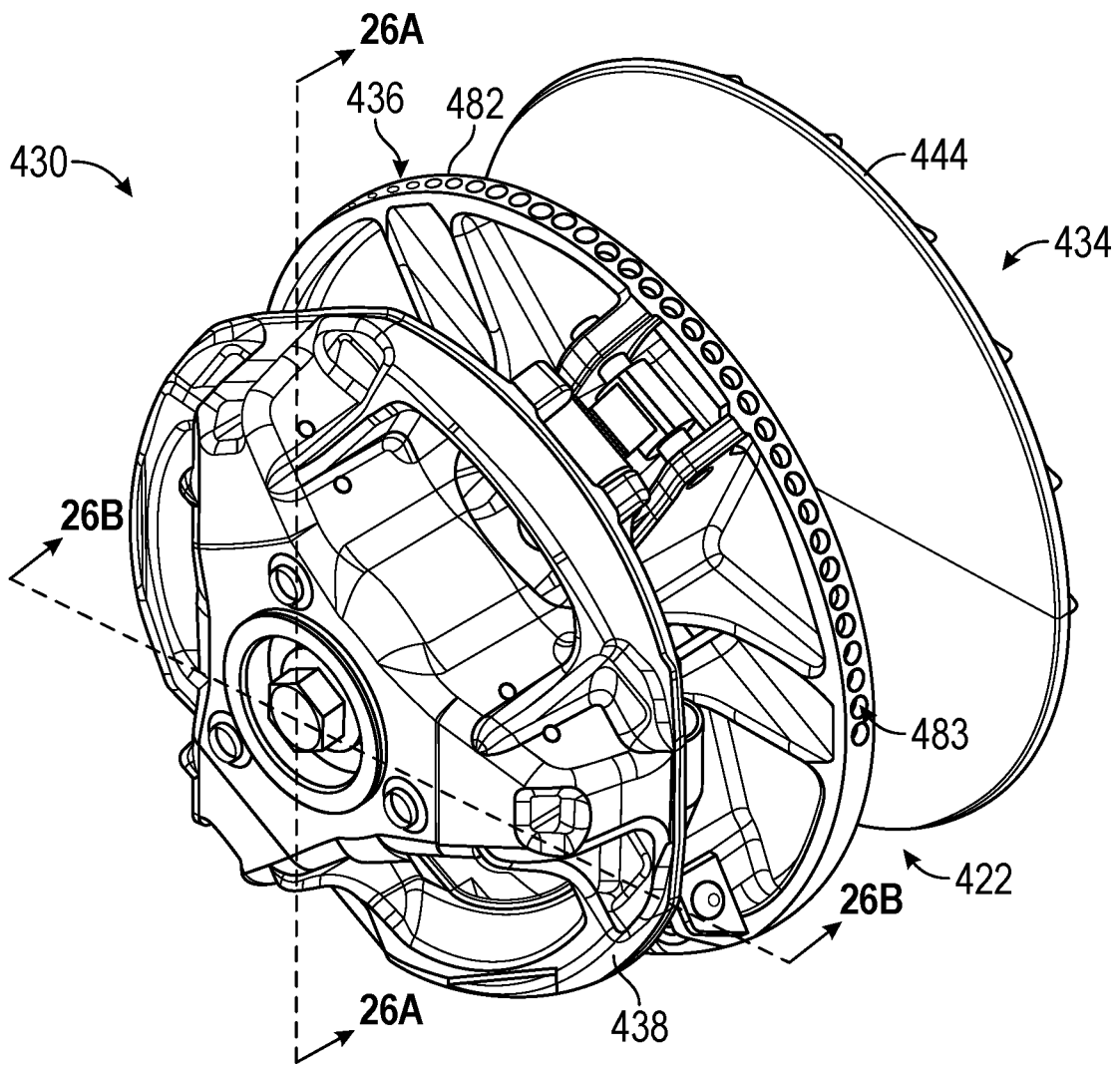


FIG. 24

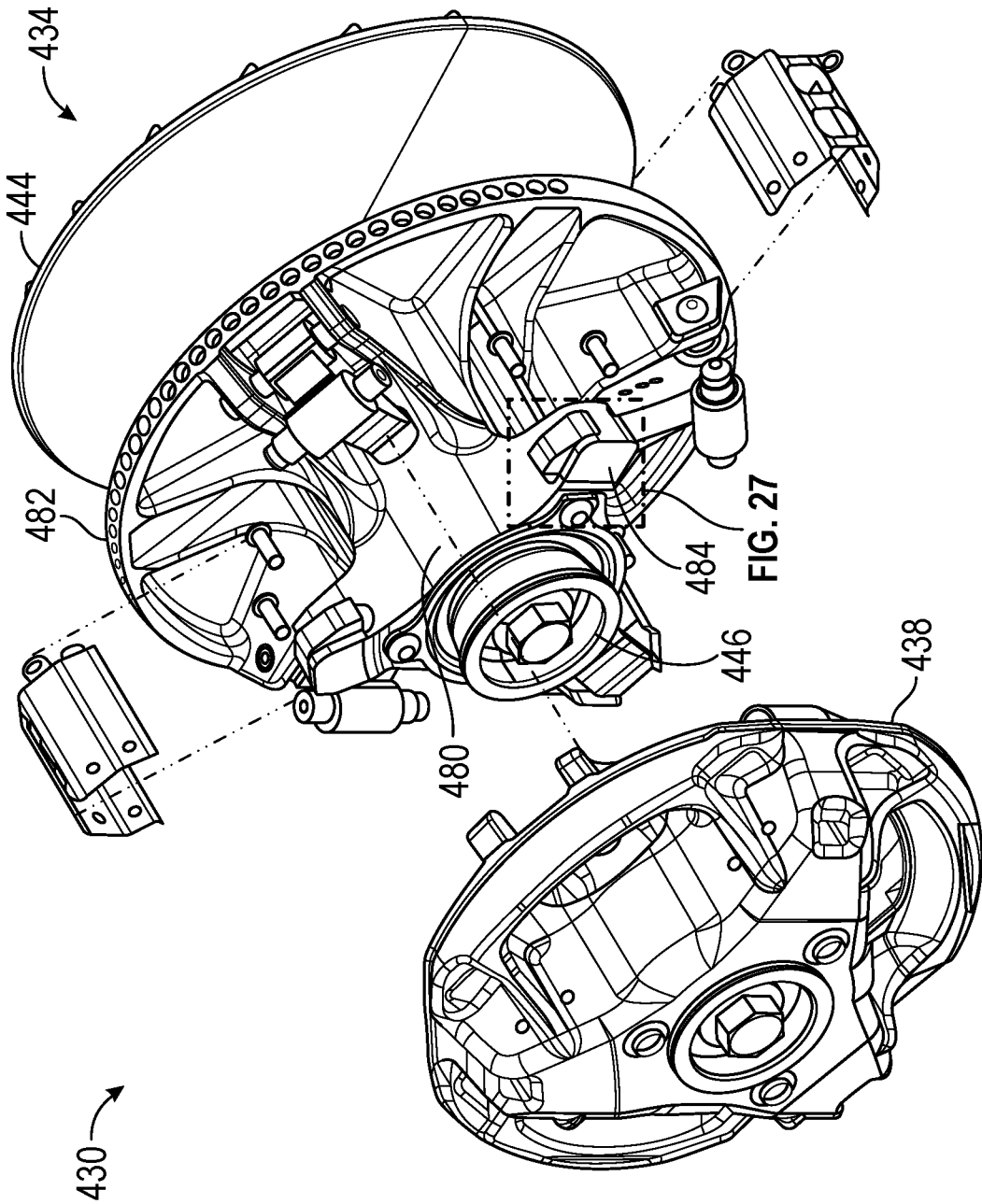


FIG. 25

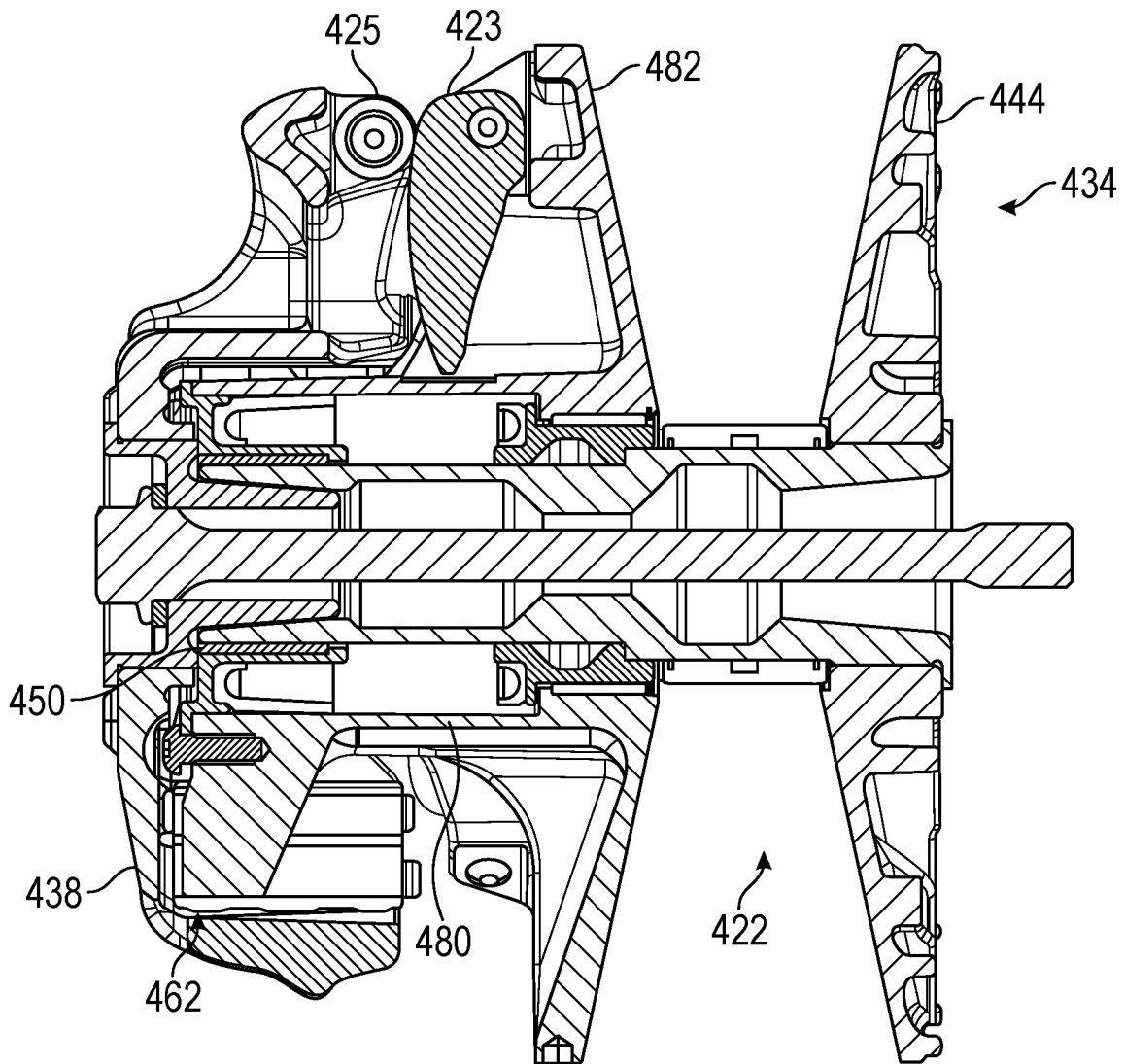


FIG. 26A

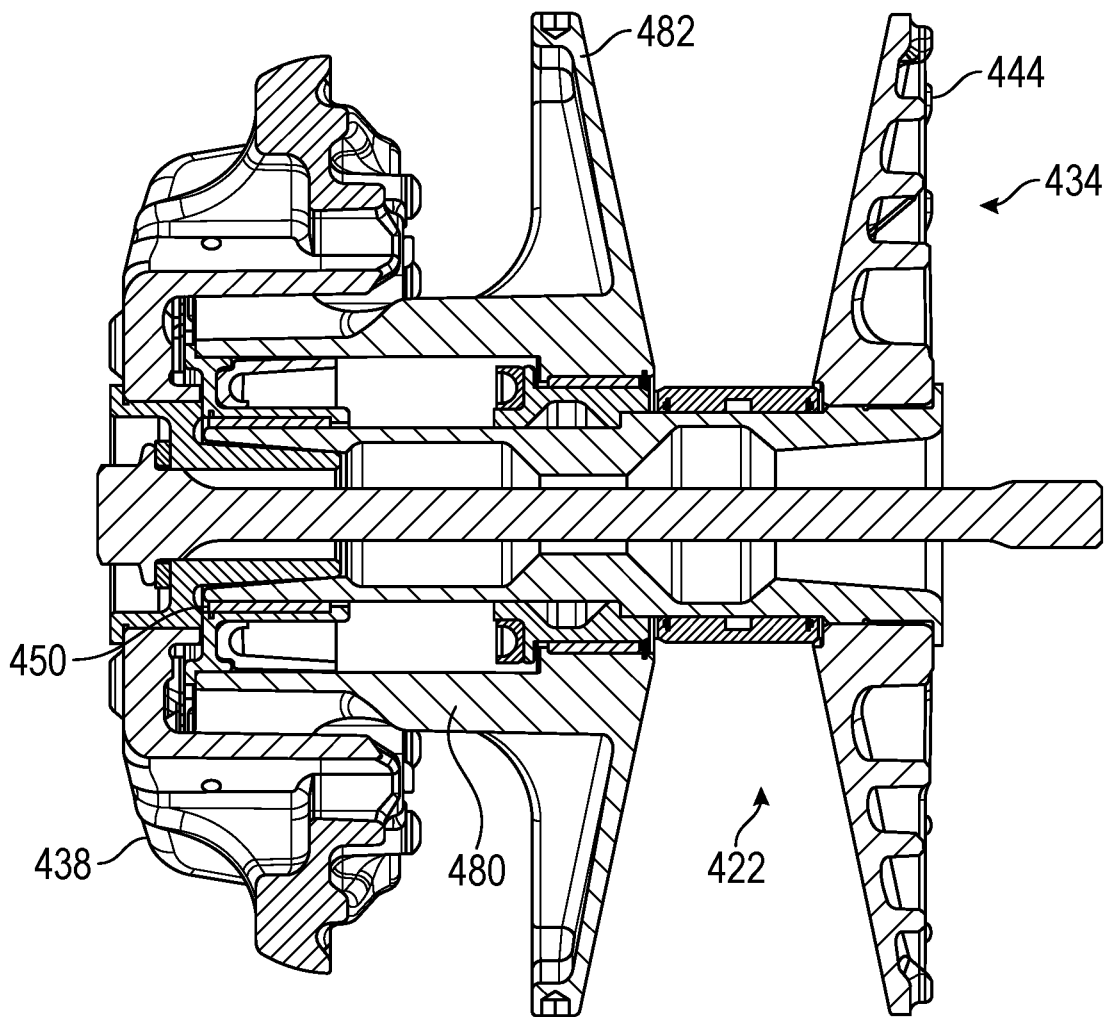


FIG. 26B

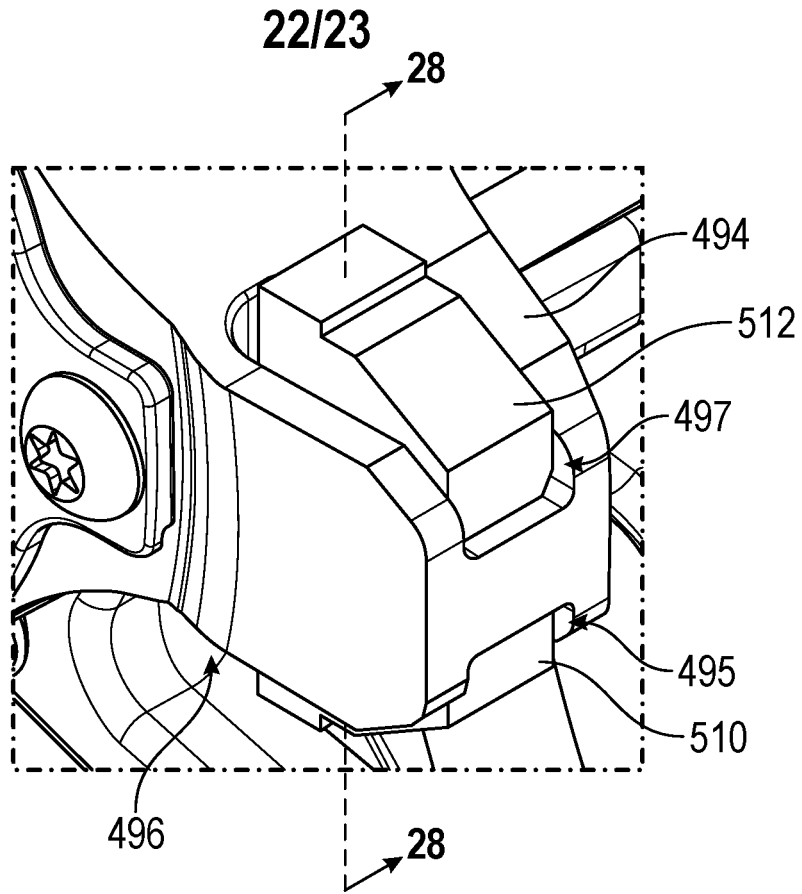


FIG. 27

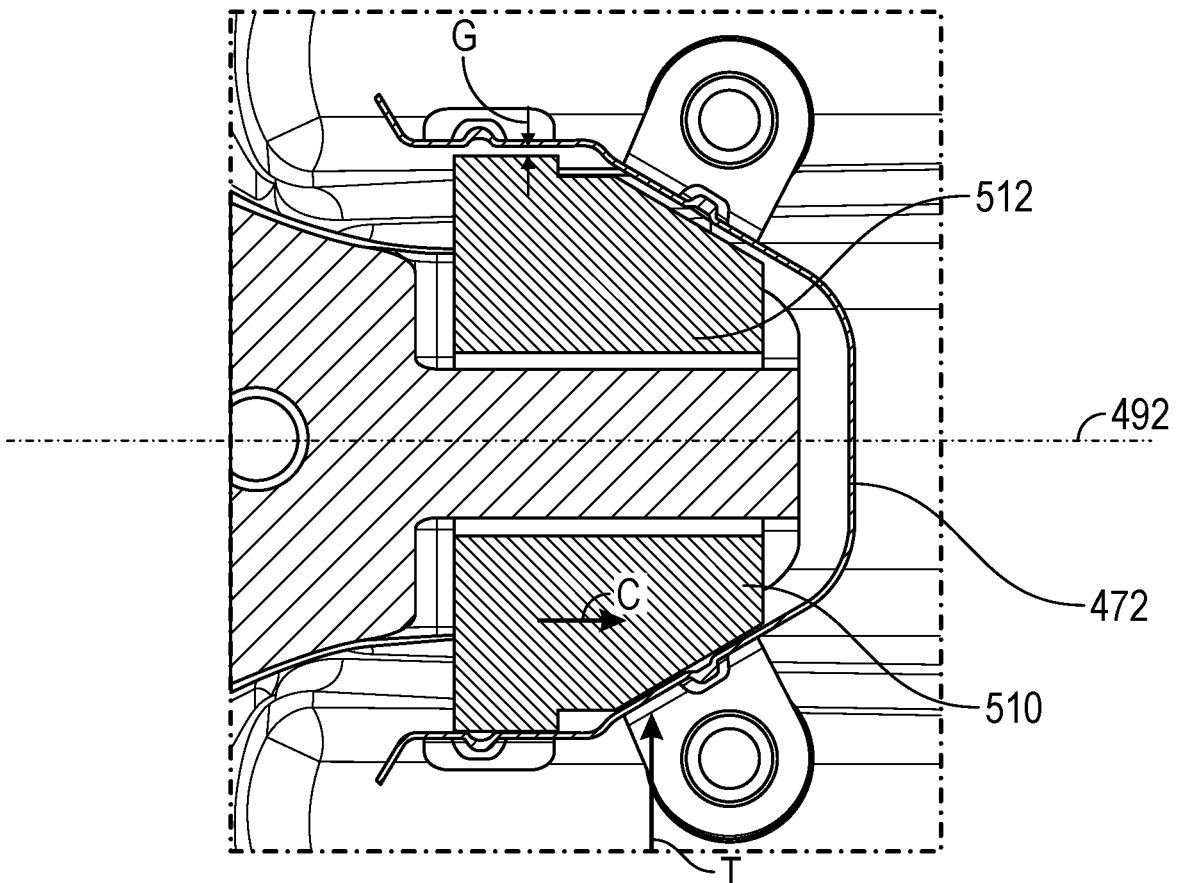


FIG. 28

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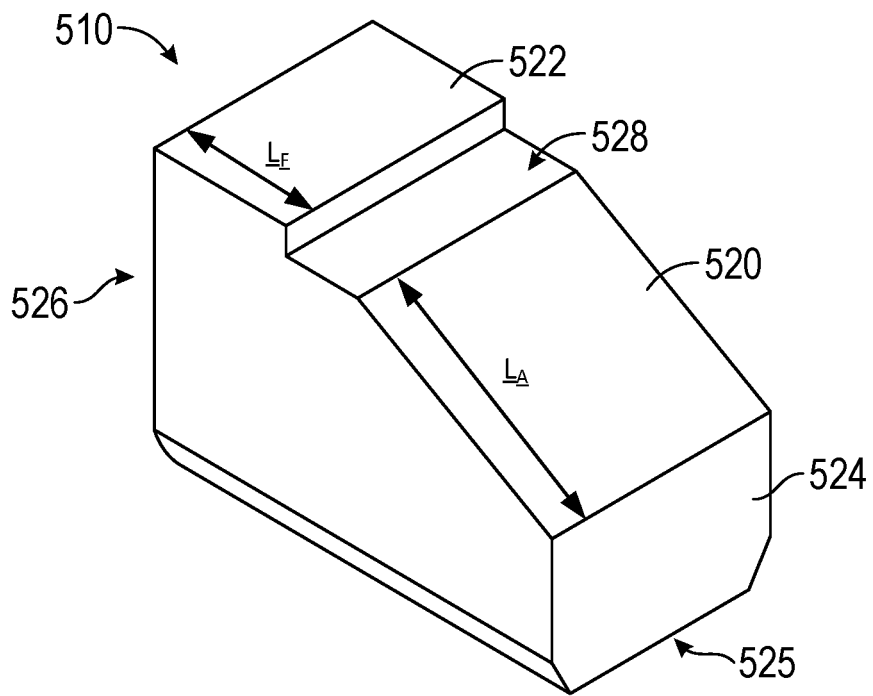


FIG. 29A

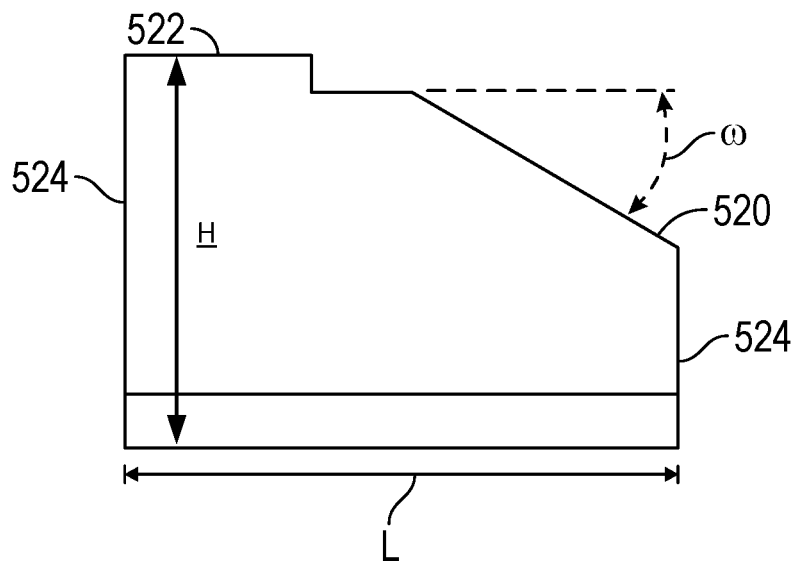


FIG. 29B

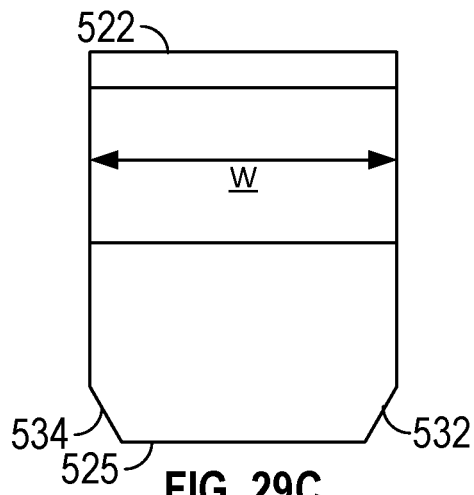


FIG. 29C